The International Conference on Regional Climate-CORDEX 2016 (ICRC-CORDEX 2016), to be held in Stockholm 17th-20th May 2016, will bring together the international regional climate research community, focusing on high resolution climate information and its applications to vulnerability, impacts and adaptation and the full spectrum of potential end users of regional climate information. It will promote the CORDEX vision to advance and coordinate the science and application of regional climate downscaling through global partnerships.
ORAL SESSIONS
## Orals - Table of contents

<table>
<thead>
<tr>
<th>Name</th>
<th>Abstract Title</th>
<th>Day/time</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akperov Mirsed</td>
<td>Cyclone activity in the Arctic from an ensemble of regional climate models (Arctic CORDEX)</td>
<td>Thursday 19 May - 11:45-12:00</td>
<td>LXXII</td>
</tr>
<tr>
<td>Argueso Daniel</td>
<td>Does convection-permitting resolution improve simulated precipitation in the Maritime Continent?</td>
<td>Wednesday 18 May - 14:30-14:45</td>
<td>XXXVII</td>
</tr>
<tr>
<td>Arritt Raymond</td>
<td>Extreme precipitation in an ensemble of regional climate models</td>
<td>Thursday 19 May - 11:30-11:45</td>
<td>LXXI</td>
</tr>
<tr>
<td>Belda Michal</td>
<td>Urban climate - air quality interactions in regional scale over Central Europe</td>
<td>Wednesday 18 May - 15:00-15:15</td>
<td>XLIX</td>
</tr>
<tr>
<td>Benestad Rasmus</td>
<td>PCA-based strategy to represent stations for empirical-statistical downscaling.</td>
<td>Wednesday 18 May - 15:45-16:00</td>
<td>LIX</td>
</tr>
<tr>
<td>Betolli Maria</td>
<td>Statistical downscaling of daily precipitation in the Argentine Pampas region</td>
<td>Wednesday 18 May - 15:45-16:00</td>
<td>LX</td>
</tr>
<tr>
<td>Bonanno Riccardo</td>
<td>Changes in heavy precipitation events over Mediterranean Basin</td>
<td>Thursday 19 May - 10:45-11:00</td>
<td>LXVI</td>
</tr>
<tr>
<td>Brauch Jennifer</td>
<td>Simulation of snow bands in the Baltic Sea area with the coupled atmosphere-ocean-ice model COSMO-CLM/NEMO-Nordic</td>
<td>Thursday 20 May - 10:45-11:00</td>
<td>LXXVIII</td>
</tr>
<tr>
<td>Buccignani Edoardo</td>
<td>Estimation of sensitivity and added value of climate simulations for the Israeli region using COSMO-CLM with three nested domains</td>
<td>Wednesday 18 May - 15:45-16:00</td>
<td>XL</td>
</tr>
<tr>
<td>Bukovsky Melissa</td>
<td>NA-CORDEX Simulation Assessment for the North American Monsoon</td>
<td>Wednesday 18 May - 11:30-11:45</td>
<td>XVI</td>
</tr>
<tr>
<td>Cabos William</td>
<td>The role of internal and external variability in the simulated Caribbean climate</td>
<td>Wednesday 18 May - 11:00-11:15</td>
<td>XXIII</td>
</tr>
<tr>
<td>Casanueva Ana</td>
<td>Added value of high resolution RCM simulations and comparison with Statistical Downscaling Methods within the EURO-CORDEX framework</td>
<td>Wednesday 18 May - 11:45-12:00</td>
<td>XVII</td>
</tr>
<tr>
<td>Cassano John</td>
<td>Simulation of the Arctic climate system with the Regional Arctic System Model (RASM): Sensitivity to atmospheric processes</td>
<td>Wednesday 18 May - 11:30-11:45</td>
<td>XXV</td>
</tr>
<tr>
<td>Chen Cheng-Ta</td>
<td>Is There an Added Value from Regional Climate Modeling for Projected Change in Future Northwest Pacific Tropical Cyclone Activities?</td>
<td>Wednesday 18 May - 11:15-11:30</td>
<td>XV</td>
</tr>
<tr>
<td>Cheneke Bedassa Regassa</td>
<td>Searching for an Added Value of Precipitation in Downscaled Seasonal Hindcasts over East Africa: COSMO-CLM Forced by MPI-ESM</td>
<td>Wednesday 18 May - 10:45-11:00</td>
<td>XIII</td>
</tr>
<tr>
<td>Christensen Ole</td>
<td>HIRHAM5: A Regional Coupled Model System to Examine Ocean-Atmosphere-Sea Ice, Ice Sheet and Permafrost Interactions in the Arctic</td>
<td>Wednesday 18 May - 09:30-09:45</td>
<td>XIX</td>
</tr>
<tr>
<td>Coppola Erika</td>
<td>Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations</td>
<td>Tuesday 17 May - 16:00-16:15</td>
<td>V</td>
</tr>
<tr>
<td>Dairaku Koji</td>
<td>High resolution probabilistic regional climate projection using a regression method with multi-model ensemble</td>
<td>Wednesday 18 May - 15:00-15:15</td>
<td>LVIII</td>
</tr>
<tr>
<td>Daron Joe</td>
<td>Visual Summaries of Ensemble Regional Projections</td>
<td>Wednesday 18 May - 10:45-11:00</td>
<td>XXXI</td>
</tr>
<tr>
<td>Das Lalu</td>
<td>Selection of suitable predictors and predictor domain for statistical downscaling: A case study over the Western Himalayan region of India</td>
<td>Wednesday 18 May - 14:30-14:45</td>
<td>LVI</td>
</tr>
<tr>
<td>De la Cruz Gustavo</td>
<td>Future precipitation in central Andes of Peru</td>
<td>Wednesday 18 May - 16:00-16:15</td>
<td>LX</td>
</tr>
<tr>
<td>Deque Michel</td>
<td>Extreme rainfall in South East France: convection resolving simulation versus EuroCordex approach</td>
<td>Wednesday 18 May - 14:45-15:00</td>
<td>XXXVIII</td>
</tr>
<tr>
<td>Di Luca Alejandro</td>
<td>Quantifying the overall added value of dynamical downscaling and the contribution from different spatial scales</td>
<td>Wednesday 18 May - 09:45-10:00</td>
<td>XI</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Date/Time</td>
<td>Page</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Diaconescu Emilia Paula</td>
<td>Daily precipitation extremes over Northern Canada estimated from Arctic and North-America CORDEX simulations and reanalysis</td>
<td>Thursday 19 May - 09:30-09:45</td>
<td>LXXV</td>
</tr>
<tr>
<td>Drobinski Philippe</td>
<td>Scaling of precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios</td>
<td>Thursday 19 May - 09:45-10:00</td>
<td>LXVI</td>
</tr>
<tr>
<td>Ekström Marie</td>
<td>Estimating change in future stream flow based on a limited sample of different downscaling products</td>
<td>Thursday 19 May - 09:00-09:30</td>
<td>LXXXII</td>
</tr>
<tr>
<td>Engelbrecht Francois</td>
<td>The Variable-resolution Earth System Model and its simulations of the Benguela upwelling system</td>
<td>Wednesday 18 May - 10:00-10:15</td>
<td>XXI</td>
</tr>
<tr>
<td>Essery Richard</td>
<td>Observations and downscaling for alpine hydrological modelling</td>
<td>Thursday 19 May - 11:15-11:30</td>
<td>LXXXVI</td>
</tr>
<tr>
<td>Fabien Solmon</td>
<td>Regional climate-chemistry simulations over the med-cordex domain</td>
<td>Wednesday 18 May - 16:15-16:30</td>
<td>LI</td>
</tr>
<tr>
<td>Fernandez Jesus</td>
<td>The Multi-MIP regional distillation dilemma. Results from the Spanish PNACC-2012 Program</td>
<td>Wednesday 18 May - 11:30-11:45</td>
<td>XXXIV</td>
</tr>
<tr>
<td>Fuentes Franco Ramon</td>
<td>Assessment of the Regional Climate Earth System Model (RegESM) simulation in reproducing observed climatic features of the atmosphere over the CORDEX Central America domain</td>
<td>Wednesday 18 May - 10:45-11:00</td>
<td>XXII</td>
</tr>
<tr>
<td>Gamal Abd El-Motey Gamil</td>
<td>Impacts of land use change and horizontal resolution in local climate by RegCM4 model</td>
<td>Wednesday 18 May - 15:45-16:00</td>
<td>L</td>
</tr>
<tr>
<td>Ghimire Shreta</td>
<td>Assessment of the performance of CORDEX-South Asia experiments for monsoon precipitation over the Himalayan region during present climate: part I</td>
<td>Tuesday 17 May - 16:45-17:00</td>
<td>VIII</td>
</tr>
<tr>
<td>Giorghi Filippo</td>
<td>A fine scale topographical modulation of summer precipitation change over the European Alps challenging current GCM projections.</td>
<td>Wednesday 18 May - 11:00-11:15</td>
<td>XIV</td>
</tr>
<tr>
<td>Gutierrez Escribano Claudia</td>
<td>MULTIMODEL ANALYSIS OF SOLAR RADIATION OVER IBERIAN PENINSULA FOR RENEWABLE ENERGY PURPOSES</td>
<td>Thursday 19 May - 09:30-09:45</td>
<td>LXXIV</td>
</tr>
<tr>
<td>Gutmann Ethan</td>
<td>High Resolution Climate Modeling of the Water Cycle over the Contiguous United States Including Potential Climate Change Scenarios</td>
<td>Wednesday 18 May - 16:45-17:00</td>
<td>XLIV</td>
</tr>
<tr>
<td>Halsnæs Kirsten</td>
<td>From regional climate scenarios to economics: identifying uncertainties and risks in the adaptation modelling chain</td>
<td>Wednesday 18 May - 09:00-09:30</td>
<td>XXVII</td>
</tr>
<tr>
<td>Hamdi Rafiq</td>
<td>Future climate of Brussels and Paris for the 2050s under the A1B scenario</td>
<td>Wednesday 18 May - 14:30-14:45</td>
<td>XLVII</td>
</tr>
<tr>
<td>Hempelmann Nils</td>
<td>From [big]data to information visualization with birdhouse: a collection of Web Processing Services</td>
<td>Wednesday 18 May - 10:00-10:15</td>
<td>XXX</td>
</tr>
<tr>
<td>Katzfey Jack</td>
<td>High-resolution (10km) ensemble regional climate projections for SE Asia</td>
<td>Wednesday 18 May - 09:30-09:45</td>
<td>XXVIII</td>
</tr>
<tr>
<td>Kjellstrøm Erik</td>
<td>Production and use of CORDEX projections – a Swedish perspective on building climate services in practice</td>
<td>Tuesday 17 May - 16:30-16:45</td>
<td>VIII</td>
</tr>
<tr>
<td>Knist Sebastian</td>
<td>Added value and land-atmosphere coupling in convection-permitting WRF climate simulations over a Middle European domain</td>
<td>Wednesday 18 May - 15:00-15:15</td>
<td>XXXXIX</td>
</tr>
<tr>
<td>Krienkamp Frank</td>
<td>Results from a downscaled Multi-GCM-Ensemble using the ESD-method EPISODES</td>
<td>Wednesday 18 May - 16:30-16:45</td>
<td>LXII</td>
</tr>
<tr>
<td>Laprise Rene</td>
<td>Challenges in the quest for added value of climate dynamical downscaling: Evidence of added value in North American regional climate model simulations with increasing horizontal resolutions</td>
<td>Wednesday 18 May - 09:00-09:30</td>
<td>IX</td>
</tr>
<tr>
<td>Larsen Morten Andreas Dahl</td>
<td>Preparing for fully coupled climate-hydrological modelling in data-sparse regions applied over the Crati River catchment in Southern Italy</td>
<td>Thursday 19 May - 10:00-10:15</td>
<td>LXXV</td>
</tr>
<tr>
<td>Lennard Christopher</td>
<td>CORDEX-Africa – Integrating climate and impact science for policy</td>
<td>Tuesday 17 May - 16:15-16:30</td>
<td>VI</td>
</tr>
<tr>
<td>Liszewska Malgorzata</td>
<td>Climate change scenarios for low carbon agriculture in Poland based on EURO-CORDEX (EUR-11) simulations</td>
<td>Wednesday 18 May - 14:45-15:00</td>
<td>LVII</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Session Date</td>
<td>Session Time</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Llopart Marta</td>
<td>The role of land use change over Amazon Forest in simulating climatology and extreme hydroclimatic indices</td>
<td>Wednesday 18 May</td>
<td>14:45-15:00</td>
</tr>
<tr>
<td>Maruaun Douglas</td>
<td>VALUE perfect predictor validation results, part 2: spatial, multivariate and process-based aspects</td>
<td>Wednesday 18 May</td>
<td>14:00-14:30</td>
</tr>
<tr>
<td>Mearns Linda</td>
<td>An Overview of Climate Projections Performed for North America CORDEX</td>
<td>Tuesday 17 May</td>
<td>14:30-15:00</td>
</tr>
<tr>
<td>Meier Markus</td>
<td>Estimating uncertainties in projections for the Baltic Sea region based upon an ensemble of regional climate system models</td>
<td>Thursday 19 May</td>
<td>11:00-11:15</td>
</tr>
<tr>
<td>Misra Vasu</td>
<td>Regional coupled ocean-atmosphere simulation of the Indian Monsoon</td>
<td>Wednesday 18 May</td>
<td>11:45-12:00</td>
</tr>
<tr>
<td>Montavez Juan Pedro</td>
<td>The impact of climate change on photovoltaic power generation in Europe</td>
<td>Tuesday 17 May</td>
<td>15:45-16:00</td>
</tr>
<tr>
<td>Mtongori Habiba</td>
<td>Parallel Session A3: From data to information: a distillation dilemma, Parallel Session B3: A focus on ESD specific opportunities</td>
<td>Wednesday 18 May</td>
<td>11:45-12:00</td>
</tr>
<tr>
<td>Nikiema Pinguhounde</td>
<td>Multimodel CMIP5 and CORDEX simulations of Historical Summer Temperature and Precipitation Variabilities over West Africa</td>
<td>Wednesday 18 May</td>
<td>10:00-10:15</td>
</tr>
<tr>
<td>Nikulin Grigory</td>
<td>CORDEX achieving: achievements, status and perspectives</td>
<td>Tuesday 17 May</td>
<td>14:00-14:30</td>
</tr>
<tr>
<td>Nishimori Motoki</td>
<td>On the bias correction for regression-based ESD result for multi agro-meteorological elements over Japan and their comparing with RCMs results</td>
<td>Wednesday 18 May</td>
<td>16:45-17:00</td>
</tr>
<tr>
<td>Obermann Anika</td>
<td>Mistral and Tramontane in MedCORDEX Simulations: Present Day and Future Climate</td>
<td>Thursday 19 May</td>
<td>11:15-11:30</td>
</tr>
<tr>
<td>Paquin Dominique</td>
<td>Who should adapt to climate change? A tale of multiple timescales.</td>
<td>Wednesday 18 May</td>
<td>09:45-10:00</td>
</tr>
<tr>
<td>Park Changyong</td>
<td>Multi-RCM Future Projections of Climate Extremes over East Asia</td>
<td>Thursday 19 May</td>
<td>11:00-11:15</td>
</tr>
<tr>
<td>Pinto Izidine</td>
<td>Future changes in extreme rainfall events and circulation patterns over southern Africa</td>
<td>Thursday 19 May</td>
<td>11:15-11:30</td>
</tr>
<tr>
<td>Prein Andreas</td>
<td>Impacts of uncertainties in European gridded precipitation observations on regional climate analysis</td>
<td>Wednesday 18 May</td>
<td>14:00-14:30</td>
</tr>
<tr>
<td>Preuschmann Swantje</td>
<td>The IMPACT2C web-atlas</td>
<td>Wednesday 18 May</td>
<td>11:00-11:15</td>
</tr>
<tr>
<td>Pryor Sara C.</td>
<td>Can/will climate change impact the wind energy industry?</td>
<td>Thursday 19 May</td>
<td>09:00-09:30</td>
</tr>
<tr>
<td>Rasouli Kabir</td>
<td>Precipitation downscaling using the Intermediate Complexity Atmospheric Research model (ICAR) in Western Canada</td>
<td>Thursday 19 May</td>
<td>09:30-09:45</td>
</tr>
<tr>
<td>Rechid Diana</td>
<td>EURO-CORDEX-LUC: A new initiative on coordinated regional land use change experiments</td>
<td>Wednesday 18 May</td>
<td>14:00-14:30</td>
</tr>
<tr>
<td>Remedio Armelle Reca</td>
<td>Influence of ocean and atmosphere coupling in a regional climate simulation over the CORDEX Southeast Asia domain</td>
<td>Wednesday 18 May</td>
<td>09:45-10:00</td>
</tr>
<tr>
<td>Remke Thomas</td>
<td>Towards the assessment of climate change impacts on critical energy infrastructure applied for offshore wind farms</td>
<td>Thursday 19 May</td>
<td>11:30-11:45</td>
</tr>
<tr>
<td>Sannino Gianmaria</td>
<td>Inter-annual variability of the modelled Mediterranean thermohaline circulation in Med-CORDEX simulations and the role of tidal forcing</td>
<td>Thursday 19 May</td>
<td>09:45-10:00</td>
</tr>
<tr>
<td>Schär Christoph</td>
<td>European-Scale Convection-Resolving Climate Modeling</td>
<td>Wednesday 18 May</td>
<td>16:30-16:45</td>
</tr>
<tr>
<td>Schwitala Thomas</td>
<td>Convection permitting latitude belt simulation using the Weather Research and Forecasting (WRF) model</td>
<td>Wednesday 18 May</td>
<td>16:15-16:30</td>
</tr>
<tr>
<td>Sharmar Tarul</td>
<td>Understanding the propagation of uncertainties in CORDEX and GCM derived hydro-climatic projections</td>
<td>Thursday 19 May</td>
<td>11:00-11:15</td>
</tr>
<tr>
<td>Sillman Jaana</td>
<td>Assessing Climate Extremes across Scales – from Global to Regional Climate Modeling</td>
<td>Thursday 19 May</td>
<td>09:00-09:30</td>
</tr>
<tr>
<td>Silva Yamina</td>
<td>High resolution modeling to understand the physical processes relating to rainfall in the Mantaro basin (central Peruvian Andes) using WRF</td>
<td>Wednesday 18 May</td>
<td>16:00-16:15</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Date and Time</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Soares Pedro M.M.</td>
<td>The Summer Iberian Coastal Low-Level Wind Jet in a Warming Climate</td>
<td>Thursday 19 May - 10:00-10:15</td>
<td>LXXVI</td>
</tr>
<tr>
<td>Sobolowski Stefan</td>
<td>Precipitation seasonality, variability and associated dynamical processes over eastern Africa</td>
<td>Thursday 19 May - 11:45-12:00</td>
<td>LXXIX</td>
</tr>
<tr>
<td>Solman Silvina</td>
<td>Evidence of added value in North American regional climate model simulations with increasing horizontal resolutions.</td>
<td>Wednesday 18 May - 09:30-09:45</td>
<td>X</td>
</tr>
<tr>
<td>Somot Samuel</td>
<td>How can high-resolution representation of the regional seas and aerosols modify regional climate change? A fully-coupled regional climate system approach to question current CORDEX experimental protocol</td>
<td>Wednesday 18 May - 09:00-09:30</td>
<td>XVII</td>
</tr>
<tr>
<td>Sorensso Anna</td>
<td>Spatio-temporal analysis of the coupling between soil moisture and surface climate in the La Plata Basin: combining results from regional climate models and satellites</td>
<td>Thursday 19 May - 11:30-11:45</td>
<td>LXXXIX</td>
</tr>
<tr>
<td>Strandberg Gustav</td>
<td>Biogeophysical effects from land-cover changes in Europe</td>
<td>Wednesday 18 May - 16:30-16:45</td>
<td>LIII</td>
</tr>
<tr>
<td>Sylla Mouhamadou Bamba</td>
<td>CMIP5, CORDEX and higher resolution RegCM4 multimodel ensembles comparison of projected changes in climate zones over West Africa</td>
<td>Wednesday 18 May – 11:15-11:30</td>
<td>XXXIII</td>
</tr>
<tr>
<td>Tangang Fredolin</td>
<td>Evaluation of Two Land Surface Schemes (BATS1se vs CLM4.5) in the simulation of the Southeast Asia Precipitation using RegCM4</td>
<td>Thursday 19 May - 11:45-12:00</td>
<td>XC</td>
</tr>
<tr>
<td>Teichmann Claas</td>
<td>High-resolution climate change simulations within EURO-CORDEX: Assessing extremes in the RCP 2.6 low emission scenario</td>
<td>Thursday 19 May - 10:00-10:15</td>
<td>LXVII</td>
</tr>
<tr>
<td>Termonia Piet</td>
<td>CORDEX.be: Combinin Regional climate Downscaling Expertise in Belgium</td>
<td>Tuesday 17 May - 15:00-15:15</td>
<td>III</td>
</tr>
<tr>
<td>Timbal Bertrand</td>
<td>Impact of climate change on streamflow across Victoria: making use of statistical downscaling</td>
<td>Thursday 19 May - 09:45-10:00</td>
<td>LXXXIV</td>
</tr>
<tr>
<td>Verfaillie Deborah</td>
<td>A downscaling and bias-correction approach for climate projections of snow conditions in mountain regions using energy balance land surface models</td>
<td>Thursday 19 May - 10:45-11:00</td>
<td>LXXXVI</td>
</tr>
<tr>
<td>Warrach-Sagi Kirsten</td>
<td>An Integrated Land System Model System to study soil-vegetation-atmosphere feedbacks in agricultural landscapes under climate change</td>
<td>Wednesday 18 May - 16:00-16:15</td>
<td>LI</td>
</tr>
<tr>
<td>Wu Minchao Wu</td>
<td>Vegetation-climate feedbacks modulate rainfall patterns in Africa under future radiative forcing</td>
<td>Wednesday 18 May - 11:15-11:30</td>
<td>XXIV</td>
</tr>
<tr>
<td>Zhao Tianbao</td>
<td>Contributions of anthropogenic and external natural forcings to climate changes over China based on CMIP5 model simulations</td>
<td>Wednesday 18 May - 16:45-17:00</td>
<td>LIV</td>
</tr>
</tbody>
</table>
PLENARY SESSION 1:
CORDEX IN ACTION: ACHIEVEMENTS & LESSONS LEARNED

TUESDAY 17TH MAY 2016
14:00

CORDEX achiving: achievements, status and perspectives

Grigory NIKULIN
PLENARY SESSION 1:
CORDEX IN ACTION: ACHIEVEMENTS & LESSONS LEARNED

TUESDAY 17TH MAY 2016
14:30

An Overview of Climate Projections Performed for North America CORDEX

Linda MEARNS

National Center for Atmospheric Research - United States

The North American CORDEX program (NA-CORDEX) has produced a good number of projections of climate according to the first phase of the CORDEX program. These simulations are based on a wide range of regional and global climate models, and some matrices of combinations have resulted. The RCMs involved include: WRF, CanRCM4, CRCM5, RegCM4, RCA4, and HirHam5. Driving GCMs include: EC-EARTH, CanESM2, HadGEM2-ES, GFDL-ESM2M, MPI-ESM-LR. These GCMs nicely span the equilibrium climate sensitivity (ECS) of the GCMs making up the CMIP5 suite of models. Simulations have been performed both at .44 and .22 spatial resolutions and often for both RCP8.5 and 4.5. From these simulations, several matrices result. Both RegCM4 and WRF are driven by HADGEM and MPI for RCP 8.5 at both spatial resolutions, thus forming a 2 x 2 x 2 matrix. Both HirHam5 and RCA4 have been driven by EC-EARTH, for both RCP8.5 and 4.5 at .44 resolution, thus forming a 2 x 2 matrix. Finally, CanRCM4, CRCM5, and RCA4 have been driven by CanESM2 for both RCP 8.5 and 4.5 at .44 spatial resolution, resulting in a 3 X 2 matrix. We will present overview results for the quality of the current climate simulations, contrasts between the relevant GCMs and RCMs regarding climate change in the mid-21st century and late 21st century for both temperature and precipitation. Contrasts in spatial correlations of the changes will also be presented.

Linda O. Mearns1, Ray Arritt2, Melissa Bukovsky1, Chris Castro3, Hsin-I Chang3, Jens Christensen6, Ole Christensen8, Anne Frigon4, William Gutowski2, Erik Kjellstrom5, Rene Laprise6, Seth Mcginnis1, Grigory Nikulin5, John Scinocca7, L. Sushama6, and Katje Winger6

1National Center for Atmosperic Research, 2Iowa State, 3U. Arizona, Danish Meteorological Institute, 4Ouranos, 5Swedish Meteorological and Hydrologic Institute, 6University of Quebec at Montreal, 7Canadian Centre for Climate Modeling and Analysis
PLENARY SESSION 1:
CORDEX IN ACTION: ACHIEVEMENTS & LESSONS LEARNED

TUESDAY 17TH MAY 2016
15:00

CORDEX.be: COmbining Regional climate Downscaling EXpertise in Belgium

Piet TERMONIA
Royal Meteorological Institute - Belgium

The main objective of the ongoing project CORDEX.be, “COmbining Regional Downscaling EXpertise in Belgium: CORDEX and Beyond”, is to gather existing and ongoing Belgian research activities in the domain of climate modelling to create a coherent scientific basis for future climate services in Belgium. The project regroups 8 Belgian Institutes under a single research program of the Belgian Science Policy (BELSPO). The project involves three regional climate models: the ALARO model, the COSMO-CLM model and the MAR model running according to the guidelines of the CORDEX project and at convection permitting resolution on small domains over Belgium.

The project creates a framework to address four objectives/challenges. First, this project aims to contribute to the EURO-CORDEX project. Secondly, RCP simulations are executed at convection-permitting resolutions (3 to 5 km) on small domains. Thirdly, the output of the atmospheric models is used to drive land surface models (the SURFEX model and the Urbclim model) with urban modules, a crop model (REGCROP), a tide model and a storm model (COHERENS) and the MEGAN-MOHYCAN model that simulates the fluxes emitted by vegetation. Finally, one work package will translate the uncertainty present in the CORDEX database to the high-resolution output of the CORDEX.be project.

The organization of the project will be presented and first results will be shown, demonstrating that convection-permitting models can add extra skill to the mesoscale version of the regional climate models, in particular regarding the extreme value statistics and the diurnal cycle.

Piet Termonia1, Bert Van Schaeybroeck1, Patrick Willems2, Nicole Van Lipzig2, Jean-Pascal van Ypersele3, Philippe Marbaix3, Xavier Fettweis4, Koen De Ridder5, Anne Gobin5, Trissvgeni Stavrakou6, Patrick Luyten6, Eric Pottiaux6

1Royal Meteorological Institute, 2University of Leuven, 3Université catholique de Louvain, 4Université de Liège, 5Vlaamse Instelling voor Technologisch Onderzoek, 6Belgian Institute for Space Aeronomy, 7Royal Belgian Institute of Natural Sciences, 8Royal Observatory of Belgium
The impact of climate change on photovoltaic power generation in Europe

Juan Pedro MONTAVEZ

University of Murcia - España

Ambitious climate change mitigation plans call for a significant increase in use of renewables, which could, however, make the supply system more vulnerable to climate variability and changes. Here we evaluate climate change impacts on solar photovoltaic (PV) power in Europe using the recent EURO-CORDEX ensemble of high-resolution climate projections together with a PV power production model and assuming a well-developed European PV power fleet. Results indicate that the alteration of solar PV supply by the end of this century compared to the estimations made under current climate conditions should be in the range [-14%;+2%], with the largest decreases in Northern countries. Temporal stability of power generation does not appear as strongly affected in future climate scenarios either, even showing a slight positive trend in Southern countries. Therefore, despite small decreases in production expected in some parts of Europe, climate change is unlikely to threaten the European PV sector.

Sonia Jerez¹, Isabelle Tobin², Robert Vautar², Juan Pedro Montávez¹, Jose María López-Romero¹, Françoise Thais³, Blanka Bartok⁴, Ole Bøssing Christensen⁵, Augustin Colette⁶, Michel Déqué⁷, Grigory Nikulin⁸, Sven Kotlarski⁹, Erik van Meijgaard⁹, Claas Teichmann¹⁰, Martin Wild¹¹

¹University of Murcia, ²Laboratoire des Sciences du Climat et de l’Environnement, ³Institut de Technico-Economie des Systèmes Energétiques (I-Tésé), ⁴ETH Zürich, Institute for Atmospheric and Climate Science, ⁵Danish Meteorological Institute, ⁶Institut National de l’Environnement Industriel et des Risques
We assess the statistics of different daily precipitation indices in ensembles of Med-CORDEX and EURO-CORDEX experiments at high resolution (grid spacing of ~0.11°, or RCM11) and medium resolution (grid spacing of ~0.44°, or RCM44) with regional climate models (RCMs) driven by the ERA-Interim reanalysis of observations for the period 1989-2008. The assessment is carried out by comparison with a set of high resolution observation datasets for 9 European subregions. The statistics analyzed include quantitative metrics for mean precipitation, daily precipitation Probability Density Functions (PDFs), daily precipitation intensity, frequency, 95th percentile and 95th percentile of dry spell length. We assess both an ensemble including all Med-CORDEX and EURO-CORDEX models and one including the Med-CORDEX models alone. For the All Models ensembles, the RCM11 one shows a remarkable performance in reproducing the spatial patterns and seasonal cycle of mean precipitation over all regions, with a consistent and marked improvement compared to the RCM44 ensemble and the ERA-Interim reanalysis. A good consistency with observations by the RCM11 ensemble (and a substantial improvement compared to RCM44 and ERA-Interim) is found also for the daily precipitation PDFs, mean intensity and, to a lesser extent, the 95th percentile. In fact, for some regions the RCM11 ensemble overestimates the occurrence of very high intensity events while for one region the models underestimate the occurrence of the largest extremes. The RCM11 ensemble still shows a general tendency to underestimate the dry day frequency and 95th percentile of dry spell length over wetter regions, with only a marginal improvement compared to the lower resolution models. This indicates that the problem of the excessive production of low precipitation events found in many climate models persists also at relatively high resolutions, at least in wet climate regions. Concerning the Med-CORDEX model ensembles we find that their performance is of similar quality as that of the all-models over the Mediterranean regions analyzed. Finally, we stress the need of consistent and quality checked fine scale observation datasets for the assessment of RCMs run at increasingly high horizontal resolutions.
CORDEX-Africa – Integrating climate and impact science for policy

Christopher LENNARD

University of Cape Town - South Africa

Between 2011 and 2013 a series of workshops were held under the CORDEX-Africa banner to analyze data from the CORDEX-Africa downscalings with the purpose of publishing the results of these in accredited climate science journals. This process yielded 9 papers whose first authors were all young African scientists. Additionally, a number of user engagement workshops were held in which climate and impacts scientists and decision-makers were brought together to discuss various climate information needs and to develop working relationships between these communities. However, the scientific analyses focused on model evaluation with very little assessment of projections and the trans-disciplinary engagement is in hiatus as a result of lack of funding.

Through funding provided by the Swedish government we have been able to resume a coordinated analysis of CORDEX-Africa downscaled data by the four African analysis teams. Representatives from West, East, Central and southern Africa have met for three workshops to discuss and plan climate analysis strategies for their regions that will result in the production of another eight to ten climate science orientated papers and at least three impacts orientated papers within the next two years. A particularly encouraging development from these meetings has been the emergence of regional vulnerability-impact-adaptation teams who will facilitate the incorporation of CORDEX-Africa downscaled data into impact modelling literature (e.g. water, energy, health, agriculture) as well as downstream decision-making frameworks.

We report on the activities of these groups and present working paper titles and some preliminary results.
PLENARY SESSION 1:
CORDEX IN ACTION: ACHIEVEMENTS & LESSONS LEARNED

TUESDAY 17TH MAY 2016
16:30

Production and use of CORDEX projections –
a Swedish perspective on building climate services in practice

Erik KJELLSTRÖM

SMHI - Sweden

The Rossby Centre regional climate model RCA4 has been used to dynamically downscale ten different coupled atmosphere ocean general circulation models (AOGCMs) from the CMIP5 project with horizontal resolution varying from about 1º to 3º. For Europe downscaling has been done at 0.44º (c. 50 km) and at 0.11º, (c. 12.5 km). In addition, RCA4 has also been used to dynamically downscale ERA-Interim reanalysis data as part of the model evaluation process. Results from the RCA4 EURO-CORDEX simulations has been analysed for model performance, added value of high resolution and various features of climate change. Particularly, a dialogue with Swedish end users has resulted in analysis of a number of climate variables and indices that are reported upon in this study. Examples are given of how information from the climate change experiments is used in a national climate service perspective which includes dissemination through the SMHI web page.

Erik Kjellström¹, Lars Bärring¹, Grigory Nikulin¹, Carin Nilsson², Gustav Strandberg¹

¹SMHI, ²University of Lund
PLENARY SESSION 1:
CORDEX IN ACTION: ACHIEVEMENTS & LESSONS LEARNED

TUESDAY 17TH MAY 2016
16:45

Assessment of the performance of CORDEX-South Asia experiments for monsoonal precipitation over the Himalayan region during present climate: part I

Shreta GHIMIRE

International Center for Integrated Mountain Development (ICIMOD) - Nepal

The suite of 11 combinations from 6 Regional Climate Models (RCMs) with 10 initial and boundary conditions from different Global Climate Models (GCMs) collectively referred here as 11 COordinated Regional Climate Downscaling Experiment in South Asia (CORDEX-South Asia) are considered to study precipitation sensitivity associated with the Indian Summer Monsoon (ISM) over the Himalayan region for the present climate (1970-2005). The summer monsoon precipitation climatology over the study area has not been studied with the help of CORDEX data. An approach has also been made to study the degree of agreement among individual experiments compared with the gridded observational dataset to quantify uncertainty among them. The experiments though show a wide variation among themselves with time and space in simulating precipitation distribution, but noticeably show dry precipitation along the foothills of the Himalayas against the corresponding observation. The experiment driven by Irish Center for High-End Computing (ICHEC) and downscaled using Rossby Center regional Atmospheric model version 4 developed by Swedish Meteorological and Hydrological Institute (SMHI) simulate precipitation closely in correspondence with the observation. Overview of the study suggests that these experiments facilitate precipitation evolution and structure over the Himalayan region with certain degree of uncertainty.

Shreta Ghimire¹, Aubhav Choudhary², A. P. Dimri²

¹International Center for Integrated Mountain Development (ICIMOD), ²Jawaharlal Nehru University
PARALLEL SESSION A : BENEFITS OF DOWNSCALING
A1: ADDED VALUE OF DOWNSCALLING

WEDNESDAY 18TH MAY 2016
09:00

Challenges in the quest for added value of climate dynamical downscaling: Evidence of added value in North American regional climate model simulations with increasing horizontal resolutions.

René LAPRISE

Université du Québec (UQAM), Montréal - Canada

The added value afforded by the use high-resolution regional climate models (RCMs) to perform dynamical downscaling of coarse-resolution boundary conditions has not yet been fully explored and efforts in determining this added value are too few. This presentation will first review some of the challenges in determining RCMs’ added value. Then, recent simulations performed with CRCM5 over North America using grid meshes of 0.44°, 0.22° and 0.11° will be compared with available observations, with a focus on five specific regional weather phenomena. The analysis shows that the orographic precipitation on the West Coast of North America is enhanced and more realistic, with two rainy bands in the finer resolution simulation. The spatial distribution of precipitation in August and the high frequency of summer precipitation extremes over southwestern United States reveal that the North American monsoon is improved with increasing resolution. Only the finer RCM simulation shows skill at producing snowbelts around the Great Lakes, as a result of an adequate simulation of lake-effect snow. A comparison of simulated wind roses in the St. Lawrence River Valley (SLRV) indicates that, due to an improved representation of complex orography, the finer mesh simulation is able to reproduce wind channeling, which is an important factor for freezing rain occurrence in the SLRV. Finally, the simulation of the summer land-sea breezes at higher resolution leads to added value in the diurnal cycle of precipitation over the Florida peninsula and the Caribbean islands. Overall, almost systematic improvements are found in the finer resolution simulations.

René Laprise1, Philippe Lucas-Picher1

1 Université du Québec (UQAM), Montréal, Canada
Multiscale analysis of precipitation variability over South America: A preliminary analysis of the added value of RCMs.

SILVINA SOLMAN

Centro de Investigaciones del Mar y la Atmósfera (CIMA/CONICET-UBA)-DCAO(FCEN-UBA)-Buenos Aires - Argentina

Multiscale temporal variability of rainfall over South America as depicted by a high-resolution Regional Climate Model (RCM) and its driving low-resolution Global Coupled Model (GCM) is evaluated in this study with the aim of identifying the added value of downscaling. Rainfall over South America is characterized by significant variability patterns at different temporal scales. At the interannual timescales, the variability signal is mainly associated with the El Niño-Southern Oscillation (ENSO) and is characterized by either positive or negative precipitation anomalies over La Plata Basin (LPB) during the warm season. At the intraseasonal timescales the variability pattern is characterized by a seesaw between the South Atlantic Convergence Zone (SACS) and south-eastern South America. At the higher frequencies, the synoptic-scale variability is much associated with the passage of frontal systems and its largest signal is located over the LPB region. The richness of the precipitation variability patterns over the South American continent and the well documented studies identifying the main characteristics and drivers of these patterns offer an excellent opportunity in evaluating the added value of high-resolution RCMs in reproducing these features.

In this preliminary analysis the REMO RCM from the CLARIS-LPB ensemble and the driving EC5OM GCM from the CMIP3 dataset have been evaluated for the period 1979-1990 against several observational datasets. The spatial resolution of the RCM and GCM are approximately 0.5° and 1.875°, respectively. Gridded precipitation data from monthly and daily datasets were used. The analysis is carried out for two extended seasons: from October to March and from April to September. For interannual timescales, the standard deviation of the monthly timeseries of rainfall anomalies was computed. For the intraseasonal and high-frequency timescales, the daily timeseries of rainfall anomalies were filtered using the Lanczos filter retaining periods of 10 to 90 days, and 4 to 10 days, respectively.

Overall, it was found that the REMO RCM is able of better reproducing the main features of rainfall variability compared with the driving EC5OM GCM in terms of its spatial scale and magnitude at the interannual, intraseasonal and higher frequency timescales, suggesting the added value of the RCM compared with the driving GCM.
Quantifying the overall added value of dynamical downscaling and the contribution from different spatial scales

Alejandro DI LUCA

University of New South Wales - Australia

As shown by a large number of studies, the finding of “mixed results” where RCMs produce some improvements but also deteriorations compared to the driving data is relatively common in added value studies. A question that remains open is which of these two situations is more dominant. That is, whether we can quantify if RCMs produce in general –independently of the statistic chosen– an overall improvement over the driving data.

In this presentation, we will present results from a study that evaluates the added value in the representation of surface-climate variables from an ensemble of RCM simulations by comparing the relative skill of the RCM simulations and their driving data over a wide range of RCM experimental setups and climate statistics. The methodology is specifically designed to compare results across different variables and metrics, and it incorporates a rigorous approach to separate the added value occurring at different spatial scales.

Results show that the RCMs added value strongly depends on the type of driving data, the climate variable and the region of interest, but depends rather weakly on the choice of the statistical measure, the season and the RCM physical configuration. Decomposing climate statistics according to different spatial scales shows that improvements are coming from the small scales when considering the representation of spatial patterns, but from the large-scale contribution in the case of absolute values.

Alejandro Di Luca¹, Daniel Argueso¹,², Jason Evans¹,², Ramón de Elía³,⁴ and René Laprise⁴,⁵

¹ Climate Change Research Centre, Faculty of Science, University of New South Wales, Sydney, Australia; ² ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, Australia; ³ Consortium Ouranos, Montréal, Canada; ⁴ Centre pour l’Étude et la Simulation du Climat à l’Échelle Régionale (ESCER), Montréal, Canada; ⁵ Université du Québec à Montréal (UQAM), Montréal, Canada.
In this paper, the mean climatology, the intermodel variability and the spatio-temporal patterns of temperature and precipitation over West Africa from CMIP5, CMIP5_SUBSET (ensemble of GCMs driving CORDEX) and CORDEX multimodel ensembles (MMEs) are evaluated and intercompared over West Africa for the monsoon season (June-September) during the historical period. We found that while CORDEX fails to outperform the simulated mean climatology of temperature by the CMIP5 ensembles, it substantially improves that of precipitation and provides more fine-scale features tied to local topography and landuse. The ensemble spread and descriptive statistics reveal that such an improvement is more a result of cancellation of errors in the Gulf Guinea but originates from a more consistent and realistic simulation of monsoon precipitation among the various Regional Climate Models (RCMs) in the Sahel. Analysis of the Rotated Empirical Orthogonal Function (REOF) indicates that all MMEs capture the spatio-temporal variability of both temperature and precipitation depicting the recent warming and the Sahel precipitation recovery that occur in recent decades over West Africa as identified in the first REOF mode. However, for the spatial patterns of the last two modes along with their associated time series, CORDEX mostly follows CMIP5_SUBSET. Our results thus points towards the strong influence of boundary forcing on the simulation of mean and spatio-temporal variability of temperature and precipitation over West Africa but also to the capability of CORDEX RCMs to pick regional contribution and improve upon the CMIP5 GCMs to some extent.

Pinghoudine Michel NIKIEMA

WASCAL - BURKINA FASO
Searching for an Added Value of Precipitation in Downscaled Seasonal Hindcasts over East Africa: COSMO-CLM Forced by MPI-ESM

Bedassa Regassa CHENEKA

Agriculture Transformation Agency - Ethiopia

Downscaling of seasonal hindcasts over East Africa with the regional climate model (RCM) COSMO-CLM (CCLM), forced by the global climate model (GCM), MPI-ESM is evaluated. The simulations are done for five months (May to September) for a ten year period (2000-2009), with the evaluation performed only for June to September. The accuracy of the RCM simulations is assessed using ground based and satellite gridded observation data. Both COSMO-CLM and MPI-ESM overestimate June to September precipitation over the Ethiopian highlands and in parts of the lowland with respect to all reference datasets. In addition we investigated the potential and real added value for both the RCM and the GCM hindcasts by up-scaling (arithmetic mean) the precipitation resolution both in temporal and in spatial scales. RCM forecast has a higher value of total monthly precipitation compared to the GCM over the lowlands of East Africa. Over different parts North Ethiopia (EN), South Ethiopia (ES), South Sudan (SS), and Sudan (S) for the daily precipitation 90th and 95th percentiles, the potential added value is high over EN and ES. In contrast, it is less in the lowlands region S and SS. The potential and relative potential added value decrease with decreasing the temporal resolution.

Bedassa R.Cheneka\textsuperscript{1,2}, Susanne Brienen\textsuperscript{1}, Kristina Fröhlich\textsuperscript{1}, Shakeel Asharaf\textsuperscript{1}, Barbara Früh\textsuperscript{1}

\textsuperscript{1}Deutscher Wetterdienst, Offenbach, Germany, \textsuperscript{2}Agriculture Transformation Agency, Addis Ababa, Ethiopia
A fine scale topographical modulation of summer precipitation change over the European Alps challenging current GCM projections.

Filippo GIORGI

Abdus Salam International Centre for Theoretical Physics (ICTP) - Italy

We analyze an ensemble of high resolution regional climate model (RCM) projections for the 21st century (RCP8.5 scenario) over the European Alps and find that, while on the broad scale a future reduction of summer precipitation is projected by the driving global models over the region, the RCM ensemble simulates an increase in precipitation over the high elevations of the Alpine chain. This positive precipitation change is due to a fine scale topographical modulation of the change signal induced by an increase in convective rain associated with increased potential instability by high elevation surface heating. This topographic signal is mostly consistent across models and similar across future time slices, and the full change signal is approximately given by the broad scale change (mostly driven by the GCMs) plus this topographical correction (produced by the fine scale RCMs). A similar topographical modulation of the change signal is also found for surface air temperature and precipitation extremes. Our results thus challenge the picture of a decreasing summer precipitation change signal over the Alps found in most GCM projections and point to the role of high resolution RCMs in adding valuable information on future climate projections in areas of complex topography. These conclusions are important for the estimation of impacts over the Alpine region.

Filippo Giorgi¹, Csaba Torma¹, Erika Coppola¹, Nikolina Ban², Christoph Schaer², Samuel Somot³

¹ICTP, ²ETHZ, ³MeteoFrance
PARALLEL SESSION A : BENEFITS OF DOWNSCALING
A1: ADDED VALUE OF DOWNSCALING

WEDNESDAY 18TH MAY 2016
11:15

Is There an Added Value from Regional Climate Modeling for Projected Change in Future Northwest Pacific Tropical Cyclone Activities?

CHENG-TA CHEN

National Taiwan Normal University, Department of Earth Sciences - Taiwan

The majority of current approach for using dynamical model to project future seasonal tropical cyclone (TC) activity involves counting the number of TC-like vortices simulated in the model. It can be done using global climate model forced by observation or regional climate model forced by the same global model provided the thresholds used for TC detection and tracking are adjusted by the model characteristics and resolution. However, there could still be significant differences when comparing such two simulations, even though the regional model are forcing by the global model from lateral boundary and the same sea surface condition for lower boundary. Our study aims on using regional climate model to explore the added value of dynamical downscaling of TC activities over Northwest Pacific. In particular, we examined and compared the reliability of model to capture the TC-climate interactions including large-scale seasonal cycle, ENSO variability, and long-term trend.

Further, the similarity and difference of the future projected change in seasonal TC activities between global climate model and regional climate model would be highlighted. The detailed review on the potential contribution from the large scale environmental conditions for TC genesis and preferred tracking and how they differ in the two simulated future projection would be analyzed.

Cheng-Ta Chen¹, Teng-Ping Tseng¹, Chao-Tzuen Cheng², Yuqing Wang³

¹National Taiwan Normal University, Department of Earth Sciences, ²National Science and Technology Center for Disaster Reduction, Taiwan, ³International Pacific Research Center, University of Hawaii at Manoa
In this presentation, an overview of the simulations produced for the North American Coordinated Regional Climate Downscaling Experiment (NA-CORDEX) will be assessed for their performance in simulating the North American monsoon (NAM) system. Differences between the 25km and 50km resolution NA-CORDEX simulations, and the benefits of using 25km versus the cost of doing so for this region will be emphasized. This analysis will particularly focus on precipitation and local phenomena and processes that govern its distribution and intensity across the NAM region during the baseline/current climate period; however, projections will be discussed as well. Notable differences between these simulations and the set produced for the North American Regional Climate Change Assessment Program (NARCCAP) will also be identified.
 Added value of high resolution RCM simulations and comparison with Statistical Downscaling Methods within the EURO-CORDEX framework

Ana CASANUEVA

University of Cantabria - Spain

High resolution Regional Climate Model (RCM) simulations and Statistical Downscaling Methods (SDMs) are important tools to provide the meteorological variables required in climate impact assessments. The present study analyzes two aspects that should be taken into account before using these methods in specific applications. First, we assess the added value of high resolution simulations from a EURO-CORDEX RCM ensemble. Secondly, RCMs are compared with SDMs, in order to show the merits and limitations of both downscaling techniques. Both aspects are assessed in terms of mean and extreme precipitation indices in Spain.

The EURO-CORDEX initiative provides an appropriate framework for this study, since a common grid is used for all RCMs and the high and low resolution grids match each other at the grid cell boundaries. The ability of the high-resolution RCM simulations (0.11°) to represent observed precipitation is assessed at their skillful scale, by aggregating the 0.11° grid to the 0.44° resolution and evaluating the added value with respect to the low resolution (0.44°) runs. Since RCMs are prone to systematic biases, the added value of the high resolution runs is also analyzed after applying bias correction methods to the RCMs. Gridded observational products are available over the same grids as the RCMs, such as the Spain02 v4 family of EURO-CORDEX-compliant gridded datasets over Spain. Therefore, the evaluation of the RCMs and the development of the SDMs can be carried out on exactly the same grids, and SDMs produce a downscaling output comparable to the RCMs. A set of SDMs (namely analog resampling, weather typing and different versions of Generalized Linear Models) are applied using ERA-Interim predictor variables under a cross-validation approach.

Results show limited evidence for an added value of the high resolution RCM simulations in terms of seasonal mean biases. There is an indication of added value in the spatial patterns; however, this is not statistically significant after bias correcting both simulations. The comparison of RCMs and SDMs based on specific precipitation-derived indices may not be fair as long as they are related to parameters that have been optimized in the calibration phase of SDMs. When the comparison is performed in terms of non-optimized parameters (e.g. dry spells), both downscaling techniques present similar skills and limitations.

Ana Casanueva1, Sixto Herrera1, Jesús Fernández1, Sven Kotlarski2 and José Manuel Gutiérrez3

1Meteorology Group, Dept. Applied Mathematics and Computer Sciences. University of Cantabria. Spain,
2Federal Office of Meteorology and Climatology MeteoSwiss, Switzerland, 3Meteorology Group, Instituto de Física de Cantabria (CSIC-University of Cantabria). Spain
PARALLEL SESSION A : BENEFITS OF DOWNSCALING
A2: MODELS OF THE COUPLED REGIONAL CLIMATE SYSTEM

WEDNESDAY 18TH MAY 2016
09:00

How can high-resolution representation of the regional seas and aerosols modify regional climate change? A fully-coupled regional climate system approach to question current CORDEX experimental protocol

Samuel SOMOT

Météo-France/CNRM - France

Past and future regional climate change is potentially influenced by many global and regional drivers and, in particular, by various factors within the region of interest such as regional land-sea contrast, high-resolution representation of the topography, regional land-use change, high-resolution sea surface temperature change, regional aerosol load change, ... In the first phase of CORDEX, only part of these regional driving factors has been taken into account in the definition of the experimental protocols for the evaluation, historical and scenario runs. For example, the regional evolution of the SST and of the aerosol load were either not considered (use of constant values) or taken from the low-resolution driving GCMs. Here, we propose to question the limits of the current CORDEX protocol in the frame of historical and scenario simulations, using the Med-CORDEX domain for illustration. More specifically we focus on the impacts of the high-resolution representation of the SST changes and of the aerosol load changes on the projected Euro-Mediterranean climate change.

Twin simulations using the ALADIN-Climate RCM have been performed in addition to the classical CORDEX framework for present and future climate periods. To explore the role of the high-resolution SST changes, a fully-coupled Atmosphere-Ocean-River RCM has been developed for the Mediterranean Sea using an interactive daily coupling frequency. To explore the role of the high-resolution aerosol changes, a fully-coupled Atmosphere-Aerosol RCM has been developed including the interactive representation of the main natural and anthropogenic aerosol species as well as their radiative effects. The results show that the climate change signal of the Euro-Mediterranean region is significantly modified in the twin simulations. For example, the coupled Atmosphere-Ocean-River RCM reduces the Mediterranean SST warming which in turn influences the coastal climate whereas the coupled Atmosphere-Aerosol RCM reveals finescale pattern in the aerosol concentration changes inducing regional modifications in surface shorwave radiation and in surface temperature.

Our results question the design of the CORDEX experimental protocol and the preparation of the CORDEX Flagship Pilot Studies. They are also of interest for different communities of regional climate data users (e.g. marine ecosystem-based managers, fisheries, coastal tourism, wind- and solar-energy producers, air quality managers).

Samuel Somot¹, Florence Sevault¹, Pierre Nabat¹

¹Meteo-France/CNRM
We introduce a high resolution fully coupled regional model system that describes ocean, atmosphere and sea ice processes in the Arctic Ocean and North Atlantic and treats atmosphere/ocean/ice sheet interactions as well as land and sub-sea permafrost processes in an advanced semi-coupled form. The system has been developed using five existing model components: the high resolution regional climate model HIRHAM5, the regional ocean model HYCOM and the CICE model that describes sea ice dynamics, the PISM ice sheet model and the GIPL permafrost model. These models have been interactively coupled which enables us to perform experiments examining the relative importance of ocean and atmospheric forcing as well as internal dynamics, to explain the recent rapid decline of Arctic sea ice, recent changes in the Greenland ice sheet mass balance together with both land and sub-sea permafrost conditions. Analysis of the model results indicates the model can successfully reproduce the interannual and seasonal variability in sea ice extent, describe recent changes in the Greenland ice sheet surface mass balance as well as permafrost conditions around Greenland and possibly under the Arctic Ocean sea floor. This opens up the possibility of a range of process based experiments as well as simulations to project the future and study the past of Arctic sea ice that we plan to run using the EC-Earth GCM as boundary forcing.

Examples, focusing on various coupling issues will be presented and the need for further refinements will be assessed by highlighting processes that appear to be essential to the interactions and hence possibly important at climate scales.

Jens H. Christensen¹, Ole B. Christensen¹, Ruth Mottram¹, Cathrine Fox Maule¹, Peter L. Langen¹, Fredrik Boberg¹, Martin Stendel¹, Christian Rodehacke¹, Martin Olesen¹, Kristine S. Madsen¹, Tian Tian¹, Mads H. Ribergaard¹

¹Danish Meteorological Institute
Coupling of ocean to the atmosphere can potentially improve climate simulations including cyclonic activities within a region heavily influenced by the ocean-atmosphere interactions. From previous studies, atmosphere-only simulations have a tendency to produce higher number of cyclones compared to observations. In this study, REMO coupled with the Max Planck Institute Ocean Model or ROM, which is a regional atmosphere coupled with a global ocean model, is used to evaluate the impact of the atmosphere-ocean interaction to the tropical climate focusing on the typhoon activities. The aim is to identify the importance of the atmosphere-ocean coupling in the CORDEX Southeast Asia domain. The model domain spans 80 E to 180E and -15 S to 40 N, with a horizontal resolution of 50- and 25 km, and 27 hybrid vertical levels. The model is driven by the ERA-Interim reanalysis and run from the period of 1980 to 2012. To compare the influence of atmosphere-ocean coupling, the atmospheric model is also run uncoupled. Results on the simulated precipitation and temperature are compared to observations as well the changes in the tropical cyclone activity. Preliminary results indicate that the warm and wet biases over the ocean in the uncoupled simulations are reduced in the coupled simulations especially during the typhoon season. The frequency of typhoon occurrences is lower compared to the uncoupled model and is comparable to observations.
A new coupled climate model, the Variable-resolution Earth System Model (VRESM) is currently under development through collaborative research between the Council for Industrial Research (CSIR) in South Africa and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. The model employs ocean, atmosphere and land-surface models all cast on a cube-based grid and can be applied at quasi-uniform horizontal resolution to function as a global climate model, or in stretched-grid mode to function as a high-resolution regional climate model. The atmospheric model component is the Variable-cubic Atmospheric Model (VCAM) of CSIRO, which has evolved from the widely used Conformal-cubic Atmospheric Model (CCAM). The CSIRO Atmosphere Biosphere Land Exchange model (CABLE) provides VRESM with a dynamic land-surface, whilst the ocean is simulated by the newly developed Variable-cubic Ocean Model (VCOM) of the CSIR. VRESM development is taking place with the immediate objective of generating African-based projections of future global climate change as a contribution to CMIP6, whilst the stretched-grid version of the model is to be used to generate simulations of the coupled southern African climate system as part of the second phase of CORDEX.

Here we present the first VRESM simulations of the coupled regional southern African ocean-atmosphere system, through the application of the model in stretched-grid mode. Of interest is the state of the Benguela upwelling system along the southern African west coast under climate change. The coupled model was applied at a resolution of about 8 km over a domain of about 2000 x 2000 km2 over a domain stretching from the western parts of southern Africa into the Atlantic Ocean, covering the western coastal areas of South Africa, Namibia and Angola. The simulations were nudged in the 50 km resolution global CCAM CORDEX simulations, performed earlier for the period 1960-2100 (six ensemble members under RCP8.5, with forcing from different host GCMs). The 8 km resolution downscalings indicate that a southward shift in the prevailing south-easterly winds along the southern African west coast may lead to a weakening of upwelling zones along the Namibian coast. This may have implications for the frequency of occurrence and intensity of fog events, and on the distribution and abundance of fish species relying on the nutrient-rich water of the upwelling zones.

Francois Engelbrecht1++, John McGregor3, Marcus Thatcher3, Mthetho Sovara1

1CSIR Natural Resources and the Environment - South Africa, 2North West University - South Africa, 3Commonwealth Scientific and Industrial Research Organisation
Assessment of the Regional Climate Earth System Model (RegESM) simulation in reproducing observed climatic features of the atmosphere over the CORDEX Central America domain

Ramón FUENTES FRANCO

ICTP - Italy

We use the recently developed Regional Earth System Model (RegESM) to assess its skill in reproducing climatic features of several atmospheric variables over the CORDEX Central American domain. The RegESM is composed by RegCM4 using CLM4.5 as land model, MITgcm ocean model and the Hydrological Discharge (HD) model, as atmospheric, land, ocean an river models respectively. By doing a comparison between atmosphere-only and RegESM simulations with observations, we show the main added value of the regional coupled model. In a ten year-period (1989-1998) simulation we analyze particularly the representation of the annual cycle over Southern Mexico and over the North American Monsoon region. The density and tracks of simulated tropical cyclones, the intensity and position of the Caribbean Low Level Jet (CLLJ), and of the Inter-tropical Convergence Zone (ITCZ) are also analyzed.

The position and intensity of the ITCZ is better reproduced by the coupled model than the atmospheric-only simulation, however over the Pacific off the coast of Mexico there is an overestimation of precipitation due to warmer SST bias. Both models are able to capture the Mid-summer drought over Southern Mexico, however the North American monsoon is better reproduced by RegESM, this due to a better reproduced moisture flux from the Pacific ocean into the Monsoon region. Higher density of tropical cyclones is also found over both (Atlantic and Pacific) oceans in the coupled model simulation, due to greater evaporation as a consequence of the ocean-atmosphere fluxes in the coupled model compared with the atmospheric only simulation.

Ramón Fuentes-Franco¹, Lina Sitz², Riccardo Farneti¹, Erika Coppola¹, Filippo Giorgi¹

ICTP
The role of internal and external variability in the simulated Caribbean climate

William CABOS

University of Alcala - Spain

The geographical location of the Caribbean Sea makes it a crossroads to different climate signals that contribute to shape its mean state and variability, adding to its own regional factors. The roles of internal and external forcings in the Caribbean climate is pursued in this study by means of simulations with the regional coupled atmosphere-ocean model ROM. The model includes a global ocean with regionally high horizontal resolution, which is coupled to an atmospheric regional model and global terrestrial hydrology model. The coupling is only effective within a selected domain, where the ocean and the atmosphere are interacting. Outside this domain, the ocean model is uncoupled, driven by prescribed atmospheric forcing, thus running in a so-called stand-alone mode. Therefore, selecting a specific area for the regional atmosphere implies that the ocean-atmosphere system can develop ‘freely’, but for boundary conditions, in that area, whereas for the rest of the global ocean, the circulation is driven by prescribed atmospheric forcing without any feedbacks. Simulations with various coupled domains, centered on the region of interest and including different neighboring areas with a possible impact on the Caribbean climate, allow to identify what that influence amounts to and how the internal variability is affected by diverse elements. Four different coupled setups are chosen for ensemble simulations. The choice of the coupled domains was done to estimate the influences of the Subtropical Atlantic, Tropical Atlantic and Tropical Pacific regions on the Caribbean climate. Our simulations show that the regional coupled ocean atmosphere model is sensitive to the choice of the modeled area. The different model configurations reproduce differently both the mean climate and its variability. The mechanisms explaining such differences are diagnosed, and the key processes for a realistic simulation of the Caribbean climate are pointed out. Attention is given to the representation in our runs of relevant players in the climate fluctuations of the region, such as the Caribbean Low Level Jet.

Francisco Álvarez-García1, William CabosNarváez1, Dmitry Sein2, Nikolay Koldunov3, Daniela Jacob3

1University of Alcala, 2Alfred Wegener Institute, 3Climate Service Center Germany
Vegetation-climate feedbacks modulate rainfall patterns in Africa under future radiative forcing

Minchao Wu WU

Lund University - Sweden

Africa has been undergoing significant and rapid changes in climate patterns and vegetation in recent decades. Continued changes may be expected over the coming century, especially for the savannah areas where a fine balance between coverage of trees and grasses is upheld by seasonal patterns of water availability. Vegetation cover and composition imposes important influences on the physical climate system, and climate-driven changes in vegetation patterns may feed back to climate via shifts in surface-atmosphere energy balance, hydrological cycling and resultant effects on air pressure patterns and atmospheric circulation. The potential role of such feedbacks in the future evolution of African climate has not been previously addressed in detailed studies. We used a regional Earth system model uniquely incorporating interactive vegetation-atmosphere coupling to investigate the potential role of vegetation-mediated biophysical feedbacks on climate dynamics in Africa in an RCP8.5 future climate scenario. The model was applied at high resolution (0.44 x 0.44 degrees) across the African continent forced by lateral boundary conditions from the CanESM2 general circulation model. We found that changed vegetation patterns associated with a CO2 and climate-driven increase in net primary productivity particularly over sub-tropical savannah areas not only imposed important local effect on regional climate by altering surface energy fluxes, but also resulted in meso-scale remote effects over central Africa by modulating the land-ocean thermogradient, near-surface circulation and moisture inflow via the Atlantic Walker circulation feeding the central African tropical rainforest region with precipitation. The vegetation-mediated feedbacks were in general negative with respect to temperature, dampening the warming trend simulated in the absence of feedbacks, and positive with respect to precipitation, enhancing rainfall reduction over rainforest areas. Our results emphasize the importance of accounting for vegetation-atmosphere interactions in climate model projections for tropical and sub-tropical Africa.

Minchao Wu1, Guy Schurgers2, Benjamin Smith1, Patrick Samuelsson3, Christer Jansson2, Joe Siltberg1, Wilhelm May4, Paul Miller1, Markku Rummukainen4

1INES, Lund University, 2University of Copenhagen, 3SMHI, 4CEC, Lund University
Simulation of the Arctic climate system with the Regional Arctic System Model (RASM): Sensitivity to atmospheric processes

John CASSANO

University of Colorado - United States

A new regional Earth system model focused on the Arctic, the Regional Arctic System Model (RASM), has recently been developed. The initial version of this model includes atmosphere (WRF), ocean (POP), sea ice (CICE), and land (VIC) component models coupled using the NCAR CESM CPL7 coupler. The model is configured to run on a large pan-Arctic domain that includes all sea ice covered waters in the Northern Hemisphere and all Arctic Ocean draining land areas.

Results from a suite of multi-decadal (1990 to 2014) simulations with RASM will be presented and will focus on the simulated climate system's sensitivity to atmospheric processes and parameterizations. These simulations show that the modeled climate is sensitive to changes in the boundary layer and cumulus parameterizations used in the atmospheric component of RASM. Depending on the WRF parameterizations used the model either overestimates or underestimates cloud cover over the ocean. Underestimation of clouds over land areas is common in all versions of the model evaluated. The differences in simulated cloud impacts the surface and top of the atmosphere radiation budget, alters biases in land and ocean surface temperature, changes precipitation distribution within the domain, and leads to different sea ice states being simulated. Simulations with only the atmospheric component of RASM were also run and highlight the model response that is solely due to atmospheric processes and the model response arising from coupled processes in RASM.

John Cassano¹, Alice DuVivier¹, Andrew Roberts², Mimi Hughes¹, Mark Seefeldt¹, Michael Brunke³, Anthony Craig³, Brandon Fisel⁴, William Gutowski⁴, Joseph Hamman⁵, M. Higgins¹, Wieslaw Maslowski², Bart Nijssen⁵, Robert Osinski⁶, Xubin Zeng³

¹University of Colorado, ²Naval Postgraduate School, ³University of Arizona, ⁴Iowa State University, ⁵University of Washington, ⁶Institute of Oceanology
Regional coupled ocean-atmosphere simulation of the Indian Monsoon

Vasu MISRA

Florida State University/COAPS - United States

This study highlights the importance of the high resolution air-sea coupling for the simulation of the Indian Monsoon. These simulations were carried out using a fully coupled regional ocean-atmosphere modeling system, which contains the RSM (Regional Spectral Model) as the atmospheric part and ROMS (Regional Ocean Modeling System) as the ocean counterpart. The RSM has 28 terrain following sigma levels that is identical to the NCEP-DOE reanalysis, while ROMS has 30 vertical ocean sigma levels. High-resolution ETOPO5 bathymetry is used in ROMS for the coupled simulation. The RSM and ROMS share the same domain and resolution to avoid interpolation between ocean and atmosphere model grids. SST and fluxes are exchanged between atmosphere and ocean model without using any SST-flux coupler. The Coupled downscaling is a free run without any heat or salinity corrections. The two analyzed regional simulations use for one atmospheric and ocean reanalysis (NCEP-DOE atmospheric reanalysis and Simple Ocean data assimilation) and the other CCSM4 20th century simulation as lateral boundary conditions. In addition we also downscale the CCSM4 with just the RSM using the CCSM4 boundary conditions and SST. In comparing and analyzing these model integrations we will highlight the ocean rectification effect on the monsoon simulation from downscaling, which is otherwise missed in atmospheric downscaling.
From regional climate scenarios to economics: identifying uncertainties and risks in the adaptation modelling chain

Kirsten HALSNÆS

Planning and decision-making for instance in terms of supporting adaptation related to fundamental societal infrastructure such as transport, energy and water systems increasingly rely on quantitative information regarding climate change impacts and risks derived from combinations of different data sources e.g. climate, physical/environmental and socio-economic models and their inherent uncertainties. In practical terms it is however generally difficult to carry out full and unbiased analyses due to critical assumptions and methodological challenges related to key uncertainties along all steps of the modelling chain (scenarios, climate models, impacts models, economics, decision-making, etc.) which may be in parts related to lack of information crucial for determining future impacts and risks. For example at the regional or local scale such impact assessments are typically contingent on the availability and quality of high-resolution regional climate change projections made available through communities such as CORDEX. In this study we present the results of using a methodological framework for integrated analysis of extreme events and damage costs aimed at distilling information obtained through trans-disciplinary approaches while systematically identifying key factors and uncertainties in the modelling chain, which are relevant for specific adaptation decisions. The approach is here applied to a case study of urban flooding for the medium sized Danish city of Odense. We address a number of different combinations of climate scenarios/projections, damage cost curve approaches, and economic assumptions, including risk aversion and equity represented by discount rates. Considering a wide range of these different types of assumptions we find a very wide range of risk estimates, but we are also able to identify a range of robust decisions, and we investigate some of the major impacts of alternative assumptions. The study demonstrates that in terms of decision-making the actual expectations concerning future climate impacts and the economic assumptions applied are very important in determining the risks of extreme climate events and, thereby, of the level of cost-effective adaptation seen from the society’s point of view.


Kirsten Halsnæs¹, Martin Drews¹, Per Skougaard Kaspersen¹

¹Technical University of Denmark
High-resolution (10km) ensemble regional climate projections for SE Asia

Jack KATZFEY

CSIRO - Australia

To assist the government of Vietnam in its efforts to better understand the impacts of climate change and prioritise its adaptation measures, detailed climate change projections at 10 km resolution across Vietnam were produced for the High-resolution Climate Projections for Vietnam (HCPV) project. Six of the latest available global climate models (GCMs) from the Coupled Model Intercomparison Project Phase 5 were selected on the basis of their ability to realistically capture current climate and climate features such as El Niño-Southern Oscillation (ENSO). Using bias-corrected sea surface temperatures from the GCMs, global simulations were first made using the Conformal Cubic Atmospheric Model (CCAM). Then, two RCMs (CCAM and RegCM) were then used to further dynamically downscale the global data to produce high-resolution (10 km or 20 km) simulations for current and future climate. Simulations were performed for historical (1970-2005) and future (to 2099) time periods using two representative concentration pathways: RCP4.5 and 8.5.

The GCM selection process was done through both internal assessments of accuracy as well as international studies. The bias correction technique used in this study corrects both the monthly means, as well as interannual variability, in order to capture the magnitude and location of SST variability such as ENSO. The current climate is validated against both station and gridded datasets. The main results presented will focus on the projected changes in temperature and rainfall, as well as extremes. The key point the need for ensembles in order to capture the spread of the possible projections. For many variables, the ensemble projected changes spread across zero. For a few variables though, the changes by the end-of-the-century show more one-sided changes.

Finally, the use of a risk-based approach to using the projections will be discussed. Although the projected changes may not be significant, the risk of the more extreme changes could have significant implications for adaptation planning.
Who should adapt to climate change? A tale of multiple timescales.

Dominique PAQUIN

Ouranos - Canada

As climate change adaptation is increasingly discussed and becoming a mainstream concept, different kinds of users are asking themselves if and when they should develop an adaptation strategy, often not knowing where to begin. Climate experts, on the other hand, have access to an enormous amount of data that could be useful to users but often do not know how to translate it into something practical. Both users and experts can be connected through two timescales, the system lifespan and climate vulnerability. While the system lifespan relies exclusively on the user’s estimation of planning timeframe (or infrastructure life expectancy), the climate vulnerability is estimated from climate model projections and observations. We propose a simple tool to relate user and climate expert knowledge by combining the two timescales. To be reliable, the interconnection implies a dialogue to identify sensitive climate variables that will impact the system and a measure of how it will impact it. Climate data can then be used to identify the section of a simple diagram where the system is located and help the users to position themselves about the urgency of adaptation. The concept has been successfully presented and applied to the tourism industry, which will be showcased in this presentation.

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Creating robust climate change information messages from multiple, distributed sources requires workflows capable of handling various technical and computational challenges. Data access, download or storage and diverse data/metadata formats, etc. can be workflow bottlenecks. Appropriate statistical methods for robust results are currently not centralized, thus analysis scripts are often produced in-house. This unnecessarily "re-invents the wheel" and proliferates unstandardized workflows that lack common benchmarks. Also, we underutilize the wide range of powerful interactive visualization tools increasingly available. These include JavaScript libraries and their Python/R derivatives that allow e.g. dimensional filtering of large datasets, and web map services that provide "slippy maps" from NetCDF files at different resolutions on the fly.

We present birdhouse, a growing collection of web processing services (WPS) and web mapping services for data access, analysis and visualization connected with standard protocols over HTTP. This enables data processing close to data archives such as ESGF, reducing data transport, and the modular architecture allows data processing with a variety of methods that can be shared and combined.

Birdhouse consists of "birds" (Python-based WPS components) to simplify the usage of WPS in the climate science context. For example, Malleefowl simplifies the access of NetCDF files from Thredds catalogues (ESGF), Flyingpigeon contains a collection of climate analysis algorithms and impact models as well as basic operations like extraction of polygon subsets from a grid. Phoenix is a web user interface to run WPS processes with an easy-to-use data selection component. Finally, there is Birdy, a command-line tool to interact with WPS processes.

To illustrate a full workflow, we present a use case based on bias-adjusted CORDEX and EOBS observation data to calculate extreme weather events in Europe. Birdhouse modules were used to calculate the means over 251 European regions of a selection of climate indices in yearly and seasonal aggregates under 2 RCP scenarios for several models. After birdhouse processing, extreme events (below/above the 10th/90th percentile of EOBS data, reference period 1976–2005) were then visualized using dc.js to produce an interactive dashboard that can be filtered based on any of the dimensions, alone or in combination.

With such workflows, robust information of big data can be produced and visualized.

Nils Hempelmann1, Carsten Ehbrecht2, Stephan Kindermann2, Patrick Brockmann1, Cathy Nangini1, Robert Vautard1

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Visual Summaries of Ensemble Regional Projections

Joe DARON

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The regional climate projection data available for regional climate change assessments and impact and adaptation studies has become increasingly complex; often multi-model, multi-method and multi-scale. Visual summaries of ensemble projection data can be used to distil and convey key messages about projected regional climate change, but involve challenging decisions about how best to reduce and present the data in order to convey those messages clearly and intuitively.

In this study, various methods of communicating a range of plausible climate scenarios are investigated, with the aim to identify effective methods of communicating ensemble regional projections with varying levels of complexity. Specifically, novel methods of communicating uncertainty within climate model projections on a range of spatial scales are portrayed, improving on existing approaches of communicating a distribution of regional projections. We demonstrate a number of approaches to address the following issues with representing key spatial, temporal and uncertainty characteristics of projection information:

(a) Quantitative information about uncertainty from multi-model GCM spread and distribution can be challenging to express clearly alongside quantitative, spatial projection information. An additional challenge and opportunity exists where multi-method data are available, to show how the datasets relate to one another in an uncertainty context – for example, by indicating where members of a downscaled subset of CMIP5 models sit in the context of the broader CMIP5 ensemble before and after downscaling.

(b) The physically plausible spatial patterns of change generated by individual models can be lost or masked in the context of ensemble uncertainty, when data are regionally averaged or mapped as ensemble averages or percentiles. We demonstrate that showing regionally averaged summary information from multiple models, methods and forcings alongside mapped projections from individual can provide both the uncertainty context and realistic spatial patterns simultaneously.

(c) To provide context for interpreting projected changes in the mean climate state a representation of quantitative estimates of natural variability is required.

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The policy discussion of whether we can limit global warming to not more than +2°C will be of central importance at the COP21 negotiations in Paris in December, 2015.

In this context, the following scientific questions are of major importance:

- what might be the potential impacts of a +2°C global warming compared to the preindustrial period for various regions of the globe, and economic sectors?
- what are the differences between a +2°C and a +3°C global warming?
- what might be prevented if global warming is limited to +2°C rather than +3°C?

Parts of these questions have been answered in the IMPACT2C project. Raising policymakers’ and society’s awareness of potential climate change impacts under a +2°C global warming compared to the preindustrial period has been one of the major aims of the IMPACT2C project. For this purpose, the IMPACT2C web-atlas was developed in order to present the findings of the project easily accessible for a wide range of users.

The IMPACT2C web-atlas depicts the climate change impacts of a +2°C global warming for the key sectors – energy, water, tourism, health, agriculture, ecosystems and forestry, as well as coastal and low-lying areas, – at both the pan-European level, and for some of the most vulnerable regions of the world. By using a multi-model ensemble of both climate and impact projections it is possible to define ranges of impacts and therefore quantify some of the uncertainty around future climate and climate impact projections.

For each of the sectors and regions, the IMPACT2C web-atlas tells visual stories of potential impacts for different topics related to a specific sector or region. The web version of the atlas allows the reader to explore the various interlinkages within a specific sector and regions as well as between sectors. By presenting a wide variety of potential climate change impacts, the IMPACT2C web-atlas aims to serve various audiences in gathering information for the development of recommendations on possible adaptation strategies on national and international levels.

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CMIP5, CORDEX and higher resolution RegCM4 multimodel ensembles comparison of projected changes in climate zones over West Africa

Mouhamadou Bamba SYLLA
WASCAL Competence Center Ouagadougou Burkina Faso,

West African climate have evolved in recent decades to respond to elevated anthropogenic greenhouse gas (GHG) forcing. Projected climate change generated by the multimodel ensemble of the CORDEX indicates continuous and stronger warming (1.5oC to 6.5oC) and a wide range of precipitation uncertainty (roughly between -30% to 30%) larger in the Sahel and increasing in the farther future consistent with CMIP5. This prevents a rigorous assessment of risks and impacts associated with the anthropogenic climate change over West Africa.

To overcome this issue and provide useful climate information, we employ the revised Thornthwaite climate classification applied to ensembles of CMIP5, CORDEX, and higher-resolution ICTP RegCM4 experiments (HIRES) and investigate shifts in climate zones over West Africa as a response to anthropogenic climate change. Such information on projected shifts of climate zones can help policymakers to develop response strategies for the most vulnerable areas. Evaluation of the reference period simulations indicates that the ensembles reproduce fairly well the observed climate zones, although with some notable discrepancies, larger in the CMIP5. CORDEX and HIRES provide realistic fine-scale information which enhances that from the coarser-scale CMIP5, especially in the Gulf of Guinea encompassing marked landcover and topography gradients. The late 21st century projections reveal an extension of torrid climates throughout West Africa. In addition, the Sahel, predominantly semi-arid in present-day conditions, is projected to face moderately persistent future arid climate. Similarly, the Gulf of Guinea shows a tendency in the future to experience highly seasonal semi-arid conditions. Finally, wet and moist regions with an extreme seasonality around orographic zones become less extensive under future climate change. Consequently, West Africa evolves towards increasingly torrid, arid and semi-arid regimes with the recession of moist and wet zones. These features are common to all multimodel ensembles with more pronounced changes in the higher-resolution RegCM4 projections. These modifications are largely due to the temperature forcing, as the contribution of precipitation change is comparatively smaller. Such changes point towards an increased risk of water stress and thus add an element of vulnerability to future anthropogenic climate change for West African water management, ecosystem services and agricultural activities.

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The Multi-MIP regional distillation dilemma. Results from the Spanish PNACC-2012 Program

Jesús FERNANDEZ
Universidad de Cantabria - Spain

During the last decades, a huge amount of global and regional climate change projections have been produced as a result of successive projects and MIP initiatives, with a focus on the observed warming trend of the last century and the projection of future scenarios for the current one. This heterogeneous (and sometimes contradictory) global and statistical/dynamically downscaled data has been used as primary input to feed vulnerability, impacts and adaptation (VIA) studies.

Over Europe, regional climate downscaling output from EU FP7 ENSEMBLES and CORDEX has become available in the last 10 years. Additionally, national efforts have produced additional information for particular regions. For instance, the National Adaptation Program for Climate Change (PNACC-2012) produced two additional datasets of statistical and dynamically downscaled scenarios for Spain. Even though such initiatives have promoted coordination, the ensembles produced remain as ensembles of opportunity, in the sense that their experimental design does not favour the systematic study of different sources of uncertainty. In any case, this is the information available to assess climate change. Even though new models, or even new processes, are included in the most recent MIPs, previous efforts still contain valid, and widely unexplored, information.

This work focuses on simple, common analyses, based on temperature and precipitation delta changes, arising from three recent regional MIPs which produced future climate information over continental Spain. The main focus is on analysing different sources of uncertainty (GHG scenarios, GCMs, downscaling approaches, and spatial resolution) and compare the common or conflicting messages arising from the available datasets. The work is based on publicly available data provided by the ENSEMBLES, EURO-CORDEX, and the Spanish PNACC2012 initiatives. The latter used roughly the same global (CMIP3) and downscaling model generation as ENSEMBLES. However, additional GHG scenarios were considered. CORDEX relies on the latest generation of scenarios and models (CMIP5), reaching unprecedented spatial resolution over the area. The grand ensemble contains over 100 future projections for the region, including those downscaled at different resolutions and the raw output of their driving GCMs. This is a great source of potential information, but conflicting messages necessarily appear and need to be understood by both the climate and VIA communities.

Jesús Fernández1, M. Dolores Frías1, Sixto Herrera1, José Manuel Gutiérrez2, ESCENA Team3, esTcena Team4

Climate is one of the factors controlling agricultural productivity in Africa. Changes in meteorological variables such as rising temperatures and changes in precipitation amounts and regimes affect crop production. Using regression based Empirical Statistical Downscaling, future projection for three rainfall parameters namely, total precipitation, wet-day mean and wet-day frequency considered to be relevant to crop agriculture in Tanzania were performed for three rainfall seasons; March-May (MAM), October-December (OND) and December-April (DJFMA).

The multi-model mean projections in response to RCP 4.5 and 8.5 suggested a shift towards wetter (drier) conditions for OND (DJFMA) seasons for three future periods; near-term, mid-century and end-of-century. For MAM season some areas are projected to feature wetter and some drier conditions. In the mid and end-of century, there is an increase of precipitation to about 40% for some areas getting OND rainfall and a decrease of precipitation up to about 10% for some areas getting MAM or DJFMA rainfall.

Using the Decision Support System for Agrotechnology Transfer Cropping System Model (DSSAT), sensitivity experiments were conducted to evaluate response of maize yields to a range of principal changes in rainfall and temperatures during maize growing season. The studied cultivars were UH6303, H628 and PAN691 that are grown in southern part of Tanzania (Iringa, Mbeya, Njombe, Songea and Rukwa).

Our findings showed that, dry-spells caused yield losses for all cultivars and the loss reached to 43% for prolonged dry-spells of 20 days. Increased rainfall intensity during vegetative and reproductive stages caused yield loss of 5 and 2% respectively and a 50-100% decrease in rainfall intensity caused loss of yields between 40-100%. A decrease in temperature from the baseline to 20°C less had an overall impact of yields loss for all cultivars. However, yields increased with an increase of temperature for up to 2.5°C (UH6303 and H628) and up to 4.5°C (PAN691).

The average growing season temperature for Iringa and Songea already exceeded the optimal production temperature for all three cultivars. Thus, for present climate UH6303 and H628 cultivars will already experience slight reductions in yield in these areas. In addition, under projected warmer and drier climate in the future, these cultivars are expected to experience serious losses in yields and therefore may be less suitable for these regions.

Habiba Mtongori1,2, Frode Stordal2, Rasmus Benestad3

1Tanzania Meteorologica agency, 2 University of Oslo, 3 The Norwegian Meteorological Institute
Regional Convection-Permitting Climate Modeling: Demonstrations, Prospects, and Challenges

Andreas PREIN

National Center for Atmospheric Research - USA

Very high-resolution atmospheric models, that enable the explicit simulation of deep convection, revolutionized severe convective weather forecasting. These convection-permitting models (CPMs; horizontal grid spacing ≤4 km) viable for climate simulation because of advances in computational resources. CPM climate simulations have the potential to provide climate information on regional- to local scales compared to the more traditional large-scale models (LSM; horizontal grid spacing >10 km). CPMs also allow a more accurate representation of surface and orography fields. We aim to provide a common basis for CPM climate simulations by giving a holistic review of the topic. The most important components in CPMs such as physical parameterizations and dynamical formulations are discussed critically. An overview of weaknesses and an outlook on required future developments is provided. Most importantly, this review presents the consolidated outcome of studies that addressed the added value of CPM climate simulations compared to LSMs. Improvements are evident mostly for climate statistics related to deep convection, mountainous regions, or extreme events. In conclusion, CPMs are a very promising tool for future climate research. However, coordinated modeling programs are crucially needed to advance parameterizations of unresolved physics and to assess the full potential of CPMs.
PARALLEL SESSION B : FRONTIER DOWNSCALING TOOL
B1: VERY HIGH RESOLUTION MODELLING

WEDNESDAY 18TH MAY 2016
14:30

Does convection-permitting resolution improve simulated precipitation in the Maritime Continent?

Daniel ARGUESO

Climate Change Research Centre, UNSW - Australia

The Maritime Continent has consistently been identified as a challenging region in terms of simulating precipitation. Its intricate configuration of islands with complex topography surrounded by a warm and shallow ocean makes this tropical archipelago an unequaled setting to test potential benefits of very high-resolution models. In this study, we focus on the western Maritime Continent to determine features of precipitation that are better represented with increased horizontal resolution, as well as those characteristics that deteriorate at finer grid spacing.

We investigated the impact of spatial resolution on rainfall amounts and diurnal cycle using the Weather Research and Forecasting model. A set of simulations running over a 5-year period at resolutions of 50, 10 and 2 km were completed and compared against satellite-derived observational products. While annual biases over the mountains are larger as resolution increases, our results suggest that precipitation is physically more realistic in the convection-permitting experiment performed at 2-km grid spacing. For example, the shape and phase of the diurnal cycle in the region, which are traditionally misrepresented in models, are substantially improved at higher resolution when comparing with the observational datasets. The amplitude of the diurnal cycle is also improved over most areas, although deficiencies still exist in that the strength of the cycle is overestimated.

In this talk, the resolution dependence of near-surface temperature, 10-m winds and cross-sections of different variables will also be analyzed. As a result, possible mechanisms that contribute to better simulating aspects of precipitation will be put forward, such as finer representation of the land-sea thermal contrast and the local circulation.

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Extreme rainfall in South East France: convection resolving simulation versus EuroCordex approach

Michel DEQUE

Météo-France - France

EuroCordex simulations at 12 km resolution provide some insight into extreme precipitations in a future climate. However they do not explicitly resolve the convective phenomena which are responsible for the heavy accumulated rainfall. Arome model is derived from Aladin model (used in EuroCordex) but uses non-hydrostatic equations, 2.5 km horizontal resolution, and a dedicated set of physical parameterizations. Its domain covers South-East France, a region which undergoes severe rainfall events in autumn. We present here three families of simulations with Aladin (12 km) driving Arome (2.5 km): ERA-interim driven, CNRM-CM5 historical run driven, and CNRM-CM5 RCP8.5 scenario run driven. The analysis is focussed on daily and hourly precipitation in extended autumn (ASOND) in the central part of the domain. We compare Aladin (i.e. EuroCordex) and Arome simulations in their ability to simulate observed data (ERA-interim driven simulations) and in the way they respond to RCP8.5 radiative forcing (CNRM-CM5 driven simulations). In addition, we examine the impact of restarting Arome each 1st June rather than performing a continuous multi-year simulation as in EuroCordex.

Michel Déqué¹, Antoinette Alias¹

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Added value and land-atmosphere coupling in convection-permitting WRF climate simulations over a Middle European domain

Sebastian KNIST

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High-resolution regional climate models with a more detailed representation of heterogeneous land surface properties, as well as an explicit treatment of deep convection can lead to an improved simulation of meteorological processes and the climate system at the meso-gamma scale.

In this study, results from 10 years of convection-permitting WRF evaluation simulations at 3 km spatial resolution for a central European model domain are analyzed. The 3 km domain is nested into the pan-European Coordinated Regional Downscaling Experiment (CORDEX) EUR-11 (12 km) model grid, driven by ERA-Interim reanalysis data. The simulated time spans (1992-1995, 2002-2003, 2010-2013) cover much of the variability of central European weather conditions.

In our analysis, we focus on two aspects: The first focus is on the validation of precipitation. Results from both resolutions are compared with each other and evaluated against high-resolution reanalysis data and gridded observations. Hourly precipitation data over three regions with a very moderate, low mountain and high mountain topography are compared. Added value in the 3 km simulation is found especially at the sub-daily scale in the reproduction of intensity, diurnal cycle and spatial extent of precipitation. A positive precipitation bias found in both resolutions is more dominant in the 12 km simulation, where too much light precipitation is generated. For different seasons precipitation exhibits clear differences between the simulations whereby largest differences occur in mountainous regions and during the summer months with high convective activity.

The second focus is on the comparison of land-atmosphere coupling strength whereby different metrics focusing on the soil moisture-temperature coupling are used. In both resolutions a clear interannual variability in coupling strength, consistent with the individual climate conditions, is seen. The 3 km simulation generally shows a slightly stronger coupling strength in summer.

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Estimation of sensitivity and added value of climate simulations for the Israeli region using COSMO-CLM with three nested domains

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In this analysis, we evaluate the capabilities of different configuration of the regional climate model COSMO-CLM in reproducing the average and extreme climate patterns over the Israeli region located in the near-coastal eastern Mediterranean area. COSMO-CLM is the climate version of the operational non hydrostatic mesoscale weather forecast model COSMO-LM. The model version used in this work offers, in particular, the possibility to easily exchange data sets of aerosol optical depth (AOD) and surface albedo. Model configuration has been chosen on the basis of a previously performed sensitivity analysis, aimed to ascertain model performances with respect to changes in physical and tuning parameters. Three simulations driven by ERA Interim reanalysis data for 1979-2011 have been performed using the 0.44 deg 0.22 deg and 0.0715 deg horizontal resolutions (respectively about 50 km, 25 km and 8 km). The CORDEX-MENA domain has been employed for the simulation at resolutions 0.44 and 0.22 deg, while the simulation at the highest resolution is performed considering a smaller geographical domain covering the Israeli region, adopting a nesting procedure.

The response for the three different configurations to the increase in the horizontal resolution has been analyzed, for monthly 2-m temperature, precipitation and a subset of climate indicators defined by the Expert Team on Climate Change Detection and Indices (ETCCDI) for temperature and precipitation. These indices highlight various characteristics of extremes, including frequency, amplitude and persistence and are widely used to assess the ability of global and regional model to simulate extremes and to assess future changes. The results have been then extensively inter-compared and evaluated against the observational data available.

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High resolution modeling to understand the physical processes relating to rainfall in the Mantaro basin (central Peruvian Andes) using WRF

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The Mantaro River Basin (MRB), located in the central Peruvian Andes, has a great economic importance for the country, because it provides about 35% of the hydropower energy for the country. On the other hand, the Mantaro Valley is highly productive and supplies with the main food stock to Lima (IGP, 2005). However, the agriculture in this area is developed almost 80% without irrigation, so this activity is highly sensitive to rain variability and other extreme weather events such as frost.

Previous studies on climate variability and trends in the MRB indicate high variability at different scales and changes in the seasonality of rainfall and frost (Silva et al, 2007; Trasmonte et al, 2007; Silva and Trasmonte, 2011). Therefore in the present study, the WRF is used in order to understand the physical mechanisms responsible for climate variability in the basin, focusing primarily on the dynamics of rainfall.

This paper we present preliminary results of the runs made with the WRF with tree domains (27, 9 and 3km) for the MRB for February (the wettest month in the central Andes of Peru). The model was forced with the final NCEP reanalysis data for 2000-2012 period. The validation of the interannual variability for the study period were done using observed data of 20 stations and for the spatial distribution the 3B42 and 2A25 from the Tropical Rainfall Measuring Mission (TRMM) products were used.

Preliminary results of 9km resolution, compared with TRMM 2A25 product, indicate a better distribution of rainfall in the southern part of the basin; however, the model tends to overestimate the precipitation. When analyzing the rainfall variability in comparison with the station data, the correlation is low. However, the model reproduces the diurnal cycle, according to the TRMM most precipitation occurs on the western edge of the Andes around 4pm to 7pm, while the WRF is given a little further east, on the Valley. Analyzing the dynamics, the WRF produces a strong convergence of moisture between 4 and 7pm, being more intense at 4pm. These results indicate that more observed data are needed to validate the TRMM data and models. For this purpose, the Laboratory of Microphysics and Radiation -LAMAR (for its acronym in Spanish) where implemented in the Mantaro valley, with many atmospherics instruments and wind profiler and clouds radar.
Convection permitting latitude belt simulation using the Weather Research and Forecasting (WRF) model

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In contrast to global climate models, regional climate models are usually applied as limited area models with 12 to 50 km resolution with the domain centered over the region of interest due to limited computing resources. However, the boundary relaxation zone can deteriorate the representation of synoptic features. At longer time scales, these errors can penetrate into the model domain and impact the results of the higher resolution domain.

In order to study the effect of very high resolution climate modeling we applied the WRF model for a northern hemisphere latitude belt between 20°N and 65°N to omit boundary effects in our scaling study and to study the interaction of small-to-large scale processes with CP resolution. The model was operated both at 12 km and 3 km resolution (comparable to EURO-CORDEX) for July and August 2013. This period covered the European heat wave as well as a major part of the Indian Monsoon. The model was forced with ECMWF operational analyses data at the northern and southern boundary. No additional data assimilation was performed.

A resolution of 12 km still requires the application of a convection parameterization. This often results in an incorrect diurnal cycle of precipitation due to the coarse model orography. We demonstrate the benefit of a very high resolution by validating both simulations with respect to temperature, moisture and wind at different altitudes including surface variables.

Due to the better representation of orographic features, the CP simulation shows a more realistic mesoscale circulation and produces more realistic precipitation patterns as compared to the 12 km simulation. Also the large-scale situation over the North Atlantic and Central Europe is better captured at the CP resolution.

The CP simulation is also capable of simulating low level clouds over the Atlantic. This is especially important for climate simulations where Stratocumulus clouds play a major role for the radiation budget as e.g. over the ocean.

A highlight of the CP experiment is the realistic simulation of Typhoon Soulik at July 10, 2013. The predicted typhoon track is in accordance with the observation with a delay of 6 hours and a track error of approx. 250 km with 10 days lead time. Here, the CP simulation predicted sustained 10-m winds of 60 m/s whereas the 12 km simulation shows maximum 10-m winds of 45 m/s.

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Moist convection is a fundamental process in our climate system, but is usually parameterized in climate models. The underlying approximations introduce significant uncertainties and biases, and there is thus a general thrust towards the explicit representation of convection. For climate applications, convection-resolving simulations are still very expensive, but are increasingly becoming feasible. Here we present recent results pertaining to the development and exploitation of convection-resolving regional climate models. We highlight validation using decade-long simulations, explore convection-resolving climate change scenarios, and provide an outlook on the use of next-generation supercomputing architectures.

Detailed results will be presented using the COSMO model over two computational domains at a horizontal resolution of 2.2 km. The first covers an extended Alpine region from Northern Italy to Northern Germany (500x500x60 grid points). For this domain decade-long simulations have been conducted, driven by both reanalysis as well as CMIP5 model data. Results show that explicit convection leads to significant improvements in the representation of summer precipitation, and to substantial differences in climate projections of precipitation. The simulations are particularly relevant for assessing projections of hourly precipitation events, and in order to assess the scaling of short-term heavy events with temperature (Ban et al. 2015, GRL).

The second domain covers most of Europe (1536x1536x60 grid points) and the respective simulations exploit heterogeneous many-core hardware architectures with GPUs. To efficiently use such computers, the model code underwent significant development, including a rewrite of the dynamical core in C++. Results demonstrate realistic mesoscale processes embedded into the synoptic scale, such as line convection along cold frontal systems, or the triggering of moist convection by propagating cold-air pools (Leutwyler et al., GMD, in preparation). Validation of a 10-year simulation driven by reanalysis data will also be presented. The European-scale simulation capability is currently further explored in an interdisciplinary project (crCLIM, see http://www.c2sm.ethz.ch/research/crCLIM.html).

It is argued that today’s largest supercomputers would in principle be able to support – already now – global convection-resolving climate simulations, provided the respectively refactored codes would be available.

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High Resolution Climate Modeling of the Water Cycle over the Contiguous United States
Including Potential Climate Change Scenarios

Ethan GUTMANN

National Center for Atmospheric Research - USA

The NCAR Water System program strives to improve the full representation of the water cycle in both regional and global models. Our previous high-resolution simulations using the WRF model over the Rocky Mountains revealed that proper spatial and temporal depiction of snowfall adequate for water resource and climate change purposes can be achieved with model grid spacings less than 6 km horizontal and appropriate microphysical parametrization. The climate sensitivity experiment consistent with expected climate change showed an altered hydrological cycle with increased fraction of rain versus snow, increased snowfall at high altitudes, earlier melting of snowpack, and decreased total runoff. In order to investigate regional differences between the Rockies and other major mountain barriers and to study climate change impacts over other regions of the contiguous U.S. (CONUS), we have expanded our prior CO Headwaters modeling study to encompass most of North America at a horizontal grid spacing of 4 km. A domain expansion provides the opportunity to assess changes in orographic precipitation across different mountain ranges in the western USA, as well as the very dominant role of convection in the eastern half of the USA. The WRF model has been run for eight years of present climate (2000 - 2008) and eight years in the future. The high resolution WRF-downscaled climate change data is available to the community through an NCAR web site for Universities and other groups interested in studying regional climate changes and impacts but unable to perform such long-duration and high-resolution WRF-based downscaling simulations of their own. The scientific goals and details of the model dataset will be presented including some preliminary results.

Roy Rasmussen¹, Changhui Liu¹, Kyoko Ikeda¹, Julio Bacmeister¹, Stan Trier¹, Jimmy Dudhia¹, Martyn Clark¹, Andreas Prein¹, David Gochis¹, Fei Chen¹, Ethan Gutmann¹, David Yates¹, Mike Barlage¹, Trude Eidhammer¹, Gregory Thompson¹, Aiguo Dai²

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EURO-CORDEX-LUC: A new initiative on coordinated regional land use change experiments

Diana RECHID

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We introduce a new initiative within EURO-CORDEX focussed on coordinated regional land use change (LUC) experiments, that will be carried out in collaboration with the LUCID international intercomparison project. LUC in this context refers to human activities at the land surface, and we consider land cover conversions as well as land management changes. We want to explore robust impacts of LUC on regional climate under current and future changing global climate conditions. Our primary questions are:

• What is the relative contribution of LUC on the regional climate change signal?
• Which temporal and spatial scales are relevant for LUC effects on climate?
• What is the effect of LUC on changes in climate extremes?
• What is the feedback of LUC for adaptation and mitigation purposes under today's and potential future climate conditions?

Prior to solving those important questions, there are major challenges for coordinated LUC experiments with regional climate models on high spatial resolution. Some key challenges which we will address include:

• How to achieve land use information based on a common land use distribution for all models to start from
• How to generate consistent LUC information for potential flag ship pilot studies at high spatial resolution beyond 0.25°
• How to define and implement a standardized LUC protocol
• Evaluation of model performances, based on Re-analyses driven simulations
• How to design the LUC experiments and conduct an efficient RCM matrix combined with global climate models for historical time periods, and for future time periods based on different emission scenarios
• Inter-comparison of model sensitivities related to LUC

As a climate service for Europe, we aim to establish an ensemble of coordinated regional climate change projections based on land use change scenarios in addition to emission scenarios. One major goal is to provide realistic and robust regional climate change information. The investigation of regional LUC feedbacks can also support the planning of regional land management strategies. With this conference contribution we would like to present and discuss an initial concept for the EURO-CORDEX-LUC activity as a strategy to invite and engage widespread collaboration, also beyond EURO-CORDEX.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOL
B2: HUMAN-CLIMATE REGIONAL INTERACTIONS, TOWARDS RESMS

Diana Rechid¹, Nathalie de Noblet-Ducoudré ², Oliver Branch³, Rita M Cardoso⁴, Erika Coppola⁵, Edouard Davin⁶, Rowan Fealy⁷, Borbála Gálos⁸, Filippo Giorgi⁵, Miguel Angel Gaertner⁹, Klaus Goergen¹⁰,¹¹, Andreas Haensler¹, Nils Hempelmann², Daniela Jacob¹, Eleni Katragkou¹², Klaus Keuler¹³, Enrique Sánchez⁹, Sebastian Knist¹⁰,¹¹, Juliane Otto¹, Andrew Pitman¹⁴, Swantje Preuschmann¹, Pedro MM Soares⁴, Gustav Strandberg¹⁵,¹⁶, Claas Teichmann¹, Robert Vautard²

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Within the framework of the ACCEPTED project (an Assessment of Changing Conditions, Environmental Policies, Time-activities, Exposure and Disease), a high-resolution urban dynamical downscaling technique has been applied for the cities of Paris and Brussels. The ACCEPTED project aims to improve our understanding of future exposure situations to air pollution and its impact on health to a mid-century horizon 2050s accounting for the effects of a changing urban climate. In this study simulations of present and future urban climate over Brussels and Paris areas are conducted. The regional climate simulations were performed with a new version of the limited-area model of the ARPEGE-IFS system at 4km resolution coupled with the Town Energy Balance scheme (TEB). In order to further downscale the regional climate projections to a urban scale of 1km resolution, a stand-alone surface scheme was employed in offline mode. The downscaling strategy was first evaluated for a 10-years period [2001-2010] using ERA-INTERIM re-analysis data. This 10-year period is considered as the warmest period on record since modern meteorological records began around the year 1850. In a next step, a downscaling simulation for the period 2046-2055 under the A1B scenario was performed. Results from our simulations indicate that while both cities warm substantially for the 2050s horizon (1.6 °C and 1.8 °C for Brussels and Paris respectively), climate change will have a neutral impact on annual mean urban heat island (UHI) intensity. The largest and statistically significant change of nocturnal (daytime) UHI is noted during winter (summer) season with an increase (decrease) of +0.2 °C (-0.1 °C) for both cities. During summer, the decrease in daytime UHI is directly connected to soil drying over rural areas, while the increase in nocturnal UHI during the winter can be explained by the projected decrease of wind speed. However, large impacts on urban climate can be expected from the combination of urban development and potentially more frequent occurrence of extreme events such as heat waves.

Rafiq Hamdi1, Olivier Giot2, Rozemien De Troch1, Alex Deckmyn1, Piet Termonia1

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The role of land use change over Amazon Forest in simulating climatology and extreme hydroclimatic indices

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The most important anthropogenic influences on climate are the emission of greenhouse gases and land use change (LUC). In particular, the Amazon (AMZ) basin is a highly vulnerable area to climate change due to substantial modifications of the hydroclimatology of the region expected as a result of LUC forcing. However, the magnitude of these changes is still highly uncertain. The goal of this work was to analyze the simulated Amazon deforestation and its impacts on climate and changes of three extreme hydroclimatic indices (Heat Wave Day Index, HWD; Maximum Consecutive Dry Day index, CDD; and fraction of precipitation above the 95th intensity percentile, R95). In this work we used the Common Land Model version 4.5 coupled within the Regional Climate Model (RegCM4) over CORDEX South America Domain. We perform one simulation with RegCM4 default land cover map (Ctrl_exp) and one simulation under deforestation scenario (LUC_exp), i.e., we changed all broadleaf evergreen trees tropical to C3 grass. Both simulations were driven by Era Interim reanalysis. The climate change signal due to AMZ deforestation is evaluated by comparing the climatology of the Ctrl_exp with the LUC_exp. The results show a dipolar response consisting of reduced precipitation over eastern AMZ and an increased precipitation over western AMZ. Concerning the temperature we found a predominant positive signal change over all AMZ. The extreme indices analysis shows increases in HWD, CDD and R95, implying a regime shift towards more intense, less frequent rain events and increasing risk of heat wave in LUC_exp. These last results also show a remotely effect of extreme indices over other regions in SA continent.

Marta Llopart, Erika Coppola, Filippo Giorgi, Rosmeri da Rocha

São Paulo State University (UNESP), International Center for Theoretical Physics (ICTP), University of São Paulo (USP)
Urban climate - air quality interactions in regional scale over Central Europe

Michal BELDA
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When aiming for higher resolution in dynamical downscaling, effects of land use and land use changes play an increasing role. For the purpose of qualifying and quantifying the impact of urban surfaces on climate, surface parameterization in regional climate model RegCM4 has been extended with the Single Layer Urban Canopy Model (SLUCM), which can be used both in dynamic scale within BATS scheme and in a more detailed SUBBATS scale to treat the surface on a higher resolution subgrid. A set of experiments was performed for the period 1990-2010 over central Europe, either without considering urban surfaces and with the SLUCM treatment. Results show a statistically significant impact of urbanized surfaces on temperature and boundary layer height. Additionally, new version of land-surface scheme using CLM with urbanization is tested and the same arrangement of experiments performed for comparison. Both versions will be compared and validated using EOBS data.

For the purpose of qualifying and quantifying the impact of urban emission from Central European cities on the present-day regional air-quality, the regional climate model RegCM was coupled with the chemistry transport model CAMx, including two-way interactions. A series of simulations was carried out for the 2001-2010 period either with all urban emissions included (base case) or without considering urban emissions. Sensitivity of ozone production to urban emissions was examined by performing reduction experiments with -20% emission perturbation of NOx and/or NMVOC. The model was validated using surface measurements of key pollutants.

Due to urban emissions, significant ozone titration occurs over cities while over rural areas further from them, ozone production is modeled. Air pollution over cities is largely determined by the local urban emissions, considerable fraction of the concentration is attributable to other sources from rural areas and minor cities. The radiative impact of the perturbed air chemistry due to urban emissions is dominated mainly by the aerosol direct/indirect effect. Decreases are modeled for the PBL height as well. The impact of all (urban and non-urban) emissions is up to -0.2, so considerable part of the radiative effects of all emissions is attributable to urban emissions. Partial climate impacts of urban emissions induced ozone, sulfate and nitrate changes are presented as well.

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Impacts of land use change and horizontal resolution in local climate by RegCM4 model

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The climate system is a complex system by its interactions which occur between its contents such as atmosphere, biosphere, plant and hydrology, etc. The climate model is an important tool which can be used to study these interactions. RegCM4-BATS model was employed to study the response of regional climate to land use change when it will be replaced by tall grass at Southern Sudan which Sudd wetland is one of the biggest swamps in Africa and belongs to the most extensive wetlands of the world. The Sudd region is located between 6° to 9°N and 29° to 32°E. The RegCM4-BATS were simulated twice, first run is to control and the second run to modify land use. This simulation done over Sudd swampy region which replaced into tall grass at two horizontal distances 50 km and 15 km. It is found that finer resolution has a strong impact on local climate of Sudd region which soil moisture increases led to increase in evapotranspiration and then precipitation (positive feedback mechanism) and temperature decreases as albedo decreases and sensible heat decreases. From the first experiment, replaced wetland by tall grass has only local impact over Sudd region; temperature will increase by up to 2 oC degree for all months except the wet season. For precipitation, we found an increase mainly in (May-June-July) by 25%. Second, by decreasing horizontal distance has a strong impact on local climate of Sudd region. Soil moisture increases led to increase in evapotranspiration and then precipitation (increases up to 60 %). Temperature decreases by 2 oC as albedo and sensible heat decreases. At high resolution experiment, there is difference in results between tall grass and short grass expect for evapotranspiration and albedo. For Sudd region replaced it by tall or short grass does not make a significant difference under high resolution.

Gamil Gamal Abd El-Motey1, Ahmed Shalaby2, Fawzia Moursy1, Gamal Salah4, Magdy Abdel Whab1

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An Integrated Land System Model System to study soil-vegetation-atmosphere feedbacks in agricultural landscapes under climate change

Kirsten WARRACH-SAGI

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Given that emission reduction commitments to mitigate global climate change will likely not be successful, there is a general shift in the research focus, not the least driven by climate politics, from exploring the future climate under different emission scenarios to possible adaptation measures. Current climate projections and recommendations for adaptation measures deduced from them fall short of accounting for important feedbacks:

1) Regional climate simulations neglect important feedback processes in the soil-crop system. An example is the assumption that vegetation dynamics are independent from weather conditions, even under a changing climate. However, the development of crop canopies and roots controls energy partitioning at the land surface. This will directly affect evapotranspiration, cloud formation, and precipitation, as well as, via additional feedbacks, soil carbon pools, crop yields and agricultural land use.

2) Changes in agricultural land use as a consequence of adaptations to climate change may feed back into local climate conditions. Predicting changes in land use is, however, complex. Human-human interactions (e.g., land markets, machinery and farm-related investments) and human-environment interactions (changes in crop mix and crop management) are not captured in conventional simulation models, but are required for projections of land system change on the regional scale. Extreme events have significant influence in shaping the trajectory of climate change adaptation by raising awareness and consequently triggering farmer responses.

We introduce an Integrated Land-system Model System (ILMS) capable of capturing complex land-atmosphere as well as human-environment interactions at high spatial (~1 km) and temporal resolution. ILMS considers the relevant biophysical and socioeconomic processes and accounts for the feedbacks listed above allowing the simultaneous study of their inter-linkages under climate change conditions. ILMS consists of an advanced Atmosphere-Land surface-Crop Model based on WRF and coupled to a Bio-Economic Model System.

In the future ILMS will be applied to downscale EURO-CORDEX hindcasts and climate projections until 2040 for southern Germany to study at which scale vegetation and soil moisture dynamics and land use change will affect regional climate through feedback mechanisms, and if the adaptive capacity of agricultural land users will be sufficient under these conditions to ensure economic survival.

Kirsten Warrach-Sagi, Christian Troost, Joachim Ingwersen, Scott Demyan, Joachim Aurbacher, Petra Högy, Thomas Berger, Georg Cadisch, Arne Poyda, Thilo Streck, Volker Wulfmeyer

University of Hohenheim, Germany
Regional climate-chemistry simulations over the med-cordex domain

Solmon FABIEN

ICTP - Italy

We discuss results from the RegCM4 climate chemistry model applied to the study of ozone and aerosol cycles over the Mediterranean basin for present and future climate conditions. We put the emphasis on the ability of the coupled climate chemistry model to simulate international variability of surface ozone in relation to climate extremes and air quality.

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Biogeophysical effects from land-cover changes in Europe

Gustav STRANDBERG

SMHI - Sweden

This study aims to estimate the magnitude and size of biogeophysical forcing in Europe. Globally the green-house gas forcing is of much greater importance, but on local/regional scale the size of the biogeophysical forcing may be of equal size. Furthermore, the sign of the biogeophysical forcing varies between regions. The biogeophysical forcing is a potentially large forcing that is not well constrained. Three scenarios for land-cover changes are simulated: 1) potential vegetation 2) present conditions and 3) potential deforestation. By comparing these three scenarios of land use we can estimate the impact of historical land-cover changes until today and also investigate the possible effects of deforestation and afforestation as possible mitigation strategies for the future.

The sensitivity in climate to changes in land cover is simulated by two RCMs, RCA4 and HCLIM. To minimise model dependencies in the results the RCM simulations are driven by the ERA Interim observation set. Both RCA4 and HCLIM reads the same vegetation files. By using the same climate forcing in all simulations and the same vegetation forcing in both models the results, and differences in results, in the two RCMs are only an effect of how vegetation and climate interacts within the RCMs. This approach minimises model dependencies and at the same time estimates the potential spread in results between models. Most previous studies have been relying on results from a single model.

The response in temperature can be as much as ±1.5 °C (somewhat more in maximum temperature and less in minimum temperature) in summer depending on local/regional surface characteristics. Generally changes in heat fluxes and evaporation have a larger effect than changes in albedo. The results show that land-cover changes can have significant effects on the simulated climate and be a driver of climate change at the regional scale. Furthermore they show that climate-vegetation interactions must be simulated with high resolution since the response depend on small scale features. Changes in vegetation as a mitigation strategy should be used with caution since it may lead to undesired climate change at the local/regional scale.

Gustav Strandberg 1,2

1 SMHI, 2 Department of Meteorology and Bolin Centre for Climate Change Stockholm Universitycal
Contributions of anthropogenic and external natural forcings to climate changes over China based on CMIP5 model simulations

Tianbao ZHAO

Institute of Atmospheric Physics of Chinese Academy of Sciences - China

Based on observations and historical simulations from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) archive, the contributions of human activities (including greenhouse gases (GHGs), anthropogenic aerosols (AAs), and land use (LU)) and external natural forcings (Nat) to climate changes in China over the past 50 years were quantified. Both anthropogenic and external natural forcings account for 95%–99% of the observed temperature change from 1951–1975 to 1981–2005. In particular, the temperature changes induced by GHGs are approximately 2–3 times stronger than the observed changes, and AAs impose a significant cooling effect. The total external forcings can explain 65%–78% of the observed precipitation changes over the past 50 years, in which AAs and GHGs are the primary external forcings leading to the precipitation changes; in particular, AAs dominate the main spatial features of precipitation changes in eastern China. Human activities also dominate the long-term non-linear trends in observed temperature during the past several decades, and, in particular, GHGs, the primary warming contributor, have produced significant warming since the 1960s. Compared to the long-term non-linear trends in observed precipitation, GHGs have largely caused the wetting changes in the arid-semiarid region since the 1970s, whereas AAs have led to the drying changes in the humid-semihumid region; both LU and Nat can impose certain impacts on the long-term non-linear trends in precipitation. Using the optimal fingerprinting detection approach, the effects of human activities on the temperature changes can be detected and attributed in China, and the effect of GHGs can be clearly detected from the observations in humid-semihumid areas. However, the anthropogenic effects cannot be detected in the observed precipitation changes, which may be due to the uncertainties in the model simulations and to other issues. Although some results in this paper still need improvement due to uncertainties in the coupled models, this study is expected to provide the background and scientific basis for climate changes to conduct vulnerability and risk assessments of the ecological systems and water resources in the arid-semiarid region of China.

Tianbao Zhao, Chunxiang Li

Institute of Atmospheric Physics, Chinese Academy of Sciences
VALUE perfect predictor validation results, part 2: spatial, multivariate and process-based aspects

Douglas MARAUN

Wegener Center for Climate and Global Change, University of Graz - Austria

VALUE is an open European network to validate and compare downscaling methods for climate change research (http://www.value-cost.eu). As a key deliverable, VALUE developed a systematic validation framework to assess and compare the performance and added value of dynamical and statistical downscaling methods. The framework comprises three experiments with (1) perfect predictors, (2) GCM predictors and (3) pseudo-reality predictors (see Maraun et al., 2015, for more details). For an overall validation of marginal and temporal aspects, refer to the abstract submission by Gutierrez et al.

Here we present validation results of the perfect predictor experiment for spatial and multivariate aspects, including process-oriented diagnostics. We show the performance of a broad range of classical perfect prognosis statistical downscaling methods as well as bias correction methods across all European climates. Specifically, we assess how these methods simulate

(1) the spatial dependence expressed by, e.g., empirical orthogonal functions, de-correlation lengths, decay lengths of tail dependence;

(2) multi-variable dependence between different meteorological variables expressed by, e.g., correlations and more generally parameters of conditional distributions; and

(3) the relationships between dominant weather phenomena and local surface weather at different scales, such as the North Atlantic oscillation, blocking, synoptic weather types and regional scale wind phenomena including Mistral and Bora.

Douglas Maraun1, Martin Widmann2, Renate Wilcke3, Jose Gutierrez4, Radan Huth5, Sven Kotlarski6, Elke Hertig7, Joanna Wibig8 and the VALUE team

1Wegener Center for Climate and Global Change, University of Graz, 2University of Birmingham, 3SMHI, 4University of Cantabria, 5Charles University Prague, 6MeteoSwiss, 7University of Augsburg, 8University of Lodz
Selection of suitable predictors and predictor domain for statistical downscaling:
A case study over the Western Himalayan region of India

Lalu DAS

Bidhan Chandra Krishi Viswavidyalaya (A state Agricultural University) - India

For statistical downscaling, selection of suitable predictors and predictor's domain is crucial and challenging issue as there is no general consensus regarding the methodology for the same. All available reanalysis dataset including ERA-Interim provide large numbers of predictor variables. Some of them have strong influence on the local scale meteorological predictant variables namely rainfall and temperature of target region which needs to be identified using any innovative techniques. Present study attempted to select a group of suitable predictors over one of the most highly topographic region of the Western Himalayan from the ERA-Interim reanalysis data sets. The method involves computation of the Principal Components of a group of available 16 temperature and 22 rain-gauge stations. For each large-scale gridded predictor field, EOF analysis has been performed and retained the first three leading EOFs, which could explain maximum variance of the data. A Step-wise Linear Multiple Regression method was employed to filter out the significant (95%) EOFs. In case of precipitation the suitable predictors are 10m V wind component, 10m wind speed, 2m surface air temperature (t2m), instantaneous moisture flux and synoptic monthly precipitation out of a probable 26 numbers of reanalysis predictor fields. Similarly the potential predictors for monthly mean temperature are t2m, 2m dew point temperature, vertical integral of divergence of geopotential flux, medium cloud cover and snow density out of 24-numbers of probable predictors.

For selection of the suitable predictor domain, we have followed different methods like, Canonical Correlation Analysis, spatial correlation analysis and temporal correlations of the mean seasonal cycles between the observation and the predictor fields. The size of domain is highly sensitive to get suitable downscaling results, which can be considered from a visual interpretation of the linear association between the observed climatic variable and the reanalysis predictor. Finally, the whole Indian domain (5-45 0N, 60-100 0E) is considered as a suitable predictor domain to provide reliable downscaling results both for rainfall and temperature over the Western Himalayan region.

Lalu Das¹, Monami Dutta¹, Javed Akhter², Jitendra Meher¹ and Abdelkader Mezgani² and Rasmus E Benestad³

¹ Bidhan Chandra Krishi Viswavidyalaya, ² Jadavpur University, ³ Meteorological Institute of Norway
Climate change scenarios for low carbon agriculture in Poland based on EURO-CORDEX (EUR-11) simulations

Malgorzata LISZEWSKA

Warsaw University Interdisciplinary Centre for Mathematical and Computational Modelling - Poland

Presented are results of regional climate change assessments in Poland carried out in frame of the NCBR BIOSTRATEG project: Support for the low carbon agriculture able to adapt to climate change today and in the 2030, 2050 time perspectives. The aim of the project is to work out the guidelines for the crop production in Poland in order to improve an efficiency of use of available resources through implementing innovative low carbon agricultural practices under climate change conditions.

For climate change evaluations results of 10 rcms’ simulations from the EURO-CORDEX (EUR-11) are applied. Simulations have grid sizes of about 12 km (.11 degree). Considered are two Representative Concentration Pathways RCP4.5 and RCP8.5 describing two possible climate futures. CORDEX simulations are verified for selected regions in Poland, using observations from experimental farms. In order to adjust model outputs to specific regional characteristics and special needs of the users a downscaling post processing is applied. Series of daily projections of climate parameters (temperature, precipitation, humidity, surface radiation) are generated for the 2020-2090 period. Also, a selection of climate indices convenient for agricultural assessments is computed. A detailed analysis of direct and downscaled model results for the experimental farms is provided. Two ensembles of simulations for two RCPs are compared.

A very important issue is an appropriate and understandable presentation of climate change assessments to stakeholders. To illustrate the conclusions of our results various visualizations are proposed.

Malgorzata Liszewska¹, Krystyna Konca², Maciej Sadowski³

¹University of Warsaw, ²Institute of Meteorology and Water Management, ³Institute of Environmental Protection
We have developed a statistical downscaling method for estimating probabilistic climate projection using multi general circulation models (GCMs). A regression model was established so that the combination of weight of GCMs reflects the characteristics of the variation of observations at each grid point. Cross validation was conducted to select GCMs and to evaluate the regression model. By using spatially high resolution observation system, we achieved statistically downscaled probabilistic climate projections. Biases in GCMs were typically reduced in this method for the monthly mean of the surface air temperature and precipitation in Japan. The corrected biases for the current climate were much smaller than those from dynamical downscaling results nested in single GCM and were comparable to biases corrected based on cumulative distribution function. Furthermore, this method generated probabilistic information for the future projection, such as exceedance probability of the temperature increase and several quantile values. Sensitivity of future changes on the emission scenario were investigated. We also discussed the difference of the probabilistic projections derived from multi-model ensemble and ensemble from single GCM. This probabilistic climate projection based on the statistical method can be expected to bring important information on the impact study and risk assessment.

Noriko N. ISHIZAKI1, Koji DAIRAKU1, and Genta UENO2

1National Research Institute for Earth Science and Disaster Prevention, 2The Institute of Statistical Mathematics
PCA-based strategy to represent stations for empirical-statistical downscaling.

Rasmus BENESTAD

MET Norway - Norway

We test a strategy for downscaling seasonal mean temperature for many locations within a region, based on principal component analysis (PCA), and assess potential benefits of this strategy which include an enhancement of the signal-to-noise ratio, more efficient computations, and reduced sensitivity to the choice of predictor domain. These conditions are tested in some case studies for parts of Europe (northern and central) and northern China. Results show that the downscaling was not highly sensitive to whether a PCA-basis or a more traditional strategy was used. However, the results based on a PCA were associated with marginally and systematically higher correlation scores as well as lower root-mean-squared errors. The results were also consistent with the notion that PCA emphasises the large-scale dependency in the station data and an enhancement of the signal-to-noise ratio. Furthermore, the computations were more efficient when the predictands were represented in terms of principal components. An example of PCA-based ESD strategy will be presented that includes full CMIP5 ensembles (RCP2.6, RCP4.5, and RCP8.5) for the Barents Region, based on temperature and precipitation from the Arctic part of Norway, Sweden, Finland and Russia.

Rasmus E. Benestad¹, Kaisa M. Parding¹, Abdelkader Mezghani¹

¹Norwegian Meteorological Institute
In this research, we explored ten geographical domains and a set of 33 predictors, which are the physical large-scale forcing for precipitation, minimum and maximum temperature of representative locations in the Upper Mantaro basin. This basin provides surface water to Lima, and is located in an arid region that now is home to nine million 689 thousand 011 inhabitants, but it's estimated to reach in 2021, the year of the bicentennial of the Republic, ten million 764 thousand 428 people. For this reason, water demand will increase in the coming decades and it is necessary to study the water availability in the basin under climate change conditions.

The representative stations located in areas of interest were grouped using the Regional Vector Method. For precipitation, five main groups were defined, while for temperature only one group was defined because the low number of stations measuring this variable in the area under study. Predictors and optimal domains were selected under the principle that should have a significant and physically interpretable association with the predictand, in addition to the necessary statistical support. We used several different statistical downscaling methods (from the analogs, weather typing and regression families) in order to find the most appropriate technique for future projections of temperature and precipitation in different climate change scenarios.

Gustavo De la Cruz, Delia Acuña Azarte

National Service of Meteorology and Hydrology of Peru
Statistical downscaling of daily precipitation in the Argentine Pampas region

Maria BETTOLLI

Department of Atmospheric and Ocean Sciences, University of Buenos Aires/CONICET - Argentina

The Pampas region comprises the most productive agricultural lands of Argentina. Grains such as soybean, corn, wheat and sunflower are grown in this region. Together with their byproducts, these crops promote the social and productive system of the region, and are one of the principal sources of fiscal incomes. Since the grains are cultivated extensively without artificial irrigation, the precipitation is one of the climatic variables of main influence for the production. The Pampas region is then particularly vulnerable to precipitation variability and to changes in precipitation regimes. Despite the importance of empirical statistical downscaling for regional climate impact studies, in southern South American regions much work remains to be done. In this context, the exploration and development of statistical downscaling techniques are of special interest for the region.

The objective of this work was to calibrate and validate a statistical method to downscale daily precipitation in the Argentine Pampas region. Daily mean fields of the NCEP-NCAR Reanalysis 2 were used as predictor variables for the period 1979-2010. The predictands were daily precipitation data from 28 meteorological stations. The statistical downscaling was based on the analogue method. Different predictors over different domain sizes were tested, including circulation, temperature and humidity variables.

The accuracy of the method was evaluated by means of several skill measures (bias, RMSE, correlation, indices assessing precipitation occurrence and precipitation amount, etc). Probability density functions were also compared by means of the K-S test. The downscaling performance depended on the season under consideration. The lowest skill was found for summer probably due to small scale processes that leads to precipitation in the region. Zonal and meridional wind components and relative humidity at 850 hPa were found to be the best combination of predictor variables. This could be related to the fact that near the Andes range mountain the wind components perform better in representing circulation and moisture advection at low levels. The results show the great potentialities of the method that is able to reproduce daily precipitation with a high level of accuracy. The performance of the method is very good at estimating seasonal cycles and spatial and temporal variability as well as at representing the transition climate regime over the western area of the region.

Maria L. Bettolli¹, Olga C. Penalba¹

¹Department of Atmospheric and Ocean Sciences, University of Buenos Aires/CONICET
The latest generation of climate projections for the 21st century were provided by the Coupled Model Intercomparison Project Phase 5 (CMIP5). However, their spatial resolution is rather coarse but information is needed on a fine spatial scale. Due to the high demand of computer resources, RCM models are only able to downscale a small part of this projections. Empirical statistical downscaling (ESD) methods can fill this gap.

The ESD-method EPISODES is used to downscale a large ensemble of GCM scenario runs. The downscaling is based on a gridded observational data set covering the territory of Germany. The spatial resolution is 0.11 degree, as an equivalent to the European fine scale CORDEX grid, with a daily temporal resolution. Most downscaled projections cover the time period 1951 to 2100.

Here, an analysis of this unique set of high resolution climate change projections for Germany is presented.

Frank Kreienkamp¹, Barbara Früh¹
¹Deutscher Wetterdienst, Germany
On the bias correction for regression-based ESD result for multi agro-meteorological elements over Japan and their comparing with RCMs results

Motoki NISHIMORI

National Institute for Agro-Environmental Sciences - Japan

Current estimates and future projections of surface agro-meteorological elements by using empirical statistical downscaling (ESD) are essential to apply climate impact and adaptation analyses together with regional climate models (RCMs) output. Recently, the CORDEX-ESD activities has proposed an experiment protocol to estimate the inherent uncertainty of the ESD. In this study, a multivariate multiple linear regression (MMLR) -based ESD method that comprehensively analyzed for seven surface predictands (daily averaged, maximum and minimum temperatures, precipitation, solar radiation, relative humidity and wind speed) is applied over Japan by using atmospheric circulation factors derived by JRA-25 reanalysis dataset as predictors. Then the result compared and validated with the RCMs' output drive by the same boundary conditions as the ESD. The experiment basically operated in accordance with the CORDEX-ESD protocol to set various calibration and validation periods.

Generally, ESD results were still provided estimated bias, so the initial value of the ESD was adjusted to have the same variance as observed climate (scaling method) on the elements except the precipitation. The scaling method is, however, insufficient for precipitation. As the example for applying to Argentina, common research field for the ESD protocol, weak rainfall tended to drizzle in the linear regression-based ESD, which is associated with significant overestimation of rainfall, especially in the dry season. Here, an alternative bias correction technique, adjusting the number of the rainy days, was developed. The reproducibility for daily precipitation was improved with each season over Argentina, so the same procedure is also applied to Japan, characterized by much more warm and wet climate. As the result, the ESD with new bias correction method obtained the good estimation with observed climate relative to the RCMs result, even on the daily time-scale over Japan.
Assessing Climate Extremes across Scales – from Global to Regional Climate Modeling

Jana SILLMANN

CICERO - Center for International Climate and Environmental Research – Oslo, Norway

“Understanding and Predicting Weather and Climate Extremes” is one of the Grand Challenges of the World Climate Research Programme (WCRP) focusing on advancing research on geophysical aspects of weather and climate extremes. Considerable effort was taken by Working Group 1 (WGI) in the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) to assess climate extremes in a consistent manner across chapters, from observations to model evaluation and near- to long-term projections of changes in climate extremes.
Daily precipitation extremes over Northern Canada estimated from Arctic and North-America CORDEX simulations and reanalysis

Emilia Paula DIACONESCU

Institut national de la recherche scientifique, Eau Terre Environnement - Canada

Climate extremes indices as defined by the Expert Team on Climate Change Detection and Indices (ETCCDI) have proved to be very useful in this endeavor. The ETCCDI indices, for instance, provide the basis for an improved gridded observational dataset of temperature and precipitation extremes and were used in the coordination of indices calculation for multi-model climate simulations of phase 3 and 5 of the Coupled Model Intercomparison Project (CMIP3 and CMIP5) and their evaluation with observations and reanalyses.

Emilia Paula Diaconescu¹, Alain Mailhot¹, Diane Chaumont², Ross Brown²,³, Patrick Grenier²

¹Institut national de la recherche scientifique: Eau Terre Environnement, ²Ouranos, ³Environment Canada, Québec, Canada
Scaling of precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios

Philippe DROBINSKI

IPSL/LMD, CNRS and Ecole Polytechnique - France

Future climate change projections indicate that many temperature and precipitation extremes become more frequent and intense in a warmer climate on a global scale, and concomitantly the risks of severe impacts to society will increase, calling for proactive adaptation measures. In order to support the adaptation decision making process, information on climate extremes is especially needed on a regional to local scale including time scales from sub-seasons to decades.

P. Drobinski (1), N. Da Silva (1), G. Panthou (2), S. Bastin (3), C. Muller (4), B. Ahrens (5), M. Borga (6), D. Conte (7), G. Fosser (8), F. Giorgi (9), I. Gütter (10), V. Kotroni (11), L. Li (1), E. Morin (12), B. Onol (13), P. Quintana-Segui (14), R. Romera (15), Torma Csaba Zsolt (9)

(1) IPSL/LMD, Palaiseau and Paris, France; (2) IPSL/LSCE, Gif sur Yvette, France; (3) IPSL/LATMOS, Guyancourt, France; (4) LADHYX, Palaiseau, France; (5) IAU, Goethe-University Frankfurt, Frankfurt, Germany; (6) University of Padova, Legnaro, Italy; (7) CMCC, Lecce, Italy; (8) Meteo-France/CNRM, Toulouse, France; (9) ICTP, Trieste, Italy; (10) DHMZ, Zagreb, Croatia; (11) NOA, Athens, Greece; (12) Hebrew University of Jerusalem, Jerusalem, Israel; (13) Istanbul Technical University, Istanbul, Turkey; (14) Ebro Observatory, Roquetes, Tarragona, Spain; (15) Environmental Sciences Institute, University of Castilla-La Mancha, Toledo, Spain
PARALLEL SESSION C: IMPACTS AND APPLICATIONS
C1: REPRESENTING & PROJECTING EXTREMES

THURSDAY 19TH MAY 2016
10:00

High-resolution climate change simulations within EURO-CORDEX:
Assessing extremes in the RCP2.6 low emission scenario

Claas TEICHMANN

Climate Service Center Germany (GERICS) - Germany

With the new global and regional climate simulations, CMIP6 and CORDEX respectively, being under way, coordination of activities across these communities regarding the calculation and dissemination of climate extremes indices would be of major advantage. This could ensure that extremes indices are consistently calculated and used, which would enable comprehensive inter-model comparison analyses and model evaluation and also allow for regular updates of currently used climate extremes indices, for instance, with indices addressing the needs of the climate impact community and climate change risk assessment.

Claas Teichmann1, Bastian Eggert1, Andreas Haensler1, Arne Kriegsmann1, Lennart Marien1, Susanne Pfeifer1, Swantje Preuschmann1, Diana Rechid1, Thomas Remke1, Kevin Sieck1, Daniela Jacob1 and the EURO-CORDEX team

1Climate Service Center Germany (GERICS)
Changes in heavy precipitation events over Mediterranean Basin

Riccardo BONANNO
RSE S.p.A. - ITALY

Extreme weather events represent serious risks for human activities and infrastructures. In particular hazards such as floods and droughts are one of the main challenges of the 21st century with significant societal and economic implications. The aim of this work is to assess potential changes in precipitation extremes that would have serious impacts over Mediterranean with focus over Italy.

For this analysis, daily precipitation fields provided by Med-CORDEX (MED-11 simulations under the RCP8.5 scenario) and by E-OBS and EURO4M archives (as reference data) have been used.

Two 30–year long records have been analyzed: the reference period 1971-2000 and the future period 2021-2050.

An investigation of the upper tail of the precipitation distribution has been done. The 90th (90p) and the 99th (99p) percentile have been computed by aggregating daily precipitation values in the two investigated periods for each single grid point. Then by inspecting the metric 99p-90p, the changes in the right tail of the distribution of precipitation events have been investigated.

Moreover changes in heavy precipitations have been investigated by computing the number of days with precipitation higher than 10 mm, with the assumption that significant changes in extremes is mostly based on exceedance numbers of moderate thresholds.

The results highlight an increase of heavy precipitation in regions where average precipitations are likely to decrease.

Paola Faggian¹, Riccardo Bonanno¹
RSE S.p.A. Italy
Multi-RCM Future Projections of Climate Extremes over East Asia

Changyong PARK

Pohang University of Science and Technology - Republic of Korea

This study examines future changes in summer climate extremes over East Asia using five Regional Climate Models (RCMs) participating in the CORDEX-East Asia project (HadGEM3-RA, RegCM4, SNU-MM5, SNU-WRF, and YSU-RSM). Generalized extreme value analysis is used to describe extreme intensity of temperature and precipitation. All RCMs predict increases in temperature and precipitation across East Asia for both means and extremes. The intensification of precipitation extremes is well consistent with the Clausius-Clapeyron relation (increase in moisture availability as warming). Relationships between model performances and future projections are explored. Better models tend to predict less warming, which is clearer in extremes than in means. Close inter-RCM relationship is found between mean and extreme projections, which holds even at grid scales with overall stronger relation in temperature than in precipitation. Sub-regional analysis is conducted in order to explore future changes in probability distributions of daily temperature and precipitation. Results show that temperature increase involves overall shift of distribution toward warmer conditions whereas increases in moderate-heavy rainfall dominate changes in precipitation.

Changyong Park¹, Seung-Ki Min¹

¹Pohang University of Science and Technology
Future changes in extreme rainfall events and circulation patterns over southern Africa

Izidine PINTO

University of Cape Town (UCT), Climate System Analysis Group (CSAG) - South Africa

Changes in precipitation extremes are projected by many global climate models as a response to greenhouse gas increases, and such changes will have significant environmental and social impacts. Hence there is critical need to understand the nature of weather and climate extremes. Results from an ensemble of regional climate models from the Coordinated Regional Downscaling Experiment (CORDEX) project are used to investigate projected changes in extreme precipitation characteristics over southern Africa. Indices for extreme events, which capture moderate extreme events, are calculated on the basis of model data and are compared with indices from two observational gridded datasets at annual basis. The physical drivers of the projected change are evaluated by examining the models ability to simulate circulation patterns over the regions with the aid of Self-Organizing Maps (SOM).

The evaluation data show that the RCMs can adequately simulate the current extreme rainfall climate, however differences exist depending on which observed dataset is used for the evaluation. The synoptic circulation patterns are well simulated which indicates that the differences in precipitation extremes between the regional models and observations are related to model physics and parameterizations. In an assessment of value the regional downscaling added to GCM results, positive added value was computed generally and found specifically to be a function on the type of metric used and geographical location. This added value over GCMs justifies the additional computational effort of RCM simulation for the generation relevant climate information for regional application. Regional climate models projections indicate that annual total precipitation will decrease while the maximum number of consecutive dry days increases. The decrease in annual total precipitation is primarily associated with increases in the frequency of high-pressure systems over the region and decreases in the occurrence of mid-latitude cyclones. Circulation changes include an increase in the occurrence of the oceanic high-pressure systems, a more dominant high-pressure circulation poleward of the continent and a decreased occurrence of patterns of continental lows and mid-latitude lows.

Izidine Pinto, Chris Lennard, Bruce Hewitson, Mark Tadross

University of Cape Town (UCT), Climate System Analysis Group (CSAG)
Extreme precipitation in an ensemble of regional climate models

Raymond Arritt
Iowa State University - USA

The north-central United States is one of the world’s most productive agricultural regions and also is implicated in environmental issues such as the hypoxic “dead zone” in the Gulf of Mexico. During the late 20th century this region has seen a marked increase in the occurrence of extreme precipitation, which affects both agricultural production and its environmental consequences. We have performed an ensemble of simulations using RegCM4 to examine the ability to reproduce the observed trend in precipitation intensity and to project future changes through the 21st century. We created a matrix of simulations over the CORDEX North America domain for 1950-2099 by driving the regional model with two different global models (HadGEM2-ES and GFDL-ESM2M, both for RCP8.5), by performing simulations at both 50 km and 25 km grid spacing, and by using three different convective parameterizations. The result is a set of 12 simulations (two GCMs by two resolutions by three convective parameterizations) that can be used to systematically evaluate the influence of simulation design on predicted precipitation. The two global models were selected to bracket the range of climate sensitivity in the CMIP5 models: HadGEM2-ES has the highest ECS of the CMIP5 models, while GFDL-ESM2M has one of the lowest.

Trends in frequency of extreme precipitation (defined as amounts exceeding 76.2 mm/day) for most simulations are similar to the observed trend but with notable variations depending on RegCM4 configuration and on the driving GCM. This trend is predicted to continue and intensify through the 21st century, with the magnitude varying by model configuration. Most configurations also show a marked increase in the number of long runs of dry days. These results are tempered by complex interactions among resolution, choice of convective parameterization, and the driving GCM. As an example, the Emanuel scheme produced the smallest precipitation increase of the three convective parameterizations when used in simulations driven by HadGEM2-ES but the largest increase when driven by GFDL-ESM2M. These findings reiterate that large ensembles using multiple RCM configurations and driving GCMs are essential for projecting regional climate change.

This research was sponsored by the U.S. Department of Agriculture National Institute of Food and Agriculture.

Raymond Arritt1, Ariele Daniel1, Pavel Groisman2
1Iowa State University, 2Hydrology Science and Services Corp

Thursday 19th May 2016
11:30
Cyclone activity in the Arctic from an ensemble of regional climate models
(Arctic CORDEX)

Mirseid AKPEROV

A.M. Obukhov Institute of Atmospheric Physics, RAS - Russia

The ability of the regional climate models (Arctic CORDEX) to simulate cyclone activity for the Arctic region is investigated. 10 regional climate models (RCMs), including models with and w/o “nudging” are considered. Comparing the characteristics of cyclone activity with the use of an ensemble of RCM’s hindcast simulations and ERA-Interim reanalysis for four seasons (winter, spring, summer, autumn) and for last decades, biases in cyclone frequency, intensity and size over the Arctic (region ca. north of 60°N) are quantified. In spite of these biases RCM’s are able to represent the characteristics of cyclone activity in the Arctic region, in particular RCM’s with “nudging”. The spread across the models are estimated. Additionally, the characteristics of extreme mesocyclones (polar lows) are investigated. The ability of RCM’s and reanalyses (ERA-Interim, Arctic system reanalysis - ASR) to represent polar lows over the Barents and Kara Seas in comparison with satellite observations is assessed. Reanalyses and RCM’s with high spatial resolution are able to represent ca. 50% of the observed polar lows.

Mirseid Akperov¹, Annette Rinke², Igor Mokhov¹, Doerthe Handorf², Klaus Dethloff² and the Arctic Cordex Team

¹A.M. Obukhov Institute of Atmospheric Physics, RAS, Moscow, Russia, ²Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, AWI, Potsdam, Germany
Can/will climate change impact the wind energy industry?

Sara C. PRYOR

Cornell University - USA

It is still technically possible to limit global warming to 2°C, but this scenario is unlikely. What will this mean for sectors like wind energy that are impacted by weather-related variables? In order for any climate change impact to be important the changes must be detectable on the lifetime of wind farms (of the order 30 years) and the resource and operating conditions must evolve beyond (sometimes poorly characterized) current variability and engineering design standards.

Despite many challenges, progress has been made both in developing tools to project climate change impacts and in quantifying uncertainties and their sources. I present an overview of those methods, limitations and results to date using examples drawn from Northern Europe and North America. In these regions, aside from areas with significant thermo-topographic forcing, the wind resource (and to some degree operating conditions) in the primary resource-rich areas, is primarily determined by the track, translational speed and intensity of mid-latitude cyclones which are increasingly well-resolved by RCMs. Accordingly dynamical and statistical downscaling of near-surface wind speed distributions exhibit skill in reproducing current wind climates, indicating it may be possible to make robust projections of wind resources and changes therein. Projected changes in wind resources in the two focus regions are generally modest: e.g. Model ensembles indicate small increases in resource magnitude or no change over Scandinavia and the US Great Plains regions to the middle of this century, but small decreases in wind resources for the US Northwest. In the near-term, differences in projected wind resources are equally or more pronounced across models than emission scenarios. Potential impacts from changes in operating conditions such as extreme winds and icing are more challenging to quantify. However, preliminary work indicates current standards provide a large safety margin that is not exceeded by projected changes in, for example, extreme wind speeds. Uncertainty remains regarding factors such as model skillful scale and also the robustness in model response to different forcings, and how both vary with model architecture. Possible approaches to addressing those issues and improving treatment of internal climate variability, and thus reducing uncertainty and risk, will be described.

S.C. Pryor, R.J. Barthemie

Cornell University
Multimodel analysis of solar radiation over Iberian Peninsula for renewable energy purposes

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The aim of this work is to analyse the output of several high resolution simulations of RCMs in the frame of CORDEX program from the point of view of a potential end user. Solar irradiation is the variable selected to evaluate the results due to its importance in terms of renewable energy electricity production and its assessment. In a society committed to the 2020 objectives of CO2 emissions reduction, a good knowledge of spatio-temporal features of the resources is crucial.

RCMs provide a high quality tool to evaluate solar resource in a spread area and its evolution in time. They are an alternative source of data due to the lack of well-spread and long-period observations databases in most places. In addition, it is a coherent database in case several variables are needed for further studies such as wind, solar radiation or temperature.

This study makes use of clustering techniques to evaluate spatial patterns of solar radiation over the Iberian Peninsula. These methods provide an non-supervised classification, which facilitates the spatio-temporal analysis of the solar radiation. The clusters are selected based on the temporal variability of solar irradiation, after applying a bias correction to this field, taking as observed values the CM-SAF satellite data. The use of several RCM simulations from EURO-CORDEX allows us to analyse the consistency of the results between different models.

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Inter-annual variability of the modelled Mediterranean thermohaline circulation in Med-CORDEX simulations and the role of tidal forcing

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The ocean plays a fundamental role in the evolution of the climate on our planet, and the Mediterranean area is one of the regions described as a “hot spot” under global warming, thus meaning that climate in this area is expected to significantly respond to global changes. The availability of atmospheric reanalysis products, such as ERA40 and ERA-interim, together with the subsequent numerous regional dynamical downscaling hind-cast simulations performed so far, prompted the HyMeX/Med-CORDEX community to test the ability of current oceanographic models of the Mediterranean Sea to represent the response of the circulation to realistic inter-annual variability in the atmospheric forcing, in the perspective of fully coupled regional ocean-atmosphere models.

This work presents an inter-comparison of recent hind-cast simulations of the Mediterranean Sea Circulation, at resolutions spanning from 1/8° to 1/16°. The inter-annual variability of the modeled Mediterranean thermohaline circulation has been investigated at basin and sub-basin scale, and compared to available observations. We analyze the mean circulation on both the long-term and decadal time scale, and the represented inter-annual variability of intermediate and deep water mass formation processes in both the Eastern and Western sub-basins, finding that models agree with observations in correspondence of specific events, such as the 1992-1993 Eastern Mediterranean Transient, and the 2005-2006 event in the Gulf of Lion. Simulations generally appear to be in good agreement, the main differences being attributable to different initializations and to alternative prescriptions of the Atlantic boundary condition. A special attention is devoted to the representation of water exchange between the Mediterranean and the Atlantic ocean in the Strait of Gibraltar, which is significantly affected by tidal forcing. Such effects on the simulated MTHC are evaluated by comparing results from two hind-cast numerical simulations, with and without tidal forcing, both implementing a high resolution representation of the SoG.

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Coastal Low-Level Jet (henceforth referred to as “coastal jet” or simply as CLLJ) is a low-tropospheric wind feature driven by the pressure gradient produced by a sharp contrast between high temperatures over land and lower temperatures over the sea. Although being a mesoscale feature, coastal low level jets (CLLJ) have a larger scale synoptic pattern forcing behind them: a high pressure system and a thermal low in land. For this reason CLLJ potential regions coincide with cold eastern boundary currents in the mid-latitudes. These regions are amongst the most productive ocean ecosystems, where the atmosphere-land-ocean feedbacks, which include marine boundary layer clouds, coastal jets, upwelling and inland soil temperature and moisture, play an important role in defining the regional climate along the sub-tropical mid-latitude western coastal areas.

During the summertime the Iberian Peninsula is under the effect of the Azores High and of a thermal low pressure system inland, giving rise to a seasonal northerly wind, and CLLJ. This study presents future projections of the Iberian Peninsula CLLJ based on a 2-member GCM EC-Earth simulations (the “ensemble”), on EURO-CORDEX WRF simulations and on a WRF high resolution (9km) regional climate simulation. The impact of a warmer climate on the Iberian coastal low-level wind jet in the twenty-first century is briefly analyzed, using the classification and filtering criteria of CLLJ detection proposed by Ranjha et al. (2013). A twentieth century period (1971-2000) from present climate is used as control run. The projections are analyzed for a time slice at the end of the 21st century (2071-2100) with the RCP8.5 greenhouse gas emissions scenario. The projections show that the Iberian Peninsula CLLJ wind speed maximum is higher in height and stronger in wind speed, and a significant increase of the frequency of occurrence of CLLJ. There is also a projected expansion of the offshore extension to the west.
Simulation of snow bands in the Baltic Sea area with the coupled atmosphere-ocean-ice model COSMO-CLM/NEMO-Nordic

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Long bands of snow over the Baltic Sea area are common during late autumn and early winter. The phenomenon occurs when cold air flows over warm water surface, enhancing convection and leading to heavy snow fall. Six snowband events from 1985 to 2010 are simulated by using the coupled atmosphere-ocean-ice model COSMO-CLM/NEMO. The model results showed that the stand-alone COSMO-CLM forced by re-analysis data ERA-Interim and the coupled system COSMO-CLM/NEMO-Nordic well reproduced the snowband events with high contrast of temperature between the surface and higher atmosphere layer as well as the sharp bands of precipitation over the sea.

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Estimating uncertainties in projections for the Baltic Sea region based upon an ensemble of regional climate system models

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Multi-model ensemble simulations for the Baltic Sea region are presented for the period 1850–2098. For the past period 1850–2006, atmospheric, hydrological and nutrient forcings were reconstructed, based on historical measurements. For the future period 1961-2098, scenario simulations were driven by regionalized global general circulation model (GCM) data using several regional climate system models (RCSMs) and forced by various future greenhouse gas emission and air- and riverborne nutrient load scenarios (ranging from a pessimistic ‘business-as-usual’ to the most optimistic case). To estimate uncertainties caused by biases of RCSMs and GCMs, natural variability and unknown forcing scenarios, different models for the various parts of the Earth System, different initial conditions and different scenarios were applied. These simulations constitute the largest ever analyzed multi-model ensemble for the Baltic Sea allowing, inter alia, the statistical analysis of the ensemble spread. Assuming the IPCC greenhouse gas emission scenarios A1B or A2, we found that water temperatures at the end of this century may be higher and salinities and oxygen concentrations may be lower than ever measured since 1850. There is also a tendency of increased hypoxia and eutrophication in the future, depending on the nutrient load scenario. Despite considerable shortcomings of state-of-the-art models, this study suggests that the future Baltic Sea ecosystem may unprecedentedly change compared to the past 150 yr. As stakeholders today pay only little attention to adaptation and mitigation strategies, more information is needed to raise public awareness of the possible impacts of climate change on marine ecosystems.

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Mistral and Tramontane in MedCORDEX Simulations: Present Day and Future Climate

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The Mistral and Tramontane are mesoscale winds in the Mediterranean region that travel through valleys in southern France. The cold and dry Mistral blows from the north to northwest, and travels down the Rhône valley, between the Alps and Massif Central. The Tramontane travels the Aude valley between the Massif Central and Pyrenees. Over the sea, these winds cause deep-water generation, and thus impact the hydrological cycle of the Mediterranean Sea.

The occurrence and characteristics of Mistral and Tramontane depend on the synoptic situation, the channeling effects through mountain barriers, and land and sea surface characteristics. We evaluate Mistral and Tramontane wind speed and direction patterns in several regional climate models from the MedCORDEX framework with respect to these challenges for modeling.

Furthermore, time series of Mistral and Tramontane days events in historical and projection runs are derived from sea level pressure patterns. The development of Mistral and Tramontane days per year and the average length of such events is studied, as well as the development of wind speeds.

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Towards the assessment of climate change impacts on critical energy infrastructure
applied for offshore wind farms

Thomas REMKE

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Critical infrastructures are facilities of special importance for countries and broader economic regions. Implications can result in severe consequences for associated sectors and society as a whole. Regarding critical energy infrastructure, planning and operational horizons usually span several years to decades. Hence, climate and climate change information of potential direct or indirect impacts for such infrastructure is of interest for planning purposes serving risk management and to assure secure and sustainable energy supply.

Here we present a first step towards a methodological framework to assess the climate related impacts on critical energy infrastructure, which is exemplarily applied for offshore wind energy. As part of the project management financing is an important key aspect. Large wind farm projects of the size of power plants are most commonly based on financing, which in turn is covered by sold energy produced during operational phase. As the variable renewable resource wind might be affected by climate change energy production from wind could be affected directly. Furthermore, extreme events might be affected potentially causing enhanced machine malfunction. This could impact on project financing as well as in a broader sense on energy security.

In a first attempt, high-resolution climate simulations addressing wind farm characteristics will be carried out with the regional climate model REMO. First results of a systematic process-based analysis will be presented with a focus on wind climate in terms of variability and boundary layer characteristics. This information can serve as valuable climate information for climate service applications as well as subsequent economic assessment.

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Precipitation seasonality, variability and associated dynamical processes over eastern Africa

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Most of the annual rainfall over the Horn of Africa (HoA) occurs in two distinct rainy seasons, from June to September (known as Kiremt) and from February to May (Known as Belg), which correspond to periods when the ITCZ crosses the equator in its annual migration. In general, rainfall in the HoA depends on the interplay between low-level inland moisture transport by the regional tropical circulation systems and upper-level dynamic perturbations inducing sufficient vertical motion and/or destabilization of the air column with respect to moist convection to produce deep precipitating cloud. With regard to the former, the East African low-level jet (EALLJ) is a prominent feature of the spring circulation over the HoA. The EALLJ strongly affects the temporal and spatial distribution of rainfall over East Africa. Failures of rainfall are a recurring phenomenon, with recent major droughts recorded in 1999-2000, 2008-2009, and 2011. These often have catastrophic consequences, with many millions of people suffering starvation and displacement and appear to be part of a decadal trend of declining precipitation. Climate projections also indicate that rainfall over this region is vulnerable to global warming. Here the representation of precipitation seasonality, variability and associated dynamical processes in the Africa-CORDEX ensemble is investigated. The focus region is eastern Africa, generally, and the Horn of Africa, in particular. In order to have confidence in future projections over this important region, we must first understand how well the Africa-CORDEX ensemble is able to reproduce observed variability, trends and dynamics. To this end we begin with the evaluation runs before investigating projected changes in the future simulations.

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Estimating change in future streamflow based on a limited sample of different downscaling products

Marie Ekström
CSIRO - Australia

For many geographical regions outside Europe and US, downscaled data to support climate change impact analysis are still limited, particularly when requiring downscaled information over large regions that is internally consistent across multiple variables. This is certainly a challenge for streamflow projections, as most hydrological rainfall-runoff models require information about areal potential evaporation and rainfall over a specified spatial domain (catchments or river basins).

Within the Victorian Climate Initiative (VicCI), pros and cons of different regionally available downscaling products are assessed for the production of streamflow projections. VicCI is a regional climate initiative launched by the Victorian State of Australia that is tasked to provide knowledge that leads to improved forecasts of water availability in the short term and improved risk assessment on water supplies due to medium to long term changes in the climate.

The majority of existing regional streamflow projections in Australia use climate change information from empirically scaled observational time series, where observations are scaled using scaling factors from global climate models. This approach is easily implemented and can consider the full range of outputs from global climate models. Within VicCI, we investigate if downscaled products can provide added value to the estimation of the regional climate change signal, particularly in areas with marked relief such as the Victorian Alps. All regionally available downscaled data sets are considered, representing different complexity and includes both statistical and dynamical downscaling techniques. Here, we discuss challenges encountered and how to phrase policy guidance for regional water supply projections based on the entire suite of outputs.

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Precipitation downscaling using the Intermediate Complexity Atmospheric Research model (ICAR) in Western Canada

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Performance of precipitation simulations in climate and weather forecast models over complex terrain are challenging as the physical atmospheric processes are difficult to model. High spatial variability of meteorological variables (e.g. precipitation, temperature, and wind) in complex terrain has important hydrologic consequences, thus requiring careful treatment particularly for climate change simulations. However, the assumption of stationary relationships between atmospheric variables and local observations in both current and future climates, as applied in statistical approaches, and high computational cost of dynamical models such as the Weather Research and Forecasting model (WRF) as run for current and future climates with both sufficient resolution to represent alpine terrain, with ensembles based on many global climate models necessitate the consideration of an alternative solution that considers the main physical processes while minimizing computational resources. In this study, downscaling of the meteorological variables is carried out using the Intermediate Complexity Atmospheric Research model (ICAR) (Gutmann et al., 2016). Outputs from the regional climate models applied in the North American regional climate change assessment program (NARCCAP) have been used as the initial and boundary conditions and the model is run over the Canadian Rockies and southern Yukon Territory. Results for precipitation are compared with local observations from the Canadian Rockies Hydrological Observatory and Wolf Creek Research Basin. Results show that with reasonable reductions in model complexity, we can still obtain reasonably good simulation for precipitation in complex terrain in cold regions. Reliable downscaling of orographic precipitation with non-linear characteristics and higher spatiotemporal variability improves the hydrometeorological prediction uncertainties. This is important to understand the interactions between precipitation phase change, snow energetics, and glacier dynamics in alpine areas under current and future climates in Canadian Rockies and northern Canada. The results help to better assess the vulnerability and resiliency of the water resources that are dependent on alpine snow and glaciers and so support the objectives of GEWEX’s International Network for Alpine Research Catchment Hydrology (INARCH).

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Streamflows in key Victorian catchments a State of Australia located in the extra-tropical half of the continent, are projected into the future utilising a combination of a simple linear regression based a temporal range of rainfall and temperature driven by an ensemble of statistically downscaled CMIP5 global climate models (GCMs). Based on a previously developed streamflow regression, the application of this method to the downscaled GCMs required significant calibration of model rainfall and temperature output compared to that of gridded observations. The evaluation of model performances also highlight the fact that the statistical downscaling of the climate models removed the largest biases in reproducing the surface climate as the evaluation of downscaled climate models and direct outputs form the climate models does not yield similar results. Whilst changes in rainfall are relatively consistent across the state albeit with a topographic influence as expected from using downscaled information, changes in streamflow are much more sensitive, with each subregion responding to rainfall reductions in different ways. Results for Victoria as a whole indicate that by 2090, streamflow will be 20% to -40% less than the 1990 average. For the catchments close to the main orography, this is the equivalent to the streamflow conditions experienced during the Millennium drought, the worse historical protracted drought experienced in Victoria during 1997 to 2009. For catchments in the far west and east of the state, the model results indicate that the 2085 streamflow reductions will not be as severe as those in the Millennium drought. In this study, the effect of temperature on streamflow was analysed by using reconstructions with and without maximum temperature. On average, streamflow responses to temperature changes are very small, in line with the negligible effect that temperature had in the skill of the linear streamflow reconstruction. Results from this work indicate that whilst catchments across Victoria will respond differently to the effects of climate change, the majority are projected to see reductions of streamflow similar to those experienced during the Millennium drought by the end of the century, severely limiting Victoria’s water capacity if it were to rely on rainfall alone. Alternative water sources, along with more efficient water management and use will be essential in the future if the state is to provide for increasing population demands.
Preparing for fully coupled climate-hydrological modelling in data-sparse regions applied over the Crati River catchment in Southern Italy

Morten Andreas Dahl LARSEN

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Dynamically coupled atmospheric and hydrology modelling is an emerging field of research driven by an ambition to include a wider range of processes at a high spatio-temporal level of detail by utilizing or extending existing model codes to achieve a more skillful reproduction of model output variables. With the use of highly advanced model codes follows a higher demand for a wider range of high quality data used to both drive and validate the models in terms of spatial coverage, temporal resolution, representation of local attributes and data selection. Most notable in terms of local data demands is the land surface/hydrology model representing local features on even sub-km scales. Therefore, most studies have been performed over regions of vast data coverage. The improvement in model outcome as sought by the coupled approach however is not targeted exclusively for regions with good data.

We here investigate the performance of the distributed MIKE SHE hydrology model coupled with the SWET land surface model as used in recent studies with a dynamical coupling to atmospheric simulations using the HIRHAM regional climate model (RCM). The study is performed over the Crati River catchment in Southern Italy. The catchment is selected due to: 1) availability of data in terms of discharge, a flux tower station, climate stations and gridded data products such as ERA-I, E-OBS, SWBM and RCM output (e.g. MED-CORDEX) but otherwise resembles problems of data sparse regions in terms of lack of temporal overlap, gap filling, availability, hydrogeological interpretations and land use. 2) The regional location in the Mediterranean area previously shown to exhibit substantial biases which could potentially be reduced by the future coupled setup. 3) The local scale location in the Mediterranean highlands with large variations in orography and land use which can be difficult to represent in models and 4) existing model runs using the WRF-Hydro model enabling the basis for valuable comparison studies. In the present study the model is parameterized through inverse calibration using variations of the available data to highlight the influence of data quality and availability on the model outcome and assets/disadvantages of individual products.

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A downscaling and bias-correction approach for climate projections of snow conditions in mountain regions using energy balance land surface models

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Projections of future climate change have been increasingly called for lately, as the reality of climate change has been gradually accepted and societies and governments have started to plan upcoming mitigation and adaptation policies. In mountain regions such as the Alps, where a large fraction of the revenue comes from winter tourism (about 20% of the French tourism revenue) and water and hydropower production, particular attention is brought to current and future snow availability. The question of the vulnerability of alpine ecosystems as well as the occurrence of climate-related hazards such as avalanches is also under consideration.

In order to generate projections of snow conditions, however, downscaling global climate models (GCMs) by using regional climate models (RCMs) is not sufficient to capture the fine-scale processes and thresholds at play. In particular, the altitudinal resolution matters, since the phase of precipitation is mainly controlled by the altitude-dependent temperature. Simulations from GCMs and RCMs moreover suffer from biases compared to local observations, due to their rather coarse spatial and altitudinal resolution, and often provide outputs at too coarse time resolution to drive impact models. RCM simulations must therefore be corrected and further downscaled using empirical-statistical downscaling and error correction methods, before they can be used to drive specific models such as energy balance land surface models.

In this study, time series of hourly temperature, precipitation, wind speed, humidity, and short- and longwave radiation were generated over the French Alps for the period 1950-2100, by using a new approach based on quantile mapping. Outputs from the EURO-CORDEX simulations spanning 11 different RCMs forced by different GCMs under 4 representative concentration pathways scenarios over Europe were downscaled at the massif scale and for 300 m elevation bands and statistically corrected against the extensive SAFRAN reanalysis (1958-2015). These corrected fields were then used to force the SURFEX/ISBA-Crocus land surface model over the French Alps. Here we illustrate our method using one GCM/RCM combination from the EURO-CORDEX ensemble, the ARPEGE/ALADIN combination. An extensive evaluation of the downscaling method was carried out using RCM model runs driven by a global reanalysis and some preliminary results in terms of projected meteorological and snow conditions using this GCM/RCM combination are presented.

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General Circulation Models (GCMs) form the basis for any study pertaining to climate change impact assessment. In order to understand the cascade of impacts at various levels, projections of climatic variables are at first derived from parent GCMs. However, because of its coarser resolution, it is difficult to use GCM outputs directly at regional scale; which necessitates a need for downscaling by either statistical and/or dynamical technique. Hence, present study involves bias correction of GCM outputs by applying widely used quantile-based remapping technique, to project climate change impacts over the entire India. To compare the climatic projections derived from two different scales, here, bias corrected dynamically downscaled Regional Climate Model (RCM) outputs obtained from COordinated Regional Downscaling EXperiment (CORDEX) framework and bias corrected GCM outputs have been considered. Furthermore, changes in climatic variables serve as a major driving force for disturbing the hydrological cycle, and hence hydrological impacts at a meso-scale have been assessed by simulating Variable Infiltration Capacity (VIC) model considering bias corrected meteorological GCM and RCM outputs. Since current objective here is to analyse the impacts derived from different scales, changes in hydroclimatic variables have been assessed and uncertainties lying in their projections have been estimated. Quantification of these uncertainties plays a significant role in strategizing different watershed management practices which may change with the model outputs used, and hence should be considered in order to reduce adverse impacts of future climate change more precisely.

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Observations and downscaling for alpine hydrological modelling

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University of Edinburgh - UK

Downscaling information from global and regional climate models is particularly challenging in mountainous regions, where surface elevation, slope and aspect have strong variations on scales much smaller than achievable model resolutions. Alpine catchments receive and produce disproportionate fractions of precipitation and streamflow, contributing to floods and water supplies for vast downstream areas that include at least half of humanity. Understanding the sensitivity of hydrological processes to climate change in high elevation catchments is therefore of paramount importance, but data for monitoring mountain hydrometeorology and improving models are scarce. The International Network for Alpine Research Catchment Hydrology (INARCH) is now facilitating collaboration between researchers working in well-instrumented mountain catchments to develop consistent datasets and to improve transferable models of alpine hydrology. This presentation will review dynamical and statistical downscaling methods being developed and used by INARCH researchers and upscaling of observations to improve model predictability.

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Spatio-temporal analysis of the coupling between soil moisture and surface climate in the La Plata Basin: combining results from regional climate models and satellites

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The La Plata Basin (LPB), located in southeastern South America, has been identified as a hotspot of soil moisture - atmosphere coupling, that is, a region where land surface impacts substantially on the atmosphere, and in particular where seasonal climate predictions could be improved by incorporation of realistic soil moisture information. Furthermore, the monitoring and forecast of the hydrological status of LPB is very important since it is affected by cyclical drought and flood episodes that impact on the large agricultural, hydroelectrical and industrial production of this densely populated region.

Strong soil moisture – precipitation and evapotranspiration coupling during austral summer in LPB has been found in studies using different tools such as regional climate models, off-line land surface models and different definitions of coupling. Nevertheless these studies have several limitations related to model assumptions and vegetation parameterizations, as well as the lack of observational data for the evaluation of models performance.

On the other hand, in the last decade several instruments on board satellites are providing soil moisture products globally and in a continuous way. A recent work has shown that satellite soil moisture can capture the Standardized Precipitation Index pattern under extreme wet and dry conditions over the southern LPB.

In order to deepen and overcome some of the model limitations, this work adds satellite soil moisture and vegetation products in the spatio-temporal analysis of the regions of strong soil moisture – atmosphere interactions. The main objectives and related outcomes are: the verification of already identified regions where soil moisture anomalies may have an influence on subsequent precipitation, evapotranspiration and temperature anomalies, and the study of their seasonal characteristics and land cover influences in LPB.

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The performances of the ICTP Regional Climate Model Version 4 (RegCM4) in simulating the precipitation over the Southeast Asia with two land-surface schemes namely the Biosphere-Atmosphere Transfer Scheme version 1e (BATS1e) and Community Land Model version 4.5 (CLM4.5) were evaluated. The domain was that of the CORDEX Southeast Asia (i.e. 89.4891 E to 146.511 E, 14.8144 S to 26.9569 N) with the horizontal resolution of 25 km and 18 sigma vertical levels. Both simulations were forced with ERA interim and other identical physical parameterizations include the Holtslag Planetary Boundary Layer scheme, Emanuel cumulus parameterization scheme over both land and ocean, SUBEX moisture scheme and Zeng scheme for ocean flux parameterization, in which the surface roughness length is assumed as a function of friction velocity and viscosity. The simulations were carried out for a period from 1 January 1989 to 31 December 2007 with the first year used as model spin-up. Precipitation from four gridded products (TRMM, ARPHRODITE, CRU and GCPC) were used as observed data. Generally, the BATS1e simulation systematically overestimated the precipitation amount throughout the domain compared with the CLM4 scheme which shows lower biases. This overestimation was clearly indicated in the annual cycles of precipitation of 20 sub-regions, although both schemes performed reasonably well in simulating the cycles. The year-to-year coefficient of variance of the precipitation for both the simulations was found to be similar and closely resembled that of the observations. The ratios of convective precipitation amount to total precipitation for both simulations are found to be similar but notably different from that of observation. This result suggests that shortcoming in the simulation may largely due to convective parameterization but not the land surface scheme. The simulation results of surface air temperature also indicate that both schemes produced cold biases with CLM tended to produce larger magnitude of cold biases compared with the BATS1e. However, both schemes reproduced the annual cycles of the surface temperature of the 20 sub-regions reasonably well. Overall, the results show modest improvements have been achieved by using CLM4.5. However, further diagnostics are still needed in identifying major deficiencies in the simulation.

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POSTER SESSIONS

A: BENEFITS OF DOWNSCALING (PA)
B: FRONTIER DOWNSCALING TOOLS (PB)
C: IMPACTS AND APPLICATIONS (PC)
<table>
<thead>
<tr>
<th>Name</th>
<th>Abstract Title</th>
<th>Poster ID</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AALBERS EMMA</td>
<td>To what extent is climate change detection at the local scale 'clouded' by</td>
<td>PA-001</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>internal variability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdella Elias</td>
<td>Climate change Impact Analysis on the Hydro-climatology of Upper Blue Nile</td>
<td>PC-001</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Basin Using SWAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABERA TAREKEGN</td>
<td>Climate Change Impact on Sugarcane water requirement in Wonji-Shoa Sugar</td>
<td>PB-001</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>Factory West Oromia, Central Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adakudlu Muralidha</td>
<td>Evaluation and implications of the bias of a regional atmospheric model in</td>
<td>PC-002</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>the Arctic CORDEX framework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGARWAL ANSHUL</td>
<td>Assessment of climate change impacts and uncertainty on hydrological</td>
<td>PC-003</td>
<td>194</td>
</tr>
<tr>
<td></td>
<td>extremes in the Koshi river basin, Nepal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ahn Joong-Bae</td>
<td>Agro-climate changes over the Korean Peninsula and nearby regions under</td>
<td>PA-002</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>RCP scenarios simulated by WRF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akhtar Naveed</td>
<td>Climate Modeling over the Mediterranean Sea: Impact of Resolution and</td>
<td>PA-003</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Ocean Coupling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akther Javed</td>
<td>Spatial downscaling on gridded precipitation over India</td>
<td>PB-002</td>
<td>144</td>
</tr>
<tr>
<td>All Shaukat</td>
<td>CORDEX data application for climatic and hydrological changes over</td>
<td>PC-004</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>mountainous region of Himalaya</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambade Balram</td>
<td>Seasonal variations of black carbon and PM2.5 over Jamshedpur, East India</td>
<td>PB-003</td>
<td>145</td>
</tr>
<tr>
<td>Anders Ivonne</td>
<td>COPAT – towards a recommended model version of COSMO-CLM</td>
<td>PA-004</td>
<td>14</td>
</tr>
<tr>
<td>Anders Ivonne</td>
<td>Continuously on-going hindcast simulations for impact applications</td>
<td>PA-005</td>
<td>15</td>
</tr>
<tr>
<td>Anders Ivonne</td>
<td>Capturing flood-to-drought transitions in 2002/2003 and 2013 by CCLM-</td>
<td>PC-005</td>
<td>196</td>
</tr>
<tr>
<td></td>
<td>simulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andersson Lotta</td>
<td>Use of climate information in local and regional decision processes</td>
<td>PA-006</td>
<td>16</td>
</tr>
<tr>
<td>Armand Joel</td>
<td>Impact of anthropogenic aerosols on precipitation and surface air</td>
<td>PB-004</td>
<td>146</td>
</tr>
<tr>
<td>Komkoua Mbienda</td>
<td>temperature over Central Africa by using a regional climate model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armenta Porras</td>
<td>Producing high spatial resolution climate scenarios for tropical America</td>
<td>PC-006</td>
<td>197</td>
</tr>
<tr>
<td>Guillermo Eduardo</td>
<td>using WRF model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ashraf Shakeel</td>
<td>Performance of dynamically downscaled ensemble seasonal forecasts over</td>
<td>PA-007</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>east Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ayanaide Ayansina</td>
<td>When there are atmospheric data gaps: Use of GIS interpolation and</td>
<td>PA-008</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>downscaling methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ayanaide Ayansina</td>
<td>Impact of Climate variability/change: How do local farmers adapt</td>
<td>PB-005</td>
<td>147</td>
</tr>
<tr>
<td>Bartholy Judy</td>
<td>Projection of extreme temperature and precipitation conditions using</td>
<td>PC-007</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>RegCM experiments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basher MD Abul</td>
<td>Assessing the Performance of CORDEX South Asia Regional Climate Models</td>
<td>PA-009</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>in simulating rainfall of North-East region of Bangladesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaumet Julien</td>
<td>Climate changes in Antarctica: analysis of ARPEGE and LMDZ global climate</td>
<td>PA-010</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>models (GCM) at a high regional resolution and oceanic forcing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>contributions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belda Michal</td>
<td>On the comparison of EuroCORDEX ensemble and ENSEMBLES ensemble of regional</td>
<td>PA-011</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>simulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belda Michal</td>
<td>Changes of climate zones in the Euro-CORDEX scenarios simulations</td>
<td>PA-012</td>
<td>22</td>
</tr>
<tr>
<td>Belusic Andreina</td>
<td>EURO-CORDEX and MED-CORDEX near-surface wind field over the Adriatic region:</td>
<td>PA-013</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>is there an added value in high resolution RCM simulations?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benjamin Martinez-Lopez</td>
<td>Midsummer Drought simulated by a coupled regional climate model</td>
<td>PA-014</td>
<td>24</td>
</tr>
<tr>
<td>Berckmans Julie</td>
<td>Reinitialised versus Continuous Simulation using the coupled Regional</td>
<td>PA-015</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Climate Model ALARO-0 with the Externalised Surface Model SURFEX:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>investigating the land-atmosphere feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bis Hoy Ratna Satyaban</td>
<td>Regional Climate Downscaling over Southeast Asia using WRF Model: Mean</td>
<td>PA-016</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Climatology and Interannual Variability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bobodeye Ayodotun</td>
<td>Assessing household vulnerability of Maasai pastoralist community to</td>
<td>PC-008</td>
<td>199</td>
</tr>
<tr>
<td></td>
<td>climate change and variability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borges de Amorim Pablo</td>
<td>Addressing key issues of statistical downscaling in the development of single-</td>
<td>PB-006</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>site projections in the framework of an IWRM concept in Distrito</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Federal, Brazil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- CANCELLED: Indicates the presentation has been cancelled.
- ID: Indicates the poster ID.
<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borges de Amorim Pablo</td>
<td>Addressing key issues of statistical downscaling in the development</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>of single-site projections in the framework of an IWRM concept in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distrito Federal, Brazil</td>
<td></td>
</tr>
<tr>
<td>Bosshard Thomas</td>
<td>Estimating the representativeness of a subset of hydrological climate</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>impact projections compared to a larger ensemble</td>
<td></td>
</tr>
<tr>
<td>Brankovic Cedo</td>
<td>Variability and projected climate change of precipitation indices</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>over Croatia in a EURO-CORDEX ensemble</td>
<td></td>
</tr>
<tr>
<td>Bring Arvid</td>
<td>Implications of freshwater flux data from the CMIP5 multimodel output</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>across a set of Northern Hemisphere drainage basins</td>
<td></td>
</tr>
<tr>
<td>Buccignani Edoardo</td>
<td>COSMO-CLM simulations over MENA-CORDEX domain: performance evaluation</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>and climate projections for the XXI century</td>
<td></td>
</tr>
<tr>
<td>Bulo Bhati</td>
<td>Which information is needed from a regional climate model ensemble</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>to plan climate adaptation?</td>
<td></td>
</tr>
<tr>
<td>Caporaso Luca</td>
<td>Climate-vegetation interactions in the coupled RegCM4 - CLM4.5 CNDV</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>model</td>
<td></td>
</tr>
<tr>
<td>Cardoso Rita M</td>
<td>Moisture recycling in regional climate simulations: Spatiotemporal</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>analysis and impact on the precipitation regime</td>
<td></td>
</tr>
<tr>
<td>Cavalcanti Iracema</td>
<td>Future precipitation and extremes changes in several sectors of La</td>
<td>201</td>
</tr>
<tr>
<td></td>
<td>Plata Basin projected by four regional models of CLARIS-LPB project</td>
<td></td>
</tr>
<tr>
<td>Cavao Tereza</td>
<td>Extreme precipitation in the North American Monsoon derived from two</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>CORDEX models</td>
<td></td>
</tr>
<tr>
<td>Ceglar Andrej</td>
<td>The impact of future cold spells on crop production in Europe</td>
<td>32</td>
</tr>
<tr>
<td>Ceglar Andrej</td>
<td>Evaluation of extreme precipitation and drought in high-resolution</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>EURO-CORDEX simulations over highly complex terrain</td>
<td></td>
</tr>
<tr>
<td>Chamani Romeo</td>
<td>Projections of daily extremes rainfall over Central Africa using</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>CMIP5 models</td>
<td></td>
</tr>
<tr>
<td>Chen Youmin</td>
<td>On regional climate downscaling of Africa domain in CORDEX using WRF</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>model</td>
<td></td>
</tr>
<tr>
<td>Cheneka Bedassa Regassa</td>
<td>The Search for an Added Value of Precipitation in Downscaled Seasonal</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Hindcasts over East Africa: COSMO-CLM Forced by MPI-ESM</td>
<td></td>
</tr>
<tr>
<td>Cherif Sadia</td>
<td>Toward building a robust climate change information : plea for</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>incorporating traditional knowledge into scientific ones</td>
<td></td>
</tr>
<tr>
<td>Choi Yeon-Woo</td>
<td>Changes in Drought Characteristics over South Korea projected by Multi</td>
<td>206</td>
</tr>
<tr>
<td></td>
<td>Regional Climate Models with the Standardized Precipitation Index</td>
<td></td>
</tr>
<tr>
<td>Chotamonsak Chakrit</td>
<td>Dynamical downscaling of Global Climate Model over Thailand using</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Regional Climate Model</td>
<td></td>
</tr>
<tr>
<td>Choudhary Anubhav</td>
<td>Performance of CORDEX Regional Climate Models in Simulating</td>
<td>207</td>
</tr>
<tr>
<td></td>
<td>Precipitation Climatology of Indian Summer Monsoon</td>
<td></td>
</tr>
<tr>
<td>Choudhary Anubhav</td>
<td>Recent climatic changes over Himalayan region: Previous studies and</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>CORDEX-South Asia experiments</td>
<td></td>
</tr>
<tr>
<td>Christensen Ole B.</td>
<td>Scenarios for future changes in extremes for agricultural modelling</td>
<td>37</td>
</tr>
<tr>
<td>Coppola Erika</td>
<td>Impact of climate change on runoff timing over the Alpine region</td>
<td>209</td>
</tr>
<tr>
<td>Cruz Faye Abigail</td>
<td>Regional climate simulation over Southeast Asia using NHRCM</td>
<td>210</td>
</tr>
<tr>
<td>Da Rocha Rosmeri</td>
<td>A comparative analysis of the horizontal resolution impacts in</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>simulated climate over South America in 2005</td>
<td></td>
</tr>
<tr>
<td>Dairaku Koji</td>
<td>Development of probabilistic regional climate scenario in East Asia</td>
<td>38</td>
</tr>
<tr>
<td>Daniel Maxime</td>
<td>Regional climate simulations to assess impacts of climate change on</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>cities and urban climate</td>
<td></td>
</tr>
<tr>
<td>Daron Joseph</td>
<td>Do regional climate projections help in managing complex socio-</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>ecological systems?</td>
<td></td>
</tr>
<tr>
<td>Daron Joseph</td>
<td>Projected changes in tropical cyclone activity in the Phillipines</td>
<td>211</td>
</tr>
<tr>
<td>Das Mohan Kumar</td>
<td>Predictability of Pre-Monsoon Heavy Rainfall Events over Bangladesh</td>
<td>212</td>
</tr>
<tr>
<td></td>
<td>using WRF under the Changing Climate</td>
<td></td>
</tr>
<tr>
<td>Das Neves Roque da Silva</td>
<td>Response of a hydrological model to two rainfall scenarios from RegCM4</td>
<td>213</td>
</tr>
<tr>
<td>Felipe</td>
<td>regional and MIROC3.2 global models</td>
<td></td>
</tr>
<tr>
<td>Davin Eduard</td>
<td>Is land surface processes representation a possible weak link in</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>current Regional Climate Models?</td>
<td></td>
</tr>
<tr>
<td>Davy Richard</td>
<td>Wind Energy Potential over the Black Sea: Current representation and</td>
<td>214</td>
</tr>
<tr>
<td></td>
<td>projections</td>
<td></td>
</tr>
<tr>
<td>De Troch Rozemien</td>
<td>On the added value of subdaily precipitation simulated by the ALARO-0</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>model within the EURO-CORDEX framework</td>
<td></td>
</tr>
<tr>
<td>Dedekind Zane</td>
<td>High Resolution Rainfall Modelling over the Eastern Escarpment of</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>DELHI A P</td>
<td>Performance of CORDEX Regional Climate Models in Simulating Precipitation Climatology of Indian Summer Monsoon (CANCELLED)</td>
<td>PC-024</td>
</tr>
<tr>
<td>DELL’AQUILA ALESSANDRO</td>
<td>Evaluation of simulated decadal variations over the Euro-Mediterranean region from ENSEMBLES to Med-CORDEX</td>
<td>PC-025</td>
</tr>
<tr>
<td>DEVANAND ANJANA</td>
<td>Sensitivity of Indian summer monsoon simulations to cumulus and microphysics parameterization schemes in WRF model</td>
<td>PC-026</td>
</tr>
<tr>
<td>DI SANTE FABIO</td>
<td>The ICTP Regional Earth System Model (RESM) to simulate the monsoon in the South East Asia CORDEX domain</td>
<td>PA-034</td>
</tr>
<tr>
<td>DIATTIA SAMO</td>
<td>Evaluation of two statistical downscaling models over Casamance sub-basin areas in South of Senegal (CANCELLED)</td>
<td>PB-010</td>
</tr>
<tr>
<td>DIMRI A P</td>
<td>Performance of CORDEX Regional Climate Models in Simulating Precipitation Climatology of Indian Summer Monsoon</td>
<td>PA-035</td>
</tr>
<tr>
<td>DOMINIC MATTE</td>
<td>Small-scale development in regional climate model simulations</td>
<td>PB-011</td>
</tr>
<tr>
<td>DOSIO ALESSANDRO</td>
<td>Effect of bias-adjustment on the projection of temperature and precipitation extremes from an ensemble of EURO-CORDEX RCMs Will be only displayed in Session C – Poster PC-027</td>
<td>PB-012</td>
</tr>
<tr>
<td>DOSIO ALESSANDRO</td>
<td>Effect of bias-adjustment on the projection of temperature and precipitation extremes from an ensemble of EURO-CORDEX RCMs</td>
<td>PC-027</td>
</tr>
<tr>
<td>DROBINSKI PHILIPPE</td>
<td>Scaling of precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios</td>
<td>PC-028</td>
</tr>
<tr>
<td>DUTTA MONAMI</td>
<td>Station level downscaled temperature over the Western Himalaya region of India</td>
<td>PC-029</td>
</tr>
<tr>
<td>EGEBEBIYI TEMITOPE</td>
<td>Future Changes in Extreme Rainfall Events and African Easterly Waves over West Africa</td>
<td>PC-030</td>
</tr>
<tr>
<td>EKSTROM MARIE</td>
<td>Qualifying differences in catchment rainfall characteristics between convective permitting and parameterised convection simulations</td>
<td>PA-036</td>
</tr>
<tr>
<td>ELEMIDE OYEBOLA ADEBOLA</td>
<td>Climate seasonal outlooks for water management assistance in Sub-Saharan Africa</td>
<td>PA-013</td>
</tr>
<tr>
<td>EMERALD SARAH</td>
<td>The understanding of CORDEX models in simulating future extreme climatic events over East Africa</td>
<td>PC-031</td>
</tr>
<tr>
<td>FERNANDEZ ALFONSO</td>
<td>Using dynamical downscaling to force a glacier surface energy and mass balance model</td>
<td>PC-032</td>
</tr>
<tr>
<td>FIILHI SAID</td>
<td>Evaluating the present day simulation of Climate extreme indices in Morocco</td>
<td>PC-033</td>
</tr>
<tr>
<td>FITA BORRELL LLUIS</td>
<td>MCGlimDeX: Martinique &amp; Guadaloupe Climatic Dynamical down-scaling eXperiment</td>
<td>PA-014</td>
</tr>
<tr>
<td>FOX MAULE CATHRINE</td>
<td>Comparing climate change signals: GCM’s vs. RCM’s, raw model statistics vs. bias-adjusted</td>
<td>PA-037</td>
</tr>
<tr>
<td>FRÜH BARBARA</td>
<td>The CLM-Community</td>
<td>PA-038</td>
</tr>
<tr>
<td>FUENTES FRANCO RAMON</td>
<td>Sensitivity of Tropical Cyclones to Resolution and Convection Scheme over Eastern Tropical Pacific and Tropical North Atlantic Oceans in RegCM4 Model</td>
<td>PC-034</td>
</tr>
<tr>
<td>GAERTNER MIGUEL ANGEL</td>
<td>Multi-model analysis of the impact of high resolution and ocean-atmosphere coupling on the simulation of medicanes with RCMs</td>
<td>PC-035</td>
</tr>
<tr>
<td>GAITAN CARLOS</td>
<td>Regional differences in the value-added by statistical downscaling precipitation over North America using support vector regression</td>
<td>PA-039</td>
</tr>
<tr>
<td>GAITAN CARLOS</td>
<td>Effects of variance adjustment techniques and time-invariant transfer functions on heat wave duration indices and other metrics derived from downscaled time-series</td>
<td>PA-016</td>
</tr>
<tr>
<td>GAMPE DAVID</td>
<td>Analyzing RCM outputs as benchmark for climate change impacts on the hydrology of selected river basins under conditions of water scarcity.</td>
<td>PC-036</td>
</tr>
<tr>
<td>GAO XUEJIE</td>
<td>Impact of Climate Change on Heating and Cooling Degree Days and Potential Energy Demand in the Household Sector of China</td>
<td>PA-040</td>
</tr>
<tr>
<td>GIANNAKOPOULOS CHRISTOS</td>
<td>Using high resolution CORDEX RCMs to assess impacts on Mediterranean islands’ agriculture</td>
<td>PA-041</td>
</tr>
<tr>
<td>GIORGI FILIPPO</td>
<td>Development of a non-hydrostatic version of the regional climate model RegCM44</td>
<td>PB-017</td>
</tr>
<tr>
<td>GOERGEN KLAUS</td>
<td>Fully coupled terrestrial water cycle simulations with TerrSysMP: Features and applications</td>
<td>PA-042</td>
</tr>
<tr>
<td>GUTIERREZ JOSE M.</td>
<td>VALUE perfect predictor validation results, part 1: marginal, extremal and temporal aspects</td>
<td>PA-043</td>
</tr>
<tr>
<td>GUTJAHIR OLIVER</td>
<td>Extreme value analysis of 10m wind speed in the CORDEX Arctic domain</td>
<td>PC-124</td>
</tr>
<tr>
<td>GUTMANN ETHAN</td>
<td>The Use of an Intermediate Complexity Atmospheric Research Model (ICAR) for Climate Downscaling</td>
<td>PB-018</td>
</tr>
</tbody>
</table>
Integrated modeling of the human-natural system to improve local water management and planning

Self-Organizing Maps Analysis of CORDEX Simulation of Extreme Daily Precipitation in Alaska

Effects of climate change and other drivers of global changes on biodiversity in Caspian Sea

The impact of climate change on water and living resources in Sepidrud River (Iran)

Evaluation of 12-km ERA-Interim simulations from multiple models and CORDEX domains over the eastern Mediterranean

The MENA-CORDEX domain: progress and achievements

Estimating the impact of an improved soil hydrology module on the simulation of the hydrological cycle of various river basins of the globe

Hydrological modeling as an evaluation tool of CORDEX RCMs and bias correction methods

Schooling on the Boat – Adapt with the Climate Change

Climate change assessment on the CORDEX South Asian summer monsoon precipitation using high resolution RegCM4.3 simulation

Dynamical downscaling with bias correction of the sea-surface conditions: The CGCM-AGCM-RCM approach using the CRCM5 over the CORDEX Africa domain

Effective Degree of Freedom in Ensemble Experiment of Atmospheric Climate Model: Dependence on Temporal and Spatial Averaging Scales

Benefit from using atmosphere-ocean coupled systems for summer dry bias of regional climate models over Central Europe

Mapping and Visualizing Vulnerability to Natural Hazards in Coastal Regions of Bangladesh

Assessment of Water Availability in the Ganges Basin inside Bangladesh using CORDEX Climate Projection

challenge in current climate modeling

Fostering climate-resilient biodiversity framework in West Africa and implications for regional development

Added value of 3D-Var Data assimilation using WRF model in West and Central Africa

Jet stream Representation in the CORDEX South Asia by the RCA4

Towards a framework for regional system modeling

A contribution of Fine-scales to Added Value in Precipitation Simulated by High-resolution CORDEX South Asia Regional Climate Models and Observations

Africa and global climate change politics and scientific governance

Evaluation of aerosol optical properties in an ensemble of regional chemistry-climate coupled models over Europe

Future changes in extremes of precipitation over South Korea projected by HadGEM2-AO and 5-RCM ensemble under RCP scenarios.

The difference of climate change at East China Sea and adjacent Northwest Pacific Ocean from 1871 (CANCELLED)

Recovery of a ultra-high resolution synethetic precipitation and temperature data and future projection in the Korean peninsula

Sensitivity study of convective cloud feedbacks on radiation and impacts on precipitation

Simulating the probability distribution of rainfall at convective permitting scales with a variable resolution, global atmospheric model

Regional climate projections of changes in the monsoon, droughts and rainfall extremes for SE Asia

Future changes in extreme snowfall in Japan projected by large ensemble regional climate experiments

The Performance of RegCM with Different Convective Parameterization Schemes in the Mid Latitude Himalaya Region

Decomposition analysis of energy related carbon dioxide emissions

Modeling of the effects of AR landfalls in the US Pacific coast on the winter precipitation and temperatures in western US: Sensitivity to resolutions and spectral nudging scales

A ultra-high resolution precipitation data for urban floods

Changes in extreme precipitation indices by climate change over South Korea

High-resolution simulation of the longest heavy snowfall

A multi-CORDEX-domain study with the Rossby Centre regional climate model RCA4
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Code</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATULLA CHRISTOPH</td>
<td>UnLoadC3: Climate change modelling as part of an uncertainty assessment with modeling the future of hydrological regimes and chemical pollution loads within two pre-alpine river catchments.</td>
<td>PC-072</td>
<td>263</td>
</tr>
<tr>
<td>MBAYE MAMADOU LAMINE</td>
<td>Climate change signals over Senegal River Basin using five Regional Climate Models of the CORDEX Africa simulations</td>
<td>PA-074</td>
<td>84</td>
</tr>
<tr>
<td>MEHER JITENDRA KUMAR</td>
<td>Downscaled precipitation change over the station locations in the lower Western Himalayas region of India</td>
<td>PB-026</td>
<td>168</td>
</tr>
<tr>
<td>MEHMOOD SHAHID</td>
<td>Performance of RegCM4.1 in simulating extreme precipitation events of Pakistan</td>
<td>PA-075</td>
<td>85</td>
</tr>
<tr>
<td>MEHMOOD SHAHID</td>
<td>Performance of RegCM4.1 in simulating extreme precipitation events of Pakistan</td>
<td>PC-073</td>
<td>264</td>
</tr>
<tr>
<td>MENGISTU DANIEL</td>
<td>Climate change projections for the Upper Blue Nile (Abay) River Basin, Ethiopia</td>
<td>PA-076</td>
<td>86</td>
</tr>
<tr>
<td>MENGISTU DANIEL</td>
<td>Climate change projections for the Upper Blue Nile (Abay) River Basin, Ethiopia</td>
<td>PA-077</td>
<td>87</td>
</tr>
<tr>
<td>MENZ CHRISTOPH</td>
<td>The OptiBarn project - The effect of regional climate change on naturally ventilated dairy housings</td>
<td>PA-078</td>
<td>88</td>
</tr>
<tr>
<td>MENZ CHRISTOPH</td>
<td>The conditional resampling model STARS: weaknesses of the modeling concept and development</td>
<td>PB-027</td>
<td>169</td>
</tr>
<tr>
<td>MIN SEUNG-KI</td>
<td>Mechanisms of future changes in extreme precipitation over Northeast Asia and South Korea: A multi-RCM study</td>
<td>PC-074</td>
<td>265</td>
</tr>
<tr>
<td>MISIANI HERBERT</td>
<td>Evaluating the added value of dynamically downscaled products from CORDEX over Eastern Africa Region</td>
<td>PA-079</td>
<td>89</td>
</tr>
<tr>
<td>MOHANTY MOHT PRAKASH</td>
<td>A Comparative Flood Hazard Assessment with Regional Climate Model Projections for India</td>
<td>PC-075</td>
<td>266</td>
</tr>
<tr>
<td>MONTAVEZ JUAN PEDRO</td>
<td>Interactions of air-quality, climate and renewable energy: the REPAIR project.</td>
<td>PA-080</td>
<td>90</td>
</tr>
<tr>
<td>MOONEY PRISCILLA</td>
<td>Diurnal cycle of precipitation in a dynamically downscaled multiphysics regional climate ensemble using the Weather Research and Forecasting (WRF) model</td>
<td>PA-081</td>
<td>91</td>
</tr>
<tr>
<td>MOUNKAILA SALEY MOUSSA</td>
<td>Assessing the potential impacts of climate change and reforestation on rainfall onset and cessation over West Africa</td>
<td>PC-076</td>
<td>267</td>
</tr>
<tr>
<td>MURARI KAMAL</td>
<td>Differences in the heat wave simulations between GCMs and corresponding RCMs for India</td>
<td>PA-082</td>
<td>92</td>
</tr>
<tr>
<td>MUTHIGE MAVHUNGU</td>
<td>Impacts of spectral nudging on the simulation of present-day rainfall patterns over southern Africa</td>
<td>PB-028</td>
<td>170</td>
</tr>
<tr>
<td>NALUBEGA ROSEMARY</td>
<td>Climatic variability in the Sub – Saharan region</td>
<td>PB-029</td>
<td>171</td>
</tr>
<tr>
<td>NALUBEGA ROSEMARY</td>
<td>Mitigating the impact of environmental degradation on climatic change and global warming</td>
<td>PB-030</td>
<td>172</td>
</tr>
<tr>
<td>NARISMA GEMMA TERES</td>
<td>Simulating the influence of ENSO episodes on rainfall variability in the Philippines during the monsoon season</td>
<td>PA-083</td>
<td>93</td>
</tr>
<tr>
<td>NAYAK SRIDHARA</td>
<td>Future projection of precipitation extremes linked to temperature with multi-model ensemble downscaling over Japan</td>
<td>PC-077</td>
<td>268</td>
</tr>
<tr>
<td>NGUYEN DANG MAU</td>
<td>Statistical downscaling of temperature and precipitation over Vietnam using RCMES</td>
<td>PB-031</td>
<td>173</td>
</tr>
<tr>
<td>NGWENYA SANDILE BLESSING</td>
<td>Evolution of anomalous tropical lows over Botswana</td>
<td>PC-078</td>
<td>269</td>
</tr>
<tr>
<td>NIKULIN GRIGORY</td>
<td>Downscaling seasonal hindcasts over eastern Africa in the EUPORIAS project</td>
<td>PA-084</td>
<td>94</td>
</tr>
<tr>
<td>NIKULIN GRIGORY</td>
<td>Bias-adjustment-related uncertainties in climate projections</td>
<td>PA-085</td>
<td>95</td>
</tr>
<tr>
<td>NKRUMAH FRANCIS</td>
<td>Heavy Daily Rainfall Characteristics over agro-ecological zones of Ghana</td>
<td>PC-079</td>
<td>270</td>
</tr>
<tr>
<td>NKRUMAH FRANCIS</td>
<td>The potential of CORDEX models to capture present extreme events of the Guinea Coast</td>
<td>PC-080</td>
<td>271</td>
</tr>
<tr>
<td>NTOLE MUTALEMBA</td>
<td>Forecasting of the agricultural calendar for the culture of corn from models of global circulation of the atmosphere in the Plain of the Ruizi</td>
<td>PA-086</td>
<td>96</td>
</tr>
<tr>
<td>OKE MICHAEL</td>
<td>The Overview of the Nigerians 2012 Flood Disaster in Nigeria and the Risk Management Strategist</td>
<td>PB-032</td>
<td>174</td>
</tr>
<tr>
<td>OLESEN MARTIN</td>
<td>Enhance and utilize the climate information from one RCM simulation</td>
<td>PA-087</td>
<td>97</td>
</tr>
</tbody>
</table>
OLIVEIRA CRISTIANO  
Climate Projection for Africa: RegCM4 Driven by HadGEM2-ES  
PA-088  98

OLSSON JONAS  
Assessment of short-duration precipitation extremes in 12.5 km Euro-CORDEX projections by RCA4: historical performance and future changes  
PC-081  272

ONOL BARIS  
Extreme Summer Precipitation Increase in the Med-CORDEX Simulations: Analysis of The Evaluation Period  
PC-082  273

OSIMA SARAH  
THE UNDERSTANDING OF CORDEX MODELS IN SIMULATING FUTURE EXTREME CLIMATIC EVENTS OVER EAST AFRICA  
PC-083  274

OSUCH MARZENA  
Projected changes of hydrological extremes (floods) in the 21st century in selected catchments in Poland  
PC-084  275

OTTO JULIANE  
Methodology for qualitative uncertainty assessment of climate impact indicators  
PA-089  99

OTTO FRIEDERIKE  
The Attribution of Extreme Weather Events and their Impacts to External Drivers of Climate Change  
PC-085  276

OVCHARUK VALERIYA  
Using of information GCM and RCM in the calculation of the maximal runoff of the rivers of Ukraine  
PC-086  277

PAMPUCHI LUANA  
Dry periods in Southeastern Brazil: A numerical simulation with changes in sea surface temperature  
PC-087  278

PANTHI JEEBAN  
Response of Vegetation to Change in Climate in Himalayan Region - A Case from Gandaki River Basin in Central Nepal  
PA-090  100

PAQUIN DOMINIQUE  
Representing and projecting freezing rain over North America.  
PC-088  279

PARODI ANTONIO  
Simulating extreme hydro-meteorological events with DRIHM(2US) services  
PC-089  280

PAROTTIL AJAY  
Obtaining best parameterization scheme for Regional Climate model simulation over Indian Subcontinent  
PB-033  175

PFIEFER SUSANNE  
Target Group Adapted Visualization of the EURO-CORDEX Ensemble Results  
PA-091  101

PONGRACZ RITA  
Analysis of climate change impact on runoff characteristics in the Zagyva catchment located in Hungary  
PC-090  281

PORTILLA FREDI  
Analisis multitemporal de la sensibilidad a la desertificacion de la Provincia del Azuay a partir del año 1982*  
PB-034  176

PREIN ANDREAS  
Extreme precipitation in a continental-scale convection-permitting climate model  
PC-091  282

PRYOR SARA C.  
Assessing value-added by high-resolution regional simulations of climate-relevant aerosol particle properties  
PA-092  102

QUAGRaine KWESI  
Regional climate model based simulations of interannual rainfall variability over the Guinean Coast of West Africa  
PC-092  283

RAGHAVAN KRISHNAN  
High-resolution model simulations for deciphering the recent changes in the South Asian monsoon precipitation distribution  
PA-093  103

RAHEEM USMAN  
Global Environmental Change and Urban Health Analysis: Emerging Complexities in Multi-Scale Representation of Extreme Events in Africa  
PA-094  104

RAHMAN MD. MIZANUR  
Rainfall and temperature scenarios for Bangladesh for the middle of 21st century based on RCP scenarios using RegCM  
PC-093  284

RAMANATHAN AL  
Mass balance processes of Chhota Shigri Glacier (Western Himalaya, India) assessed by point-scale surface energy balance as well as in-situ measurements  
PC-094  285

RANA ARUN  
Regional and global climate projections in South Asia  
PC-095  286

RAUB THOMAS  
The BALTEX Box Revisited: The Energy Budget of the Baltic Sea in the Coupled Regional Climate Model REMO-BSIOM  
PA-095  105

RAUSCHER SARA A.  
A Multimodel Intercomparision of Resolution Effects on Precipitation: Simulations and Theory  
PA-096  106

REBOITA MICHELLE  
RegCM4 climatic projections of wind power density over Brazil  
PB-035  177

RULFOVA ZIZANA  
Characteristics of convective and large-scale precipitation in Central Europe based on EURO-CORDEX data  
PC-096  287

SABITZ JUDIT  
Impacts of different simulation settings to climate change signal based on ALADIN-Climate results  
PA-097  107

SALAMI TAIRO  
Variability of climatic elements in Nigeria over recent 100 years  
PB-036  178

SALINAS JOSE-ANTONIO  
Global Ensamble Models for the tropical area  
PA-098  108

SAMAPAN SENTHILNATHAN  
Statistical Assessment of Rice Yield Changes over Southern India to Regional Climate Model Projected Solutions  
PC-097  288

SAMUEL KAHASSOU  
Seasonal variations of surface duct conditions in Ngaoundere, North Cameroon (CANCELLED)  
PC-098  289

SANCHEZ ENRIQUE  
A review of procedures to compute climatological length of seasons based on CORDEX simulations over Europe and Southamerica  
PC-099  290

SACHVENKO ANATOLII  
Impact of climate change on extreme cooling of the Black Sea in winter period  
PC-100  291

SEIN DMITRY  
Projected climate change scenario over Central America simulated by the regionally coupled climate model ROM  
PA-099  109

SEMENTOVA INNA  
Basis of droughts catalog for Ukraine in modern period  
PC-101  292
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEMENOVA INNA</td>
<td>Features of the regional circulation of atmosphere and sea breeze development on northern Black Sea coast</td>
<td>PC-102</td>
</tr>
<tr>
<td>SHKOLNIK IGOR</td>
<td>High resolution hydrological events in future climate as projected by a large ensemble of high resolution RCM for northern Eurasia</td>
<td>PC-103</td>
</tr>
<tr>
<td>SIECK KEVIN</td>
<td>The non-hydrostatic REMO</td>
<td>PB-037</td>
</tr>
<tr>
<td>SILVA YAMINA</td>
<td>High resolution modeling to understand the physical processes relating to rainfall in the Mantaro basin (central Peruvian Andes) using WRF</td>
<td>PB-038</td>
</tr>
<tr>
<td>SINGH SWATI</td>
<td>Coupled Statistical-Dynamic Downscaling Approach for Regional Projections of Indian Summer Monsoon</td>
<td>PC-104</td>
</tr>
<tr>
<td>SITZ LINA</td>
<td>Transients and ocean-atmosphere coupling in the South Atlantic Convergence Zone</td>
<td>PC-105</td>
</tr>
<tr>
<td>SLIZHE MARIJA</td>
<td>Preliminary assessment of wind resources in Morocco</td>
<td>PC-106</td>
</tr>
<tr>
<td>SOARES PEDRO M. M.</td>
<td>Climatic cooling potential of direct ventilation and evaporative cooling with high resolution and spatiotemporal analysis</td>
<td>PA-100</td>
</tr>
<tr>
<td>SOHOULANDIE Djabou</td>
<td>Approach to assessing hydrologic alteration and ecosystem degradation under climate change: application in the Sahel</td>
<td>PA-101</td>
</tr>
<tr>
<td>SOHOULANDIE Djabou</td>
<td>Integrated approach to assessing streamflow and precipitation alterations under environmental change: Application in the Sahel</td>
<td>PA-039</td>
</tr>
<tr>
<td>SOLIDORO COSIMO</td>
<td>Impact of future climate on the state and ecological goods and services of the Mediterranean Sea</td>
<td>PA-040</td>
</tr>
<tr>
<td>SOLIS ANA LIZA</td>
<td>Present and Future Climate in the Philippines Simulated by a Super High Resolution GCM</td>
<td>PA-041</td>
</tr>
<tr>
<td>SOLMON FABIEN</td>
<td>Increasing Arabian dust activity and the Indian summer monsoon</td>
<td>PA-102</td>
</tr>
<tr>
<td>SOLMON FABIEN</td>
<td>Estimates of common ragweed pollen emission and dispersion over Europe using the RegCM-pollen model</td>
<td>PA-103</td>
</tr>
<tr>
<td>SOLLAND SULJE LUND</td>
<td>Dynamical downscaling five GCMs with CCLM: can RCM compensate for some of the GCM bias?</td>
<td>PA-104</td>
</tr>
<tr>
<td>SRNEC LIDija</td>
<td>Characteristics of the future summer temperatures in Croatia obtained from a EURO-CORDEX ensemble</td>
<td>PC-107</td>
</tr>
<tr>
<td>STIEGER CHRISTIAN</td>
<td>Towards detecting the minimal number of simulations for robust climate change information</td>
<td>PA-105</td>
</tr>
<tr>
<td>STENCHIKOV GEORGEY</td>
<td>Regional climate downscaling using a High-resolution Global Atmospheric Model</td>
<td>PA-106</td>
</tr>
<tr>
<td>STILINOVIC TOMISLAV</td>
<td>EURO-CORDEX regional climate models: evaluation of mean temperature and precipitation over the PRUDENCE regions and Croatia</td>
<td>PA-107</td>
</tr>
<tr>
<td>STROBACH EHUD</td>
<td>Regional Decadal Climate Predictions: Israel as a Case Study</td>
<td>PA-108</td>
</tr>
<tr>
<td>SYKTUS JOZEF</td>
<td>High-resolution downscaling for Queensland</td>
<td>PA-109</td>
</tr>
<tr>
<td>SYLLA MOHAMADOU Bamba</td>
<td>CMIP5, CORDEX and higher resolution RegCM4 multimodel ensembles comparison of projected changes in climate zones over West Africa</td>
<td>PA-110</td>
</tr>
<tr>
<td>SYLLA MOHAMADOU Bamba</td>
<td>Future changes in water availability and drought intensity over major West African rivers basin based on CMIP5 and CORDEX multimodel ensembles projections</td>
<td>PA-111</td>
</tr>
<tr>
<td>SZABO PETER</td>
<td>Sources of uncertainty over Central Europe based on the recent climate model experiments</td>
<td>PA-112</td>
</tr>
<tr>
<td>TAGUELLE NDETATSI THIERRY</td>
<td>Evaluation of CORDEX Regional Climate Models over Central Africa</td>
<td>PA-113</td>
</tr>
<tr>
<td>TAKISHA MARYAM</td>
<td>CRCM5 dynamical downscaling over the CORDEX Arctic domain with empirical correction of CGCM-simulated sea-surface conditions</td>
<td>PA-114</td>
</tr>
<tr>
<td>TAMOFFO TCHOI ALAIN</td>
<td>Daily characteristics of Central African rainfall in REMO model</td>
<td>PA-115</td>
</tr>
<tr>
<td>TANG CHAO</td>
<td>Model estimations of possible changes of surface solar radiation at regional scales over the South West Indian Ocean</td>
<td>PA-042</td>
</tr>
<tr>
<td>TANVIR AHMED</td>
<td>Impacts of different cumulus physics over south Asia region with case study tropical cyclone Viyuru</td>
<td>PC-110</td>
</tr>
<tr>
<td>TARANU LILIA</td>
<td>Projections of future changes in productivity of major agricultural crops in the Republic of Moldavia according to the EURO-CORDEX ENSEMBLE OF 9 RCMs for RCP 4.5 and RCP 8.5 scenarios</td>
<td>PA-111</td>
</tr>
<tr>
<td>TEICHMANN CLAAS</td>
<td>The Vulnerability, Impacts, Adaptation, and Climate Services (VIACS) Advisory Board for CMP6</td>
<td>PA-112</td>
</tr>
<tr>
<td>TESHOME ASAMINEW</td>
<td>Modelling the potential impact of climate change on cotton production over North eastern Afare and Western Tigray region of Ethiopia</td>
<td>PA-113</td>
</tr>
<tr>
<td>TETTEN ISAAC</td>
<td>Impact of Monthly-Scale Global Sea Surface Temperature (SST) Patterns on the East African Long Rains</td>
<td>PC-114</td>
</tr>
<tr>
<td>THIERY WIM</td>
<td>Rapid future intensification of hazardous thunderstorms over Lake Victoria</td>
<td>PC-115</td>
</tr>
<tr>
<td>TIWARI PUSHP RAJ</td>
<td>From GCMs to river flow in the midst of uncertainties: Can potential future plights could be alleviated with currently available forecasting skill?</td>
<td>PC-116</td>
</tr>
<tr>
<td>TORMA CSABA ZSOLT</td>
<td>Added value of regional climate modeling over areas characterized by complex terrain – Precipitation over the Alps</td>
<td>PA-117</td>
</tr>
</tbody>
</table>
Internal variability, i.e. the natural variability of the climate system, has been shown to be an important source of uncertainty in climate change projections of mean and (especially) extreme climate events. Also, to quantify model uncertainty internal variability should be known. To estimate the internal variability and get a robust estimate of the forced climate response, large ensembles of climate model simulations of the same model provide essential information. For global climate models (GCMs) a number of these single model ensembles are indeed available. So far however, the size of single model ensembles for regional climate models (RCMs) has been limited to only a very few members. Here, we use a 16 member ensemble generated with the RCM KNMI-RACMO2 driven by the GCM EC-EARTH. The initial atmospheric state of EC-EARTH was perturbed in 1850, after which each member was run until 2100 assuming the historical emission scenario until 2005 and the RCP8.5 emission scenario from 2006 onwards. Each of the EC-EARTH members was then downscaled on a 12-km resolved domain covering Western Europe including the Alps for the period 1950-2100.

For this ensemble we show the climate change signal, the noise due to internal variability and the signal to noise ratio, and how these depend on parameter, season, location and projection period. Using the aggregated spatial probability perspective of Fischer et al. (2013) we also examine whether spatially aggregated responses yield more robust changes, and earlier detection times of climate change.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-002

Agro-climate changes over the Korean Peninsula and nearby regions under RCP scenarios simulated by WRF

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2Division of Climate Change, Korea Polar Research Institute, Incheon, Korea

In this study, the projected regional agro-climate changes over Northeast Asia (118°E-138°E, 30°N-45°N) for the late 21st century (2071-2100) are analyzed in terms of the indices, such as vegetable and crop periods, frost days, and the climatic yield potential (CYP) for Japonica type rice (hereafter, rice). The model employed for dynamical downscaling is the Weather Research and Forecasting (WRF), with a 12.5-km horizontal grid spacing in the domain. According to our results, the CYP for rice, one of the major crops presently cultivated in the area, is expected to decrease throughout most of the region, despite a projected expansion of both vegetable and crop periods. This is projected to occur particularly in South Korea, Japan, and Southeast and Northeast China. Such a change is related to the projected rise in temperature within these regions, which will exceed the grain-filling optimum temperature of rice. In contrast, the climate projection of the RCPs is that the CYP will increase over northeastern parts of the Korean Peninsula and the Russian Far Eastern region (Primorsky), because temperatures in these regions are expected to rise and approach the grain-filling optimum temperature. For the RCPs, the optimum heading date, on which the domain averaged CYP is the highest, is expected to be later than that of the Historical by approximately 17-24 days. In addition, the maximum CYP in the RCPs is projected to decrease compared to that of the Historical, and the possible period of rice ripening (period in which the CYP is greater than 0) is also expected to decrease.

Acknowledgments

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Reference

Climate Modeling over the Mediterranean Sea: Impact of Resolution and Ocean Coupling

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(1) IAU, Goethe University, (2) Deutscher Wetterdienst, Offenbach am Main, Germany

The feedbacks between the Mediterranean Sea and the atmosphere on top at various temporal and spatial scales play an important role in the regional climate system by modifying the air-sea fluxes. A regional climate model COSMO-CLM with ~9 km and ~50 km horizontal grid spacings in atmosphere-only and coupled, with the ocean component NEMO-MED12, configuration is employed to study the impact of horizontal atmospheric grid resolution and ocean coupling on air-sea fluxes of heat and wind speed on seasonal and annual timescales. Furthermore, the impact of diurnal variations of sea surface temperature simulated by the atmosphere-ocean coupled model on air-sea fluxes of heat and wind speed is analyzed on sub-daily timescale. The results show that the estimates of air-sea fluxes of heat are largely and wind speed is moderately improved through ocean coupling. However, the wind speed is considerably improved with finer atmospheric grid simulations especially around the coastal areas. The finer atmospheric grid resolution moderately improves the seasonal mean of air-sea fluxes of heat in some areas of the Mediterranean with minor impact on the basin-averaged. The air-sea fluxes of heat are largely improved by the ocean coupling and wind speed by finer atmospheric grid resolution. Temporally, the winter and autumn seasons and spatially, north and western parts of the Mediterranean Sea are more sensitive to the ocean coupling and finer atmospheric grid resolution. The results suggest that ocean coupling and finer atmospheric grid resolution improve the simulation of the regional climate system in representing the air-sea fluxes over the Mediterranean Sea. The sensitivity experiment shows that sea surface temperature diurnal variations strongly modify the sub-daily air-sea fluxes, but are of minor relevance at longer timescales in the investigated parameters over the Mediterranean Sea.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-004

COPAT – towards a recommended model version of COSMO-CLM

Ivonne Anders1, Susanne Brienen2, Eduardo Buchignani3, Andrew Ferrone4, Beate Geyer5, Klaus Keuler6, Daniel Lüthi7, Mariano Mertens8, Hans-Jürgen Panitz9, Sajjad Saeed10, Jan-Peter Schulz2, Hendrik Wouters10

1ZAMG- Central Institute for Meteorology and Geodynamics, 2DWD - Deutscher Wetterdienst, 3CMCC, 4LIST - Luxembourg Institute of Science and Technology, 5Helmholtz-Zentrum Geesthacht, 6BTU - Brandenburg University of Technology Cottbus, 7ETHZ - Federal Institute of Technology of Zurich 8DLR - Deutsches Zentrum für Luft- und Raumfahrt, 9KIT - Karlsruhe Institute of Technology, 10KU Leuven

The regional climate model COSMO-CLM is a community model (www.clm-community.com). In close collaboration with the COSMO-consortium the model is further developed by the community members for climate applications. One of the tasks of the community is to give a recommendation on the model version and to evaluate the models performance.

The COPAT (Coordinated Parameter Testing) is a voluntary community effort to allow different institutions to carry out model simulations systematically by different institutions in order to test new model options and to find a satisfactory model setup for hydrostatic climate simulations over Europe. We will present the COPAT method used to achieve the latest recommended model version of COSMO-CLM (COSMO5.0_clm6).

The simulations cover the EURO-CORDEX domain at two spatial resolutions 0.44° and 0.11°. They used ERAInterim forcing data for the time period of 1979-2000. Interpolated forcing data has been prepared once to ensure that all participating groups used identical forcing. The evaluation of each individual run has been performed for the time period 1981-2000 by using ETOOL and ETOOL-VIS. These tools have been developed within the community to evaluate standard COSMO-CLM output in comparison to observations provided by EOBS and CRU.

COPAT was structured in three phases. In Phase 1 all participating institutions performed a reference run on their individual computing platforms and tested the influence of single model options on the results afterwards. Derived from the results of Phase 1 the most promising options were used in combinations in the second phase (Phase 2). These first two phases of COPAT consist of more than 100 simulations with a spatial resolution of 0.44°. Based on the best setup identified in Phase 2 a calibration of eight tuning parameters has been carried out following Bellprat et al. (2012) in Phase 3. A final simulation with the calibrated parameters has been set up at a higher resolution of 0.11°. The results were compared to previous model versions. The new model version led to the same or better results and therefore had been defined as the new recommended model version of the community.

Reference

Observational for e.g. temperature, precipitation, radiation, or wind are often used as meteorological forcing for different impact models, like e.g. crop models, urban models, economic models and energy system models. To assess a climate signal, the time period covered by the observation is often too short, they have gaps in between, and are inhomogeneous over time, due to changes in the measurements itself or in the near surrounding. Thus output from global and regional climate models can close the gap and provide homogeneous and physically consistent time series of meteorological parameters.

CORDEX evaluation runs performed for the IPCC-AR5 provide a good base for the regional scale. However, with respect to climate services, continuously on-going hindcast simulations are required for regularly updated applications.

In this study two projects are presented where hindcast-simulations optimized for a region of interest are performed continuously.

The hindcast simulation performed by HZG covering Europe includes the EURO-CORDEX domain with a wider extend to the north to cover the ice edge. The simulation under consideration of the coastDat-experiences is available for the period of 1979 – 2015, prolonged ongoing and fulfil the customer’s needs with respect of output variables, levels, intervals and statistical measures. CoastDat – customers are dealing e.g. with naval architecture, renewable energies, offshore wind farming, shipping emissions, coastal flood risk and others. The evaluation of the hindcast is done for Europe by using the EVAL-tool of the CCLM community and by comparison with HYRAS - data for Germany and neighbouring countries.

The Climate Research group at the national Austrian weather service, ZAMG, is focusing on high mountain regions and, especially on the Alps. The hindcast-simulation is forced by ERA-interim and optimized for the Alpine Region. One of the main tasks is to capture strong precipitation events which often occur during summer when low pressure systems develop over the Golf of Genoa, moving to the North-East. This leads to floods and landslide events in Austria, Czech Republic and Germany. Such events are not sufficiently represented in the CORDEX-evaluation runs. ZAMG use high quality gridded precipitation and temperature data for the Alpine Region (1-6km) to evaluate the model performance. Data is provided e.g. to hydrological modellers (high water, low water), but also to assess icing capability of infrastructure.
Use of climate information in local and regional decision processes

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SMHI, Linköping University, SMHI, SMHI, SMHI

Reports with geographically detailed information about climate change, based on RCP 4.5 and RCP 8.5, were released for all 21 Swedish counties in November 2015. The work was carried out within a government mission to SMHI, in dialogue with the county boards in order to ensure that the results corresponded to identified needs. Results are provided in the form of climate indices, i.e. averages, seasonal variations and probabilities for extremes. The provided information is based on geographically detailed climate data, as well as hydrological modeling. All reports include information on precipitation, runoff and soil moisture. For the Northern counties, also information about snow, as well as more detailed information on streamflow generation is included. For the southern counties, additional info is provided with regard to low flow conditions, cooling and heating requirements, as well as additional rainfall characteristics. For most counties, similar reports, based on earlier IPCC scenarios have previously been made available, although not as an governmental mission but on consultancy basis. In early 2016, visits will be made to county boards and municipalities in different parts of Sweden, with the aim to inform about the content of the new regional reports. In connection to these visits, interviews will be held to assess how regional climate information have been or is planned to be used in local and regional decision processes. A main focus will be on assessments of perceptions of how to handle uncertainties. This includes evaluation of to what extent existing decision making processes rest on a traditional subjective utility decision framework, vs a more robust decision making with a vulnerability-and-response-option rather than a predict-then-act decision framework.
Performance of dynamically downscaled ensemble seasonal forecasts over east Africa

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Truthful and reliable seasonal rainfall predictions have an important social and economic value for the East African countries as their economy is highly dependent on rain-fed agriculture and pastoral systems. Only June to September (JJAS) seasonal rainfall accounts to more than 80% crop production in Ethiopia. Hence, seasonal forecasting is a challenging concern for the regions. The European Provision of Regional Impact Assessment on a seasonal to decadal timescale (EUPORIAS) project is a strategic approach to provide improved skill and to address user needs for seasonal prediction. It offers a common framework to understand model uncertainties through the use of multi-model and multi-member simulations over East Africa. Under this program, the participating regional climate models (RCMs) were driven by the atmospheric-only version of the ECEARTH global climate model, which provides hindcasts of a five-months period (May to September) from 1991-2012. In this study the RCMs downscaled rainfall is evaluated with regard to the observed JJAS rainfall over East Africa. Both deterministic and probabilistic based forecast skills are assessed. Our preliminary results show the potential usefulness of multi-model ensemble simulations in forecasting the seasonal rainfall over East Africa.
This study aims at describing and evaluating the relevance of Geographical Information System (GIS) procedures as a standard technique to model atmospheric parameters when there are several data gaps. Generally, high resolution atmospheric parameters are needed to assess the impacts of climate change on crop productivity at the local level, using data at the level of individual farm units. Such high resolution climatic data are non-existent in the West African setting because of the extremely sparse meteorological station network. The problems often arise as to what values to attach to climatic variables at points other than these nodes where there are data gaps. This study examines the standard techniques for solving these problems. Therefore, GIS interpolation and downscaling methods were used to assess how gaps in climatic parameters could be filled using Nigeria as a case study. Using Nigeria as a case study, several GIS interpolation methods have been tested for the production of maps in this study. After many attempts and qualitative and quantitative validations, the last of these—Ordinary Kriging—was chosen for the map productions. A major strength of the method is that measured spatial dependence in the weather parameter of interest and this is used to produce digital maps. Ordinary Kriging was used to interpolate the point observations from a network of rainfall base stations. The results from this study show that GIS interpolation are helpful for downscaling spatial dynamics of climate and also useful in forecasting probable period for farming activities.
Assessing the Performance of CORDEX South Asia Regional Climate Models in simulating rainfall of North-East region of Bangladesh

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This paper will investigate the performance of Regional Climate Models (RCMs) used in Coordinated Regional Climate Downscaling Experiment over South Asia (CORDEX South Asia) domain in simulating rainfall of North-East region of Bangladesh for the period of 1975 to 2005. The North-East part of the country is one of the most vulnerable part within the country due to its geo-graphical location, complex climatic condition and geo-morphological characteristics. The changes of climate over this region would have substantial impact on agricultural production, water resources management and overall economy of the country. This study will provide a valuable information to climate scientist for further study of assessing impact of climate over the region. The simulated rainfall for individual model as well as for multi model ensemble mean will be evaluated against observed data. The Bayesian approach will be applied for evaluating multi model ensemble mean as this approach yields less error than arithmetic ensemble mean. Finally the Taylor diagrams will be used for comparing different models and their ensemble mean using three related parameters: standard deviation, correlation with observed data, and centered root mean square (RMS).
Climate changes in Antarctica: analysis of ARPEGE and LMDZ global climate models (GCM) at a high regional resolution and oceanic forcing contributions.

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1. LGGE (UJF) 2. LGGE (CNRS) 3. Meteo France (CNRM)

Future projections using Coupled ocean-atmosphere climate model show an increasingly positive surface mass balance over Antarctica for the twenty-first century. This is due to increasing precipitations induced by a higher air moisture holding capacity in a warmer climate. Recent publications agree on the fact that this increased mass gain from rising precipitations overcompensate mass loss due to higher melt rates at the ice sheet margins in future climate. However, uncertainties remain on the amplitude of this precipitation change causing large uncertainties on the Antarctic ice sheet contribution to sea level changes. A first cause of uncertainty are the significant biases in coupled climate-ocean model for the representation of sea surface conditions (SSC) of the Antarctic ocean (i.e. sea surface temperatures (SST) and sea ice cover (SIC)), even for present climate. A second source of uncertainty is the horizontal resolution of climate models, as major changes in precipitation are expected in regions with steep topography such as coastal areas and ice sheet margins.

In this work, we present our first evaluation and comparison of LMDZ4 and ARPEGE GCM’s for the modelling of Antarctic’s climate and surface mass balance over recent years (1981-2000). LMDZ4 (Laboratoire de Météorologie Dynamique-Zoom, CNRS Paris) is the atmospheric component of the IPSL CM4 (Institut Pierre Simon Laplace Coupled Model). ARPEGE (Action de Recherche Petite Échelle Grande Échelle) is the atmospheric component of the CNRM-CM coupled climate model. Then, further developments of the anomaly method proposed by Krinner et al. (2008) which allows the reduction of the biases in SSC coming from coupled models and more realistic prescribed SSC for future simulations, are presented and discussed. Other methods from the literature are also tested and discussed. This discussion deals with interannual variability and the added value of quantile methods such as presented by Ashfaq et al., (2011).

This research project also aims at providing model outputs that fit polar CORDEX experiment specifications using ARPEGE and LMDZ4 models with a stretched grid allowing a higher horizontal resolution over Antarctica. The contribution of such simulations with respect to regional climate model such as MAR (Modèle Atmosphérique Régional) used at the same horizontal resolution will also be analyzed and discussed.
PA-011

On the comparison of EuroCORDEX ensemble and ENSEMBLES ensemble of regional simulations

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When preparing for climate services provision the reliable information from the modelling simulations has to be available. The assessment of the ensemble of available Euro-CORDEX simulations will be provided in terms of monthly mean analysis of surface temperature and precipitation monthly amount. Both ERA-Interim perfect boundary conditions simulations and historical runs driven by different GCMs from CMIP5 are validated against E-OBS data and compared for both available resolutions (0.11 and 0.44 deg). The results are presented using the maps of model biases as well as in terms of the areal statistics for PRUDENCE regions, where former ENSEMBLES ensemble of regional simulations is used for comparison. No significantly better results can be seen when comparing the results of 0.11 deg. resolution with respect to the 0.44 deg. Moreover, while both ensembles (basically all the members) are in very good agreement in annual cycle for temperature and very close to the reality, for precipitation quite significant disagreements appear for many of the simulations over some regions, in both ensembles, especially in terms of annual course. The analysis on the source of the biases is performed to clarify the reasons of such behaviour.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-012

Changes of climate zones in the Euro-CORDEX scenarios simulations

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The analysis of climate patterns can be performed for each climatic variable separately or the data can be aggregated using e.g. some kind of climate classification. These classifications usually correspond to the vegetation distribution in the sense that each climate type is dominated by one vegetation zone or eco-region. In this regard climate classifications also represent a convenient tool for the assessment and validation of climate models and for the analysis of simulated future climate changes.

Euro-CORDEX results for both 0.11 and 0.44 degree resolution are validated using Köppen-Trewartha types in comparison to E-OBS based classification. ERA-Interim driven simulations are compared to both present conditions of CMIP5 models as well as their downscaling by Euro-CORDEX RCMs. Finally, the climate change signal assessment is provided using the individual climate types. In addition to the changes assessed similarly as for GCMs analysis in terms of the area of individual types, in the continental scale shifts of boundaries between the selected types can be studied as well providing the information on climate change signal. The shift of the boundary between the boreal zone and continental temperate zone to the north is clearly seen in most simulations as well as eastern move of the boundary of maritime and continental type of temperate zone. However, there can be quite clear problems with model biases in climate types association.
Over the past few decades the horizontal resolution of regional climate models (RCMs) has steadily increased. In parallel, efforts were put into creation of coordinated sets of regional downscaled simulations with typical horizontal resolutions ranging from 50 km to 12.5 km. This enables to tackle two important questions: Do RCMs add value beyond the resolution of the global reanalysis or global climate simulations? Do the 12.5 km resolution simulations provide further information to 50 km resolution simulations, and if so how it is perceived? To address these questions, our study explores observed and simulated near-surface wind over the eastern Adriatic and Pannonian regions. Due to the diverse topography, these particular regions represent an excellent test area for the climate simulations of the latest generation of the RCMs. Surface station observation data from the 1996-2008 period have been compared against the daily output obtained from a suite of nine CORDEX RCM simulations (six from EURO-CORDEX: CLMcom-CCLM4-8-17, DMI-HIRHAM5, IPSL-INERIS-WRF331F, KNMI-RACMO22E, SMHI-RCA4, DHMZ-RegCM4, and three from MED-CORDEX: CNRM-ALADIN5, ICTP-RegCM4, UCLM-PROMES), where all simulations are forced by the ECMWF ERA-Interim reanalysis. Each ensemble member has a 12.5 km and 50 km resolution simulations. Furthermore, for the proper comparison between 12.5 km and 50 km resolution simulations, the upscaling of the 12.5 km model resolution is performed. This approach adds nine wind fields to the evaluation set. Moreover, several methodological aspects related to the interpolation techniques when comparing RCMs and observations (or RCMs at two different resolutions) are examined. To provide an answer to the first question of interest, we discuss a measures-oriented approach (e.g. Brier skill score) and a distributions-oriented approach (e.g. Perkins skill score), both disclosing season and location dependence. The evaluation reveals strong sensitivity of the simulated wind flow to the RCM horizontal resolution (12.5 km vs. 50 km), giving an insight to the later question. Moreover, RCMs are explored in terms of skill in reproducing specific wind regimes over the Adriatic region (e.g. the bora) where large spread in the RCM ensemble is found. The results of this study will provide the basis for the next steps where wind field, in an ensemble of RCMs forced by the GCMs in historical and future climate runs, will be examined over the Adriatic and Pannonian regions.
Midsummer Drought simulated by a coupled regional climate model

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In this work, a regional climate model of limited area, in both atmospheric and coupled mode, is used to simulate the historical period over a domain including Mexico and Central America. In the atmospheric mode, the REMO atmosphere model is used, while in the coupled simulation, REMO is coupled to the MPI-OM ocean model. In all simulations, REMO is forced at the open boundaries by reanalysis data from ERA-interim. Several numerical experiments are performed using three different computational domains as well as three different spatial resolutions (100 km, 50 km and 25 km). Taylor diagrams of some meteorological and oceanic variables are used to get a quantitative idea of model performance. Additionally, the observed patterns of the Midsummer Drought are compared with the simulated ones. Among the results, it is noted that the coupled model with a resolution of 25 km has the best performance to simulate the observed pattern of the Midsummer Drought.
Regional Climate Model (RCM) simulations are widely done in a long-term continuous climate prediction mode. However, the simulated circulation starts to deviate from the driving Lateral Boundary Conditions (LBCs) after some time. Previous studies have shown that the use of reinitialisations for RCM simulations reduces the error growth. However, only few research groups have adapted this downscaling approach, mainly because of increased computational costs.

At the Royal Meteorological Institute of Belgium (RMI), the so-called ALARO-0 model is run in forecasting mode, which is a version of the Aire Limite Adaptation Dynamique Développement International (ALADIN) with revised physical parameterizations. It was also shown that the ALARO-0 model is a good candidate model for regional climate modelling.

The ALARO-0 RCM uses an old surface scheme called ISBA. This model has been validated for continuous climate runs and is now being used to contribute to the EURO-CORDEX project.

Meanwhile the newer scheme SURFEX has been implemented in this ALARO-0 RMI version, and this setup has shown improvements in NWP and climate applications. The scheme is externalised which facilitates a more flexible setup for different climate run configurations.

The modelling experiment consists of a reinitialised versus a continuous climate simulation, using downscaled LBCs from the ERA-Interim reanalysis. Both simulations cover a period of 10 years at a Western European domain with a 20km horizontal resolution, and both keep the surface in free running mode.

Overall, the reinitialised climate simulation improves the 2 meter temperature w.r.t. the continuous simulation, compared to E-OBS. However, large differences appear over the domain during summer, which implies that the sensitivity to the choice of downscaling approach seems to depend on the region.

The results suggest an interaction between the soil moisture, evapotranspiration, sensible heat flux and air temperature. This land-atmosphere feedback is further analysed by the distribution of the energy fluxes, compared to FLUXNET sites. For many sites, the continuous simulation overestimates the latent heat flux, while the values are more close to the observations for the reinitialised simulation.

This powerful setup of an inline coupled land surface model to an atmospheric model allows us to analyse more in-depth the land-atmosphere feedback using different dynamical downscaling approaches for regional climate modelling.
Regional Climate Downscaling over Southeast Asia using WRF Model: Mean Climatology and Interannual Variability

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In this study we investigate the skill of weather research and forecasting (WRF) model for downscaling regional climate variability over the Southeast Asia (hereafter SE Asia). The model was dynamically downscaled over the 22 year period (1991 – 2012) at 27 km horizontal resolution and forced by the global reanalysis from the ECMWF reanalysis (ERA) interim data. The performance of the model in simulating the observed climate is evaluated with a main focus on the rainfall for four different sub-regions of SE Asia during the different seasons (MAM, JJA, SON and DJF) of the year. The model could reproduce the climatology and annual cycle reasonably well, although with some biases. Model overestimated the rainfall over the mainland SE Asia during the boreal summer and over eastern Indonesia region during the austral summer.

The model could simulate the interannual variability of rainfall over the mainland Southeast Asia and Philippines for all seasons of the year except for the boreal summer (JJA). However, Malaysia, Singapore, Brunei, western Indonesia shows good performance of interannual variability only during boreal summer. This study also evaluates the WRF model’s ability to simulate the regional rainfall variability over Southeast Asia associated with the large scale climate mode such as ENSO and IOD. The results indicated that the model has the ability to simulate the spatio-temporal variability of rainfall with relation to ENSO and IOD.
PA-017

Variability and projected climate change of precipitation indices over Croatia in a EURO-CORDEX ensemble

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Performance of regional climate models (RCMs) from the EURO-CORDEX initiative is examined in terms of various precipitation indices. We focus on those RCMs that provided pairs of 50-km and 12.5-km simulations over Europe forced by historical and RCP-scenario simulations of the CMIP5 global climate models (GCMs). In addition to an overview for European domain, we focus on Croatia and surrounding region which is characterized by a complex orography and coastline. In this sub-region, a possible added value attained by the 12.5-km simulations relative to 50-km simulations can be detected in terms of total precipitation amounts and associated indices.

Total precipitation is decomposed into the number of wet days (when precipitation amount is over a specific threshold) and a simple daily intensity index (mean total precipitation amount over wet days only). A comparison of the modelled total precipitation against the E-OBSv11 data for the historic period 1971-2000 reveals the spread of RCMs from the observations. For example, for the RegCM4 model (DHMZ-RegCM4), it was found that the model strongly overestimates the number of wet days (especially at 12.5 km), but it is relatively close to observations in terms of daily intensity index. In most simulations with both spatial resolutions, the change in total precipitation and associated indices between the historic period and the near-future period (2021-2050) is generally lower than the amplitude of systematic errors. For the pairs of RCMs and GCMs using several RCP scenarios (e.g. SMHI-RCA4), a weak sensitivity to the RCP scenario is found. This can be expected since statistically significant changes in precipitation over relatively large areas do emerge only in the later decades of the 21st century.

The existence of non-negligible systematic errors in some RCMs indicates that additional customization of the model setup and/or more work on the model development is needed. In addition, an increase of RCMs’ horizontal resolution and application of more comprehensive parameterizations must be complemented by availability of high-quality high-resolution observational datasets.
PA-018

Implications of freshwater flux data from the CMIP5 multimodel output across a set of Northern Hemisphere drainage basins

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The freshwater system on land, particularly runoff, has so far been of relatively low priority in global climate models, despite the societal and ecosystem importance of freshwater changes, and the science and policy needs for such model output on drainage basin scales. These limitations are also important to and affect regional climate modeling and hydrological impact modeling that rely on global climate model output. Here we investigate the implications of CMIP5 multimodel ensemble output data for the freshwater system across a set of drainage basins in the Northern Hemisphere. Results of individual models vary widely, with even ensemble mean results differing greatly from observations and implying unrealistic long-term systematic changes in water storage and level within entire basins. The CMIP5 projections of basin-scale freshwater fluxes differ considerably more from observations and among models for the warm temperate study basins than for the Arctic and cold temperate study basins. In general, the results call for concerted research efforts and model developments for improving the understanding and modeling of the freshwater system and its change drivers. Specifically, more attention to basin-scale water flux analyses should be a priority for climate model development, and an important focus for relevant model-based advice for adaptation to climate change.
PA-019

Which information is needed from a regional climate model ensemble to plan climate adaptation?

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High resolution climate information from a multi model ensemble is required for the development and the planning of measures to adapt to changing climate (e.g. German Adaptation Strategy). Assuming different emission scenarios, using a multi model ensembles and multi downscaling methods is essential to achieve information on possible ranges of future climate change for climate impact research and as background information for policy and economy.

The BMBF project ReKliEs-De will provide consistent and user-tailored information for federal agencies and climate impact and adaptation research. To achieve this, a national coordinated effort is proposed to examine the EURO-CORDEX simulations on 12 km horizontal resolution for Germany and to systematically complement them by further simulations with both dynamical and statistical downscaling methods.

The assessment of data and information needs of users will be introduced, which forms the basis of the user tailoring of the project result. First results of the calculated climate indices will be presented and how condensed information of the range of possible changes in mean and extreme climate can fulfil the requirements of users.
The heat flux dynamics in the Mediterranean Sea simulated by the regional coupled model ROM

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We examine the variability of heat flux in the Mediterranean Sea during the cold season using the regional coupled model (ROM) and assess the impact of ocean-atmospheric interaction on this variability. ROM, forced by ERA-Interim reanalysis, was integrated from 1980 to 2014 on a domain covering the Mediterranean and most of the North Atlantic regions. In ROM a global ocean (MPIOM) with regionally high horizontal resolution is coupled to an atmospheric regional model (REMO) and global terrestrial hydrology model (HD). This way of coupling divides the global ocean model setup into two different domains: one coupled, where the ocean and the atmosphere are interacting, and one uncoupled, where the ocean model is driven by prescribed atmospheric forcing and runs in a so-called stand-alone mode.

We performed a modal decomposition and analyzed the first two mode of variability. While the first mode, which explains most of the variance, is associated with domain average fluctuations and is dominated by high frequency, the second mode appears as a dipole structure and is related to the low frequency variability. We explore the connection of the low-and high frequency variability of the modes to the large scale climate patterns and examine the physical mechanisms through which the two modes influence the interannual variability of the heat fluxes in the Mediterranean Sea. Also, we study the heat fluxes over deep water formation regions.

To assess the role of the ocean-atmospheric interaction in the response of the Mediterranean Sea to changes in the regional circulation associated to the large scale climate patterns, we compare the results of coupled simulations to stand alone runs with both the atmospheric and oceanic components of our model.
PA-021

Climate-vegetation interactions in the coupled RegCM4 - CLM4.5 CNDV model

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We use the latest version of International Center for Theoretical Physics (ICTP) regional climate model (RegCM4) coupled with the Community Land Model version 4.5 (CLM4.5) including a dynamic vegetation model to study biogeophysical feedbacks in the climate system related to vegetation composition and structure.

Sets of parallel experiments are conducted over the Africa and South America CORDEX domains using the RegCM4-CLM4.5 in its standard configuration and with the CNDV activated (CLM 4.5 with both the Carbon Nitrogen and the Dynamic Vegetation Model activated).

The potential role of regional vegetation feedbacks within the climate system and the impact of climate variability and change on the ecosystem dynamics is assessed for both domains. In addition, the sensitivity to initial vegetation conditions and different idealized climate forcings is investigated.

Preliminary results show that the changes in the climate forcing can have substantial effects on the dynamics and evolution of different vegetation types over both domains, and that the vegetation coupling can have a substantial effect on the simulated regional climate regimes.

Our results thus indicate on the one hand that climate change can have profound effects on the evolution of important ecosystems for the two regions, and on the other that vegetation dynamics can indeed affect the climate response at the regional scale.
Gradually cooling temperatures in autumn induce winter-hardiness in winter crops and this protect plant cells from freezing. This acclimatization generally takes 6-8 weeks and needs crown temperatures below 10°C. Winter survival of crops depends on this process that contributes to avoid damages connected with cold spells/snaps. Spring crops lack of this protection and are (increasingly) sown earlier to avoid drier and hotter summers. Here, we investigate whether in a warming and more variable climate, as the one we expect for the next decades, winter crops become more vulnerable to cold snaps in early spring, late autumn and winter.

Using bias-corrected EURO-CORDEX climate model runs, we calculate indices representing the cold hardening process and the probability of cold snaps across Europe. Meteorological and eco-physiological aspects of future cold spell patterns are analysed.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-023

On regional climate downscaling of Africa domain in CORDEX using WRF model

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Focusing on the Africa domain in term of the CORDEX standard regions, the climate downscaling simulation has been carried out. The WRF model at the version of 3.3.1 is employed, and the Norwegian Earth System Model (NorESM) data, and the ERA-Interim data from ECMWF are used as large-scale climate forcing. And finally, four cordex-standard datasets that simulated respectively with ERA-Interim (1979-2013); NorESM-historical (1950-2005); NorESM-RCP45 (2006-2100) as well as NorESM-RCP85 (2006-2100) were generated. The metadata of these datasets were checked by means of the DKRZ QC Tool (https://redmine.dkrz.de/projects/cordex/wiki/DKRZ_QC_Tool), and numerous selected variables, such as precipitation, air temperature, wind fields, geopotential height, sea level pressure, soil water content and so on, in its diurnal, seasonal and inter-annual cycle were analysed.

It is concluded that the simulated climate variables has, not only significantly improve the climate data resolution in temporal and spatial scale, and may also increase the accuracy in comparison with the in-situ observation, which would require the further examination and validation.
The Search for an Added Value of Precipitation in Downscaled Seasonal Hindcasts over East Africa: COSMO-CLM Forced by MPI-ESM

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In this study downscaling of seasonal hindcasts over East Africa with the regional climate model (RCM) COSMO-CLM (CCLM), forced by the global climate model (GCM), MPI-ESM is evaluated. The simulations are done for five months (May to September) for a ten year period (2000-2009), with the evaluation performed only for June to September. The accuracy of the RCM simulations is assessed using ground based and satellite gridded observation data. It is found that both COSMO-CLM and MPI-ESM overestimate June to September precipitation over the Ethiopian highlands and in parts of the lowland with respect to all reference datasets. In addition we investigated the potential and real added value for both the RCM and the GCM hindcasts by upscaling (arithmetic mean) the precipitation resolution both in temporal and in spatial scales. Results showed that the RCM forecast has a higher added value for the monthly total precipitation compared to the added value of GCM over the lowlands of East Africa. Looking more closely to different parts of North Ethiopia (EN), South Ethiopia (ES), South Sudan (SS), and Sudan (S) for the daily precipitation 90th and 95th percentiles, we found that the potential added value is high over EN and ES. In contrast, it is less in the lowlands region S and in SS. The potential and relative potential added value decrease with decreasing the temporal resolution
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-025

Toward building a robust climate change information: plea for incorporating traditional knowledge into scientific ones

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The dependence agriculture / rain submits agricultural productivity to climatic constraints in Man and Korhogo in Côte d’Ivoire and limits strongly search for food safety. Farmers adopt traditional techniques of minimization of the risks for the improvement of the productivity of grounds and crops. However, there has been a tendency for the impact of climate change on SubSaharan Africa’s agricultural sector to be studied primarily by natural science experts. There have also been attempts to estimate its macroeconomic effects and to specify viable technological options. This literature has only begun to address the subject from the various interdisciplinary perspectives necessary to understand the scope of adaptation to climate change. There is, therefore, a need to bring the pieces together in a broader analysis and relate them to the agenda of sustainable development today. Of paramount importance in this regard is the question of how local knowledge can contribute to climate change monitoring, mitigation and adaptation. This paper addresses the need to explore in greater detail the implications of climate challenges for developing countries. It aims to add cultural dimensions to the existing literature where techno-economic analysis is predominant. From analyzing former and present practices and their justifications, this study makes a plea for incorporating traditional knowledge into scientific ones which perfect translation remains real increase of adaptive capacity of Côte d’Ivoire’s farmers. If carried out in a systematic way, cultural dimension can serve to advance our understanding of the process and assist in decision-making through a cultural “revolution” resulting in extensive value reorientation within Côte d’Ivoire’s traditional rural society.
Dynamical downscaling of Global Climate Model over Thailand using Regional Climate Model

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The Weather Research and Forecasting (WRF) model is widely used as a regional climate model for dynamical downscaling in many regions world-wide. The objectives of this study are: 1) to simulate high-resolution present and future climate change for Thailand; and 2) to analyze the climatic change and climatic variability over Thailand and nearby countries. The GCM forcing data that provide initial and lateral boundary conditions to the regional climate model in this study is the ECHAM5 SRES scenario A1B. The WRF regional climate model with the 20km grid resolution reproduces the observed spatial distribution of temperature well, with a cold bias for maximum temperatures and a warm bias for minimum temperatures. The 2045-2064 projected warming is 1.41 °C averaged over Thailand compared to the 1990-2009, with greater warming at nighttime (1.52 °C) than daytime (1.30 °C) temperature, leading to decrease in diurnal temperature range about 0.22 °C. The highest increasing in temperature is in the rainy season (especially from June to August) and the mid of cool season (December and January), while the lowest increasing occurs during the early of cool season (November) and the end of cool season (February). A slight decrease in annual mean precipitation is projected over Thailand. The decrease in precipitation during the rainy is seen over all parts of Thailand, with an average of 0.31 mm/day. An averaged increase in precipitation of about 0.31 mm/day is found in the hot season except over the east and south of Thailand where a decease in hot-dry season precipitation is found. The decreasing rate of precipitation during June-August is obviously related to the weakening trend of the southwest summer monsoon. The increase in pre-monsoon precipitation (especially in April) is likely from increasing moisture transport from the oceans across Thailand and nearby countries leading to intensify thunderstorm precipitation. The increase in late monsoon precipitation (October) is indicated from tropical cyclone intensified that likely increases moisture transport across northern and central Thailand leading to more precipitation and slightly extending the rainy season. It was found that a pronounced decrease in the number of wet days, while an increase of precipitation intensity is simulated across most of Thailand.

Keywords: Dynamical Downscaling, Regional Climate Model, Climate Change, WRF, Thailand
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-027

Scenarios for future changes in extremes for agricultural modelling

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In order to apply CORDEX data as input to agricultural yield models, the RCM data will normally need to be bias corrected, since agricultural models are very sensitive to the realism of meteorological input. Furthermore, for areas such as Europe and Africa, a rather large number of simulations are available, which necessitates a selection of models from the available multi-model ensemble.

Here we present the work within the MODEXTREME project related to model availability, bias correction and model selection. For Europe, bias correction has been performed on a lattice, since the E-OBS observation-based gridded dataset is available. For South America, South Africa and China, such data have not been compiled around all MODEXTREME sites. Therefore we have used station-based observations instead. The bias correction is a standard quantile-quantile algorithm for precipitation and temperature with a 31-day sliding calendar window.

Model selection for Europe and Africa has been performed with principal component analysis for an area surrounding the MODEXTREME sites. The goal has been to find one central model and 3 other models spanning the ensemble distribution of change in 8 precipitation-related extremes indices calculated after bias correction. For Europe this has been done separately for the Ukraine and for South-Western Europe.

This poster is a practical example of the use of CORDEX data in a particular kind of impacts models.
Development of probabilistic regional climate scenario in East Asia

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Climate information and services for Impacts, Adaptation and Vulnerability (IAV) Assessments are of great concern. In order to develop probabilistic regional climate information that represents the uncertainty in climate scenario experiments in East Asia (CORDEX-EA and Japan), the probability distribution of 2m air temperature was estimated by using developed regression model. The method can be easily applicable to other regions and other physical quantities, and also to downscale to finer-scale dependent on availability of observation dataset. Probabilistic climate information in present (1969-1998) and future (2069-2098) climate was developed using CMIP3 SRES A1b scenarios 21 models and the observation data (CRU_TS3.22 & University of Delaware in CORDEX-EA, NIAES AMeDAS mesh data in Japan). The prototype of probabilistic information in CORDEX-EA and Japan represent the quantified structural uncertainties of multi-model ensemble experiments of climate change scenarios. Appropriate combination of statistical methods and optimization of climate ensemble experiments using multi-model ensemble experiments are investigated.
Regional climate simulations to assess impacts of climate change on cities and urban climate

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Climate change and global warming due to greenhouse gases emissions are already observed and tend to intensify. In particular, cities concentrate populations and human activities causing both a large vulnerability to climate changes, and a possible local intensification by the specific properties of the urban physiography. It thus is an important issue in studies related to climate change. In addition, the combined evolution of the specific micro-climate of cities, characterized by the urban heat island, and the global climate could exacerbate problems of thermal stress and energy dependence. Many research projects studied these complex interactions and evaluated possible adaptation strategies. These impact studies are based on an urban canopy model forced by regional climate projections from climate models. It now becomes important to explore new approaches to study interactions between cities and climate, including the possible feedback of urban effects on regional climate.

Here, we perform regional climate simulations over the metropolitan France domain (ALADIN, 12 km used in EuroCordex), coupled with SURFEX land model that allowed the activation of an urban climate model: Town Energy Balance model. We evaluate the benefits of a coupled approach compared to a simplified representation (bare sol or vegetation) of cities. Evaluation simulations cover the time period 1979-2009, and results are average over each seasons to study impacts on summer, winter and transitional seasons. Observation data from Météo-France network allow to compute bias and uncertainties on precipitations, incoming shortwave radiation, maximal and minimal surface temperatures.

With the aim of understanding and assessing the impacts of climate change and global warming on cities micro-climate, an evolution of the city based on “business as usual” trend is explored and coupled climate simulations until 2100 have been carried out. The study is first focused on urban climate indicators such as 2m-air temperature, urban heat island expansion and outdoor thermal comfort. In addition, the feedback on atmospheric variables such as day-time and night-time temperatures, wind speed and direction, humidity and precipitations is analysed.
Do regional climate projections help in managing complex socio-ecological systems?

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The reliability of climate model projections is limited by model inadequacies, imperfect representations of key system processes, and practical challenges in sampling multiple sources of uncertainty. Additional issues are introduced in dynamical and statistical downscaling. As identified in a critique of downscaling approaches by Wilby and Pielke (2012) errors in the large-scale conditions supplied by global climate models remain, and can be amplified, in downscaled projections. Moreover, climate is only one of many factors for decision makers to consider in responding to environmental and societal change. It is therefore pertinent to ask whether or not downscaled climate model projections provide additional value to help guide management and planning decisions for complex socio-ecological systems (SESs). To address this question we draw on experiences across a range of regional downscaling projects and present the findings outlined in a recently published paper in Regional Environmental Change (Daron et al. 2015).

Using CORDEX output and a case study of the Dwesa-Cwebe region in South Africa we demonstrate that the management of SESs under changing environmental and socio-economic conditions requires a nuanced and holistic approach that addresses cross-scale system interdependencies and incorporates "complexity thinking". We argue that regional climate projections have an important role to play in understanding the complexities of the scale dependent climate system and in helping to identify possible future futures that are worth incorporating in decision processes. Moreover, we stress that to better inform the assessment of appropriate adaptation options and interventions, decision makers and information providers must co-explore the system’s ecological, climate and socio-economic thresholds. Management decisions in SESs vulnerable to climate change will be most effective when they incorporate holistic analyses of system sensitivities and thresholds rather than rely on segmented efforts to predict the future of different system variables in isolation.

References:


Is land surface processes representation a possible weak link in current Regional Climate Models?

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The representation of land surface processes and fluxes in climate models critically affects the simulation of near-surface climate over land. Here we present an evaluation of a Regional Climate Model (COSMO-CLM) augmented by a state-of-the-art Land Surface Model (CLM4.0). Given the relatively simple land surface scheme included in the original COSMO-CLM, this coupling aims at improving the representation of land surface processes in the model system. The EURO-CORDEX RCM ensemble is also included in the evaluation such that the added value of improving land processes is assessed in the context of the performance achieved by a set of state-of-the-art RCMs.

We performed historical simulations over Europe with this newly developed coupled system following the EURO-CORDEX intercomparison protocol. We then evaluate simulations performed with our coupled system, the standard COSMO-CLM and other EURO-CORDEX RCMs against various observational datasets of temperature, precipitation and surface fluxes. Overall, the results indicate that the coupled system outperforms both the standard COSMO-CLM and the other EURO-CORDEX models in simulating sensible, latent and radiative fluxes as well as 2-meter temperature across different seasons and regions. The performance improvement is particularly strong for turbulent fluxes and for daily maximum temperatures and more modest for daily minimum temperature, indicating that land surface processes affect daytime more than nighttime temperatures. The coupled system also alleviates a long-standing issue of overestimation of interannual summer temperature variability present in all EURO-CORDEX models. For precipitation, the coupling does not result in any clear improvement, suggesting that land processes are more critical for the simulation of surface temperature than for precipitation. Finally, we show that several factors contribute to the performance improvements achieved with the coupled system. In particular the representation of ground heat flux plays an important role, an aspect that has received so far only very little attention from the climate and land modelling community.
PA-032

On the added value of subdaily precipitation simulated by the ALARO-0 model within the EURO-CORDEX framework

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The model skill to simulate realistically extreme daily precipitation is mainly determined by the spatial resolution and convective parameterization of the model. An earlier study of De Troch et al. (2013) assessed the relative importance of the increase in spatial resolution versus the improvement of the parameterization formulation on the model skill to simulate realistically daily extreme precipitation over Belgium from the ALARO-0 model. Their results demonstrated that the new parameterizations, that are centered around an improved convection and cloud scheme, contributes to the improvement in the modeling of daily extreme precipitation events at multiple spatial resolutions, rather than the increase in spatial resolution.

However, for impact studies of extreme precipitation events, decision makers often require current and projected future climate information at the local scale and at higher temporal resolutions than the daily scale. Over the last decade considerable efforts were made to further develop and improve Regional Climate Models (RCMs) by increasing their complexity and resolution. The refinement in the spatial resolution of the RCMs is suggested to add value compared to the driving lower resolution data from global reanalysis or GCMs. The added value can generally be found on small spatial and temporal scales (e.g. subdaily precipitation), in the timing of the onset and peak of convective precipitation (i.e. diurnal cycle) and for high precipitation intensities (Prein et al., 2013 and Prein et al., 2015).

A good quantification of the added value of higher resolution runs is thus in particular important as it has to compensate for the extra computational cost that accompanies with the increase in spatial resolution. The aim of this work is to extend the work of De Troch et al. (2013), by testing the added value in the simulation of subdaily precipitation with an increase in spatial resolution. For this, hourly cumulated observed precipitation data for three different station locations in Europe (Uccle, Prague and Uppsala) is compared with model output from the ERA-Interim driven ALARO-0 EURO-CORDEX runs at 50 km and 12.5 km resolution (Giot et al., 2015). Subdaily precipitation characteristics are analyzed through assessment of the diurnal cycle, intensity and frequency characteristics and scaling properties such as the linear behavior of the Generalized Extreme Value (GEV) parameters and the Clausius-Clapeyron relation.
High Resolution Rainfall Modelling over the Eastern Escarpment of South Africa

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Steep topography has an adverse effect on the realistic representation of the spatial and temporal distribution of rainfall totals within regional climate model (RCM) simulations and even when measuring rainfall via satellite instrumentation. Here the conformal-cubic atmospheric model (CCAM) is used for present-day climate simulations, at 8 km in the horizontal, over the eastern escarpment region of South Africa. The model simulations are verified against tropical rainfall measurement mission (TRMM) satellite and South African Weather Service (SAWS) station rainfall data to analyse the representation of the observed, and well documented, west-east rainfall gradient and diurnal rainfall cycle in the model simulations. There exist large biases in the CCAM simulations, but is the model is able to capture the spatial features of the west-east rainfall gradient and diurnal cycle remarkably well. The intra-annual rainfall cycle resembles what is noted in observations, TRMM and Climte Reasearch Unit (CRU) with January being the month of maximum rainfall during the annual cycle, but there exist large rainfall biases during summer months as a result of to much convection being initiated in the model. Moreover, a new rainfall feature over Lesotho representing a rainfall maximum in the north east along the western side of the escarpment, undetected by the weather station network, was discovered from the model simulations. These simulations are independently verified through the use of 16-day mean normalized vegetation index (NDVI) data, during January, that is strongly correlated rainfall.
South Asian climate is characterized mainly by the wet and dry dipole that divides the annual cycle in two seasons: the monsoon season and the dry season. The life and the economy of those regions is very much influenced by the climate variability and the monsoon variability therefore is crucial to understand the physical mechanism associated with them.

The spatial and temporal representation of the monsoons over the South Asian region is one of the main challenge of global and regional climate models principally because they fail to represent the SST (sea surface temperature) induced rainfall when forced with observed SST resulting in a poor representation of the monsoon cycle (Fu et al. 2002).

The coupling with the ocean is essential to be able to simulate the correct air-sea interaction; the results are in general much improved and the monsoon patterns and the time representation (like the onset for example) are closer to the observations (Fu et al. 2002; Fu et al. 2007; Ratnam et al. 2008; Seo et al. 2009).

Here we present a Regional Earth System Model (RESM) composed by a regional climate model RegCM4 (Giorgi et al, 2012) coupled with the regional oceanic model MITgcm (Marshall et al, 1997) and two hydrological model: ChyM (Cetemps Hydrological Model, Coppola et al, 2007) and HD model (Max-Planck's HD model; Hagemann and Dümenil, 1998).

We simulate the Southern Asian Climate taking into account the whole hydrological cycle. Wind stress, water fluxes and heat fluxes are exchanged from the atmosphere to the ocean, SST are exchanged from ocean to the atmosphere and in order to conserve mass, the river discharge is calculated from the Hydrological model and sent to the ocean.

The main goal of this work is to evaluate the impacts of local air–sea interaction in the simulation of the interannual variability, over the Indian CORDEX (Giorgi et al, 2009) domain through regionally ocean–atmosphere-river coupled and uncoupled simulations, with a focus on monsoon season. The impact of a simplified low-resolution hydrological model (HD model) and the physical based high-resolution hydrological model (ChyM model) is also assessed in the fully coupled RESM simulations.
PA-035

Performance of CORDEX Regional Climate Models in Simulating Precipitation Climatology of Indian Summer Monsoon

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The performance of a set of 11 coordinated regional climate simulations performed under the framework of Coordinated Regional Climate Downscaling Experiment in South Asia (CORDEX-South Asia) project in representing the characteristics of summer monsoon precipitation patterns over India has been evaluated for the period 1970-2005 representing the present climate. The precipitation climatology from each of these RCM simulations and the common features and differences among them has been assessed against corresponding observational datasets.
Recent projection work on rainfall extremes suggests that fine resolution, convective permitting simulations can add value to simulations on coarser resolution with parameterised convection; the finer resolution providing an improved simulation of the intensity, position and extent of extreme rainfall events. The potential for added value in water resource projection work by convective permitting simulations is less obvious, where the relevant scale of skill is coarser both in the temporal and spatial domain. Areas of interests are on catchment or river basin scale and the temporal resolution of interest is seasonal rainfall; where water management systems may have dams that offer multi-year buffers to low rainfall years. If fine resolution simulations don’t give significantly improved representations of regional rainfall on these application relevant scales, computing resources may be better spent on widening the GCM sampling or conducting longer or multiple future time horizons.

Within the Victorian Climate Initiative (VicCI), fine resolution dynamical downscaling experiments were conducted to attempt to quantify the potential added value of convective permitting simulations versus parameterized convection simulations from a water resource perspective. VicCI is a regional climate initiative launched by the Victorian State of Australia that is tasked to provide knowledge that leads to improved forecasts of water availability in the short term and improved risk assessment on water supplies due to medium to long term changes in the climate.

Using the Weather and Research Forecasting (WRF) community model, a telescopic nest allows for assessment of rainfall characteristics at different scales whilst acknowledging interdependencies amongst the nested domains. Here, results from a multi-year simulation of WRF using a 3-domain telescopic nest (50, 10 and 2 km resolution) with boundary and initial conditions from ERA Interim is presented to illustrate distributional differences in catchment totals when estimated from the two innermost nests (2 and 10 km), where the convection scheme is switched off for the innermost domain. Results are presented for 26 catchments of different size across the State of Victoria.
Comparing climate change signals: GCM’s vs. RCM’s, raw model statistics vs. bias-adjusted

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GCM simulations provide us with information about climate change on a global scale, but for many practical purposes, information about climate change is wanted on a spatial and temporal scale higher than what can reasonably be extracted directly from the coarse resolution GCMs. One way to obtain this high-resolution information is to perform dynamical downscalings of the GCMs using RCMs over limited area domains. The output of the RCMs has in many cases been shown to provide more realistic information about local and regional climate primarily due to the better representation of complex orography and coastlines. However, the dynamical downscaling affects the climate change signal, and in many cases any localized climate change signal of the GCM-RCM is widely different from that of the driving GCM. Both GCM and RCM simulations are, however, subject to bias, which for many impact studies are sought alleviated by applying bias-adjustment procedures to the climate model output. This is also the case in the ongoing EU FP7 project IMPRESSIONS. Here, a set of five GCMs and their accompanying RCM downscalings are bias adjusted against the WATCH WFDEI data (1981-2010) using empirical statistical quantile mapping. This provides a unique data set of five GCMs with RCM downscalings, with and without bias-adjustment, all on the same grid. We compare the climate change signal of the original GCM, it’s accompanying RCM downscaling and their bias-adjusted counterparts. From this we evaluate the effects of the dynamical downscaling, the bias-adjustment and the combination of them on the regional climate change signal, and test if the differences in the climate change signals are statistically significant. We also assess to what extent the amount of bias correction influence the geographical variations in the climate change signal.
PA-038

The CLM-Community

Barbara Früh1, CLM-Community

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The CLM-Community (Climate Limited-area Modelling-Community) is an open, international network of scientists, who are employing and developing the regional climate model COSMO-CLM aka CCLM. They all accept the CLM-Community agreement as a basis of joint efforts in COSMO-CLM development and application.

In summer 2015, the CLM-Community had 251 scientific members from 67 climate research institutions all over the world. It is the largest obliging cooperation in the field of regional climate modelling aiming to address the challenges of model development, to efficiently use the computing resources and to make substantial contributions to answer the key questions of regional climate modelling.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-039
Regional differences in the value-added by statistical downscaling precipitation over North America using support vector regression
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Statistical downscaling is a post-processing technique often used to refine the coarse resolution outputs from a numerical model so the statistical characteristics of these post-processed outputs are more alike to local scale observations or observation-based datasets, as the spatial resolution of the coarse resolution numerical models is insufficient to resolve many local scale phenomena occurring at a much higher scale. However, the value added by these statistical refinements is not homogeneous in time or space.

Here we introduced a statistical downscaling method based on machine learning algorithms using support vector regression with evolutionary strategies (SVM-RES) to downscale precipitation amounts. To assess the value added by the downscaling process, the results were tested in terms of Peirce skill score (PSS), Nash-Sutcliffe efficiency factor, correlation coefficients and mean absolute error skill score (MAE SS). Additionally, in order to test if the value added by the downscaling process was time-invariant we used (historical and future) daily precipitation outputs from a high resolution (~25km grid spacing) global atmospheric model as predictands (pseudo-observations), and a coarsened version of the same high resolution outputs - interpolated to a ~100km grid – as predictors. Thus, we can compare the future downscaled outputs against the future “pseudo-observations” from the high-resolution numerical model.

The study focuses on multiple grid points from different climate regions across North America. The downscaled results were evaluated in terms of historical and future performance to assess if the skills were time-invariant. In particular, the results show that the SVM-RES model was able to reproduce the pseudo-observed rainy days variability – in terms of correlation coefficient. However, when looking at the Nash-Sutcliffe efficiency factor, the results show very heterogeneous performances. With almost zero efficiencies in the case of Las Cruces, New Mexico, and efficiencies higher than 0.8 in Yosemite, California. Our results also show that ~60% of the downscaled points had positive historical and future MAE SS. In general, the downscaled model results added more value to the coarse resolution global climate model outputs over regions with complex orography/topography, or where regional features were lost by the coarsening step.
Impact of Climate Change on Heating and Cooling Degree Days and Potential Energy Demand in the Household Sector of China

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Future changes of heating and cooling degree days (HDD and CDD) in the 21st century over mainland China are projected with a regional climate model in order to investigate the potential effects of climate change on energy demand in the household sector. Validation of the model shows a good performance in reproducing the spatial distribution, magnitude and interannual variability of the present day HDD and CDD. Significant decreases of HDD and increases of CDD are projected under the warming. These are further weighted by population projections for a first order assessment of future changes in energy demand. A larger decrease of population-weighted regional mean HDD compared to the increase of CDD is projected, indicating a decrease of about 15% in potential energy demand for different periods and scenarios in the future. In addition, the simulations show a marked spatial heterogeneity in the change of energy demand. Specifically, we find increases of both heating and cooling demand in parts of northern China due to the increased population there, an increase of cooling demand in the south and decreases in heating demand in the northernmost and western regions. Furthermore, a seasonal shift occurs, with increasing demand in summer and decreasing in winter. Finally, when the future reference temperatures for household heating and cooling change from standards currently used in China to values closer to those in Europe and the U.S., potentially large increases of energy demand (~80%) are expected, illustrating the importance of policy decisions concerning household heating and cooling.
PA-041

Using high resolution CORDEX RCMs to assess impacts on Mediterranean islands’ agriculture

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We present a preliminary assessment of climate change vulnerability in three of the largest Mediterranean islands, namely Crete, Sicily and Cyprus. Vulnerability assessment is performed using high resolution RCMs at 12x12km horizontal resolution from the CORDEX database. The target islands in fact represent the implementation areas in recently started EU LIFE ADAPT2CLIMA project (http://adapt2clima.eu/en/) . The project’s overall aim is to increase resilience of Mediterranean islands’ agriculture and to support adaptation planning. The methodology is based on the deployment of a set of climate, hydrological and crop models and on the development of an adaptation decision support tool.
PA-042

Fully coupled terrestrial water cycle simulations with TerrSysMP: Features and applications

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The Terrestrial Systems Modelling Platform (TerrSysMP) is a fully coupled scale-consistent physics-based numerical model system, currently consisting of the COSMO NWP (v4.11) model, the Community Land Model (CLM, v.3.5) and the ParFlow (v3.1) variably saturated surface and subsurface hydrological model, coupled with the external coupler OASIS3(-MCT). TerrSysMP allows for a physically-based representation of transport processes across scales down to sub-km resolution with explicit feedbacks between the individual compartments, including groundwater dynamics and a full representation of the terrestrial hydrological cycle. Ongoing developments and extensions are e.g., improvements in the coupling, updates of the component models CLM to v4.5 and COSMO to v5.1, first steps towards the consideration of bio-geochemical cycles by including CO2 coupling, the implementation of a parallel data assimilation framework in ParFlow+CLM, and steps towards an improved big data readiness in the complete modelling system. TerrSysMP is operated on multiple HPC systems, ranging from Linux clusters to highly scalable systems such as IBM BG/Q. TerrSysMP and its component models are used in a range of ongoing projects that nicely demonstrate the system’s capabilities: It is the core modelling tool in a Collaborative Research Centre on interactions and processes related to patterns in the critical zone; here, the spatial focus of the model runs is on high-resolution (1km and sub-km) model domains and river catchments. In a Research Unit on data assimilation for improved characterization of fluxes across compartmental interfaces, TerrSysMP is used with so-called virtual catchments at very high resolution. Continental evaluation simulations are run over the pan-European 12km EURO-CORDEX model domain in fully coupled mode to e.g., investigate the impact of coupled groundwater and groundwater schemes at this scale on extreme events such as droughts and floods, sub-surface surface atmosphere coupling processes and to generate river runoff. Further model developments, optimisations and setups are supported for example by extensive validation studies, a model intercomparison with the coupled ParFlow.WRF and investigations on the impact of coupling functionalities and settings. Both, the technical features and developments in combination with the ongoing applications are evolving towards an earth system modelling approach at a regional scale.
VALUE perfect predictor validation results, part 1: marginal, extremal
and temporal aspects

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VALUE is an open European network to validate and compare downscaling methods for climate
change research (http://www.value-cost.eu). A key deliverable of VALUE is the development of
a systematic validation framework to enable the assessment and comparison of both dynamical
and statistical downscaling methods. This framework is based on a user-focused validation tree,
guiding the selection of relevant validation indices and performance measures for different
aspects of the validation (marginal, temporal, spatial, multi-variable). Moreover, several
experiments have been designed to isolate specific points in the downscaling procedure where
problems may occur (assessment of intrinsic performance, effect of errors inherited from the
global models, effect of non-stationarity, etc.). The list of downscaling experiments includes 1) 
cross-validation with perfect predictors, 2) GCM predictors and 3) pseudo reality predictors
(see Maraun et al. 2015, Earth’s Future, 3, doi:10.1002/2014EF000259, for more details).
The results of these experiments are gathered, validated and publicly distributed through the VALUE
validation portal, allowing for a comprehensive community-open downscaling intercomparison
study.

As a result of the open call for contribution to the experiments, over 40 methods representative
of the main approaches (MOS and PP) and techniques (linear scaling, quantile mapping, analogs,
weather typing, linear and generalized regression, weather generators, etc.) were submitted.
This constitutes the largest and most comprehensive to date ensemble of statistical downscaling
methods. In this contribution, we present an overall validation of the first of the three
mentioned experiments, the cross-validation with perfect predictors, analyzing marginal and
temporal aspects of mean and extreme values to assess the intrinsic performance and added
value of statistical downscaling methods at both annual and seasonal levels. This validation
takes into account the different properties/limitations of different approaches and techniques
(as reported in the provided metadata) in order to perform a fair comparison. Thus, it is pointed
out that this experiment alone is not sufficient to evaluate the limitations of (MOS) bias
correction techniques. Moreover, it also does not fully validate PP since we don’t learn whether
we have the right predictors and whether the PP assumption is valid. These problems will be
analyzed in the subsequent VALUE experiments.
Communities across the world are experiencing the effects of unsustainable water management practices. Whether the problem is a lack of water, too much water, or water of degraded quality, finding acceptable solutions requires community-level efforts that integrate sound science with local needs and values. Our project uses regional climate simulation output and develops both a software technology (agent-based hydrological modeling) and a social technology (an iterative participatory approach to model development) that will allow communities to comprehensively address local water challenges. Using agent-based modeling (ABM), we are building a modeling system driven by regional climate data that includes a semi-distributed hydrologic process model coupled with agent (stakeholder) models. Information from the hydrologic model is conveyed to the agent models, which, along with economic information, determine appropriate agent actions that subsequently affect hydrology within the model. The iterative participatory modeling (IPM) process creates a learning environment in which all participants, including community members, are co-exploring relevant data, possible scenarios and solutions, and viewpoints through continuous interactions. IPM also facilitates continual development of the agent models.

Our initial work focuses on the impact of flood mitigation and conservation efforts on reducing flooding in an urban area. We are applying all research elements above to a regional watershed in the central U.S. The watershed offers many of the typical tensions encountered in water management, such as different perspectives between upstream farmers and downstream urban areas, competition for various types of recreational services, and increasing absentee land ownership that may conflict with community values. The work highlights the opportunities and challenges of engaging public discourse in exploring water management issues in the face of evolving climate and other changes imposed on the coupled natural and human system.
PA-045

Evaluation of 12-km ERA-Interim simulations from multiple models and CORDEX domains over the eastern Mediterranean

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Although the Phase I CORDEX experiments mainly contain climate downscaling simulations at a grid spacing of about 50 km, several regional climate modelling groups are also producing output, within the same framework, at the 12 km grid. Climate information in this higher horizontal resolution is in principle more suitable for vulnerability, impact and adaptation (VIA) studies which are already under way given the available access of the CORDEX data through various internet portals. In this work we assess multiple 12 km CORDEX simulations driven by the ERA-Interim re-analyses for the period 1980-2010 with a focus in the eastern Mediterranean. This region of interest is constrained by the overlapping areas of the EURO, MED, AFRICA, and MENA CORDEX domains so it includes the southern Balkans, Anatolia, Cyprus and the Levant coast (including parts of Libya and Egypt). The 12 km multi-model (and multi-domain) climatology, variability, trends and extremes of temperature and precipitation are compared with observations from gridded datasets as well as from stations representative of the different climatic regimes of the region.
The MENA-CORDEX domain: progress and achievements

Panos Hadjinicolaou1, Grigory Nikulin2, and the MENA CORDEX Team3

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The Middle East and North Africa (MENA) CORDEX domain was established in 2012 when CORDEX was already running for about 3 years. Establishing of the MENA-CORDEX domain was user-driven by a need of regional climate information from the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR). Since then regional downscaling activities in the MENA region have been significantly growing together with number of participants involved. An active working group of several regional climate modelling teams from the region and Europe was successfully launched in 2014. The first MENA-CORDEX simulations were made openly available on the Earth System grid Federation (ESGF) in 2013 and more regional climate projections are expected. We provide a detail overview on the MENA-CORDEX activities describing the MENA-CORDEX team, GCM-RCM matrix and also show the first results used for climate change research, impact assessments and adaptation planning in the MENA region.
Dynamical downscaling with bias correction of the sea-surface conditions: The CGCM-AGCM-RCM approach using the CRCM5 over the CORDEX Africa domain

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In order to reduce the biases inherited from the CGCM that provides the lateral and sea-surface boundary conditions (BC) necessary to drive an RCM simulation, we present a 3-step approach (CGCM-AGCM-RCM) in which the sea-surface conditions (SSCs; sea-surface temperature and sea-ice concentration) from a CGCM simulation are empirically corrected and used as ocean lower BC for an Atmosphere-only GCM simulation (AGCM), which in turn provides the BC to drive an RCM simulation. We analyse the impact of this strategy on the simulation of the African climate, in particular, on the simulation of the West African Monsoon precipitation, using the fifth-generation Canadian Regional Climate Model (CRCM5) over the CORDEX-Africa domain. The experiment setup allows studying the impact of (1) the bias correction of SSCs, (2) the change of driving atmospheric model, and (3) the combination of both modifications on the CRCM5 simulations. The results indicate that the climate-change projections obtained with the 3-step approach are different from those obtained following the standard CORDEX protocol (CGCM-RCM).
The reliability of climate projections is improved by many samples from ensemble experiments e.g., decrease of a confidence interval for future temperature increase. However, the reliability improvement of climate projections assumes independence of each ensemble member of the experiment. With ensemble experiments whose members are dependent on each other, the estimate of effective degrees of freedom (EDoF) is needed to determine the reliability of climate projections.

The focus of this study is precipitation climatology, which is calculated by averaging over simulation periods and over ensemble members. Its EDoF is determined by an auto-correlation of ensemble-mean inter-annual variability and cross-correlations between ensemble members. In the present study, the value of the EDoF is directly calculated using a large ensemble of atmospheric general circulation model experiments with the order of thousands: 60 years times 100 (90) ensemble members for present (future) climate (d4PDF dataset). When estimating the EDoF, temporal and spatial averaging scales for precipitation is critical; for example, daily weather conditions from different ensemble members can be regarded as independent data, while the results of annual-mean precipitation can not. In addition, the EDoF for an extreme values, such as annual maximum daily precipitation can not. In addition, the EDoF for an extreme values, such as annual maximum daily precipitation can not.

We calculated the EDoF in various locations and with various temporal and spatial averaging scales. For example, the EDoF for daily and one-grid precipitation data in the mid-latitudes is virtually the same number of ensemble experiments times simulation years (Nens). Comparing the values of EDoF in locations, those in mid-latitudes and on continents are larger than those in the tropics and on ocean, respectively. More importantly, temporal and spatial averaging operation reduce the EDoF largely e.g., to one-tenth of Nens or less for seasonally- and domain-averaged precipitation. The degree of the EDoF decrease from Nens indicates the degree to which boundary conditions i.e., sea surface temperature for the atmospheric model, affect precipitation variabilities and reflects the type of precipitation phenomena. The information of the EDoF has to be taken into account to perform climate change assessments with confidence.
Benefit from using atmosphere-ocean coupled systems for summer dry bias of regional climate models over Central Europe

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A precipitation dry bias over major mid-latitude continents is a common problem of many atmospheric models. For Europe, several studies pointed out the dry bias problem of many regional climate models (RCMs) in summer. In the present study we investigated the benefit of using atmosphere-ocean coupled systems for the summer drying problem of regional climate models over Central Europe for two RCMs, the COSMO-CLM (hereafter CCLM) and the RCA4.

For CCLM, the atmosphere-only experiment at a resolution of 0.44° is compared with an experiment of the coupled system COSTRICE in which CCLM is coupled to an ocean and a sea-ice model, which are specifically designed for the North and Baltic Sea regions. The coupling ocean domain of the COSTRICE coupled system covers not only the Baltic Sea and the North Sea as other coupled systems but also a part of the North Atlantic Ocean. For RCA4, the atmosphere-only experiment at a resolution of 0.22° is compared with the coupled simulation of RCA4-NEMO. The coupling domain of RCA4-NEMO restricts the North Sea to a northern boundary set at 60°N but covers the entire Baltic Sea. CCLM and RCA4 are set up for the EURO-CORDEX domain. The coupling impact on the dry bias is analyzed for summer (JJA) seasonal means of 30 years (1979-2009) and especially for summer extreme precipitation. The E-OBS data on the 0.5° grid are used to evaluate the model performance.

The comparisons show that benefit of the coupling is different for the considered time-scales. For example, if we look at the long-term seasonal mean, the coupled and uncoupled simulations are mostly identical, which is the case for CCLM and RCA4 as well. However, if extreme precipitation is considered, especially for the Northerly circulation type (when the air flow from the North Atlantic Ocean passes the coupling domain – the North Sea), the simulations of the COSTRICE coupled systems are generally improved compared to the CCLM atmosphere only run. However, for RCA4, the benefit of coupling is unclear. The difference between RCA4 and RCA4-NEMO is insignificant also for extreme precipitation. The different behaviour of these two RCMs may be related to different sensitivities of the atmospheric model components to the change of SST over the coupling domain. The size and exact location of the coupling domain may be also an important issue, which should be investigated in a future study, e.g. by using a larger coupling domain for RCA4-NEMO.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-050

Added value of 3D-Var Data assimilation using WRF model in West and Central Africa

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This study aims at evaluating the ability of a Numerical Weather Prediction (NWP) model to capture the spatial distribution and the magnitude of atmospheric parameters during 6 recent intense events (15-17 June 2011, 23-25 August and 04-06 September 2012, 01-04 August 2014, 23-26 July 2014 and 15-18 September 2014) observed over Western and Central Africa, as well as the associated atmospheric and near surface conditions. For each event, two numerical experiments are performed using the Weather Research and Forecasting (WRF) regional model without (CNTL) and with (DA) data assimilation. Simulations are initialized with the Global Forecast System (GFS) data and Sea Surface Temperature (SST) data.

The analyses are updated with the three dimensional variational (3DVAR) technique using prep-bufr and radiance observational data in a time window of ±1 hours. The potential added value of data assimilation is addressed by comparing meteorological variables such as relative humidity, zonal and meridional wind components, 2 m temperature and rainfall with the European Center for Medium Range Weather Forecasting Reanalysis (ERA-I) and the Tropical Rainfall Measuring Mission (TRMM) satellite-derived rainfall product datasets.

WRF accurately simulates the spatio-temporal propagation and the zonally extended structure of rainfall, as well as of relative humidity, 2 m temperature and horizontal wind components. DA exhibits different biases, root mean square error and spatial correlation leading to mixed results in terms of outperforming CNTL. Results indicated that there is an increment in control variables implying an added value from 3DVAR to the initial and boundary conditions. Rainfall forecasts were improved by 15-25%. Uncertainties in the simulation of intense events in the study domain were noticed, but improvement resulting from DA was limited due to lack of assimilated data in this region.
The South Asian climate is influenced mainly by three jet streams; a low level Somali jet, and two upper tropospheric jets - the Sub-Tropical jet and the Tropical Easterly jet. The current study evaluates the performance of the 4th release of the Rossby Centre Regional Climate model RCA4 over CORDEX South Asia, for the summer and the winter seasons from 1980-2005, with particular focus on the jet variability. The RCA4 simulations together with the deriving data sets; the general circulation model EC-Earth and the ERA-Interim reanalysis data are compared with the Climate Research Unit (CRU) data. The model is further examined over two sub-domains, which are the representative of the seasonal precipitation climatology. The results suggest that RCA4 successfully captures the main climatological features of both the seasons. The biases in the deriving data sets are amplified by the regional climate model, hence an overestimation in the RCA4 simulated surface temperature and mean sea level pressure. The spatial extent of the jets is reasonably well captured by the RCA4 in spite of a weak jet representation in EC-Earth. However the intensity of the jet is not very well simulated by the RCA4. Moreover, the moisture transport from the Arabian Sea during the summer is too pronounced in RCA4_ECEarth resulting in enhanced monsoon rainfall over the north-western parts of India. The Somali jet gets stronger during the wet summer monsoon years while the Tropical Easterly jet becomes weak. Wet-minus-dry composites in the winter shows strengthening (weakening) of the Subtropical jet over the western (eastern) parts of South Asia in both RCA4 simulations.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-052
Towards a framework for regional system modeling
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The changing climate is a challenge for regions all over the world. Decisions and actions within these regions should take into account mitigation of further warming as well as adaptation to the unavoidable climatic changes. Thus, they should be climate-responsible. For managing a region, e.g., a river delta or alpine valley, a comprehensive knowledge of the whole system is necessary. This includes climatic as well as non-climatic drivers.

Together with scientific partners, GERICS is working on a framework for regional system modeling. Depending on the region of interest, different processes and boundary conditions are important. The framework for regional system modeling will give the basis for selecting and connecting different model components depending on the region.

Some questions that arise in this process are:

How to connect the single components to a coupled system? E.g., how to couple a regional climate model and an economic model or spatial planning model? How to construct the interface between the various models as the concept of modeling could be quite different? How to generate a framework which is transferable to other regions? And how to implement the regional characteristics into this framework?

The process of developing such a framework is strongly related to the WCRP CORDEX initiative. It aims at regional climate change information at local scales and at being a transferable methodology to help regional experts to develop and assess scenarios for their region of interest.

In this presentation, the steps towards the framework for regional system modeling are presented. We are looking forward to a vivid discussion with potential partners in the audience.
PA-053

Contribution of Fine-scales to Added Value in Precipitation Simulated by High-resolution CORDEX South Asia Regional Climate Models and Observations

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The key issue in the evaluation of nested regional climate models (RCMs) is to determine whether RCM simulations improve the representation of climatic statistics compared to the driving data, that is, whether RCMs add value. In this study we will first compare the statistics of extremes (e.g., 90th percentiles) of daily precipitation during summer monsoon season of CORDEX South Asia RCMs to those of the driving CMIP5 AOGCMs over the present climate, in order to investigate whether RCMs are effectively able to add value, at regional scale, to the performances of AOGCMs. Then the concept of the potential for small-scale added value (PAVss) suggested by a given RCM simulation used in earlier studies to assess the potential benefits of using high-resolution RCMs to simulate present climate precipitation will be used to quantify the PAV of CORDEX South Asia RCMs. Further the PAVss dependence on several factors such as the temporal scales, the season, the region and the climate statistics of analysis will be investigated. The PAV will also be estimated using high-resolution datasets based on observations for evaluating the sensitivity of changing resolution in the real climate system.
Climate negative consequences on Africans are neglected in the global climate change negotiations since the Kyoto protocol. One paradox of global climate change politics and scientific governance is its inability to check the excesses of a tropical climate that has to do with abundant life and speedy death. The second paradox is the fluctuation in weather that causes flood and drought. How could Africans end climatic disasters and improve meteorological services and conditions to Africa’s desire? The third paradox of global climate change politics and scientific governance in Africa is its monumental failure to agree that Africa’s economic underdevelopment does not lie in ecology and climate. It lies in the absence of political will and leadership. The paper argues that if Africa’s climate refuses to freeze, could Africa’s political economy be permitted to thaw amidst the labyrinth of climatic and colonial impediments? Climate change leaders are using ecological metaphors to describe Africa’s climate woes, but nowhere in the world are those metaphors more powerful and environmentally determined than Europe and South America. Rising concentrations of greenhouse gases are beginning to have impact on the North Atlantic or Arctic Oscillation where molecules of carbondioxide emit heat to space rather than draping it in the upper atmosphere. This stratospheric cooling favours a winter time influx of mild marine into northern as opposed to southern Europe. No one is yet sure about the effect of stratospheric cooling. The paper concludes that the current global climate response is slow, ineffective and inaccessible, because of power inequity in climate governance.

Keywords: climate change, politics, scientific governance, Africa.
Evaluation of aerosol optical properties in an ensemble of regional chemistry-climate coupled models over Europe


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The uncertainty of the atmospheric aerosol effects over the Earth's radiative budget is much higher than any other climate-forcing agent as greenhouse gases and clouds. With the aim of reducing this uncertainty and estimating the radiative forcing caused by this forcing agent, the study of atmospheric aerosols by chemistry-climate models is needed. Working group 2 (WG2) of the COST Action ES1004 investigates the importance of different processes and feedbacks in on-line coupled chemistry-climate models. With the aim of investigating these processes in more detail two relevant case studies are identified with an ensemble of simulations. In this context, the object of this work is to assess the representation of aerosol optical properties by different online-coupled chemistry-climate models and to determine whether the inclusion of aerosol radiative feedbacks improves the modelling outputs over Europe.

The evaluated data comes from regional air quality-climate simulations performed under the aforementioned exercise. A Euro-CORDEX compliant domain has been used. The cases studies are two important aerosol episodes during 2010; the Russian wildfires episode and a Saharan desert dust outbreak. The simulations are run for three different cases, differing in the inclusion (or not) of aerosol-radiation and aerosol-cloud interactions. The evaluation of the simulations has been performed by using classical statistical figures. The evaluated variables are aerosol optical depth (AOD) and the Angström exponent (AE, which gives an idea of the particle size) at different wavelengths. The observational data used are provided by different satellite sensors as MODIS, OMI or SeaWIFS; and ground-based instrument network as AERONET or EARLINET.

The preliminary results indicate a general slight improvement of AOD in the case of including the aerosol radiative effects in the model and a slight worsening for the Angström exponent for some stations and regions. Regarding the correlation coefficient, both episodes show similar values of this statistic, which are higher for AOD. Generally, for the Angström exponent, the model tends underestimate the variability of this variable. Despite these results, the domain and time averaged performance statistics do not indicate a general improvement when aerosol feedbacks are taken into account; however, they contribute to improve the spatio-temporal variability of the studied variables in the Euro-CORDEX domain.
PA-056

The Performance of RegCM with Different Convective Parameterization Schemes in the Mid Latitude Himalaya Region

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The realistic simulation of RCMs and its suitable use in impact studies is greatly depend on the validation, configuration, and integration of different models and processes. In this connection, there arise the issues of the selection of an appropriate Convective Precipitation Scheme (CPS) and the bias correction for different regions which greatly depends on the performance of these schemes. Hence, this study is conducted to explore the performance of different schemes under coupled and uncoupled RCMs with Ocean Model for East/South Asia region. Different schemes under RCM are integrated and validated for East/South Asia region after dividing it in three sub regions as Huang-Huai-Hai (3H), Tibetan Plateau (TP), and North Pakistan (NP). The output of RegCMs is used as input to the University of British Columbia (UBC) hydrological model in offline mode for the future climatic changes and to explore the performance of two-way coupling of RegCMs with Ocean Model for the period of 2041-2050 and 2071-2080. To explore the coupled setup of RegCM4 and MITGCM, RegCM4 is run independently (uncoupled mode) and concurrently (coupled mode) with MITGCM. Results show that RegCM4 is able to properly reproduce the circulation of East/South Asian monsoon. Over Western Ghats, Bay of Bengal, and southeast of China, Grell scheme exhibited the least Root Mean Square Error (RMSE) values as compared to the observed data. Over Huang-Huai-Hai (3H), Tibetan Plateau (TP), and most part of China, Tiedtke scheme simulated summer precipitation with higher correlation (0.6-0.85). However, none of the CPSs is able to capture the seasonal variation over North Pakistan (NP). The RegCM’s data biases were corrected before using as input to calibrated UBC model. Projections of future climatic change show increased air temperature and precipitation by 1.8oC and 14% for 2041-2050 and 4.3oC and 23% in 2071-2080 respectively. The results of RegCM4 show the increased temperature during spring and winter. The regions of higher latitude show more increase in precipitation and temperature than lower latitudes. Future runoff is projected to increase by 36% in 2041-2050 and 56% for 2071-2080 in summer season. Moreover, the rate of increased temperature is high during 2041-2050 while relatively low in 2071-2080. The results of both coupled (RegCM and MITgcm with BATs and CLM) and uncoupled approaches were also compared and preliminary results were obtained for the Mediterranean region.
Modeling of the effects of AR landfalls in the US Pacific coast on the winter precipitation and temperatures in western US: Sensitivity to resolutions and spectral nudging scales

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Atmospheric river (AR) landfalls in the US Pacific coast play an important role in shaping the winter climate of the western US (WUS) and delivering a significant fraction of its fresh water. They are frequently related with heavy precipitation and flash flooding events and are associated with characteristic surface temperature anomalies. Thus, the capability of climate models to accurately simulate AR landfalls and their key hydrologic effects is an important practical concern for WUS, from flood forecasting to future water resources projections.

In order to examine the fidelity of climate model simulations, including the influences of spatial resolution and applications of spectral nudging, a NASA team has performed hindcast experiments using the GEOS5 GCM and the NASA Unified WRF (NU-WRF) regional model over a decade from Nov 1999 to Oct 2010. This study examines the skill of these hindcasts in simulating the key footprints of landfalling ARs in the WUS region on precipitation and temperatures in the WUS region. Using an AR-landfall chronology based on an application of a set of intensity and geometry criteria to the vertically-integrated water vapor flux calculated from the MERRA2 reanalysis, we have analyzed the observed and simulated precipitation and temperature anomalies associated with wintertime AR landfalls along the US Pacific coast. Model performance is measured using metrics including regional means, a skill score based on correlations and mean-square errors, Taylor diagrams and the PDF skill score in three “Bukovsky regions” in WUS. Results show that models simulate the AR-related anomalies of precipitation more reliably than the corresponding surface temperature anomalies. Model performance also varies according to regions. The AR temperature anomalies are well simulated in most of the WUS region except PNW. For precipitation, simulations with finer spatial resolution tend to generate larger spatial variability and agree better with the observations (i.e. PRISM data set) in most regions. Such a systematic resolution dependence of spatial variability is not found for temperatures. For example, MERRA2 often outperforms finer-resolution NU-WRF runs in simulating temperature variability within subregions. All model simulations and MERRA2 well represent the variations in the daily precipitation and temperature PDFs according to AR landfall locations in the all three Bukovsky regions considered, at least qualitatively.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-058

A multi-CORDEX-domain study with the Rossby Centre regional climate model RCA4

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The Swedish Meteorological and Hydrological Institute (SMHI) has contributed to CORDEX by performing a large number of regional climate model simulations with the Rossby Centre regional climate model RCA4. Reanalysis-(ERA-Interim)-driven simulations have been undertaken followed by downscaling of global climate model (GCM) projections for a majority of the CORDEX domains. Up to ten GCMs have been used for each domain under one or more of the RCP-scenarios 2.6, 4.5 and 8.5. In this study results are compared over different CORDEX domains with a primary focus on Africa, Europe, South Asia and South America where all ten GCMs have been downscaled. An important goal is to investigate the ability of RCA4 to produce realistic climate conditions in different climate zones when driven by reanalysis. Secondly, we analyse the GCM-driven runs both for the control period and for future conditions under different RCP-scenarios. Focus in this part of the work is on consistency between RCA4 and the underlying GCMs both in terms of performance in the recent past climate and in terms of the simulated climate change signal. One important result that shows up in some regions and seasons is that the simulated spread in the climate change signal is sometimes considerably smaller in RCA4 compared to that in the GCMs. We attribute this to the description of local and regional processes that have a strong influence on the regional climate.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-059

Representation of present day Arctic climate and future changes in regional model simulations with RCA and RCAO

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The regional atmosphere model RCA and the regional coupled atmosphere – ocean – sea ice model RCAO are used for downscaling ERA-interim data and CMIP5 historical and scenario simulations. We analyzed the effect of coupling the ocean-sea ice component to the regional model system. Further, we performed downscaling simulations with and without spectral nudging to assess the effect of constraining the large scale atmospheric circulation to the forcing data. The results are compared to those of the global models to analyze differences and possible added values in the regional simulations.

Both RCA and RCAO using ERA-interim as boundary conditions show seasonal SLP biases in the order of several hPa. The biases are strongly reduced using spectral nudging techniques; the bias reduction is more pronounced in RCA compared to the coupled version.

Regional historical simulations using global models as boundaries show similar biases of the large scale atmospheric circulation and temperature patterns as the global models. Often, the large scale bias patterns from the global simulations are reflected in the regional downscalings. However, locally, biases can vary strongly between global models and their regional downscalings. Using spectral nudging towards the global models resulted in a slight reduction of wind biases with positive effects for the sea ice representation in RCAO.

The projected future changes are dominated by strong warming in the Arctic Ocean area, strongly increased precipitation and reduced SLP in most of the year. The large scale change patterns in RCA are dominated by the simulated changes in the global models but regional differences occur. While atmospheric circulation changes are also dominated by the lateral boundaries, temperature changes in RCAO differ strongly from both RCA and the global originals, indicating the importance of the surface boundaries. The warming in RCAO is larger in summer but substantially smaller in winter than in RCA. The RCAO downscalings tend to simulate stronger sea ice extent variations and somewhat earlier summer ice free conditions than the global models.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-060

Coupled atmosphere-ocean regional downscaling over the Arctic with ROM model for RCP8.5 scenario

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The Arctic is a key element of the global climate system. According to climate model projections from the recent IPCC report, the dramatic changes of the Arctic climate system will continue in future decades. While IPCC models mostly agree on general trends for many climate parameters (e.g., temperature, precipitation, sea ice), there is a considerable spread when it comes to details, like the magnitude of the changes and their spatial patterns. The most notable example for such uncertainties is the sea ice projections for the Arctic. Coupled atmosphere–ocean RCMs have demonstrated improved skill in comparison to uncoupled RCMs for domains that include considerable amount of ocean surface. This is particularly true for the Arctic, where the ocean–atmosphere feedbacks are very important. Here we present results of regional downscaling over the Arctic region for RCP8.5 scenario (MPI-ESM boundary conditions) using the regionally coupled ROM model (REMO/MPIOM/HD). In order to investigate influence of coupled region, we perform downscaling for three different spatial domains. Preliminary results show that temperature and precipitation change patterns are similar among domains, while patterns of the mean sea level pressure change are quite different. We also analyze in detail differences between original GCM simulation and downscaled results as well as projected sea ice retreat.
PA-061

The role of observational reference data for climate downscaling: Insights from the VALUE COST Action

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VALUE is an open European network to validate and compare downscaling methods for climate change research (http://www.value-cost.eu). A key deliverable of VALUE is the development of a systematic validation framework to enable the assessment and comparison of downscaling methods. Such assessments can be expected to crucially depend on the existence of accurate and reliable observational reference data. In dynamical downscaling, observational data can influence model development itself and, later on, model evaluation, parameter calibration and added value assessment. In empirical-statistical downscaling, observations serve as predictand data and directly influence model calibration with corresponding effects on downscaled climate change projections.

We here present a comprehensive assessment of the influence of uncertainties in observational reference data and of scale-related issues on several of the above-mentioned aspects. First, temperature and precipitation characteristics as simulated by a set of reanalysis-driven EURO-CORDEX RCM experiments are validated against three different gridded reference data products, namely (1) the EOBs dataset (2) the recently developed EURO4M-MESAN regional re-analysis, and (3) several national high-resolution and quality-controlled gridded datasets that recently became available. The analysis reveals a considerable influence of the choice of the reference data on the evaluation results, especially for precipitation. It is also illustrated how differences between the reference data sets influence the ranking of RCMs according to a comprehensive set of performance measures.

Second, a large number of empirical-statistical downscaling methods is calibrated and validated against observational reference data reflecting conditions at different spatial scales: the point/station scale and the aggregated spatial scale as represented by the gridded EOBs 0.22° dataset. Evaluation reveals a dependency of the calibrated model parameters on the choice of the reference data and, hence, a general scale dependency.

In summary, the results obtained highlight the central role of observational reference data for the development, calibration and validation of climate downscaling methods. Their reflected spatial scales should closely match the respective target scale of the downscaling, and calibration and evaluation efforts should consider an ensemble of observational data sources in order to account for reference data uncertainty.
PA-062
Patterns of 21st Century Climate Change in the European Alps: The CORDEX RCM ensembles

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The European Alps are a hot spot of climate change and of related impacts on a large variety of natural and socioeconomic systems. Due to their physiographic complexity and their location between distinct climatic zones climate change and climate impact assessments, however, are challenging and often associated with substantial uncertainties. In particular, previous studies have highlighted the added value of high-resolution climate models to capture fine scale spatio-temporal Alpine climate variability and to assess climate change impacts for high elevation regions.

Against this background, we here exploit the currently available CORDEX multi-GHG-multi-model ensembles to assess 21st century climate change over the European Alps and its uncertainties, focusing on spatial change patterns including elevation dependencies. For this purpose we analyze the available EURO-CORDEX and Med-CORDEX ensembles carried out at resolutions of 12 km and 50 km. The results largely confirm the findings of previous studies based on the ENSEMBLES experiments, but also yield a number of new insights. The projected increase of winter precipitation, for instance, appears to be stronger and more robust while the model agreement on summer drying is less pronounced. Elevation dependencies of the near-surface climate change pattern can be substantial and are partly controlled by snow cover changes. Obvious model deficiencies in the Alpine area can be identified. For instance, several high-resolution RCM versions (12 km runs) tend to constantly accumulate snow cover at some isolated grid cells resulting in a distortion of the temperature change signal. It will be discussed how such issues could be handled, in particular for subsequent statistical downscaling and bias adjustment applications.
Implementation of the CORDEX climate information for assessing the damage risks of historic buildings

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The recent research shows that the preservation of the cultural heritage of Europe is urgent because it is particularly vulnerable to the climate change. Thus the aim of the large-scale integrated FP7 EU project “Climate for Culture” was to assess the damage risk, the economic impact and the mitigation strategies for sustainable preservation of the cultural heritage in the times of climate change.

The target of the project was to apply the regional climate model REMO alongside with the new building simulation tool to predict the future indoor climate conditions. The high-resolution climate simulations were performed on a horizontal grid of about 11 km, 27 levels are applied on the vertical grid. The IPCC RCP4.5 emission scenario was made used of. A series of 30-year time slice experiments were performed. These are the scenario simulations for the near (2021 to 2050) and far future (2071 to 2100) climate and the control simulations for the recent past (1961 to 1990).

In the presentation the results of the climate simulations are presented. These were provided both for each of the selected historical buildings and for entire Europe. The results were further used as an input for other work packages. Besides in cooperation with other project partners the list of climate variables useful for the damage risk assessment was created.
Vulnerability study of the sector of agriculture in Guinea: case of the periurban farmers community of N’Zerekore county in the South-east of Guinea

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The objective of this present work is to evaluate the present and future climatic and socio-economic vulnerability of the farmers and the means of existence of nine (09) villages that surround the urban township of Zérékoré (Guinea) on the basis of the analysis of the investigation results in situ and of the data climatic and climatic agro of temperature and precipitation of 1960-2011, and to propose some adequate strategies of adaptation then. For this analysis we used the method of the matrix of the climatic risks of the institute of the World Bank combined with approach Crystal. The perceptions farmers showed a shortening of the season of rains, a decrease of the rainfall, to the level of the survey zone. Otherwise in the context of a continuous increase of greenhouse gases on a world level, particularly in the scenario SRESAA11MI models UKHADCM3, MIROC-HI, GISS-ER, UKHADGEM of the MAGICC/SCENGEN forecast by 2025, 2050, 2075 and 2100, a rise of the temperatures respectively of 0,75°C, 1,58°C, 2,41°C and 2,96°C. In the same way, these models forecast a reduction in rainfall of - 0,8% at 2025 follow-up of an increase of 0,9% into 2050 and one drastic fall of -10%, 2075, which will continue to reach 11,6% into 2100 compared to the reference 1961-1990. As for scenario SRESBASF models CCCMA-31, CCSM30, CSIRO-30, ECHO-G of couple MAGICC/SCENGEN envisage, at horizons 2025, 2050, 2075 and 2100 a rise of the temperatures respectively of 0,69°C, 1,51°C, 2,49°C and 3,38°C followed by an increase in precipitations of 0,1% into 2025, then decrease to 0,2% in 2050 then increase of 1% in 2075 and 1,8% at horizon 2100 compared to the reference 1961-1990. The confrontation of the impacts of the four (4) risks identified with the capacities of adaptation of the farmers related to their means of existence to release their vulnerability which remains high because socio-economic precariousness and their strong dependence on only one source of income which is agriculture. Four (4) strategies of adaptation relating to the improvement of the agricultural production and the diversification of the sources of income were proposed among which two (2) were declined in priority projects.

Key words: climatic risks, impacts, mean of existence, adaptation, vulnerability, rural zone periurbanes,
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-065

Running a user-friendly regional climate model on a common PC: a capacity building activity (not only) for Africa.

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Producing/Running climate projections with a regional climate model (RCM) has the potential to improve (a) the understanding of the climate system as well as (b) the knowledge about future climate changes. Therefore, giving access to a RCM can be considered as a capacity building activity. As research activity, running RCMs is restricted to that part of the climate community that has access to modern high performance computing facilities. Configuring the model and keeping the simulation running requires knowledge of a lot of technical details. We supply a preconfigured version of the RCM Remo that is featured with a user-friendly GUI. Furthermore, in order to keep simulation time as short as possible, we port part of the calculations to the graphical processing unit.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-066

Improved simulation of precipitation on the regional scale by coupled climate and hydrology modelling

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The complexity of precipitation processes makes it difficult for climate models to reliably simulate precipitation, particularly at sub-grid scales, where the important processes are associated with detailed land-atmosphere feedbacks like the vertical circulations driven by latent heat that affect convective precipitation systems. In this paper we find simulations of precipitation using an interactively coupled regional climate system model comprised by a regional climate model and a hydrological model to be significantly improved. The model dynamically couples the DMI-HIRHAM5 regional climate model to a highly detailed fully distributed hydrological model - including groundwater-, overland- and river flow as well as land surface-atmosphere fluxes of water (evapotranspiration) and energy. The combined regional system model is found to reduce the precipitation bias considerably compared to the regional climate model alone. For a six year simulation period (2004 – 2010) covering a 2500 km2 catchment, substantial improvements in the reproduction of local precipitation dynamics are seen for time scales of approx. seasonal duration and longer. These results are attributed to a more complete treatment of land surface feedbacks. The local scale effect on the atmosphere demonstrates that coupled high-resolution climate-hydrology models including a detailed 3D redistribution of sub- and land surface water have a significant potential for improving climate projections and even diminishing the need for bias correction in climate-hydrology studies.
The ClimEx Project: dynamical downscaling of a global climate model large ensemble at very high resolution for Bavaria and Quebec

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In the context of the ClimEx (Climate Change and Hydrological Extreme Events - risks and perspectives for water management in Bavaria and Quebec) project, the Canadian Regional Climate Model (CRCM5) is used to dynamically downscale the CanESM2 Large Ensemble (LE) from 2.8° (~310 km) spatial resolution to 0.11° (~12 km). The CanESM2-LE, produced by the Canadian Center for Climate Modelling and Analysis (CCCma), is a 50-member ensemble of global transient simulations with slightly different atmospheric initial conditions, each one being run from 1950 to 2100 under the RCP8.5 scenario of future greenhouse gases emissions. The CRCM5 was developed by Universite du Quebec a Montreal’s ESCER centre, in collaboration with Environment Canada.

Most climatic and hydrologically relevant variables are archived every 3 hours (hourly for precipitation) over two domains covering about 15M km² each and centred over the regions of Bavaria and Quebec. This unprecedented dataset in terms of size and resolution aims at better sampling natural climate variability and to provide a detailed representation of extreme events with return periods up to a thousand years. Within the ClimEx framework, the CRCM5-LE will hence be used as an input to a hydrological modelling chain, thus opening new views on flood risk management and proactive adaptation strategies.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-068

Are high-resolution NASA Unified WRF simulations credible tools for predicting extreme precipitation over the Great Plains?

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Accurate simulation of extreme weather events remains a challenge in climate models. Previous studies indicate that regional climate models (RCMs) better reproduce extreme precipitation with their higher spatial resolution than coarser resolution global climate models (GCMs). This study evaluated summertime rainfall characteristics simulated using the NASA-Unified Weather Research and Forecasting (NU-WRF) model at horizontal resolutions of 24, 12 and 4 km over the Great Plains in the United States. As reference datasets, we utilized hourly precipitation data from NASA's Global Precipitation Measurement (GPM) satellite mission and NCEP's Stage IV product that is based on ground radar and gauge observations. We examined the impacts of model spatial resolution, spectral nudging and cumulus parameterization on the hourly rainfall characteristics. The rainfall characteristics in the observations and simulations were defined as a joint probability distribution function (JPDF) between duration and peak intensity of rainfall events. The Regional Climate Model Evaluation System (RCMES) is an open source software suite developed jointly by NASA's Jet Propulsion Laboratory and the University of California, Los Angeles. RCMES facilitated the NU-WRF evaluations by processing a vast amount of observational and model datasets with high resolutions. Using RCMES allowed us to calculate the JPDFs in the observational and model datasets, and the overlapping area between both JPDFs to identify the consistency. This presentation will also highlight practical benefits of this JPDF metric for application to large model datasets. The performance of NU-WRF in simulating the rainfall JPDF is strongly dependent on spatial resolution. Our analysis indicates that higher spatial resolution improves the high-frequency variability and fine-scale spatial patterns of precipitation in NU-WRF. The simulation with the highest resolution of 4 km shows the best agreement with the observations in simulating short-duration downpour events over the Great Plains. The difference between the high-resolution simulation and the two observational datasets is within the uncertainty of the observations. The simulations with lower resolutions of 12 and 24 km show reasonable agreement only with the observational data whose resolutions are similar to the simulations.
PA-069

Evaluation of the coupled COSMO-CLM+NEMO-Nordic model with focus on North and Baltic seas

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The region east of the Baltic Sea has been identified as a hot-spot of climate change by Giorgi, 2006, on the base of temperature and precipitation variability. For this purpose, the atmosphere model COSMO/CLM has been coupled to the ocean model NEMO, including the sea ice model LIM, via the OASIS coupler (Pham et al., 2014).

Our aim is to find an optimal configuration of the already existing coupled regional atmospheric-ocean model COSMO-CLM+NEMO-Nordic. So far results for the North- and Baltic seas show that the coupled run has large biases compared with the E-OBS reference data. Therefore, additional simulation evaluations are planned by the use of independent satellite observation data (e.g. Copernicus, EURO4M).

First analyzes of the model run results show anomalies of atmospheric parameters that occur in a specific pattern. It is assumed that this could be caused by rebounds at the model boundaries. To obtain further insights into the observed patterns, it is planned to change the domain size of COSMO-CLM and to compare the results afterwards.
Winter storms in the Northeast United States in a suite of high resolution NASA Unified-WRF regional climate model hindcasts: Evaluation of precipitation-based impact metrics

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The ability of a suite of NASA produced regional climate model simulations to capture observed precipitation-based impact characteristics of winter storms over the northeastern United States is evaluated. Simulations are from the NASA-Unified Weather Forecasting and Research (NU-WRF) regional climate model (RCM) and a downscaled version of the GEOS5 global climate model with boundary conditions provided by the second version of NASA’s Modern Era Retrospective-Analysis for Research and Applications (MERRA) reanalysis. The RCM is run at 24, 12, and 4 km horizontal grid resolutions over North America with and without spectral nudging and the GEOS5 run is produced at 12 km and nudged to MERRA. Storm impact metrics for model evaluation are based on individual events defined at each grid cell as one or more consecutive days with measureable precipitation. Impact metrics include storm frequency, intensity, duration, and total storm accumulated precipitation. Impact metrics are computed for all storms and separately for storms occurring when the concurrent temperature is below freezing, to gauge the ability of the models to simulate realistic partitioning of frozen and liquid precipitation in the storm climatology. Results indicate that all simulations capture the key geospatial features of the storm impact metrics at all grid resolutions and for both nudged and non-nudged runs. However, the RCMs have an overall systematic high bias in storm frequency, intensity, duration, and total precipitation which is most pronounced over higher elevations. While higher resolution is able to capture more detail, including orographic effects on precipitation type and intensity, it is not clear that higher resolution necessarily leads to more realistic simulation of Northeastern US winter storm impacts.
Regional Climate Model (RCM) output is increasingly being used to provide forcing data for crop simulation models in studies of the impacts of climate change on agriculture. This presentation describes investigations into the use of RCM output for this purpose. Specifically, the benefits of higher RCM resolution and of bias correction are addressed. The investigations focus on the wheat belt of New South Wales (NSW) in southeast Australia and involve running wheat simulations for 22 sites distributed across this region. Wheat simulations forced with climate model data and observational climate data are performed.

An initial study focuses on simulated wheat yields for a recent climatological time period. “Errors” in simulated wheat yields for this period are defined as differences between wheat yields output by simulations forced with climate model output and wheat yields output by simulations forced with observational data. This definition allows wheat-relevant errors in the simulation of the climate to be isolated from errors in simulated wheat yields arising from imperfections of the wheat model. The initial study considers the benefits of higher resolution climate model simulations by analysing output from a single set of nested climate model simulations – a Global Climate Model (GCM) simulation and WRF RCM simulations at resolutions of ~50km and ~10km. The study focuses on raw climate model output, as opposed to bias-corrected data.

A subsequent study examines the ensemble of RCM simulations performed as part of the NSW and Australian Capital Territory Regional Climate Modelling project (NARClim) to support work on climate impacts and adaptation in the region. The NARClim ensemble comprises 12 sets of ~50km and ~10km nested WRF RCM simulations (four different GCMs providing forcing for three different WRF configurations) for each of the 1990-2009, 2020-2039 and 2060-2079 periods. Increasing atmospheric greenhouse concentrations throughout the 21st century (consistent with the IPCC SRES A2 scenario) are assumed. The analysis extends to include both errors in wheat yields simulated for the recent period and simulated changes in wheat yields during the 21st century under the increasing greenhouse forcing of the climate. The effects of both higher RCM resolution and bias correction on wheat yield errors and simulated future changes in wheat yields are considered.

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India is experiencing rapid urbanisation, and consequently water demand in urban areas is escalating rapidly. The city of Patna, the capital of Bihar state, is located in the central part of the Gangetic plains. The city is amongst the oldest surviving urban centers in the world, with a continuous recorded history dating back to the fifth century BC (Ramchandran 1999). Despite the fact that Patna is located on the banks of the River Ganga, residents are primarily dependent on groundwater aquifers for domestic water supply. Increasing pressure on groundwater supplies is exacerbated by the unregulated construction of deep tube wells, along with the development of apartment complexes to accommodate a mushrooming urban population. A comparison of data sets from 1960 to 2010 shows a deep aquifer decline of 2-4 m (Saha et al 2013). This raises concerns about Patna’s water supply security, and its economic vitality and sustainability.

In this environment, with already existing pressures on water availability and use, climate change puts further stress on water management and the sustainability of water supplies. Climate change is already having impacts on temperature. Observed average minimum temperatures have increased from 19.0°C to 20.5°C over the period from 1989 to 2009. Trends in temperature also interact with non-climatic factors, which complicate planning for water supply and demand and increases water insecurity.

Moreover, regional annual average monthly maximum temperatures are projected to increase 2.5°C by 2049, based on the ensemble average of 41 CMIP5 models and assumptions of moderate future increases in greenhouse gas emissions (i.e., RCP 4.5). These projected increases in temperature will put further stress on water supplies. Furthermore, based on informal interviews with water management personnel, it is clear that they lack information on and understanding of projected climate change impacts.

In order to address these vulnerabilities, and to increase the resilience of Patna in the face of projected climate changes, this research recommends building the capacity of city water managers to understand and incorporate climate information in urban planning and development processes. These rudimentary measures, which are needed just to address Patna’s non-climate water management concerns, are necessary as a stepping-stone to transformative pathways for addressing the uncertainties associated with climate change.
The Regional Earth System Model (RegESM) using RegCM4 coupled with the MITgcm ocean model: First assessments over the MED-CORDEX domain

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In the framework of global climate studies, there is an increasingly growing concern about the vulnerability of the Mediterranean region, where high population density and intense exploitation activities pose severe questions on the sustainability of terrestrial water management, both for the present and the future. Ocean modeling studies suggest that the Mediterranean thermohaline circulation could be weakened in conditions of global greenhouse warming, an event which would undoubtedly affect regional climate, possibly triggering global feedback processes. Experiments with the atmosphere-ocean coupled system confirmed that a good comprehension of Mediterranean processes requires the explicit inclusion of the feedbacks between the atmospheric and the oceanic components, thus achieving a complete, fully coupled description of the Mediterranean hydrological cycle, at the same time gaining new insights in our current ability to reproduce the atmospheric hydrological processes and to close the hydrological balance. These issues are addressed by the upgraded PROTHEUS system which was jointly developed by ENEA and ICTP.

Here we present a first evaluation of the performances of the new PROTHEUS system (called PROTHEUS 2.0) composed by the regional climate model RegCM4 (Giorgi et al. 2012) coupled with both the ocean model MITgcm (Marshall J. et al. 1997a,b) and the HD river model (Max-Planck's HD model; Hagemann and Dümenil, 1998) using RegESM (Regional Earth System Model) as a driver.

The three-component (atmosphere, ocean and river routing) fully coupled model exchanges sea surface temperature (SST) from the ocean to the atmospheric model, surface wind stress, energy and freshwater fluxes from the atmosphere to the ocean model, surface and sub-surface runoff from the atmospheric component to the river routing model (Max-Planck's HD model; Hagemann and Dümenil, 1998). In order to have water conservation within the system, the river routing component sends the calculated river discharges to the ocean model.

The evaluation is presented for the MED-CORDEX region using three simulations: the first one uses the regional climate model RegCM4 driven by the perfect boundary conditions provided by ERA-Interim and prescribed SST; the second one is performed only with the ocean component driven by a downscaled ERA-Interim data; and the third one is performed with the fully coupled modeling system (RegCM4,MITgcm and HD).
Climate change signals over Senegal River Basin using five Regional Climate Models of the CORDEX Africa simulations

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This study provides an overview of the impact of a statistical bias correction based on histogram equalization functions on a set of high resolution climate simulations over the Senegal River Basin. The bias correction is evaluated on precipitation and mean temperature during the present day climate (1979-2005) and thereafter applied on extreme precipitation and temperature towards the end of 21st century.

During the evaluation part, we found that the correction method was able to remove successfully the regional climate models (RCMs) biases for the spatial and temporal variations of precipitation and temperature.

Regarding the future changes of extreme precipitation (greater than 50 mm), the models diverge in predicting heavy rainfall events in the majority of the basin. However, an increase of extreme precipitation is found around the Guinean Highlands. The results show also an increase of dry days length and a decrease of wet days spells by all the RCMs, except one model that shows an opposite change of these climate indices. The bias correction affects mainly the magnitude of the climate change signals of extreme precipitation. Furthermore, the changes of warm nights based on minimum temperature are found to be more pronounced than the changes of warm days based on maximum temperature. The bias correction tends to reduce the warming of RCMs simulations. For both precipitation and temperature, changes under the Representative Concentration Pathways (RCP8.5) are the most pronounced with uncorrected data. Bias corrected RCMs data are potentially usefull for climate change impact studies over the Senegal River Basin.
The objective of this study is to explore the capability of the Regional Climate Model (RegCM) version 4.1 in simulating the extreme rainfall events in Pakistan with particular reference to monsoon season (July, August and September). We analyzed the quantitative impact of different resolutions and domain sizes on simulation of precipitation characteristics by RegCM and found a best suited parameter setting for the region of Pakistan. After selection of spatial resolution, we simulated an extreme precipitation event of July 2010 and compared it with the observed data of selected five stations to analyze the performance of RegCM quantitatively. One of these extreme rainfall events was during July 2010 when countrywide total precipitation during July–September 2010 was the highest since 1994 and the sixth highest in the last 50 years (PMD 2010). The criteria of 50mm/day rain was adopted as extreme in selected 5 stations among the potential monsoon dominated regions with slightly different geographical locations, which are Balakot, Islamabad, Lahore, Murree and Muzaffarabad. In this study we presented extreme rainfall events of July 27-30, 2010, simulated by RegCM and compared with the GPCP dataset and PMD observed station data. Using ERA Interim boundary conditions, RegCM4.1 well captured the extreme rainfall events of July 2010 as well as monthly mean value and 4 days averages were well in-accordance with the GPCP and observed station data.
PA-076

Climate change projections for the Upper Blue Nile (Abay) River Basin, Ethiopia

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This study investigates changes in the mean and extreme climate over the Upper Blue Nile (Abay) River Basin of Ethiopia due to projected global warming. COSMO Climate Limited-area Model (CCLM) regional climate model (RCM) was used to downscale the simulations of four global climate models (GCMs), namely: CNRM-CM5, EC-Earth, HadGEM2-ES and MPI-ESM-LR, forced by two Representative Concentration Pathway (RCPs), RCP4.5 and RCP8.5. The regionalized data were produced in the framework of the Coordinated Regional climate Downscaling Experiment (CORDEX) Africa project. Mean annual maximum temperatures in the Basin are projected to increase up to 3.06 0C under RCP4.5 and 5.06 0C under RCP8.5 by end of the 21st century (2070–2099) compared to the reference period (1981-2010). Similar warming trends are projected for the mean annual minimum temperature, which is expected to increase 3.06 0C up to 5.43 0C under RCP4.5 and RCP8.5, respectively. Model results also reveal large seasonal and spatial variations in warming. The warming is more severe during the spring season, with the changes being larger in the lowlands than in the highlands of the Basin. Decreases in annual total precipitation of up to -7.9% under RCP4.5 and -19.0% under RCP8.5 are projected by the end of century. The decrease is more severe during spring season, and in lowlands. However, projections for precipitation showed uncertainties between RCM runs. Results of the analysis of climate extremes show decreases in cold days (TX10p) and cold nights (TN10p), while increases in warm days (TX90p) and warm nights (TN90p). Increases in consecutive dry days (CDD) coincide with decreases in heavy precipitation days (R10mm) suggesting future intensification of dry conditions. Therefore, projections of the present study suggest the potential for considerable changes in the mean and extreme climate in the Basin and the need for mitigation measures.
Climate change projections for the Upper Blue Nile (Abay) River Basin, Ethiopia

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PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-078

The OptiBarn project - The effect of regional climate change on naturally ventilated dairy housings

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The OptiBarn project aims to develop sustainable adaptation strategies for dairy housings under climate change for Europe. Therefore region specific optimization rules for the climatisation of naturally ventilated barns (NVB) will be tested.

Naturally ventilated buildings are particularly vulnerable to the outside weather conditions due to their low adaptation capabilities. Thus livestock within the barn and outdoor weather are closely related. Especially weather extremes can have a strong impact on the animal wellbeing.

To estimate the effect of climate change on the livestock within the barn high resolution projections of the regional climate conditions are needed. With regard to the animal related stress and the natural ventilation of NVBs the two most important factors are temperature and wind field. Therefore we use simulations of the CORDEX-EUR-11 ensemble to capture both elements of the regional climate system in sufficient detail.

Concerning the regional climate modeling 3 goals were established:

1. The identification of extreme weather situations in terms of high temperature and local circulation features. Therefore we will establish a measure of animal related stress with regard to outdoor weather events.

2. Evaluation of the CORDEX-EUR-11 ensemble with regard to the identified extreme weather events. Use the ensemble to assess the effect of climate change on these events and to estimate the uncertainty and robustness of the change signal.

3. Downscale single events to very high resolution to generate boundary conditions for a high resolution barn-scale circulation model.

The barn-scale circulation model can be furthermore used to test different technical implementation of an optimized climatisation strategy for the barn under climate change conditions.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-079

Evaluating the added value of dynamically downscaled products from CORDEX over Eastern Africa Region

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Climate models are currently the most significant tools for understanding our climate. The procedure has always been to run Global Climate Models (GCMs) and then downscale their outputs to regional scales using either dynamical or statistical means. It has always been assumed that downscaling the GCMs outputs results in more accurate simulations due to the fact that Regional Climate Models (RCMs) are capable of representing the local forcing features of climate and are thus able to capture the inter-annual variability of regional climate. Although this is the basis for conducting the CORDEX experiments, it still remains to be proven and documented that these RCMs actually improve the simulations from their driving GCMs especially over the Eastern African region. The aim of this paper is to investigate whether downscaling global climate data adds value and if the RCMs confirm the observed decreasing trends in rainfall which is not reproduced by the GCMs. We use gridded observed datasets from the Climate Research Unit (CRU), and model datasets from both GCMs and RCMs focusing on the MPI-ESM-LR model which has been downscaled by most RCMs. Rainfall, and both minimum and maximum temperature simulations are our main focus in this study. Firstly, we examine the skill of the models in reproducing seasonal climate patterns associated with large scale climate systems, we then analyze the spatial correlations between the models and the observed and finally examine the annual and inter-annual variability of the models. The trend for the parameters under study will be computed for the observed, RCMs and the GCM. The results from this paper will provide the necessary information on the value of CORDEX datasets and therefore increase the confidence in the datasets for use in impact and disaster risk reduction studies in the Eastern African region which is characterized by frequent episodes of extreme climate events.
This work presents the REPAIR project and first results. The objective of REPAIR lies in studying the impact of the air quality-climate interactions (AQCI) and potential future emission reductions due to the increased use of renewable energies (including wind and solar) on climate change in Europe through its mitigating role in radiative forcing and air quality. For that aim, a series of climate experiments (coupling and uncoupling atmospheric chemistry) are conducted, covering the present (1991-2010) and future (2031-2050) climatologies. Different scenarios of global radiative forcing are taken into account, together with different levels of air pollution emissions in Europe. Also experiments include future scenarios with and without reduction in anthropogenic emissions resulting from the various renewable production estimates. These estimates are be based on specific targets set by the EU member states that commit to a major deployment of wind and solar farms. Therefore, the results obtained are used to assess the adequacy of these measures and facilitate future decision-making on climate change mitigation. To date, there are no similar studies addressing the problem from the multi-disciplinary approach required. On the other hand, originality and interest of this work is also due to the use of simulation tools incorporating dynamically complex interactions between climate, air quality and emissions. Moreover, results from REPAIR provide sufficient spatio-temporal detail to be useful from the point of view of reducing the uncertainties associated with climate change projections.
PA-081

Diurnal cycle of precipitation in a dynamically downscaled multiphysics regional climate ensemble using the Weather Research and Forecasting (WRF) model

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The diurnal cycle of precipitation is an important and fundamental cycle in Earth’s climate system. While many aspects of this cycle are reasonably well understood, climate models have struggled to accurately simulate the timing of the peak and the amplitude of the cycle. Most modelling studies have tended to focus on the influence of grid spacing and/or convective parameterizations. In this report, we use the Weather Research and Forecasting model to investigate the influence of these and other factors on WRF’s ability to reproduce the diurnal cycle of precipitation over the United States. Specifically, we investigate the influence of radiation, planetary boundary layer, microphysics and cumulus parameterizations on the timing and amplitude of the diurnal cycle of precipitation. In addition, we explore the value of dynamical downscaling through comparisons of the diurnal cycle in the global driving data with members of the multiphysics ensemble.
Regional climate models (RCMs) provide simulation of climatic variables at a higher resolution than their deriving General Circulation Models (GCMs), and are increasingly used in regional-scale projections of extremes. However, there is a debate about the value addition of RCMs in comparison to their deriving GCMs. Literature provide evidence for RCMs being skillful in terms of providing regional scale climate better than their deriving GCMs, whereas, there are studies suggesting that RCMs do not provide any value addition over their deriving GCMs. Here, we compared RCMs and their deriving GCMs to test their performance in the projections of severe heat wave characteristics over India. We used mean and variation of temperature as well as characteristics of severe heat waves to compare bias-corrected RCMs and GCMs. We found that RCMs reproduced the observed inter-annual and seasonal variability of temperature better than their deriving GCMs, thereby resulting in better simulations of intensity, duration and frequency of severe heat waves. Both RCMs and GCMs project an intensification of severe heat wave characteristics in India, with variation in magnitude. We also found that simulations by RCMs have higher inter-model uncertainty in projecting severe heat wave characteristics than those by their deriving GCMs. This will have implications in the assessment of heat waves impact on human health, particularly in the context of the fact that a small increase in extreme temperature may have a serious impact on health.
Simulating the influence of ENSO episodes on rainfall variability in the Philippines during the monsoon season

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The climate of the Philippines is strongly influenced by two types of monsoons: a southwest wind system during the boreal summer season and a northeast wind system during winter. Rainfall is often associated with these monsoon systems as it identifies atmospheric heat source locations, which mainly drives circulation in the tropics (Wang, 2002). Previous studies have shown that a significant percentage of the mean annual rainfall received by the Philippines is linked with the SWM season (Cayanan et al., 2011). These intra-seasonal systems, however, have large inter-annual variations that are influenced by larger scale circulations such as the El Nino Southern Oscillation (ENSO). Here we investigate the ability of a regional climate model (RegCM4) to simulate the effects of large scale atmospheric circulation changes due to ENSO on regional climate dynamics and local climate variability, especially rainfall, in the Philippines. Previous studies based on observation data, for example, have shown significant positive rainfall anomaly (negative anomaly) during El Niño (La Niña) years during the boreal summer and a reversal during fall (Lyon and Camargo, 2009; Lyon et al., 2006). Initial climate simulation results show that the model is able to capture the presence of anomalous low-level wind and the enhanced (reduced) westerly flow associated with the observed variability in rainfall during these ENSO episodes. Establishing the ability of a regional climate model to capture the regional dynamics behind local rainfall variability due to ENSO is important for analyzing potential changes in rainfall in the Philippines due future changes in the global climate.

References:


Downscaling seasonal hindcasts over eastern Africa in the EUPORIAS project

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EUropean Provision Of Regional Impact Assessment on a Seasonal-to-decadal timescale (EUPORIAS) is a four-year collaborative project funded by the European commission under the seventh framework programme (http://www.euporias.eu/). The EUPORIAS project intends to improve our ability to maximise the societal benefit of seasonal and decadal predictions. One of the EUPORIAS tasks is to assess the utility of dynamically- and statistically-downscaling methods to provide seasonal forecast data for impact models over eastern Africa. We present an overview of EUPORIAS downscaling activities in eastern Africa and show the first results comparing global and downscaled forecasts.

Five EUPORIAS partners using different regional climate models (RCMs) have downscaled the SMHI-EC-EARTH global seasonal hindcast over eastern Africa at about 25km resolution. The 5-month global seasonal hindcast consists of 15 members, initialized on May 1st and covers the period 1991-2012. Two streams of downscaling have been defined depending on resources: i) full hindcast with all 15 members and all years; ii) a smaller subset of the full hindcast. Another global seasonal prediction system - GloSea5 has been also downscaled by one RCM.

Additionally to the dynamical downscaling a couple of statistical downscaling methods have been calibrated for eastern Africa. Large-scale predictors from ERA-Interim were used for a set of predictor patterns and applied them to the SMHI-EC-EARTH hindcast to downscale May-September precipitation over Ethiopia, thus mapping the outcome of the RCMs over the region.
Bias-adjustment-related uncertainties in climate projections

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Climate information generated by state-of-the-art climate models has different kinds of uncertainties/limitations and one of them is ability of climate models to accurately simulate the complex climate system. All models are only an approximation of the real climate system and have different errors (biases) resulting in deviation of the simulated climate from the observed one. Since decades it has been widely recognised that climate model output, as an input to impact models, cannot be always used directly and an adjustment (bias correction) towards the observed climatology is necessary. Applying bias adjustment to climate model simulations can transform them in an unpredictable way and introduces a new unexplored level of uncertainty. Such uncertainties arise from the fact that bias correction transforms specific or “targeted” statistical properties of climate simulations while other properties can be strongly modified and some information may even be lost.

In this study we present results from a Bias Correction Intercomparison Project (BCIP). The main driver for initiating the BCIP was a need in a number of European Union projects (FP 6 and 7) to provide bias-adjusted simulations for impact modelling together with information about bias-adjustment-related uncertainties and limitations. Among these EU projects are: CLIPC, HELIX, IMPACT2C, GLOBAQUA, SPECS, EUPORIAS. Within the BCIP two experiments focusing on different climate zones have been designed, namely: one on the mid-latitude climate taking the Euro-CORDEX simulations (50km) and the second on the tropical climate using the CORDEX-Africa simulations. Here we are focusing on BCIP results from the mid-latitude experiment and trying to provide preliminary recommendations for applying bias adjustment to climate projections.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-086
Forecasting of the agricultural calendar for the culture of corn from models of global circulation of the atmosphere in the Plain of the Ruzizi

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The world is confronted to several major challenges of which the answer to the present economic crisis and the applicable strategy development to attenuate the ominous effects of climate change. That’s the way this survey had how objective to foresee an agricultural calendar from the climatic local station data adapted to models of global circulation of the atmosphere. The methodology adopted for this survey rested on the analysis of the evolution of the climate in answer to the different dangers incurred by the agriculture of the plain of the Ruzizi while considering the culture of the corn in the evolution of her agricultural calendar. The mathematical equations lasting a period of 30 next years for local station data have been generated. Of this analysis, it has been noticed that the climatic variables (temperature, precipitation) would present some meaningful variations according to Scripts during next thirty years (of 2015 to 2045); it had observed itself that the distribution of the precipitation has sudden a strong modification among the period of before and according to 1995, from where the agricultural calendar for the corn foresees a period of plantation to the month of November instead of September to get round the strong falls of rain to the month of October.

Key words: Climatic change, local station, agricultural calendar, corn,
Enhance and utilize the climate information from one RCM simulation

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Evaluate the RCM robustness through pattern scaling and CMIP5. Climate change on global scale involves changes in a large quantity of specific derived society related climate indices. A climate index could for example be the length of growing season or the number of annual dry days or a combination of the two, which is of substantial importance to society in a climate adaptation context.

Detailed climate indices require very high resolution downscaling from the global models in this case 5 km resolution carried out with the regional climate model HIRHAM5 with the global model EC-Earth on the boundaries.

Evaluation of RCM output robustness is usually done with an ensemble downscaled output with multiple RCM's and GCM's. Here we introduce and test a new technique; a translation of the robustness of an ensemble of GCM models from CMIP5 into the specific index from the RCM downscaling through year-by-year correlation between absolute temperatures and its corresponding index values from the RCM output.

Basically it is a two-step procedure. 1) Estimate the correlation between the absolute temperature and a given index for the RCM (HIRHAM5) simulation by a best fit to a second order polynomial. 2) Introduce the standard deviation from the GCM ensemble (CMIP5 simulations) to show the corresponding standard deviation of the index from the HIRHAM5 run through the correlation.

The technique will be tested and bias corrected on basis of observations as well as the CMIP5 ensemble.

We will present the test results from selected indices with focus on the future climate in Greenland calculated for the rcp4.5 and rcp8.5 scenarios.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-088
Climate Projection for Africa: RegCM4 Driven by HadGEM2-ES
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In this work we present climate projections over Africa in the context of the coordinated regional climate downscaling experiment from the Regional Climate Model version 4 (RegCM4) nested in HADGEM2-ES global model. The projections consider the RCP8.5 scenario from Intergovernmental Panel on Climate Change (IPCC) and two time-slices: present (1980–2005) and future (2006–2099) climates. In the future it is found that, seasonal statistics are not always improved by the downscaling. In general, the geographical distribution of mean surface temperature, sea level pressure and precipitation is affected by the boundary conditions. The Regcm4 is generally able to better represent the annual cycle of precipitation, in particular over Southern Africa and the West Africa monsoon area. In the future, RegCM4 projections indicate cold bias over the Sahara and North Africa region, and a weak warm bias over central and southern Africa, which is more pronounced in the future period. The Regcm4 is generally able to better represent the annual cycle of precipitation, in particular over Southern Africa and the West Africa monsoon area. The lifecycle of the Africa monsoon was also investigated in the present and future climates. In the future, the projections show a slight delay of the beginning of the rainy season, resulting in a small reduction of the Africa monsoon length.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-089

Methodology for qualitative uncertainty assessment of climate impact indicators

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The FP7 project "Climate Information Portal for Copernicus" (CLIPC) is developing an integrated platform of climate data services to provide a single point of access for authoritative scientific information on climate change and climate change impacts. In this project, the Climate Service Center Germany (GERICS) is in charge of the development of a methodology on how to assess the uncertainties related to climate impact indicators.

Existing climate data portals mainly treat the uncertainties in two ways: Either they provide generic guidance and/or express with statistical measures the quantifiable fraction of the uncertainty. However, none of the climate data portals give the users a qualitative guidance how confident they can be in the validity of the displayed data. The need for such guidance was identified in a CLIPC user consultation.

Therefore, we aim to offer an uncertainty assessment that provides the users with climate impact indicator-specific guidance on how confident they can be in its validity. We will present an approach that provides information on the importance of different sources of uncertainties associated with a specific climate impact indicator and how these sources affect the overall 'degree of confidence' of this respective indicator.
The climate of the Himalayan region is changing rapidly - temperature is increasingly high and rainfall has become unpredictable. IPCC predicts that average annual mean temperature over the Asian land mass, including the Himalayas, will increase by about 3°C by the 2050s and about 5°C by the 2080s and the average annual precipitation in this region will increase by 10–30% by 2080s. Climate and the human activities can influence the land cover status and the eco-environmental quality. There are enough evidences that there is strong interaction between climate variability and ecosystems. A project was carried out in Gandaki river basin in central Nepal to analyze the relationship of NDVI vegetation index with the temperature, rainfall and snowcover information. The relationships were analyzed for different landuses classes-grassland, forest and agriculture. Results show that the snowcover area is decreasing at the rate of 0.15% per year in the basin. The NDVI shows seasonal fluctuations and lightly correlated with the rainfall and temperature.
Target Group Adapted Visualization of the EURO-CORDEX Ensemble Results

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One challenge for climate services is to provide complex information tailored to different target groups without loss in scientific depth and correctness.

In case of the communication of climate projection results, this includes that in addition to the mean changes, also the bandwidth and robustness of the projections must be communicated.

Depending on the level of expertise and on the intended use of the information, the same information must be presented differently to different groups to ensure that the main message will be understood.

Based on the precipitation projections for Germany from the EURO-CORDEX simulations, we will present a palette of target group specific products, ranging from simple imagery to complex analyses and visualizations of the ensemble statistics.
PA-092

Assessing value-added by high-resolution regional simulations of climate-relevant aerosol particle properties

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Atmospheric aerosol particles (i.e. liquid and/or solid droplets suspended in air) are one of the largest sources of uncertainty in climate change projections. This is in part because particle direct and indirect radiative effects vary with particle size and composition and the fundamental processes that both dictate particle size distributions, composition and concentrations exhibit high variability in space and time. Our analyses are focused on application of WRF-Chem at unprecedentedly high-resolution to examine fundamental properties (e.g. e-folding scales of aerosol particles) and “value-added” of ultra-high resolution simulations in characterizing properties and distribution of climatically relevant aerosol particles.

We are applying the Weather Research and Forecasting model with coupled chemistry (WRF-Chem) to simulate over North America during 2008 at 12 km and 60 km resolution. We assess model fidelity in terms of the ability of this model to describe the spatio-temporal variability of atmospheric aerosol particle properties relative to a suite of NASA satellite-borne and ground-based remote-sensing observations, in addition to in situ observations of particle size distributions and chemical composition. Our results indicate that applying the model at 12 km does improve model skill (measured for example using the Brier Skill Score) in terms of wavelength specific aerosol optical depth even when regridded back to 60 km, but the improvement in skill is highly seasonal. Improvements in the simulation of extreme events is highly dependent on metric used to evaluate value-added, the specific target data set to quantify model skill, and differences in the simulation of key physical fields such as specific humidity as a function of changing model resolution.

It is hoped that results from this research will provide key insights into the required scales for future simulations and thus strategies to optimize efficient use of numerical resources, reduce the uncertainty in aerosol particle impacts, and thus improve the fidelity of, and confidence in, future climate projections.
High-resolution model simulations for deciphering the recent changes in the South Asian monsoon precipitation distribution


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Rising propensity of precipitation extremes and concomitant decline of summer-monsoon rains are amongst the most distinctive hydroclimatic signals that have emerged over South Asia since 1950s. A clear understanding of the underlying causes driving these monsoon hydroclimatic signals has remained elusive. Using a state-of-the-art global climate model with high-resolution zooming over South Asia, we demonstrate that a juxtaposition of regional land-use changes, anthropogenic-aerosol forcing and the rapid warming signal of the equatorial Indian Ocean is crucial to produce the observed monsoon weakening in recent decades. Our findings also show that this monsoonal weakening significantly enhances occurrence of localized intense precipitation events, as compared to the global-warming response. A 21st century climate projection using the same high-resolution model indicates persistent decrease of monsoonal rains and prolongation of soil drying. Critical value-additions from this study include (a) realistic simulation of the mean and long-term historical trends in the Indian monsoon rainfall (b) robust attributions of changes in moderate and heavy precipitation events over Central India (c) a 21st century projection of drying trend of the South Asian monsoon. The present findings have profound bearing on the regional water-security, which is already under severe hydrological stress.
There is a strong scientific consensus that warming of the climate system is a fact that can no longer be ignored for human health particularly in cities of developing countries. For instance, evidences show that climate change is shifting the overall temperature distribution and thus increasing the frequency of heat waves around the world. Despite these evidences and the need for decisive actions on climate change impacts many issues remain as conceptual and methodological complexities that are open for multidisciplinary discourse These puzzles serve to cast aspersions on the ability of analysts of climate and health relationships to be able to produce concrete and flawless evidences of the postulated impacts. This paper examines some of these puzzles, using the example of urban health analysis in most cases, with a view to challenging meaningful academic discourse in a multidisciplinary environment. The study draws on grey literature from both the climate and public health sciences to identify largely unresolved issues in the climate change and human health nexus. The implications of the challenges described above are enormous for the kind of progress made in climate and environmental change research particularly as it affects urban health analysis. An immediate implication of the foregoing complexity is the development of the climate skeptics who claim that the argument that the present-day processes of global warming are produced by human activity is not proven. The paper posits that it would be profitable to adopt the concept of Global environmental change instead of Climate change. The former is broader and much flexible in interdisciplinary discourse while the latter is narrower and susceptible to dispute by climate skeptics. This will allow us to emphasis the effects of 'Environmental' rather than 'climate' in the issue of urban health.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-095

The BALTEX Box Revisited: The Energy Budget of the Baltic Sea in the Coupled Regional Climate Model REMO-BSIOM

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In this study the heat budget of the water and ice body of the Baltic Sea is investigated using a coupled regional climate model consisting of the atmospheric model REMO and the Baltic Sea ice ocean model BSIOM. The main heat fluxes into the Baltic Sea represented in the model system are quantified, namely the surface heat fluxes, the heat exchange with the North Sea, and the heat fluxes associated with river discharge, precipitation and evaporation. The surface fluxes at the ocean/ice-atmosphere are compared to observations and an atmosphere-only simulation.

In agreement with other studies, the Baltic Sea is in close thermo-dynamic balance with the atmosphere above on decadal time scales, due to its semi-enclosed nature. It is usually argued that the small remainder in the heat budget in the order of 1W/m2 results from the heat exchange between the North Sea and that the other fluxes are negligible. However, in our analysis the heat fluxes due to river discharge, precipitation and evaporation have the same order of magnitude and should be included into the budget.
An ensemble of six pairs of RCM experiments performed at 25 km and 50 km for the period 1961-2000 over a large European domain is examined in order to evaluate the effects of resolution on the simulation of daily precipitation statistics. Application of the non-parametric two-sample Kolmogorov-Smirnov test, which tests for differences in the location and shape of the probability distributions of two samples, shows that the distribution of daily precipitation differs between the pairs of simulations over most land areas in both summer and winter, with the strongest signal over southern Europe. Two-dimensional histograms reveal that precipitation intensity increases with resolution over almost the entire domain in both winter and summer. In addition, the 25 km simulations have more dry days than the 50 km simulations. The increase in dry days with resolution is indicative of an improvement in model performance at higher resolution, while the more intense precipitation exceeds observed values. The systematic increase in precipitation extremes with resolution across all models suggests that this response is fundamental to model formulation. Simple theoretical arguments suggest that fluid continuity, combined with the emergent scaling properties of the horizontal wind field, results in an increase in resolved vertical transport as grid spacing decreases. This increase in resolution-dependent vertical mass flux then drives an intensification of convergence and resolvable-scale precipitation as grid spacing decreases. This theoretical result could help explain the increasingly, and often anomalously, large stratiform contribution to total rainfall observed with increasing resolution in many regional and global models.
PA-097

**Impacts of different simulation settings to climate change signal based on ALADIN-Climate results**

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This study is focusing on simulations with ALADIN-Climate regional climate model (RCM) adapted at the Hungarian Meteorological Service. Since its adaptation in 2005, numerous experiments were achieved with different settings. Model version 4.5 was used first over an integration domain covering the Carpathian Basin on 10 km resolution. Simulations were carried out for the past applying ERA-40 reanalyses and ARPEGE-Climat as lateral boundary conditions (LBCs). Climate projection were driven by ARPEGE-Climat run using A1B scenario for prescribing future anthropogenic activity.

The model version was recently updated to version 5.2 and since the earlier integration domain was too small, new domains were tested in sensitivity studies. Due to the changes in settings, a detailed validation was performed through longer historical simulations. Current experiments were achieved over a larger domain on 10 km horizontal resolution, LBCs were provided by ERA-Interim reanalysis data and a 50 km resolution ALADIN-Climate run driven by ARPEGE-Climat global model.

These experiments make possible to analyze the influence of different settings on the RCM results. In the presentation we investigate the effects of integration area, the horizontal resolution and emission scenario on climate change signal with main focus on Hungary. Projections are evaluated for 2021–2050 and 2071–2100. The investigations are carried out for temperature, precipitation, and mean sea-level pressure.
Using numerical simulations of 15 global models of the experiment CMIP5, the potential impact on Mexico was evaluated under conditions of climate change scenarios in five Mexican regions using the daily variables: precipitation, winds and surface temperature.

The period analyzed are: historical (1979-2010) and two future periods: (2015-2039) and (2075 - 2099) using three scenarios (RCP45, RCP60 and RCP85. The spatial window analyzed is 0 to 35N and 70W to 130W. To evaluate the models behavior, we compare the results with the NARR data base (North American Regional Reanalysis).

The Reliability Ensemble Averaging method (REA) was applied to integrate 15 models in a weighted ensemble, improving the model outputs for the annual cycle for each region.
Projected climate change scenario over Central America simulated by the regionally coupled climate model ROM

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Climate projections provide information to stakeholders about the impact of changes in the future climate on the population and ecosystems. Because of this high resolution, downscaling of global climate models that provide regional scenarios of climate change are becoming increasingly important.

In this study we examine a future climate change scenario over the Central American and Caribbean regions in a simulation with the regionally coupled model ROM. It covers the CORDEX-CA region and is extended farther north in order to locate the Mexican territory far from model boundaries. In ROM a global ocean model (MPIOM) with regionally high horizontal resolution (up to 5 km resolution in the Gulf of Mexico) is coupled to an atmospheric regional model (REMO, with 50 km resolution) and global terrestrial hydrology model. The ocean and the atmosphere are interacting within the region covered by the atmospheric domain. Outside this domain, the ocean model is uncoupled, driven by prescribed atmospheric forcing, thus running in a so-called stand-alone mode.

The model is driven by the MPI-ESM climate change simulation under the RCP 8.5 scenario. We examine the climate change signal for minimum, maximum and mean temperature, as well as precipitation over land and sea. We also study the effect that a warming world will have on the oceanic upwelling systems, land-sea breezes and cyclonic activity. One of our results is that in a warming climate the number of hurricanes becomes fewer and that the coupling plays an important role in their statistics. The results are compared with the obtained in the global model and an uncoupled downscaling with REMO.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-100

Climatic cooling potential of direct ventilation and evaporative cooling with high resolution and spatiotemporal analysis

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In 2012 buildings were responsible for nearly 40% of the final energy consumption in Europe, placing the building sector as the biggest energetic consumer, above industry (31%) and transportation (26%). The rapid increase in electricity demand for air-conditioning of buildings associated with the global warming issue will further boost the primary energy demand for building’s space cooling. In the current energy paradigm this will enhance even more the anthropogenic CO2 emissions and therefore global warming and its environmentally and societal harmful consequences. The use of passive cooling systems in buildings can be an important solution to contribute to minimize cooling loads and thus the fossil fuel dependence.

In the present study, an evaluation of building’s cooling demand savings is performed in a twofold innovative way. Firstly, using a recently developed definition of the climatic cooling potential (CCP) that allows the assessment of the cooling demand savings in buildings by the use of different passive cooling systems. Secondly, the use of high resolution climate dataset for Europe using regional climate models from EURO-CORDEX and a WRF 9km horizontal resolution simulation for the Iberia Peninsula (IP).

The CCP concept here used, is applied for direct ventilation and evaporative cooling, in such a way that it allows for a direct comparison with the building's monthly cooling demand providing a direct assessment on the cooling demand savings for any building using direct ventilation or evaporative cooling for three air flow rates: Furthermore, the present work has the advantage of being applicable to any climatic observation dataset or climate simulation results, for present and future climates, and allow the assessment of global warming impact on these technologies. The impact of a warmer climate on CCP in the 21st century is here explored. Firstly, an evaluation of CCP is performed using the hindcast (1989-2009) and the historical runs (1971-2000) and secondly the projections of a time slice for the end of the 21st century (2071-2100) with the RCP8.5 greenhouse gas emissions scenario are analyzed.
The study reports an integrated approach capable to elucidate impacts of environmental degradation on streamflow and precipitation at the watershed scale. The approach combines trends and spatial analyses of long-term streamflow, precipitation, and leaf area index LAI. Specifically, I target the Niger River Basin, then I consider monthly precipitation series over the catchment. I also consider data from 8 streamgages selected along the river. Over the period 1961-2012, I conduct a change point analysis of the streamflow and report two sub-periods 1961-1982 and 1983-2012. A comparison of precipitation and streamflow during these two time-slices shows meaningful changes. I describe a Kernel density analysis of streamflow and yield a probabilistic estimate of discharge anomalies along the river. Later, I evaluate seasonal trends of precipitation and streamflow. The analyses bring out critical alterations in time and space. However, these alterations seem to foreshadow critical environmental degradations occurring across the watershed. I consider LAI series derived from MODIS images, then I examine and discuss trends in land-cover dynamics in relation with the patterns in precipitation and streamflow. This late analytical step yields a holistic picture of the ongoing alterations in the Niger River Basin as well as the implication of the changes in the monsoonal circulation over the West Africa region. Finally, I emphasize suggestions, valuable for a comprehensive water resources and environment management.
Over the past decade, aerosol optical depth (AOD) observations based on satellite and ground measurements have shown a significant increase over Arabia and the Arabian Sea, attributed to an intensification of regional dust activity. Recent studies have also suggested that west Asian dust forcing could induce a positive response of Indian monsoon precipitations on a weekly timescale. Using observations and a regional climate model including interactive slab-ocean and dust aerosol schemes, the present study investigates possible climatic links between the increasing June–July–August–September (JJAS) Arabian dust activity and precipitation trends over southern India during the 2000–2009 decade. Meteorological reanalysis and AOD observations suggest that the observed decadal increase of dust activity and a simultaneous intensification of summer precipitation trend over southern India are both linked to a deepening of JJAS surface pressure conditions over the Arabian Sea. In the first part of the study, we analyze the mean climate response to dust radiative forcing over the domain, discussing notably the relative role of Arabian vs. Indo-Pakistani dust regions. In the second part of the study, we show that the model skills in reproducing regional dynamical patterns and southern Indian precipitation trends are significantly improved only when an increasing dust emission trend is imposed on the basis of observations. We conclude that although interannual climate variability might primarily determine the observed regional pattern of increasing dust activity and precipitation during the 2000–2009 decade, the associated dust radiative forcing might in return induce a critical dynamical feedback contributing to enhancing regional moisture convergence and JJAS precipitations over southern India.
Estimates of common ragweed pollen emission and dispersion over Europe using the RegCM-pollen model

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Common ragweed (Ambrosia artemisiifolia L.) is a highly allergenic and invasive plant in Europe. Its pollen can be transported over large distances and has been recognized as a significant cause of hayfever and asthma (D’Amato et al., 2007; Burbach et al., 2009). To simulate production and dispersion of common ragweed pollen, we implement a pollen emission and transport module in the Regional Climate Model (RegCM) version 4 using the framework of the Community Land Model (CLM) version 4.5. In the online model environment where climate is integrated with dispersion and vegetation production, pollen emissions are calculated based on the modelling of plant distribution, pollen production, species-specific phenology, flowering probability, and flux response to meteorological conditions. A pollen tracer model is used to describe pollen advective transport, turbulent mixing, dry and wet deposition.

The model is then applied and evaluated on a European domain for the period 2000–2010. To reduce the large uncertainties notably due to ragweed density distribution on pollen emission, a calibration based on airborne pollen observations is used. Resulting simulations show that the model captures the gross features of the pollen concentrations found in Europe, and reproduce reasonably both the spatial and temporal patterns of flowering season and associated pollen concentrations measured over Europe. The model can explain 68.6, 39.2, and 34.3 % of the observed variance in starting, central, and ending dates of the pollen season with associated root mean square error (RMSE) equal to 4.7, 3.9, and 7.0 days, respectively. The correlation between simulated and observed daily concentrations time series reaches 0.69. Statistical scores show that the model performs better over the central Europe source region where pollen loads are larger.

From these simulations health risks associated common ragweed pollen spread are then evaluated through calculation of exposure time above health-relevant threshold levels. The total risk area with concentration above 5 grains m\(^{-3}\) takes up 29.5 % of domain. The longest exposure time occurs on Pannonian Plain, where the number of days per year with the daily concentration above 20 grains m\(^{-3}\) exceeds 30.
The importance of climate change information on regional scales is becoming more and more important, especially for climate adaption and risk managements purposes. As the global climate models (GCM) are too coarse to give satisfactory information on regional scales, information about the regional climate can be obtained by dynamical downscaling the GCMs with a regional climate model (RCM). How well the RCM performs depends on the driving GCM as well as the models representations of the different processes. Normally the skill of the RCM is found by evaluating reanalysis driven RCM results with observations. The difference between the RCM and the observations will indicate the model bias. When the RCM is driven by a GCM, the bias will be affected by the errors in the GCM as well as the imperfect RCM representation of different processes. We here dynamically downscale five different GCMs (EC-EARTH, CNRM-CMS, MPI-ESM-LR, HadGEM2-ES and MIROC5) with a calibrated version of the non-hydrostatic regional climate model COSMO-CLM version 5.0 at a horizontal resolution of 0.44° over Europe for the historical period (1950-2005) and also the future period (2006-2100) by using the Representative Concentration Pathways version 8.5 (RCP8.5) scenario. The calibrated version of the COSMO-CLM (CCLM) following the calibration method presented in Bellprat et al. (2012) has shown to reduce the model bias, especially when it comes to the warm (dry) summer temperature (precipitation) bias over Southern Europe. The frame of the experiments follows the EURO-CORDEX, and the downscaled model outputs is intended to be part of the EURO-CORDEX ensemble. We will compare the downscaled RCM-GCM chains with calibrated CCLM simulations driven by the ERA-Interim reanalysis. By including this ensemble of the RCM-GCM simulations we want to investigate whether the RCM can compensate for some of the GCM bias. Moreover, with this set of five RCM-GCM chains we can contribute to provide probabilistic estimates of climate change over the European domain. This work is in synergy with the project CH2018, which will provide information about the expected changes in the climate over Switzerland, so particular focus will be on the climate probabilities for the Alpine regions.

Reference:

PA-105

Towards detecting the minimal number of simulations for robust climate change information

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The latest generation of climate projections for the 21st century are built on new emission scenarios based on Representative Concentration Pathways (RCPs). Within the world-wide coordinated effort of the Coupled Model Intercomparison Project Phase 5 (CMIP5), their impact on climate is simulated with global models of the climate system. A sample of the global simulations is dynamically downscaled for Europe in the framework of EURO-CORDEX. Further downscaling experiments, based on both dynamical and statistical methods, with focus on Germany and the river catchments draining into Germany, are conducted within the framework of the project ReKliEs-De to account for the full range of model variability. This unique set of high resolution climate change simulations for Europe is analyzed in order to detect the minimal number of simulations that are necessary to derive robust climate change information. This is carried out by randomly adding or excluding ensemble members to find out if there is a critical number of simulations for stable results. While minimizing computing time and storage capacity, the quality and robustness of the results is retained. This result can serve as a guideline for the cost optimization of future regional climate change projects.
PA-106

Regional climate downscaling using a High-resolution Global Atmospheric Model

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A high-resolution global atmospheric model HiRAM is used to conduct climate simulations following the CORDEX protocol. HiRAM has been developed at Geophysical Fluid Dynamics Laboratory (GFDL), based on GFDL CM2.1 used in the IPCC AR4, and was specifically tuned to conduct fine-resolution global simulations. The calculations in this study were conducted with 25-km grid spacing routinely used in nested regional models for climate downscaling.

Three 30-year history simulations are calculated since 1975 to reproduce the past climate, and six future climate projections till 2050 are computed with RCP4.5 and RCP8.5 forcings. As the simulations are conducted globally, they require only sea surface temperature (SST) for the bottom boundary conditions. The past and future SSTs were taken from the different ensembles of the GFDL Earth System Model (ESM) simulations, which is coming effectively at a quarter degree resolution close to that used in the atmospheric model.

In this study we focus on the Middle East and North Africa (MENA) region. The HiRAM output is tested with observations for the history period and is compared with the future projections from the nested regional models. The model performance is also studied by evaluating regional model responses to the major volcanic eruptions. The overall analysis shows that HiRAM is able to adequately reproduce regional climate variability in the Middle East and North Africa, and correctly accounts for remote effects of ENSO, Indian Monsoon, and North Atlantic Oscillation.
Regional Decadal Climate Predictions: Israel as a Case Study

Ehud Strobach, Golan Bel

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Decadal climate predictions are intended to provide information on the climate system dynamics on time scales of one to three decades. This type of climate simulation is considered as comprising mixed forced boundary conditions and an initial condition problem. In decadal time scales, it is not only the response of the climate system to changes in the atmospheric composition and changes in the land surface that are of interest but also the natural dynamics of the climate system. Decadal prediction systems are part of the CMIP5 and have shown an improved prediction skill in several regions around the globe compared with the predictions of the long-term climate projection experiments of the CMIP5. However, the needs of agriculturists, local policy makers and other stakeholders are often regional. In these cases, downscaled decadal climate predictions may be more practical.

Israel is good example of a local market with a demand for regional decadal predictions. It is a small country that is usually represented in the global climate models by only two or three grid cells. Moreover, it has a large south-to-north gradient in the annual average precipitation (from almost zero to more than a thousand mm per year) and a large altitude variability (from around 400 m below sea level up to 2200 m above sea level). As a consequence, small changes in the global circulation over a span of several years can have a considerable effect on the climate of this region.

In this research, we tested the added value of the CMIP5 decadal predictions on a regional scale. We downscaled one of the CMIP5 decadal experiments using the WRF model with different combinations of parametrization schemes, centering our domain on Israel (6-km inner domain resolution). The regional climate simulations were tested against the station measurements of several climate variables, such as the monthly averages of the daily minimum and maximum temperature and the precipitation. Probabilistic and deterministic scores were used to quantify the performance of the predictions and to test the ability of the regional decadal climate predictions to provide accurate and reliable forecasts.
PA-108

High-resolution downscaling for Queensland

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This presentation will describe result of downscaling for Queensland, Australia using double nested Conformal Cubic Atmospheric Model (CCAM) developed by CSIRO. In this project bias corrected sea surface temperature and sea ice from selected CMIP5 global coarse resolution models were used along with RCP8.5 radiative forcing to complete set of 7 simulations with 50 km global uniform resolution CCAM for period 1950-2100. Data from those global simulations were used for nudging of simulations using 1D spectral filter in high-resolution (10 km) simulations over Queensland Region (9-32S and 132-158E). In this presentation we will present comparison of 50 km and 10 km simulations over Queensland region with focus on added value of downscaling of spatial and temporal distribution of rainfall, tropical cyclones, drought and extreme indices (ETCCDI).
PA-109

CMIP5, CORDEX and higher resolution RegCM4 multimodel ensembles comparison of projected changes in climate zones over West Africa

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West African climate have evolved in recent decades to respond to elevated anthropogenic greenhouse gas (GHG) forcing. Projected climate change generated by the multimodel ensemble of the CORDEX indicates continuous and stronger warming (1.5oC to 6.5oC) and a wide range of precipitation uncertainty (roughly between -30% to 30%) larger in the Sahel and increasing in the farther future consistent with CMIP5. This prevents a rigorous assessment of risks and impacts associated with the anthropogenic climate change over West Africa.

To overcome this issue and provide useful climate information, we employ the revised Thornthwaite climate classification applied to ensembles of CMIP5, CORDEX, and higher-resolution ICTP RegCM4 experiments (HIRES) and investigate shifts in climate zones over West Africa as a response to anthropogenic climate change. Such information on projected shifts of climate zones can help policymakers to develop response strategies for the most vulnerable areas. Evaluation of the reference period simulations indicates that the ensembles reproduce fairly well the observed climate zones, although with some notable discrepancies, larger in the CMIP5. CORDEX and HIRES provide realistic fine-scale information which enhances that from the coarser-scale CMIP5, especially in the Gulf of Guinea encompassing marked landcover and topography gradients. The late 21st century projections reveal an extension of torrid climates throughout West Africa. In addition, the Sahel, predominantly semi-arid in present-day conditions, is projected to face moderately persistent future arid climate. Similarly, the Gulf of Guinea shows a tendency in the future to experience highly seasonal semi-arid conditions. Finally, wet and moist regions with an extreme seasonality around orographic zones become less extensive under future climate change. Consequently, West Africa evolves towards increasingly torrid, arid and semi-arid regimes with the recession of moist and wet zones. These features are common to all multimodel ensembles with more pronounced changes in the higher-resolution RegCM4 projections. These modifications are largely due to the temperature forcing, as the contribution of precipitation change is comparatively smaller. Such changes point towards an increased risk of water stress and thus add an element of vulnerability to future anthropogenic climate change for West African water management, ecosystem services and agricultural activities.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-110

Sources of uncertainty over Central Europe based on the recent climate model experiments

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Climate model results cannot be considered and interpreted without their uncertainties. They are originating mainly from natural climate variability, the approximate description of physical processes and the emission scenarios applied for describing possible paths of future anthropogenic activity in models. We quantified these uncertainties from global to local scale, but scope of recent study is Europe and mainly the Carpathian Basin (Central Europe). We have analysed mean temperature and precipitation projections following the methodology of Hawkins and Sutton (2009) with some changes.

Assessing sources of uncertainty between 1951 and 2100 for global climate models (GCMs) from CMIP3 is already available. In the current work, we analyse, on the one hand, 30 global simulations from CMIP5 dataset carried out with 15 GCMs and two (RCP4.5 and RCP8.5) emission scenarios. We seek for the answer to the question, whether the CMIP5 results are leading to different conclusions than CMIP3. On the other hand, 20 regional climate model (RCM) experiments are investigated from the EURO-CORDEX database conducted with 10 RCMs and the same RCP scenarios. We investigate the added value of fine-resolution RCMs (EUR11) regarding model uncertainty against the global counterparts, also coarser resolution (EUR44) RCM outputs and the role of internal variability in regional projections.

The current investigation is concentrating on the following specific issues:

(i) fraction of total uncertainty on different lead times over the Carpathian Basin compared to projections for Europe and its seasonal variation;

(ii) limitations in reducing uncertainty through a (theoretical) perfect model selection, model choice and resolution increase;

(iii) time horizons when climate change signals exceed their total uncertainty (with investigation of signal-to-noise ratio) and when future changes are larger than natural variability (calculating time of emergence).
PA-111

Evaluation of CORDEX Regional Climate Models over Central Africa

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The study evaluates the ability of nine (9) Regional Climate Models (RCMs) from the Coordinated Regional Climate Downscaling Experiment (CORDEX) in simulating the main characteristics of rainfall and temperature patterns over Central Africa. The mean climatology, annual cycles, interannual variability and also interseasonal variability of RCMs output have been assessed over six homogeneous subregions against numerous observational datasets. It is found that most RCMs reasonably simulate the main features of the rainfall and temperature climatology over the six subregions. In addition, analysis show significant biases in individual models depending on subregion. However, the ensemble mean has better agreement with observation than individual models. In general, the analysis herein demonstrate that the multi-model ensemble mean simulates Central Africa rainfall and temperature adequately and can therefore be used for the assessment of future climate projections for the region.
As part of the CORDEX project, the fifth-generation Canadian Regional Climate Model (CRCM5) is used to simulate the Arctic climate for the historical period driven by reanalyses and for the RCP8.5 scenario driven by the MPI-ESM-LR CGCM output. In our study we have also conducted another experiment in which the CGCM-simulated sea-surface conditions (SSC; sea-surface temperature and sea-ice concentration) are empirically corrected and used as ocean boundary conditions for an Atmosphere-only GCM simulation (AGCM), which in turn provides the lateral boundary conditions to drive the RCM simulation. This is what we call the 3-step approach of dynamical downscaling (CGCM-AGCM-RCM), a technique that we have previously employed for the CRCM5 simulations over the CORDEX Africa domain.

Comparison between the CRCM5 simulation following the CORDEX protocol (CGCM-RCM) and the CRCM5 simulation using the SSCs bias correction (CGCM-AGCM-RCM) allows to show the impact of the 3-step approach on the simulation and projection of the Arctic climate.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-113

PROJECTIONS OF FUTURE CHANGES IN PRODUCTIVITY OF MAJOR AGRICULTURAL CROPS IN THE REPUBLIC OF MOLDOVA ACCORDING TO THE EURO-CORDEX ENSEMBLE OF 9 RCMS FOR RCP 4.5 AND RCP 8.5 SCENARIOS

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In the present study, relationships between observed mean temperature and precipitation during growing season and average annual crop yield based on statistical data at the Republic of Moldova's agricultural enterprises of various categories were explored and then used to estimate potential impacts of climate change scenarios on anticipated average yields for the 2021-2050, and 2071-2100 time periods. Average yields of winter wheat, grain corn, sunflower, sugar beet and tobacco in the 1981-2010 years were highly correlated with precipitation and temperature during the growing period. The impact assessment performed on national level allow conclude that the negative effect of global warming, according to the EURO-CORDEX ensemble of 9 RCMS (representing different GCM-RCM combinations) for RCP 4.5 and RCP 8.5 scenarios in the XXI century will not be offset by increase of precipitations. In these circumstances, without undertaken any adaptation measures, it can be expected by 2100: a significant drop in the productivity for grain corn, from 36% (RCP 4.5) to 86% (RCP 8.5) and winter wheat, from 29% (RCP 4.5) to 65% (RCP 8.5); a medium drop in the productivity for sunflower from 15% (RCP 4.5) to 33% (RCP 8.5), respectively for sugar beet, from 4% (RCP 4.5) to 15% (RCP 8.5); and for tobacco, from 7% (RCP 4.5) to 18% (RCP 8.5), in comparison with the average productivity of the Republic of Moldova's major agricultural crops in the most recent period of 1981-2010.

Additionally to the national level we have assessed the impact of temperature and precipitation during the growing season on major agricultural crops productivity in the Republic of Moldova's territorial administrative units (district level), in order to distinguish the most and least vulnerable districts to climate change. Without adaptation measures (if maintaining the current cultivation technologies and used varieties), due to changes in climatic conditions in the most districts of the Republic of Moldova, by the end of the XXI century, the cultivation of grain corn will be impossible or economically not cost effective according to the RCP 8.5 high emission scenario.

The sharp decline in the productivity of cereal crops can be explained by a shift of critical phenological phases in the more unfavorable humidity and temperature conditions due to climate change.
The presentation describes the motivation for the creation of the Vulnerability, Impacts, Adaptation, and Climate Services (VIACS) Advisory Board to provide a more fruitful bridge between climate change applications experts and climate modelers for CMIP6. The VIACS Advisory Board was created to facilitate a two-way dialogue between leaders of CMIP6 climate modelers and VIACS experts who are looking to apply CMIP6 results for their numerous research and climate services objectives. The Board has already been convened with leading sectoral researchers and representatives who can solicit broader feedback from key applied projects, programs, and regions.

As its first activity, the VIACS Advisory Board solicited feedback from more than a dozen groups across a number of projects, regions, and sectors in order to identify priority variables and MIP experiments for CMIP6. As different VIACS groups have different needs concerning CMIP6 variables, it is not reasonable to create a single priority list that represents the demand of the entire community. Nevertheless, some variables are clearly relevant across all sectors (e.g., temperature, rainfall, solar radiation) and the feedback created provides the clearest yet view of how different variables appeal to a number of sectoral applications. A similar pattern can be found for the MIP experiments: nearly all groups are requesting the historical DECK simulations and the RCPs, while additional requests are a mixture of priorities depending on the sector.

Here, we provide a short overview about the lessons learned in the process of using CMIP5 data for VIACS applications as well as an outlook on plans and opportunities for VIACS research and application in the frame of CMIP6.
PA-115

Modelling the potential impact of climate change on cotton production over North eastern Afare and Western Tigray region of Ethiopia

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Cotton (Gossypium hirsutum) is a globally important fiber plant. Impact of climate change and variability is already being felt in Ethiopia in the form of higher temperature, erratic nature of rains (spatially and temporally), floods and drought. These changes could adversely affect the crop life cycle and production of crop yields. The aim of this study was to characterize the climate of the study areas, analyze the impact of climate change on cotton production and to recommend suitable adaptation strategies for cotton production under changing climate at Amibara, Dansha and Kebabo areas of Ethiopia. This study was conducted in Northeastern part of Afar and Western Tigrays region of Ethiopia. Historical climate data (1980-2010), were collected from National Meteorological Agency and National aeronautical space administration while soil and cotton experimental data of the study areas were collected from respective agricultural research center. Instat+v.3.37 and Excel 2010 were used for analysis of rainfall and temperature variability and trend analysis. In order to estimate the level of climate change impact (rainfall and temperature) on cotton production for the study areas, two Representative path ways as a three time segment: Near-term (2010-2039), Midterm (2040-2069) and End-term (2070-2099) using the coupled atmosphere-ocean HadGEM2-ES GCMs model. The rainfall varies between -1.6 to 3.3%, -0.7 to 3.8% and -0.8 to 3.3% at Amibara, Dansha and Kebabo respectively. The projected increment of maximum temperature varies between 1.3 to 3.1oc, 1.3 to 5.4oc and 1.3 to 5.3oc at Amibara, Dansha and Kebabo in the future periods respectively. Climate change analysis indicated a strong influence of temperature on cotton production in Amibara and Dansha sites and yield will be substantially decreased on average by 12 to 13% with projected increasing temperature and erratic nature of rainfall. Projected model simulations predict that climate change will shift planting dates towards late planting (May 15 and July 15) for the period of 2010-2099 at Amibara and Dansha while for Kebabo site early planting June 15 is preferable. In general cotton yield will decrease but, late planting date and further research on different agronomic management practices will result in increased yield for Amibara and Dansha.

Key words: Cotton, Climate prediction, Climate impact, DSSATV4.6, Instat+3.37
Added value of regional climate modeling over areas characterized by complex terrain – Precipitation over the Alps

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We present an analysis of the added value (AV) of downscaling via regional climate model (RCM) nesting with respect to the driving global climate models (GCMs) over regions characterized by complex terrain. Specifically, we analyse precipitation from ensembles of driving GCM and nested RCM (two resolutions, 0.44° and 0.11°) simulations for the late 20th (1976-2005) and late 21st century (2070-2099) over an area encompassing the European Alps. The GCM simulations are provided by the Coupled Model Intercomparison Project Phase 5 (CMIP5) and the RCM experiments used for this study are from two regional initiatives within Coordinated Regional Downscaling Experiment (CORDEX), namely: EURO-CORDEX (whole European domain) and MED-CORDEX (centered over the Mediterranean region). The 21st century projections are for the high-end representative concentration pathway RCP8.5. Different metrics of AV are investigated, measuring aspects of precipitation where substantial AV can be expected in mountainous terrains: spatial pattern of mean precipitation, daily precipitation intensity distribution and daily precipitation extremes (R95). The metrics are calculated by comparing model precipitation output with data from a high quality, fine scale (5 km) gridded observational dataset. Our analysis shows substantial AV of RCM downscaling for all metrics selected, and in fact results are improved compared to the driving GCMs not only at fine scales but also when the RCM fields are upcaled at the scale of the GCM resolution. We also find consistent improvements in the high resolution (0.11°) vs. the medium resolution (0.44°) RCM simulations. In terms of precipitation change projections, we find that the RCM downscaling substantially modulates the GCM-derived change signal, particularly in terms of fine scale spatial pattern associated with the complex topography of the region. Our results thus clearly demonstrate the AV of RCM nesting and point to the important role that high resolution nested RCMs can play in the study of climate change over areas characterized by complex topographical features.
Benefits of high resolution regional climate modeling over the South-East Asia CORDEX domain

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The South-east Asia CORDEX domain is characterized by very complex morphological features, such as islands, peninsulas, and mountainous systems, which affect substantially the characteristics of local climates. Therefore, the high resolution CORDEX simulations can be extremely important in better understanding the effect of global warming over this region. Within this context, our study presents an analysis of a set of regional climate model (RCM) simulations with the latest version of the ICTP model RegCM4 over the South-east Asia CORDEX domain. Our set of simulations employ three different horizontal grid spacings: 50 km, 25 km and 12 km for the period 1998-2002, with driving boundary conditions fields for the coarsest simulation (50km) set up provided by ERA-Interim reanalysis of observations. At finer scales the boundary conditions are provided by the 50 km RCM simulation. The analysis focuses on the effect of resolution on the characteristics of monsoon rain over the region at different temporal scales, from daily to seasonal, and on the spatial patterns and temporal modulation of the monsoon seasons by the topographical characteristics of the region. A preliminary analysis of the results with respects to high resolution observations (e.g. from TRMM) indicates that the increase in resolution yields a substantial improvement in the placement of precipitation maximums and in the simulation of the spatial variability of the monsoon seasons. Daily precipitation statistics are also improved at the higher resolution. Our results can provide useful information to guide the selection of a minimum resolution to be used in the framework of future CORDEX experiments over the region.
In this study, we investigated future changes in seasonal temperature and precipitation climatology of CORDEX Middle East and North Africa (MENA) region for three periods of 2010 – 2040, 2040 – 2070 and 2070 – 2100 with respect to the control period of 1970 – 2000 by using regional climate model simulations. Projections of future climate conditions were realized by forcing Regional Climate Model, RegCM4.4 of the International Centre for Theoretical Physics (ICTP) with two different CMIP5 global climate models. HadGEM2-ES global climate model of the Met Office Hadley Centre and MPI-ESM-MR global climate model of the Max Planck Institute for Meteorology were used to generate 50 km resolution data for the Coordinated Regional Climate Downscaling Experiment (CORDEX) Region 13. We tested the seasonal time-scale performance of RegCM4.4 in simulating the observed climatology over domain of the MENA by using 2 different global climate model outputs. The projection results show relatively high warming of mean temperatures from 3 °C up to 9 °C over the domain for far future. A strong decrease in precipitation is projected in almost all parts of the domain according to outputs of regional model forced by scenario outputs of two global models. Therefore, warmer and drier conditions will occur more intensely over the CORDEX-MENA domain which is already arid and heavy-arid.
Projected Changes in Air Temperature and Precipitation Climatology in Central Asia 
CORDEX Region 8 by Using RegCM4.3

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This work investigated projected future changes in seasonal mean air temperature (°C) and precipitation (mm/day) climatology for the three periods of 2010-2040, 2040-2070, and 2070-2100, with respect to the control period of 1970-2000 for the Central Asia domain via regional climate model simulations. In order to investigate the projected changes in near future climate conditions, the Regional Climate Model, RegCM4.3.5 of the International Centre for Theoretical Physics (ICTP) was driven by two different CMIP5 global climate models. The HadGEM2-ES global climate model of the Met Office Hadley Centre and the MPI-ESM-MR global climate model of the Max Planck Institute for Meteorology were downscaled to 50 km for the Coordinated Regional Climate Downscaling Experiment (CORDEX) Region 8. We investigated the seasonal time-scale performance of RegCM4.3.5 in reproducing observed climatology over the domain of the Central Asia by using two different global climate model outputs. For the future climatology of the domain, the regional model predicts relatively high warming in the warm season with a decrease in precipitation in almost all parts of the domain. A warming trend is notable, especially for the northern part of the domain during the cold season. The results of our study show that surface air temperatures in the region will increase between 3°C and about 7°C on average, according to the emission scenarios for the period of 2070-2100 with respect to past period of 1970-2000. Therefore, the projected warming and decrease in precipitation might adversely affect the ecological and socio-economic systems of this region, which is already a mostly arid and semi-arid environment.
The role of atmosphere-ocean interaction in the relationship between sea surface conditions of the Mediterranean and Black Seas and regional climate over the Anatolian Peninsula

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The Mediterranean and Black Seas have very important effects on the climate system of the Anatolian Peninsula that include complex feedback mechanisms and processes. Due to the importance of the air-sea interaction in the region, the studies that aim to investigate the relationship between atmosphere and seas play very important role to improve our knowledge about the climate system of the region. In this study, the interaction between atmosphere and sea is investigated by using the results of the coupled regional climate model to reveal the effects of the semi-enclosed seas (Mediterranean and Black Seas) on the regional climate system.

The used modeling system, Regional Earth System Model (RegESM), consists of newly designed four-components (atmosphere, ocean, river routing and wave). The present study uses only the configuration of its two components: atmosphere and ocean. To distinguish the effects of the Mediterranean and Black Seas, the simulations (1979-2012) are performed over two different model domains: 1) relatively coarse resolution domain (50 km) that covers Mediterranean Basin and includes an active ocean component for Mediterranean Sea, 2) one-way nested higher resolution domain (10 km) that covers Anatolian Peninsula with active Black Sea model.

To investigate the relationship between sea surface conditions and the regional climate, a time-phase relationship analysis based simply on the lagged-correlations is applied to the model results (both standalone and coupled) and evaluated. The results of the lagged-correlation analysis show that the considered variables over the sea (SST and evaporation) and the climate variables over the land (precipitation, surface air temperature etc.) have strong relationship depending on the analyzed season and the selected sub-region over the sea. The results also indicate that the relationship is stronger in fall and winter seasons, which air-sea temperature difference is high. The lag (or response) time between anomalies of the sea related variables (SST and EVP) and the anomalies of the variables over the land is around 7-13 days for SST and 2-6 days for EVP.

Acknowledgments

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PA-121

Can dynamical downscaling provide added skill to summertime seasonal predictions on the European scale?

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The application of dynamical downscaling (DD) in the fields of weather and climate prediction is widespread. Yet, in seasonal forecasting examples of DD are isolated - e.g. the MRED-initiative focusing on the winter season in North-America – primarily because the large ensemble sizes involved pose huge computational demands on the DD experiments. Within the FP7-project SPECS an effort is dedicated in assessing the potential added skill from DD for various target domains.

In this contribution we report on the outcome a DD experiment conducted with the RCM KNMI-RACMO2 on the EURO-CORDEX 0.22 degree domain focusing on the summer season. Supposedly, this season is best suited for the purpose of exploring added value because in summer local feedbacks between processes involving soil moisture, land-atmosphere exchange and cloud formation and their mutual interactions are strongest. Large-scale information to drive the RCM is taken from a 15-member EC-EARTH ensemble produced at SMHI within the FP7-project EUPORIAS spanning the boreal summer season (MJJAS) in the period 1991-2012. For each season, perturbations in sea surface boundary conditions were used to generate an ensemble, while all members were initialized on May 1st with identical atmospheric and soil moisture conditions.

One way to see the potential usefulness of seasonal forecasts is provided by the reliability diagram. It displays whether forecast probabilities do match with the observed frequencies of occurrence of anomalous events. A standard method involves the use of terciles, i.e., all forecasts are sorted into predicting (1/3) or not predicting (2/3) a tercile event. Likewise, the observations (here E-OBS) are distributed in representing a tercile event or not. Preliminary results show that for warm events in South-European regions the RCM-ensemble provides slightly better skill than the GCM-ensemble, whereas for other events (cold season; dry/wet season) and other regions across Europe the outcomes give a somewhat mixed pattern.

To examine the role of soil moisture an additional DD experiment is conducted in which the evolution of the model prognosed soil moisture is replaced by soil moisture time series from the ERA-Interim/Land reanalysis. The extent to which cutting the soil moisture feedback link impacts on the seasonal forecast skill may provide insight into the relevance of soil moisture in this type of seasonal-scale simulations.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-122

Validation and projections of the ALARO-0 model on the EURO-CORDEX domain

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Results for the validation and the future runs are presented within the EURO-CORDEX framework using the regional climate model ALARO-0. This model has been primarily developed for operational numerical weather predictions and is therefore not tuned specifically for climate purposes. It features a new microphysics scheme called 3MT, which allows for a more sophisticated representation of convective precipitation.

The validation run uses ERA-Interim reanalysis for the period 1979-2010 as boundary conditions over Europe with resolutions of 50 and 12.5 km. Validation is possible by comparing against the E-OBS dataset but also against the ARPEGE model of the CNRM, that has many components in common with ALARO-0. Using the validation framework as presented in Kotlarski et al. (2014), it is shown that ALARO-0 is capable of representing the European climate (Giot et al., 2015). Indeed, most of the ALARO-0 scores lie within the existing EURO-CORDEX ensemble. For near-surface air temperature the large biases that are encountered by the ARPEGE model, however, persist. For precipitation, on the other hand, due to the 3MT scheme, the ALARO-0 model produces some of the best scores within the ensemble and lacks resemblance with ARPEGE, also concerning precipitation extremes. Since, in line with Kotlarski et al. (2014), the comparison with the EURO-CORDEX ensemble is performed for the short period 1989-2008, a verification of the score robustness was possible. More specifically, a jackknife procedure is applied to the results of the period 1979-2010 to construct the 95% confidence interval for each score. For most scores these intervals are very small compared to the total ensemble spread, implying that model differences in the scores are significant.

The comparison of the historical run with the scenarios runs RCP8.5, RCP6.5 and RCP2.6 allows the determination of the ALARO-0 climate changes. These runs are all coupled to the GCM of Météo-France, namely CNRM-CM5. The climate-change signals are put against the ones of the other EURO-CORDEX models (Jacob et al., 2014).


Jacob et al., 2014. Regional Environmental Change 14 (2), 563–578.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-123
Increasing the reliability of historical runs using bias correction methods

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Current climate projections such as CORDEX or CMIP5 consist of a large multi-model ensemble of climate simulations. The ensemble can be considered as a sample of potential outcomes, taking into account model and initial condition uncertainties. The ensemble spread or variance is therefore an uncertainty measure. The uncertainty is a crucial information given that some models are more appropriate to represent different regions and processes. Ideally the ensemble should be perfectly reliable such that the observations can be considered as a member from the ensemble.

Different time scales were considered in the analysis of the reliability of climate multi-model ensembles from monthly and seasonal up to decadal ones (Räisänen, 2007; Weisheimer, 2011; Corti, 212). Van Oldenborgh et al. (2013) studied the reliability of climate trends in the context of CMIP5 ensemble. It was found that, for both precipitation and temperature, the ensemble is overconfident. This also means that the observations is more frequently an outlier to the ensemble than expected. This implies that for near-term local climate forecasts the CMIP5 ensemble is not a reliable ensemble forecast. This situation is reminiscent of the one of medium-range ensemble weather forecasting what, despite huge efforts, the ensembles remain underdispersive. However, weather forecasts are commonly corrected using advanced bias-correction methods or post-processing techniques that improve the reliability (Van Schaeybroeck and Vannitsem, 2015). We present an application of post-processing (also called Model Output Statistics, MOS) techniques to climate predictions, with the aim of increasing the reliability of climate trends. The applied technique allows to correct each ensemble member in such a way that spatio-temporal correlations are preserved.

References


The attribution of human influence in single extreme events to climate change remains a challenge. A proper attribution requires long simulations with and without human-induced greenhouse gas forcing. This has remained difficult in many cases due to computational burden. In some cases, events such as convective rains are of very small scale, not resolved in practice in climate models doing attribution. However, in many cases, several methods, coming with conditioning assumptions (eg SSTs), have allowed attribution of human influence (or not).

In this paper, we use several case studies and review how regional climate simulations can be used for attribution, under large-scale driving assumptions. In particular, we use the EURO-CORDEX high-resolution simulations to estimate recent changes in odds of some events. The cases developed here are the wet and stormy winter of 2013-2014 in Western Europe, the hot summer of 2015 and the extreme fall season of heavy precipitation in the French Mediterranean area. We also show how a multi-physics approach using convection-permitting simulations can provide information on expected amplitude changes for heavy precipitation cases. This is achieved through attribution conditioned to large-scale circulation and using the spectral nudging technique.

The methods developed here are compared to the results of more classical methods (statistical, large ensembles, analogs) thanks to the framework of the EUCLEIA FP7 project, which will be presented briefly.
The impact of air-sea coupling on atmospheric moisture transport over Europe

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The climate system as an integrated system, which consist of various components, particularly the robust freshwater and heat fluxes exchanges between the ocean and the atmosphere, which is regarded as one of the most important processes for air-sea interaction. Hydrological cycle evaluation is an essential part for coupled model validations. In this study, the atmospheric moisture transport over Europe is analysed using a regional coupled model system covering the North Sea and Baltic Sea, which is composed of the regional setup of ocean model NEMO, the Rossby Centre regional climate model RCA4, the sea ice model LIM3 and the river routing model CaMaFlood. The performance of this coupled model system is assessed using a simulation forced with ERA-Interim reanalysis data at the lateral boundaries during period 1979-2010. Since the active coupling area only covers the North Sea and Baltic Sea, the impact of the ocean on the atmosphere over Europe is small. However, some local, statistically significant impacts on surface parameters are found, e.g. T2m, SST, precipitation. In general, the distribution of precipitation is reasonable, but overestimated. The air-sea interaction has a strong seasonal dependence. Compared to the atmosphere standalone model, the coupled model has slightly improved the vertically integrated moisture transport, especially in summer, which is associated with variation of precipitation. The water vapour transport in the lower troposphere is more influenced by the air-sea interaction.
Analysing regional temperature and precipitation dynamics in southern Africa from an ensemble of low emission climate change scenarios

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High resolution climate change information is needed to handle the challenges of potential climate change for the economy and society in southern Africa. This information contains possible future changes in temperature and precipitation dynamics as well as derived indices such as heat waves, dry and wet spells. To obtain high resolution climate change information, regional climate models (RCMs) are used to downscale different climate projection scenarios generated by general circulation models (GCMs).

The selection of the forcing data from GCMs is supposed to have an impact on dynamically downscaled regional climate change projections. In order to transfer the spread of projected climate change signals of the GCMs ensemble into the higher resolved RCM projections, a multitude of GCMs representing the full range of possible future climate change has to be downscaled. Commonly, the moderate emission scenario (RCP4.5) and the high emission scenario (RCP8.5) are downscaled and analysed for southern Africa whereas the low emission scenario (RCP2.6) is underrepresented.

In the framework of the SASSCAL-project (Southern African Science Service Centre for Climate Change and Adaptive Land Management project), five new low emission climate projection scenarios (RCP2.6) from different GCMs are downscaled with the regional climate model REMO for the CORDEX-Africa domain. In our presentation we will analyse the temperature and precipitation dynamics including their derived indices from an ensemble of low emission scenarios from different GCMs.
PA-127

Selecting regional climate scenario for impact modelling studies - Evaluation study

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Model inter-comparison experiments as well as regional downscaling experiments produce large matrices of GCM-RCM combinations. Such ensembles intend to sample a range of model assumptions and possible future climates. To further explore how a changing climate is affecting us and the environment, impact models use the climate model output data for the simulation of future pest development (spruce bark beetle), or in hydrological models simulating the run-off in local areas (HYPE). Even though it is advised to take all available climate model data into account, often it is not feasible in impact research projects, thus only subset are used. Therefore, the question of selecting an optimum of representative subset of models needs to be answered.

In our study we could show the importance of close communication with the users of climate model output. By using information about the needs of particular impact studies and clustering of the simulations along those information, the subset fits the purpose of climate change impact research more appropriately. Exploring the sensitivity of our method regarding the use of different climate variables, climate indices, seasons, and regions in Europe, resulted in specific sub-ensembles fitted to the provided information.

The study is based on climate change signals derived from EURO-CORDEX (EUR-44) data and includes bias adjusted temperature, precipitation, relative humidity, and wind speed as well as e.g. degree days, wet days, and frost days. The climate change signals are calculated for three future periods against a past climate. Results support the use of a selection method which considers the needs of the impact modeller. In a second step the effect of the model selection on the ensemble results of impact models is validated. Is the spread represented by the climate simulations maintained when evaluating impact model output data? Would be the same climate simulations be selected when impact model output would be used? The answers will contribute to the discussion about uncertainty and multi-model approach within the climate change research community.
Analysis of forest fires impact in semi-arid lands and identification of desertification process in Algeria

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Forest in the Algerian steppe is ecologically diverse, but with unfavourable climate conditions and the effect of wildfires we have noted deterioration of the physical environment particularly, and of the natural forest (e.g. Pinus halepensis, Quercus ilex, and Pistacia lentiscus) this deterioration of forests provokes an unbalance of environment which produces overland flow erosion that contributes to desertification. In the Algerian forest ecosystem wildfires usually start during the summer season, early June to late October, and in August multiple wildfires are often observed. Wildfires generally occur in the same ecosystem every year. Where climatic conditions are favourable, fire is an ecological agent and an integral part of the evolution of the ecosystems. The specific regeneration of plants is influenced greatly by the regime of fire (season of fire, intensity, interval), which leads to the recuperation of the vegetation after fire. Algeria has a Mediterranean climate with a long summer period (6 month) between the months of May until October. Winter precipitation is usually from December until February. Precipitation varies by regions with 600-800 mm y-1 in the sub humid coastal zones, 300-400 mm y-1 in the semi-arid steppe zones, and 100-200 mm y-1 in the arid desert zones. The forests mainly located in the Mountains of the Tell zone. The Tell, are formed by a succession of mountain, coastal and sub-littoral ranges, and plains. The topography is steep, rising from sea level to the top of the High Plateau with an elevation of about 700 m in 100 km, and to the Atlas Sahara Mountains with an elevation of about 2000 m located about 300 km from the coast. In this survey we used the images from the ALSAT-1 to detect zones with risk of forest fire and their impact on the natural’s forests in the region of Tlemcen on the northern side of the High Plateau. A detailed thematic analysis of forest ecosystems by using remote sensing data (picture ALSAT-1), has allowed us to identify and classify forests according to their floristic components. We also identified the extent of forest fires in this area. Some parameters as the slope (0-6, 6-12, 12-25, 25-100 percent), the proximity to roads and the forests formations were studied with the goal of determining the zones of risk of forest fire. Cross layer information in a GIS permitted us to classify the forest area in terms of the degree of fire risk in a semi-arid.
On the CORDEX-related climate downscaling for East Asia

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With reference of the CORDEX defined area, a relatively smaller region in comparison with the standard CORDEX domain for East Asia is selected for downscaling experiment. The ERA-Interim reanalysis data at its 80km spatial resolution would be downscaled into 28 km in its 0.25 degree grids. The WRF model is employed for this downscaling experiment. Given the target resolution, we set up time step of two minute in WRF.

The model run would continuously carry on in maximum 12-year each time, with the first two year simulation as spin-up period and being excluded from the final output result. The whole experiment is from 1979 until 2014. Though this is not a standard domain in term of CORDEX definition, the output variables are based on the CORDEX criteria in 3hr, 6hr, daily, monthly and seasonal data, of which the analysis and visualization are carried out, showing reasonable data quality. We aim to establish the high quality climate data set for the defined area in East Asia.
The influence of vegetation feedbacks on recent sea ice dynamics – results from a regional Earth system model

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CANCELLED

The Arctic has undergone an unprecedented warming rate in recent years. The rapid warming may be related to sudden reduction of sea ice over sea and dynamic vegetation changes over land. In this study, we use a state-of-the-art regional Earth system model (ESM) -RCAO-GUESS - which has integrated the individual-based dynamic vegetation model (LPJ-GUESS), the regional dynamically-downscaled atmosphere model (RCA) and the 3D ocean sea ice model (RCO) to study the impacts of interactive vegetation dynamics on sea ice for 1989-2011. The coupled model simulates spatio-temporal patterns of sea ice concentration (SIC) and areal extent (SIA) consistent with both previous modelling studies and observations, but our results also show that biogeophysical feedbacks can cause greater variations in summer and autumn SIC, including in some cases anomalously rapid reductions in SIA. The increased downward longwave radiation (DLWR) is spatially correlated with increased near-surface warming very well, and is thus the dominant factor contributing to the increased surface warming and sea ice melt. The spatial distribution of DLWR well corresponds to mean sea level anomaly, which is probably caused by land and sea surface warming. The results highlight the potential importance of including interactive vegetation dynamics in fully-coupled Earth system models in simulating and analyzing sea ice dynamics.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-131

Performance of WRF model for regional climate simulations in the MENA-CORDEX domain; A comparison of two radiation schemes

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We investigated the performance of a climate version of the Weather, Research and Forecasting (CL-WRF) Model over the Middle East and North Africa (MENA) domain. The ability of the model to reproduce recent past conditions was tested with 30-year simulations that cover the 1981-2010 period. The model was driven by the ERA-Interim re-analyses at a horizontal resolution of 50 km. We explored the sensitivity of the model to the radiation parameterizations by using the RRTMG and CAM3 schemes in order to optimize the model performance as a contribution to the MENA-CORDEX initiative. The results have been compared with gridded observational data, station and satellite measurements for several variables, including mean, maximum and minimum 2-meter air temperature and short- and long-wave radiation fluxes. We generally found that CAM3 driven simulations are relatively cooler than the RRTMG driven ones, but each radiation scheme gives better results depending on the dominant land use type of each grid point.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-132

Development of a Regional Air-Sea Coupled Model and its Application Over CORDEX-EA Domain

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A regional air-sea coupled model coupled (named FROALS) through OASIS3.0 was developed for CORDEX East Asia. The regional air-sea coupled model was composed of a regional climate model RegCM3 as its atmospheric component and a global climate ocean model (LICOM) as its oceanic component. The developed regional air-sea coupled model FROALS has been applied to CORDEX East Asia domain. Driven by the historical simulation and future climate projection under RCP scenario from a global climate system model, dynamical downscaling has been conducted at the uniformly horizontal resolution of 50 km. The impacts of regional air-sea coupling on the simulation and projection of East Asian summer monsoon rainfall have been investigated with comparisons to the corresponding standalone regional climate model (RCM) simulations. For present-day climate (1980-2005) simulation, the added value of FROALS with respect to the driving global climate was evident in terms of both climatology and interannual variability of summer rainfall over eastern China, contributing from both the high horizontal resolution and the reasonably simulated moisture fluxes convergence. Compared with the standalone RCM simulation, the spatial pattern of the simulated low level monsoon flow over East Asian-western North Pacific was improved in the FROALS due to the inclusion of regional air-sea coupling.

Changes in mean and interannual variability of summer rainfall were discussed for the period of 2051-2070 under RCP8.5 scenario with respect to the present day period of 1986-2005. Followed by an enhanced western North Pacific subtropical high and an intensified East Asian summer monsoon, an increase of total rainfall over North China, Korean Peninsula, and Japan but a decrease of total rainfall over southern China are seen in the projection of FROALS. Homogeneous increases of extreme rainfall amount were found over CORDEX East Asia. However, the atmosphere-only RCM exhibited too strong responses to the underlying SST warming anomalies, which induced an anomalous cyclone over North South China Sea and followed by an increases (decreases) of total and extreme rainfall over southern China (central China). The differences of the projected changes in both rainfall and circulations between FROALS and the atmosphere-only RCM were partly affected by the differences in the projected SST changes. The results recommend the employment of regional ocean-atmosphere coupled model in the dynamical downscaling of climate change over CORDEX-East Asian domain.
PARALLEL SESSION A: BENEFITS OF DOWNSCALING

PA-133

Representation of Monsoon Intraseasonal Oscillations in Regional Climate Model: Sensitivity to Convective Physics

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The aim of the study is to evaluate the performance of regional climate model (RegCM) version 4.4 over south Asian CORDEX domain to simulate seasonal mean and monsoon intraseasonal oscillations (MISOs) during Indian summer monsoon (ISM). Three combinations of Grell (G) and Emanuel (E) cumulus schemes namely, RegCM-EG, RegCM-EE and RegCM-GE have been used. The model is initialized at 1st January, 2000 for a 13-year continuous simulation at a spatial resolution of 50km. The models reasonably simulate the seasonal mean precipitation and low level circulation with a notable bias in precipitation over land and sea regions. All models exhibit high skill in simulating seasonal mean low level wind pattern than moisture and precipitation. On seasonal scale, the performance of RegCM-EG is more close to observation though it fails at intraseasonal time scales. In wave number-frequency spectrum, the observed peak in zonal wind (850 hPa) at 40-50 day scale is captured by all models with a slight change in amplitude, however, the 40-50 day peak in precipitation is completely absent in RegCM-EG. The space-time characteristics of MISOs are well captured by RegCM-EE over RegCM-GE, however it fails to show the eastward propagation of the convection across the Maritime Continent. Except RegCM-EE all other models completely underestimates the moisture advection from Equatorial Indian Ocean (EIO) onto Indian land region during life-cycle of MISOs. The characteristics of MISOs are studied for strong (SM) and weak (WM) monsoon years and the differences in model performances are analyzed. The wavelet spectrum of rainfall over central India denotes that, the SM years are dominated by high frequency oscillations (period < 20 days) whereas little higher periods (> 30 days) along with dominated low periods (< 20 days) observed during WM years. During SM, RegCM-EE is dominated with high frequency oscillations (period < 20 days) whereas in WM, RegCM-EE is dominated with periods greater than 20 days. Except RegCM-EE, all other models fail to capture the observed spectral features for SM and WM years.
Climate Change Impact on Sugarcane water requirement in Wonji-Shoa Sugar Factory West Oromia, Central Ethiopia

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Future climate change has been recognized as one of the largest issues facing the world in the coming century. Scientific assessment by the Intergovernmental Panel on Climate Change (IPCC) concludes that since the late 19th century, anthropogenically induced emissions of gases such as carbon dioxide (CO2) that trap heat in the atmosphere in the manner of a greenhouse have contributed to an increase in global mean surface air temperature. The warming has not been globally uniform. Some areas have been cooling and others are warming. This study investigated possible implications of climate change on sugarcane water requirements (CWRs) from the base period (1971-2000) to 2020s and 2050s at Wonji-Shoa, West Oromia in Central Rift Valley of Ethiopia. The main objective of this paper is to project the impact of climate change on sugarcane water requirement using CropWat software for two alternative future climate change scenarios. Predicted rainfall and temperature series were obtained from regional climate multi-model outputs of CORDEX-Africa for two RCP scenarios (RCP4.5 and RCP8.5). RCP8.5 scenario gives predictions that correspond to the business-as-usual development pathways. The RCP4.5 indicates possible future temperature and rainfall patterns with the medium GHG emission situation. Assuming no change in the regulations relating to agriculture and irrigation in future, CWR were predicted to be in the range of 4190.4 to 5213.3 mm for RCP4.5 scenario and 4234.6 to 5373.5 mm for RCP8.5 scenario per production season. An increase of crop water demand by 0.5 to 2% for RCP4.5 and by 1.5 to 6% for RCP8.5 scenarios were estimated. This increase of CWR for the same level of sugarcane production can cause stress on the water resource on the study locality. The increase of CWR was mainly due to the increase in temperature, while the effect of rainfall changes was minimal. This study might be useful in explaining the negative effects of climate change on CWR in Wonji-Shoa and better planning for water resources management. The above analysis more or less shows the magnitude and direction of climate change impact on sugarcane water need. These findings suggested that WSSE should begin to plan for climate contingencies. Actions that make the cane cultivation more immune to climate change can be taken in advance.
In spite of the recent advancements, Global Circulation Models (GCMs) are still not able to capture the regional climatic patterns satisfactorily. To bridge the gap between global and regional scale different types of downscaling techniques have been emerged in the past few decades. In the present study, a spatial downscaling method has been adopted where IMD high-resolution (0.25°x0.25°) gridded precipitation data considered as a predictant and multi-model ensemble (MME) of CMIP5 GCMs taken as a potential predictor for model calibration during 1951-80. This is a combined approach where bias corrected MME of GCMs is modulated by a multiplicative factor to produce fine scale mean precipitation patterns. The method used here is slightly different from the conventional Bias Correction Spatial Downscaling (BCSD) technique as both the bias correction and multiplication have been performed in the same grid resolution of observed data. Here downscaling is carried out for both the wettest (monsoon) and driest (winter) season of India as well as for the cumulative annual rainfall. To validate the downscaling results during 1981-2005, various conventional statistical indices like Nash-Sutcliffe efficiency (NSE), Index of agreement (d-index) and Ratio of RMSE to the Standard Deviation of the Observations (RSR) have been used. Results indicate that the downscaled model has been able to capture the spatial patterns of both seasonal and annual rainfall over the India. The spatial correlations for monsoon, winter and annual rainfall are 0.94, 0.88 and 0.93 respectively which are significant at >99.9% level. The correlations for MME without downscaling are 0.57, 0.80 and 0.64 respectively. Remarkable improvements in NSE, d-index and RSR have been also observed after downscaling. Therefore, this method may be used with more confidence to project future mean rainfall than using raw GCM outputs.

Keywords: Downscaling, GCMs, IMD gridded data, MME, spatial correlation, NSE, d-index, RSR
Black carbon (BC), which is one of the highly absorbing capacities of solar radiation, reduces albedo of atmospheric aerosol. BC along with fine particulate matters (PM2.5), which play crucial role in climate and health, was monitored online for an entire year of 2013 at an urban industrial of Jamshedpur, situated in the Eastern part of India. Daily mass concentration of BC varies from 0.5 to 23.1 μg m$^{-3}$, with an annual mean of 3.1 ± 1.4 μg m$^{-3}$ displayed clear monsoon minima and winter maxima; however, PM2.5 concentration was ranging from 44.4 to 248.7 μg m$^{-3}$, with an annual mean of 101.3 ± 35.4 μg m$^{-3}$. BC concentration in Jamshedpur is comparable to those measured in other mega cities of India but much higher than in similar locations of Europe, USA and Asia. High BC concentration is found both in absolute terms (4–16mgm$^{-3}$) and mass fraction (10%) yielding very low single scattering albedo (0.76). The estimated surface forcing is as high as 53 ± 21 W m$^{-2}$ and top of the atmosphere (TOA) forcing is +7 ± 2 W m$^{-2}$, which means the atmospheric absorption is +71 W m$^{-2}$. The short wave atmospheric absorption translates to a lower atmospheric heating of 1.8K/day. Large surface cooling and lower atmospheric heating may have impacts to regional climate. The study indicated that during post-monsoon season, the impact of biomass burning is higher as compared to combustion of fossil fuels. Results are well associated with the rapid growth of anthropogenic emissions and ambient meteorological conditions over the station.
PB-004

**Impact of anthropogenic aerosols on precipitation and surface air temperature over Central Africa by using a regional climate model**

Komkoua Mbienda A. J.

Laboratory of Environmental Modelling and Atmospheric Physics, Department of Physics, University of Yaounde I

The study investigates the impacts of anthropogenic aerosols on some relevant atmospheric parameters such as temperature and precipitation. For this aim, we use the International Centre for Theoretical Physics (ICTP) regional climate model version 4 named RegCM4. Two sets of simulations with one year of spin-up, from 2001 to 2006, identical in their structure have been conducted: one includes the interactions of anthropogenic aerosols (ExpA) and another simulation which does not (Exp). In this regard, it should be noted that discrepancies between ExpA and Exp imply the measurement of the impact of aerosols. The shortwave radiative forcing associated with the anthropogenic aerosols is negative throughout the entire domain with more negative values up to $-6 \text{W.m}^{-2}$ over the latitudinal band $0^\circ - 10^\circ \text{N}$ during DJF accordingly to the main sources region. This induces cooling at surface higher than $0.4^\circ \text{C}$. Elsewhere over the raining area, the effect on precipitation is largely negative and the reduction can reach up to $1 \text{mm.day}^{-1}$. Moreover, the atmospheric circulation is not systematically affected even though we note a variation of wind speed in the vicinity of the latitudinal band $6^\circ \text{N} - 10^\circ \text{N}$ resembling a dipole pattern.
This study examines impacts of climate variability on the yield of eight major crops in the guinea ecological of Nigeria, using both quantitative and qualitative methods. The Guinea ecological zone represents a rich agricultural area for Nigeria, sometime call “the food basket zone of the country”. Several studies have been show that variability of rainfall has significant implication not only on the differences in the types of crops cultivated but also the rate of yield of such crops. Majority of these studies were based on assessment of two to four crops. Thus, the present study apply GIS techniques to examine the climate variability and its implications on the eight crops (Cassava, yam, Maize, sorghum, Groundnut, Cowpea, Cocoyam and Melon), majorly cultivated in the area. Rainfall, temperature and the crops yield dataset from 1982 to 2012 were used in the analysis. A year is divided into two growing seasons. These seasons are: early growing season (April-June) and late growing season (July-October) with regard to seasonal differences and the crops yields. The results show that during the past decades the yields of these crops were associated with climate variability, which vary differently in the year with high rainfall than the year with low rainfall. The study found out that the crops yield have been dominated by reduction in the number of rain days during the middle of the rainy season and there is evidence of a significant change in the crop yield as climate varied. The study concluded by recommending the need to encourage rain fed agriculture and agricultural research to improve crop yields.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-006

Addressing key issues of statistical downscaling in the development of single-site projections in the framework of an IWRM concept in Distrito Federal, Brazil

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As a contribution to an Integrated Water Resources Management (IWRM) project, this study aims to develop single-site climate change projections of mean surface air temperature and precipitation in Distrito Federal, Brazil. We address several key aspects for a credible downscaling approach using the Statistical DownScaling Model (SDSM4.2). For instance, it applies a detailed screening of predictors, considers the end user needs in the validation procedure, assesses the added value of the downscaling model and includes several sources of uncertainties until the downscaling step. Results show that the interpolation of large-scale predictors to the target site is a reasonable alternative to predictors derived from grid-boxes. The applied validation metrics, measures (i.e., bias, root mean square error and Pearson’s correlation coefficient) and quantile-quantile plots illustrate the strengths and weakness of SDSM4.2 when compared to observations. The model tends to underestimate mean surface air temperature and precipitation; and extreme values are usually subject of considerable uncertainties. Single-site projections were derived from 27 climate models from the Coupled Model Intercomparison Project phase 5 (CMIP5) forced by Representative Concentration Pathways (i.e., RCP2.6, RCP4.5, RCP6.0 and RCP8.5) scenarios. The applied downscaling model adds substantial value in terms of amplitude of variability and its performance is higher than a simple bias correction technique (i.e., Quantile-Mapping), for instance in representing trends. In spite of the elevated level of uncertainties in the magnitude of change, most of the downscaled projections agree with positive changes in mean temperature and precipitation for the period of 2036-2055 when compared to the reference period (i.e., 1986-2005). The massive amount of climate projections is of limited application in hydrological studies and, therefore, we suggest a summarized group of projections which are representative to the central tendency and spread of the ensemble.
Addressing key issues of statistical downscaling in the development of single-site projections in the framework of an IWRM concept in Distrito Federal, Brazil

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PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-008

COSMO-CLM simulations over MENA-CORDEX domain: performance evaluation and climate projections for the XXI century

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1CIRA (Italian Aerospace Research Center)

The Middle East-North Africa (MENA) CORDEX domain offers considerable challenges for regional climate modeling due to its large size, complex topography and great climate variability. Several modeling groups are currently performing the dynamical downscaling of eight CMIP5 GCMs, employing spatial resolution of 0.75°, 0.44° and 0.22°. In this study, the capabilities of the regional climate model (RCM) COSMO-CLM in reproducing the main climate features of the MENA-CORDEX domain have been assessed. Two ERA-Interim driven simulations have been performed, respectively at 0.44° and 0.22° spatial resolution for the period 1979–2011. Model configuration has been chosen on the basis of a sensitivity study aimed to ascertain model performances with respect to changes in physical and tuning parameters.

Model response has been analyzed in terms of 2-meter temperature, precipitation and cloud cover. Evaluation was conducted with respect to a combination of available ground observations, satellite products and reanalysis, since wide areas are characterized by a scarce number of gauge stations. Results reveal that the values of the considered variables are generally in good agreement with observations, confirming that the albedo and aerosol parameterizations adopted lead to a remarkable improvement in model performances. Evidence of reasonably high model accuracy is given by the capability in reproducing the circulation and by the low values of average biases, compared with other state-of-art RCMs. A comparison between the two simulations revealed that improvements with the resolution increase have been achieved for the temperature interannual variability, for monthly precipitation mean values, for cloud cover and for the representation of extreme precipitation events.

Successively, two simulations covering the time period 1971-2100, driven by the CMCC-CM global model (the atmospheric component is ECHAM5) have been performed respectively at 0.44° and 0.22° spatial resolution, in order to quantify the climatic change signal induced by the IPCC RCP4.5 emission scenario. The consistency of these projections with literature data has been verified and discussed.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-009

A comparative analysis of the horizontal resolution impacts in simulated climate over South America in 2005

Rosmeri P. da Rocha 1, Marta Llopart 2, Michelle S. Reboita 3

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Studies have shown that the use of fine horizontal grid in climate models may improve the simulation of the location and intensity of some weather systems, for example, upper levels jets. However, few studies in South America carry out regional climate simulations with fine horizontal grid. In this context, for the year of 2005 RegCM4 (Regional Climate Model - version 4) simulations with approximately 50 km (G50) and 25 km (G25) of horizontal grid spacing with, respectively, 18 and 23 vertical levels are compared. RegCM4 simulations are nested in ERA-Interim reanalysis and they used BATS and Emanuel schemes to solve, respectively, solo-surface atmosphere interactions and moist convection processes. Simulations are compared with both CRU (grid spacing of 0.5 degrees) and GSMap (grid spacing of 0.1 degrees) dataset. Both G50 and G20 simulations reproduce the main aspects of observed spatial pattern of annual rainfall over South America, i.e., large rainfall rate over northwestern and southeastern of South America. However, in G50 simulation the rainfall rate is overestimated over a northwestern-southeastern band crossing from Amazon to southeast Brazil, while it is underestimated in southeastern South America. These biases have the same signal in G20, but in module they are smaller in G20 than in G50. The use of fine grid spacing helps to improve the simulated rainfall spatial pattern near the steep Andes Mountains and to reduce the bias in central-northern part of Amazon. In this last area, the errors are smaller when G20 simulation is compared with GSMap dataset. In addition, the annual biases the annual cycle and frequency distribution of daily rainfall over key areas of South America are also presented.
Evaluation of two statistical downscaling models over Casamance sub-basin areas in South of Senegal

Samo Diatta1, Youssouf Sané2, Mamadou Heinrich Faye1, Moctar Camara1, Bamol Sow1, Malick Wade1


CANCELLED

Two statistical models, the statistical downscaling model (SDSM) and the hidden Markov model (NHMM), which have been widely applied and proven skillful in terms of downscaling precipitation, have performed and evaluated in Casamance sub-basin region in South of Senegal, where fluvial agriculture is intensely practiced. Metrics including residual functions, correlation analyses, probability density functions and distributions have been evaluated. Both models captured the spatial distribution characteristics of precipitation for most of stations in calibration. However, there is some differences on performance models to simulate monthly precipitation.
In regional climate modelling, it is well known that domains should be neither too large to avoid large departure from the driving data nor too small to provide sufficient distance from the lateral inflow boundary to allow a full development of the small-scale features resolved by the finer resolution. Although practitioners of dynamical downscaling are well aware that the jump of resolution between the driving data and the nested regional climate model impacts the simulated climate, this issue has never been properly studied. In principle, the bigger is the jump in resolution, the larger is the distance from the lateral inflow boundary to fully develop the small-scale features permitted by the increased resolution. Misplaced domain lateral boundaries might result in an inefficient use of the full potential of finer resolutions to develop fine-scale features.

In our study with a regional model grid mesh of 0.15°, we compare results with driving data at 3.6°, 1.8°, 0.45° using the perfect-prognostic Big-Brother protocol. The results show that the small-scale transient eddies struggle to completely develop with coarser resolutions of the driving data. Overall, this study suggests that domain location must be chosen according to the jump of resolution to allow the optimal development of small-scale features allowed by the increased resolution of the nested model.
PB-012

Effect of bias-adjustment on the projection of temperature and precipitation extremes from an ensemble of EURO-CORDEX RCMs

Alessandro Dosio
European Commission Joint Research Centre

Will be displayed in Session C – Poster PC-027

In order to be used as an input for process based impact models, output from climate models are usually post-processed in order to reduce their systematic biases.

Amongst several techniques, bias-correction, or bias-adjustment, employs a transfer function to match the cumulative distribution functions of modeled and observed data.

However, as bias-adjustment affects directly the PDF of the climate variable, both in the present and future, the bias-adjusted climate change signal may be different than the ‘original’ one.

Climate models show temperature-dependent biases that can alter the climate change signal (Boeberg and Christensen, 2012). Recently, Gobiet et al (2015) discussed the effect of bias-adjustment on projected mean temperature and argue that, by removing the intensity-dependent errors, the adjusted mean climate change signal can be regarded as an improvement compared to the original one.

However, impact models are significantly dependent not only on the mean climate but also on the occurrence and frequency of extreme events, which in turn depend on the value and evolution of the tails of the PDF. The effect of bias-adjustment on the projected occurrence of climate extremes is less commonly investigated and it is the focus of this study.

In this work the outputs of an ensemble of RCMs from the EURO-CORDEX initiative has been bias-adjusted. A number of ETCCDI climate indices have been calculated for the present (1981-2010) and future (2071-2100) climate.

Indices include absolute thresholds indices (e.g. days when TX > 25°C), percentile-based indices (e.g. days when TX > than the 90th percentile of the reference period), and indices based on the duration of an event (e.g. consecutive dry days).

Results show that absolute threshold indices are the ones most affected by bias-adjustment, as they depend strongly on the shift of the mean value of the variable, which is usually largely biased in the original RCMs. Threshold-based indices are less affected, however some differences emerge when bias-adjustment affects not only the present-day PDF, but also its evolution in the future. For instance, the resulting PDF of bias-adjusted climate change signal may be different (e.g. more skewed) than the original one. As a result, despite a decrease in the mean value of the temperature signal, the value of extreme climate indices can remain constant, or even increase locally.
PB-013

Climate seasonal outlooks for water management assistance in Sub-Saharan Africa

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Climate conditions relies upon signals such as the status of El Nino Southern Oscillation (ENSO) and the interdecadal Pacific Oscillation and their implications (previous records and science) at regional and country scales.

Local scientific knowledge on circulation, seasons and developed statistical prediction tools such as similar past analogous situations and regression schemes are used to predict climates variables one to three months in advance.

Water managers and Engineers make use of climate information and predictions at the a range of temporal and spatial scales and also use their own techniques to account for climate variability.

Methods used was to find the accuracy of stream flow prediction assessment. The skill level was better than climatology (the null prediction of apportioning 33 per cent probabilities to each third). Biases in flow prediction have been examined. Prediction of normal or below normal flow predominated over above normal predictions. The biases were associated with difficulty the climate for extreme weather event a season a head. Reliable records of river flow can be presented in near real-time.

The paper finds that many hydrological modeling tools are being developed to model hydrological processes at an appropriate range of temporal and spatial scales in sub-Saharan Africa in parallel to the development of global/regional/mesoscale climate models.

Links between the climate and hydrological models may facilitate physically-base and scientific short-to medium-term climate and hydrological information and predictions.

The paper indicate that to validate climate and hydrological models, ongoing monitoring and data storage, quality assurance and analysis needs to be maintained to at least their current levels.

Keywords: Climate, seasons, water, management
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-014

MGClimeDeX: Martinique & Guadeloupe Climatic Dynamical down-scaling eXperiment

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The Martinique & Guadeloupe Climate Dynamical down-scaling eXperiment (MGClimeDeX) aims to perform a complete regional climatic analysis for the Martinique and Guadeloupe Caribbean Islands encompassing multiple angles: Analysis of the characteristics, mechanisms and trends of the climate in the area (lesser Antilles) in its multiple components: atmosphere, ocean and land. Evaluation of the potential societal and economical impacts of climate change on the two islands in all the possible vulnerable areas: food production (agriculture, fisheries), infrastructures, health, renewable energies. Diffusion, dissemination and education of the background knowledge and results to the local population. The project will use state-of-the art modeling tools creating a multidisciplinary team of scientists from different areas of expertise and institutions.

MGClimeDeX is designed in 2 phases. A first phase (that already started with partial funding from the France Foreign Office), aims at building a framework between the climate modelling and the local impact research community. The interaction of these research communities is crucial and will lead to the definition of the requirements and specificities of each impact domain (agriculture, marine ecosystems, forests, etc...) upon which the experimental setup will be built.

A second phase encompasses the design of the model experiment (an application to Antilles-FEDER funding is ongoing). It will consist in high-resolution regional climate simulations (2 km) for the two islands. The terrestrial components will be simulated with coupled runs of atmospheric WRF and land ORCHIDEE models. A triple nesting domain configuration, (from Central-America CORDEX domain) will be used. Off-line runs with the NEMO+PISCES coupled system will be used for the ocean and its biogeochemistry. A multi-physics (3 physics) and multi GCMs (3 from CMIP5 as boundary and initial conditions) ensemble will be produced, over three time-window periods (1970-2010), (2020-2050), (2070-2100). Control period (1970-2010, 3 physics) using ERA-Interim re-analysis will be also simulated.

Model outputs will be used by the local impact and risk communities in order to assess the potential impacts of change on the two islands. Transmission of the scientific results to the society is also of paramount importance for the project. Thus, a third phase of dissemination of the results, with specifically-designed tools and resources, is also planned.
PB-015

Weather climate Impact Study at High Resolution (WISER)

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In the inner domain, the project will focus on the change in precipitation patterns in Western Europe. It is proposed that this work will be in collaboration with the Climate Risk Management Unit, at the JRC, (Dr Jutta Thielen). In the inner domain, at a model resolution of between 2.5-3.5km, the model will produce rainfall patterns. In the first stage, the model, driven by era interim data at the northern and southern boundaries, will generate rainfall statistics which will be compared with observations and comparative simulations by the CESM data. The application of the bias corrections will enable an accommodation for the representation of the background global files for the future decades, with predictions of changes in precipitation available for Western Europe.
Statistical downscaling techniques are often used to generate finer scale projections of climate variables affected by local scale processes not resolved by coarse resolution numerical models like global climate models (GCMs). Statistical downscaling models rely on several assumptions in order to produce finer/local scale projections of the variable of interest; one of these assumptions is the time-invariance of the relationships between predictors (e.g. coarse resolution GCM output) and the local scale predictands (e.g. gridded observation based time-series or weather station observations). However, in the absence of future observations, statistical downscaling studies use historical data to evaluate their models and assume that these historical simulation skills will be retained in the future. In addition, regression based downscaling models fail to reproduce the observed variance, and hence their projections need to be adjusted accordingly. Two approaches are usually employed to perform this adjustment: randomization and variance inflation. Here we study the effect of the stationarity assumption when downscaling daily maximum temperatures and using the downscaled information to estimate historical and future metrics like return periods and heat waves durations over Montreal, Canada; and the effect of the two variance adjustment techniques on the historical and future time-series. To do so, we used regional climate model (RCM) output from the Canadian RCM 4.2, as proxies of historical and future local climates, and daily maximum temperatures obtained from the Canadian GCM 3.1. The results show that the root mean squared errors (RMSEs) between the pseudo-observations and the statistically downscaled time-series (historical and future) varied over time, with higher errors in the future period; the results also show the effects of randomization and variance-inflation on the tails of the statistically downscaled time-series.
Development of a non-hydrostatic version of the regional climate model RegCM4

RegCM4 Development Team

RegCM4 is the latest generation of a regional climate modeling system widely used for different applications by a broad research community. The standard version of the model employs the hydrostatic dynamical core of the mesoscale model MM5, and is thus applicable to grid spacings of the order of 10 km or more. Two important enhancements have been implemented into this model system towards the application of RegCM4 to higher resolution, convection permitting simulation. The first is the implementation of the non-hydrostatic dynamical core from the MM5 model system and the second is the development of an improved explicit cloud microphysics scheme including 4 different hydrometeors (cloud water, cloud ice, snow and rain). This non-hydrostatic version of RegCM4 is currently being tested over different regions and climatic settings in order to assess its performance in climate-type simulations. The poster will provide an overview of this model development and report results from the first test experiments. It is expected that this non-hydrostatic version of the model will be released for public community use in the spring of 2016.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-018

The Use of an Intermediate Complexity Atmospheric Research Model (ICAR) for Climate Downscaling

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High-resolution downscaling is critical for many applications, particularly for alpine hydrology. However, the computational cost of dynamical simulations with grid spacing less than 5-10km prohibits the use of such models for long-term simulations over large domains with many ensemble members, thus limiting their applicability for many end users. Here we present the recently developed Intermediate Complexity Atmospheric Research model (ICAR) which is capably of performing quasi-dynamical simulations with less than one percent of the computational cost of a traditional regional climate model. ICAR uses linear mountain wave theory to simulate perturbations to atmospheric flow induced by topography, in combination with a selection of different physics schemes from a traditional regional climate model. The physics schemes include multiple advection, microphysics, planetary boundary layer, land surface, radiation, and cumulus parameterizations, thus permitting ICAR to be used to test the sensitivity of climate change simulations to the physics packages selected, or to parameters within those physics packages. ICAR simulations are presented over a variety of locations, including the Colorado Rockies, the Columbia River Basin, and Southern Norway, and comparisons to high-resolution WRF simulations and sparse observations are made for temperature and precipitation. Coupling to a land surface model is found to be critical for temperature and the use of a more sophisticated treatment of the microphysics is critical for precipitation. Finally climate change simulations over these domains are shown for a small ensemble of different climate models, different ensemble members from the CESM large ensemble, and different physics options from within ICAR to investigate the relative importance of the global model, internal variability in the climate system, and the regional model physics. Future work to be discussed includes the comparison to larger networks of alpine catchment hydrology observations through the GEWEX INARCH project.
Schooling on the Boat – Adapt with the Climate Change

KM Taj-Biul Hasan

Dhrupad Communication-media for education & development

Bangladesh is one of the poorest and most densely populated (160 million UN 2012), country of South Asia is 10 meters above the sea level, located on the Bay of Bengal in the delta of Ganges and on the front lines of climate change. Over the next 40 years, 17 percent of the land will be lost to the sea resulting 20 million climate refugees because of climate change. Along with a very poor literacy rate (38%), Bangladesh has not only been struggling for basic human needs as well as also fighting against the incoming climate change by different means. The Northeastern regions of Bangladesh are underdeveloped due to ecological and climatic reason reasons. The inhabitants of this area are completely depended at the mercy of the environment for survival. The boat is the only means of transportation for communication. In such despair in 2002, a non-profitable organization came forward with an amazing idea to promote education and basic human needs of that impoverished regions. They tried to use the natural event of these regions - '-Water' and 'Boat' simultaneously to build up a scheme called "Education on the Boat". It is really an astonishing effort to promote education and basic needs in all perspective by considering economic, climatic, and environmental adversities. It is the first river-based environmental education and training effort in the country that teaches how to protect the environment and conserve water. Boat schools are the combinations of a school bus, schoolhouse, training boats, library and medical centers etc. Within seven years, one hundred thousand families have directly benefited by this process. This gradually increased the literacy rate and indirectly changed the total scenarios of "Cholon Beel". Certainly, this exceptional concept will be inspired all level of people of the world how to deal with the future climates change and to promote education, basic human needs as well as conserving the environment and at the same time, to lift people out of poverty in any given situation within the most cost effective manners.
Climate change assessment on the CORDEX South Asian summer monsoon precipitation using high resolution RegCM4.3 simulation

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The South Asian summer monsoon (SASM) is one of the most prominent and energetic occurrences in the planet’s climate system and exhibits highly complex variability from June to September. In the present study, we used a high resolution climate change simulation at 25 km grid spacing over CORDEX South Asia with the ICTP regional climate model RegCM4.3. RegCM4.3 is driven at lateral boundary forcing by GFDL-ESM2M for present day model’s validation (1976-2005) and for future climate conditions (2070-2099) under the moderate (RCP4.5) and the strongest (RCP8.5) representation concentration pathways. RegCM4.3 improves the simulation of seasonal mean precipitation as compared to core GCM over most parts of the CORDEX South Asia during the present day climate conditions. Despite significant variability in the mean wind fields, the location of the Somali jet, low level cyclonic circulation over the monsoon core region, and position of upper level Tibetan anticyclone are successfully reproduced by RegCM4.3. The significant increase in precipitation projection over the Western Ghats and peninsular India under RCP8.5 is possibly related with the strengthening of southwesterly seasonal flow at 850 hPa during the wet period. A quantitative analysis of spatial correlation reveals significant influence of model biases on the simulated change. The RegCM4.3 projected dry conditions over northeastern India are possibly related to the anomalous anticyclonic circulations in both scenarios. Despite some caveats in our results, this study will significantly contribute to the CORDEX project and climate change impact assessment over South Asia.
West Africa is a geographical enclave in Sub-Saharan Africa, with a population of 320 million people and endowed with diversified ecological systems; comprising tropical rain forests and mangroves in the south and coastal areas, as well as sahelian and desert landscapes to the north. From Benin, Liberia and Sierra Leone to Mali, Niger and Mauritania, the sixteen-nation sub-region is confronted with an array of development challenges. A particularly problematic issue is the threat posed by global climate change. The emergent demographic explosion has unleashed anthropogenic forces on the region’s fragile ecosystems. This development is now compounded by global climate change, posing a threat to human well-being and ecological sustainability. The Intergovernmental Panel on Climate Change (IPCC), in a report on the region, observed a significant decline in rainfall since the end of the 1960s, with a reduction of 20 to 40%, spanning the periods 1931-1960 and 1968-1990. The long-term decline in precipitation has been blamed for a southward shift of the Sahelian, Sudanese and Guinean agro-ecological zones during the second half of the twentieth century, prompting considerable loss of biodiversity across the sub-region; with the disappearance of grassland and acacia, as well as other flora and fauna. This has rendered vulnerable the peoples’ livelihoods largely tied to agriculture, which accounts for one-third of the region’s annual Gross Domestic Product. Therefore, the objective of this paper is to shed light on the impact of climate change on biological diversity in West Africa. The paper employs empirical data to unveil the worsening state of biodiversity, fuelling food insecurity and endemic poverty. The paper also presents a policy framework anchored in investment on the region’s ecosystems and making adaptation and climate risk management core elements of the post-2015 development agenda.
Simulating the probability distribution of rainfall at convective permitting scales with a variable resolution, global atmospheric model

Tony Rafter, Marcus Thatcher, Kim Nguyen and Jack Katzfey
CSIRO Oceans and Atmosphere

As regional climate models approach convective permitting spatial scales, there is potential to use such models to study extreme rainfall and other natural hazards. Such extreme rainfall events represent one of the most destructive natural hazards experienced in Australia and globally, through their contribution to flooding and the resultant risk to human lives and of damage and destruction to natural and man-made environments.

We report on our progress utilising the CSIRO Cubic Conformal Atmospheric Model (CCAM) to advance the representation of rainfall extremes at 2 km spatial resolution over regions covering Sydney, New South Wales and Brisbane, Queensland. CCAM is a variable resolution global model, where the grid can be focused over a region of interest, but still avoid lateral boundary conditions. For these experiments, the large scale evolution of the model was constrained to follow ERA-Interim reanalyses, using a scale-selective filter technique for perturbing the atmosphere winds, air temperature and surface pressure. Specifically we first performed a 50 km resolution global simulation and then downscaled to 2 km resolution using the 50 km results as a host model. Use of ERA-Interim reanalysis data enabled comparisons between our modelling results and the Australian Water Availability Project (AWAP) data set, with particular emphasis on the tail of the rainfall distribution, as well as the impact of the different grid resolution used for the simulations.

After some optimisation of the scale-selective filter, we achieved a maximum speed of 1.8 simulation years per day at 2 km resolution with a C192 grid (400 km x 400 km for the high resolution region), 35 vertical levels and using 1536 processes. The model results for the period 1980 to 2014 suggest that CCAM can produce a plausible simulation of the probability distribution of rainfall for the regions investigated. We characterise the simulated extreme rainfall using statistical analysis methods including extreme value analysis. The ability to use simulations for regional climate projections of extreme rainfall will also be discussed.
Unprecedented increase in anthropogenic gases in recent decades has led to climatic changes worldwide. CO2 emissions are the most important factors responsible for greenhouse gases concentrations. This study decomposes the changes in overall CO2 emissions in Pakistan for the period 1990-2012 using Log Mean Divisia Index (LMDI). LMDI enables to decompose the changes in CO2 emissions into five factors namely; activity effect, structural effect, intensity effect, fuel-mix effect, and emissions factor effect. This paper confirms an upward trend of overall emissions level of the country during the period. The study finds that activity effect, structural effect and intensity effect are the three major factors responsible for the changes in overall CO2 emissions in Pakistan with activity effect as the largest contributor to overall changes in the emissions level. The structure effect is also adding to CO2 emissions, which indicates that the economic activity is shifting towards more energy intensive sectors. However, intensity effect has negative sign representing energy efficiency gains, which indicate good relationship between the economy and environment. The findings suggest that policy makers should encourage the diversification of the output level towards more energy efficient sub sectors of the economy.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-024

A ultra-high resolution precipitation data for urban floods

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In order to be prepared for flooding and designing the storm sewer facilities, we need the rainfall estimate at each manholes to find out precipitation-runoff relationship. In the city of Seoul, Korea, the manholes are installed at a maximum 200 meters, but only 4-5 km intervals of precipitation observations are available. Also flash flooding occur in few hours of time, so the spatial and temporal ultra-high resolution of precipitation data is required. Due to these requirements, hourly 250 m resolution synthetic precipitation data over the Seoul has been made using a diagnostic rainfall tool, QPM (Quantitative Precipitation Model). The QPM consider the physical processes, quantifying the additional precipitation induced by orographic effect, with topography altitude and upper-level six meteorological variables (wind velocity, temperature, humidity, etc). For the heavy rainfall case, during the period of 07 UTC 26 July to 15 UTC 27 July 2011, the maximum precipitation over the Seoul was 86 mm per hour in the observation, the synthetic data represents well with the observation. The correlation coefficient of the synthetic precipitation data with the observation was 0.83 and synthetic difference compared with observation in rainy time, in the difference range between –9 and 9 mm per hour, there are the 80% of value exist during the period. This 250 m resolution hourly precipitation data provide a reasonable rainfall information for ungauged sites and appears to be useful for a preliminary data of urban flood analysis.
PB-025

Relationship among hydrological variables and precipitations in Cameroon: the case study of the NSIMI tropical experimental watershed

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Since 1993, multidisciplinary (hydrology, geochemistry, cristallography, geophysics, microbiology and pedology) study have been carried out on the Nsimi experimental watershed. In the present study, we are investigating the relationship that may exist between hydrological variables and precipitations in different temporal step (daily, monthly, quarterly and seasonaly) on the Nsimi watershed. We found that precipitations and water discharge are strongly correlated ($r = 0.83$) on the seasonal step and that the relationship between precipitations and evapotranspiration is very weak in all scales.

Keywords : Nsimi (Cameroon), Tropical Experimental watershed, Precipitations, Water discharge, Evapotranspiration, Correlation.
Downscaled precipitation change over the station locations in the lower Western Himalayas region of India

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An attempt has been taken to develop the downscaled precipitation scenarios over the Western Himalayan region of Indian using empirical statistical downscaling (ESD) method. Downscaling models was calibrated and validated using the combined approach of reanalysis monthly precipitation field from ERA-Interim and GCMs outputs of the Coupled Model Intercomparison Project phase-5 (CMIP5) as predictor and station level monthly precipitation as predictant during the period of 1979-2005. Once the downscaling models is reasonably well validated over different station locations, the same models can be utilised to construct future station level precipitation time series using four different Representative Concentration Pathways (RCPs); RCP2.6, RCP4.5, RCP6.0 and RCP8.5 for the period of 2006-2100. Future scenarios was developed over 3 station locations in Uttarakhand (UK) state and 3 stations in the Himachal Pradesh (HP) using only three CMIP5 GCMs (HadGEM2-AO, NorESM1-M and GFDL-CM3) which are commonly available in all four RCPs. The results revels that the downscaled precipitation has able to reproduce observed precipitation trends quite satisfactorily in both calibration and validation period. It also be noted that downscaled precipitation is very much closer to the observed annual decreasing trends in each station location although correlations are not so high or significant in annual scale compared to monthly scale. Future downscaled precipitation time series for six stations was generated during 2006-2036 (2020s), 2037-2076 (2050s) and 2068-2098 (2080s) using four RCPs indicates that the UK based stations will show an insignificant trend of nominal deficit precipitation in 2020s; highly deficient precipitation in both 2050s and 2080s. Similarly the HP based stations will also project a significant increasing trend in 2020s; while surplus of precipitation in the 2050s and 2080s. The annual mean precipitation in the UK based station would decrease by about 9.9%, 11.5%, 10.6% and 12.8%; while increase by about 3.5%, 5.9%, 4.4% and 10.6% for HP based station under RCP 2.6, RCP45, RCP6.0 and RCP 8.5 respectively in the 2080s.

Key Words: Empirical Statistical Downscaling, Himalaya, Himachal Pradesh, Precipitation, RCP, Uttarakhand
The conditional resampling model STARS: weaknesses of the modeling concept and development

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The Statistical Analogue Resampling Scheme (STARS) is based on a modeling concept of Werner and Gerstengarbe (1997). The model uses a conditional resampling technique to create a simulation time series from daily observations. Unlike other time series generators (such as stochastic weather generators) STARS only needs a linear regression specification of a single variable as the target condition for the resampling. Since its first implementation the algorithm was further extended in order to allow for a spatially distributed trend signal, to preserve the seasonal cycle and the autocorrelation of the observation time series (Orlovsky, 2007; Orlovsky et al., 2008).

However a detailed evaluation of the simulations revealed a fundamental weakness of the univariate resampling technique when applied to multivariate time series. The restriction of the resampling condition on a single individual variable can lead to a misinterpretation of the change signal of the remaining variables (F. Wechsung and M. Wechsung, 2014). As one example, the short-term correlations between precipitation and temperature (cooling of the near-surface air layer after a rainfall event) can be misinterpreted as a climatic change signal in the simulation series. To overcome this fundamental weakness and several minor shortcomings a redevelopment of the whole algorithm was done.

The poster discusses the main weaknesses of the earlier model implementation and the methods applied to overcome these in the new version. Based on the new model idealized simulations were conducted to show the improvement explicitly.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-028

Impacts of spectral nudging on the simulation of present-day rainfall patterns over southern Africa

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Regional climate models (RCMs) are expected to provide finer-scale simulations than those provided by global climate models, whilst maintaining the large scale circulation patterns provided by the host models. In this study we examine the influence of spectral nudging on the simulation of rainfall patterns in South Africa. We use the Conformal-Cubic Atmospheric Model (CCAM) as RCM to downscale ERA-interim reanalysis data to a resolution of 50km in the horizontal over the globe. The simulations are performed for the period 1979-2014, consistent with the design of the Coordinated Downscaling Experiment (CORDEX). A scale-selective filter (spectral nudging technique) is used for nudging the CCAM simulations. The filter is applied at length scales of 4000 km, 1000 km and 200 km and 0 km (no nudging). The filter is applied at six-hourly intervals and from 900 hPa upwards. Use of this spectral-nudging technique ensures that observed synoptic-scale circulation patterns are represented with increasing realism as the length-scale at which the filter is applied decreases. The model simulations of rainfall are compared against CRUTS3.2 observed monthly rainfall data, and the merits of the different length scales of nudging are discussed.
Background: Climatic variability in the Sub–Saharan region has been monitored, using both systematic rainfall records and proxy information concerning lakes and rivers and the occurrence of famine and drought.

Methods: Proxy data have been used to produce a semi-quantitative data set spanning most of the continent and having an annual time resolution. Various issues related to the causes of this variability are also considered: atmospheric and oceanic processes, desertification, mineral dust and hydrological feedbacks.

Results: The most significant climatic change that has occurred has been a long-term reduction in rainfall in the semi-arid regions. The Sub–Saharan region has been affected by increased aridity. Few changes in temperature have been demonstrated. These have occurred on a much smaller scale and are of considerably lower magnitude than those over the continents. Dry episode have prevailed and conditions more typical of the ‘normal’ for the current century again prevailed. Thus, another period of dry conditions evidenced in the Sub–Saharan region are not in themselves evidence of irreversible global change. On the other hand, the processes controlling rainfall over most of the continent are now reasonably well understood. One of the most important factors, particularly in the Sub – Saharan region, is sea-surface temperatures. It has been hypothesized that anthropogenic changes in the land surface, particularly land use change and desertification, have contributed significantly to the decline in rainfall. Current evidence suggests that if changes in the land surface (e.g., vegetation cover, soil moisture) significantly impact climate, they are much more strongly controlled by natural climate variations, such as the recent decline in rainfall, than by human-induced land-use change or degradation.

Conclusion: There is no any accurate large-scale assessment of the extent, nature and degree of such changes. The dreaded ‘desertification’ process appears to be confined to relatively small scales.
PB-030

Mitigating the impact of environmental degradation on climatic change and global warming

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Background: The program aims at contributing to improved effectiveness and efficiency of climatic management systems by strengthening the capacity to intervene in an appropriate, effective and timely fashion in the districts of Kampala, Tororo, and Jinja.

Methods: The districts of implementation were selected because they hold the most eminent industrial centers and trading hubs of the country that are sources of environmental degradation and industrial emissions.

Results: The program seeks to reduce the vulnerability of Ugandans and improving their coping mechanisms to effects of climate change. Environmental aspects in Uganda that have an effect on climate change include; industrial emissions and discharges, vehicle fumes, poor garbage disposal, encroachment on swamps and forest reserves. In return climate change affects the environment as well agricultural production. The unpredictable rains have led to loss of crops because rain has been either too much or too little and too late during planting or harvesting seasons. Climate change is making it difficult for people to feed themselves as crops become susceptible to diseases and unpredictable weather patterns.

Conclusions: In order to achieve long term positive effects, the capacity of environment users should be built such that they provide eco-system services through adoption of environmentally friendly practices that mitigate carbon activities, protect and restore water catchments system like massive tree planting, installation of waste treatment mechanisms, advocacy and enactment of legislations as well as installing locally designed incinerators at institutional, community public points, municipal garbage centers and households.

Key words: Mitigating, Environmental degradation, Global warming, Climate change.
PB-031

Statistical downscaling of temperature and precipitation over Vietnam using RCMES

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RCMES model (Regional Climate Model Evaluation System) is one of the statistical downscaling model developed by the Jet Propulsion Laboratory, California Institute of Technology. In our study, RCMES has been applied for statistical downscaling of monthly temperature and precipitation over Vietnam based on the scenarios of RCP 4.5 and RCP 8.5 from 3 GCMs (MPI, IPSL, MIROC5). Currently, RCMES supports 3 methods of statistical downscaling. However, we apply the Asynchronous linear regression for downscaling monthly temperature and precipitation over Vietnam. In addition, we only focus on the downscaling of mid-21 century (2014-2070) and end-21 century (2071-2100) changes in temperature and precipitation.
Flood which constitutes one of the deadliest and costliest disaster worldwide and the Nigeria Metropolitan Agency has hinted that over billion people globally would be affected by the flood by the year 2050, but Nigerians has just experience 2012 Flood disaster that destroy the lives, farming land and property. This paper therefore analyses the different risk management principles use during the period N and also analyses the economy implications that the flood have to an average Nigerians in the different state of Nigeria, the different Presidential committees on flood Relief and Rehabilitation, how effectively is the money being donated, the various plans of intervention in a variety scenario’s. Questionnaires were administered to get the different views; group discussions were also made to ascertain the different causative agents of the flood. The findings is that the emergency management requirement both at Federal and State level was overwhelming, the monies appropriated for the care of the internally displaced persons in their various camps in addition to the relief materials donated by various groups and corporate organizations is not appropriate for the intervention measures. Suggestions were made to maintain a good flood plain to avoid such disasters, the disaster mitigation awareness at the growths, disaster relief projects, and needs for various interventions programs and policy on resettlement camps for the displaced person.

Keywords: Flood, Nigeria, risk management
Obtaining best parameterization scheme for Regional Climate model simulation over Indian Subcontinent

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Climate simulation with 50km resolution is conducted over South Asian domain with main focus on Indian sub-continent using the ICTP regional climate model RegCM 4.4. Seven simulation experiments (RegCM- Grell, RegCM-Emanuel, RegCM- Tiedtke, RegCM- Klein & Fritch, RegCM-TdEm (mixed convection), RegCM-BATS and RegCM-CLM 4.5) are conducted to investigate the model sensitivity to the Cumulative precipitation schemes and also the improvement of community land model (CLM) 4.5 coupling over the inbuilt Biosphere-Atmosphere Transfer Scheme (BATS). Use of the RegCM-CLM 4.5 instead of RegCM-BATS results in significant reduction in the over estimation of precipitation and temperature and thus producing a drier and colder land surface in the monsoon, post monsoon and winter seasons over India. However, the RegCM-CLM 4.5 simulation is less satisfactory during April-June as there is an overestimation of precipitation ~2mm/day. The late precipitation peak obtained in August with RegCM-BATS is shifted to June when RegCM-CLM 4.5 is considered. RegCM with Tiedtke precipitation scheme shows a better realistic simulation over India and North-East India in comparison to the other schemes during the period 1998-2002. The simulation with Tiedtke scheme well captures the monsoon precipitation pattern over India ~7mm/day and North-East India ~12mm/day, which are comparable to CRU, TRMM and GPCP data sets with good correlation of R2 >0.93. The temperature obtained for the Tiedtke scheme experiment over the Indian region is similar to the other data sets whereas it creates a cold bias over North-East India. The results show that CLM 4.5 coupled with RegCM simulates better climate than BATS scheme and reliable cumulus precipitation for the domain is produced using the Tiedtke scheme. As results of the convective parameterization depend strongly on the assumptions made about the entrainment rate, simulation experiments with high (ENTH) and low (ENTL) entrainment rate were conducted in Tiedtke scheme to study the variation in precipitation scheme with entrainment rate.
ANÁLISIS MULTITEMPORAL DE LA SENSIBILIDAD A LA DESERTIFICACIÓN DE LA PROVINCIA DEL AZUAY A PARTIR DEL AÑO 1982

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Research highlights the importance of desertification due to the economic, social and environmental impact it generates (Poch, 2011, Abraham & Torres, 2007; Reynolds & Stafford, 2002), but efforts to determine the magnitude and impact of desertification in the country are very limited. In this context, the present study examines existing documentation whose information will enable us to historically assess the desertification process through a multi-temporal and multi-criteria analysis using geographic information systems (GIS) to determine the necessary guidelines to reverse, control and prevent the process of desertification in the province of Azuay- Ecuador. Between 1982 and 2008, areas not susceptible to desertification decreased by 2.28%, and areas with potential susceptibility by 3.75%; while fragile areas increased by 0.71 % and areas of critical susceptibility by 5.32 %.

Keywords: Desertification, diagnosis, ESAs, multi-temporal, GIS.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-035

RegCM4 climatic projections of wind power density over Brazil

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Due to the global concern about climate change, governments have encouraged the use of renewable energy sources against the fossil fuel. One of these sources is wind. However, only some parts of the earth’s surface have winds with appropriate intensity for investments in wind farms. For example, in Brazil the regions more appropriated are the northeast and south. In order to recognize areas where the wind power density (WPD) will be favorable to wind power generation two regional climate change scenarios are analyzed. The Regional Climate Model (RegCM4) provided the climate projections for the Representative Concentration Pathways RCP4.5 and RCP8.5. RegCM4 projections were driven by the global model HadGEM2-ES in the domain suggested by CORDEX, which covers South America with horizontal grid of 50 km and with 18 sigma-pressure levels. The study focus in the present (1979-2005) and future periods (2070-2098) and in the winds at 100 meters high that is the height currently used to the wind turbines. Both RCP4.5 and RCP8.5 scenarios show the same spatial pattern of the WPD in the future. However, RCP8.5 presents WPD larger relative differences compared to present climate. In the summer, from the western Amazon to Maranhão states (located in northern Brazil) there is an increase of over 100% in the WPD. In southern Brazil, the WPD increase reaches almost 90% at same time that it is projected to increase between 20-40% over northeastern Brazilian coast. Similar results are obtained in spring. During fall, over most of the northeast of Brazil it is projected an increase of WPD that may reach 100% in the coast of the region. WPD is also projected to increase over southern Brazil during fall. Over northern and southern Brazil WPD is projected to diminish, respectively, during fall and winter. In all seasons, the WPD increases in northeast coast of Brazil compared to present climate. Overall, the climate projections are promising for investments in wind farms in Brazil.
Climatic variability is essential issue when dealing with the issue of climate change. Variability of some climate parameter helps to determine how variable the climatic condition of a region will behave. The most important of these climatic variables which help to determine climatic condition in an area are both the Temperature and Precipitation.

This research deals with Long term climatic variability in Nigeria. Variables examined in this analysis include near-surface temperature, near surface minimum temperature, maximum temperature, relative humidity, vapour pressure, precipitation, wet-day frequency and cloud cover using data ranging between 1901-2010. Analyses were carried out and the following methods were used: - Regression and EOF analysis.

Results show that the annual average, minimum and maximum near-surface temperature all gradually increases from 1901 to 2010. And they are in the same case in wet season and dry season. Minimum near-surface temperature, with its linear trends are significant for annual, wet season and dry season means. However, the diurnal temperature range decreases in the recent 100 years, implies that the minimum near-surface temperature has increased more than the maximum. Both precipitation and wet day frequency decline from the analysis, demonstrating that Nigeria has become dryer than before by the way of rainfall. Temperature and precipitation variability has become very high during these periods especially in the Northern areas. Areas which had excessive rainfall were confronted with flooding and other related issues while area that had less precipitation were all confronted with drought. More practical issues will be presented.
The regional climate model REMO is well established and has proofed its value in regional climate simulations for more than a decade. However, due to the hydrostatic formulation REMO is not able to produce useful regional climate information on scales smaller than ~10 km. The demand for higher resolution data especially in the climate service sector is evident. Often climate change information on urban district or even point level is needed. A previous development of a non-hydrostatic dynamical core for REMO utilizing ideas of Miller and Pearce (1974) and Janjic (2001) has been picked up and implemented into the latest hydrostatic REMO version. One of the advantages of the Janjic formulation is that hydrostatic and non-hydrostatic computations are well separated. This offers a straightforward implementation of the non-hydrostatic calculations into an existing hydrostatic model. Other advantages are the easy quantification of the error done by the hydrostatic approximation and the lower computational costs at lower resolutions by switching of the non-hydrostatic part. We will present first results from the new REMO version using idealized as well as real data cases.
The Mantaro River Basin (MRB), located in the central Peruvian Andes, has a great economic importance for the country, because it provides about 35% of the hydropower energy for the country. On the other hand, the Mantaro Valley is highly productive and supplies with the main food stock to Lima (IGP, 2005). However, the agriculture in this area is developed almost 80% without irrigation, so this activity is highly sensitive to rain variability and other extreme weather events such as frost.

Previous studies on climate variability and trends in the MRB indicate high variability at different scales and changes in the seasonality of rainfall and frost (Silva et al, 2007; Trasmonte et al, 2007; Silva and Trasmonte, 2011). Therefore in the present study, the WRF is used in order to understand the physical mechanisms responsible for climate variability in the basin, focusing primarily on the dynamics of rainfall.

This paper we present preliminary results of the runs made with the WRF with tree domains (27, 9 and 3km) for the MRB for February (the wettest month in the central Andes of Peru). The model was forced with the final NCEP reanalysis data for 2000-2012 period. The validation of the interannual variability for the study period were done using observed data of 20 stations and for the spatial distribution the 3B42 and 2A25 from the Tropical Rainfall Measuring Mission (TRMM) products were used.

Preliminary results of 9km resolution, compared with TRMM 2A25 product, indicate a better distribution of rainfall in the southern part of the basin; however, the model tends to overestimate the precipitation. When analyzing the rainfall variability in comparison with the station data, the correlation is low. However, the model reproduces the diurnal cycle, according to the TRMM most precipitation occurs on the western edge of the Andes around 4pm to 7pm, while the WRF is given a little further east, on the Valley. Analyzing the dynamics, the WRF produces a strong convergence of moisture between 4 and 7pm, being more intense at 4pm. These results indicate that more observed data are needed to validate the TRMM data and models. For this purpose, the Laboratory of Microphysics and Radiation -LAMAR (for its acronym in Spanish) where implemented in the Mantaro valley, with many atmospherics instruments and wind profiler and clouds radar.
This paper presents an integrated approach capable to resort the impacts of environmental degradation on streamflow and precipitation at the scale of large watersheds. The approach combines trends and spatial analyses of long-term streamflow, precipitation, and leaf area index (LAI) series. Specifically, I target the Niger River basin, then I consider gridded monthly precipitation series over the catchment. I also consider monthly discharges series at 8 streamgages selected along the Niger River. Using the time-period 1961-2012, I conduct a change point analysis of the streamflow and resort two sub-periods 1961-1982 and 1983-2012. A comparison of precipitation and streamflow during these two time-slices shows meaningful changes. I describe a Kernel density analysis of streamflow and yield a probabilistic estimate of discharge anomalies along the river. Later, I evaluate seasonal trends of precipitation and streamflow, then I resort critical patterns, which magnitudes vary in time and space. However, both alterations of precipitation and streamflow seem to foreshadow critical environmental degradations occurring across the watershed. I consider gridded monthly LAI series derived from MODIS images, then I examine and discuss trends in land-cover dynamics across the basin in relation with the patterns in precipitation and streamflow. This late analytical step yields a holistic picture of the ongoing alterations in the basin, then I emphasize suggestions, valuable for a comprehensive water resources and environment management in the basin. Finally, I conclude on the relevance of the integrated approach for water resources and environmental assessments.
PB-040

Impact of future climate on the state and ecological goods and services of the Mediterranean Sea

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We developed, integrated and applied a suite of validated three-dimensional physical-biogeochemical-ecological models, in order to assess the impact of future climatic and management scenarios on biogeochemical and ecological properties of the Mediterranean sea. Results are discussed in term of temporal and spatial distributions of variables and indicators related to physical fields, carbonate system, cycles of carbon and inorganic nutrients, potential changes in higher trophic level organisms dynamics and in the distributions of critical habitats such as posidonia oceanica and coralligenous formations.

The models properly describe available experimental information on contemporary seasonal dynamic and spatial distributions at the basin and sub-basin scales of the major biogeochemical parameters, as well as of primary production, carbon fluxes at the air-ocean interface and spatial distribution of critical habitats.

Model projections suggest that the future Mediterranean sea will be globally warmer and more acidic, but with significant space variability. Plankton productivity and marine carbon sequestration will increase, even if the net primary production will remain at present level. Model results also indicate that changes in environmental parameters will alter the suitabilities of poseidonia and coralligenous over large areas, likely causing a reduction of those habitats. Intensification of extreme events occurrence will impair the survival of red coral banks, decrease marine carbon sequestration, negatively impact aquaculture production. Simulations also highlight the possibility to compensate for adverse effects of climate changes on economic activities by relocating them or by changing management policies.
Present and Future Climate in the Philippines Simulated by a Super High Resolution GCM

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The Meteorological Research Institute (MRI) super-high-resolution 20-km AGCM has made possible the simulation of the present and future (at the end of the 21st century) climate over the Philippines with characterization of complex land-sea contrast and mountain ranges. However, finer resolution does not necessarily assure accuracy. Thus, firstly, the super-high-resolution present-day simulation has been assessed based on high-resolution daily gridded, observed rainfall data. The reliability of the model in representing the present-day climatological features of the Philippine monsoon is crucial for building confidence in future projections of the country’s climate. Rainfall is realistically simulated by the 20-km MRI model, especially the detailed orographic rainfall in all seasons but with slight overestimation during the southwest monsoon (JAS) season. The model shows some weak points in the representation of interannual extremes which either relate to tropical cyclone occurrence and their tracks during the peak typhoon months or may have some fragile relation with the cumulus parameterization scheme. For the future climate change scenario for the JAS season, the predicted climate from the model is estimated using the observed climate as a basis.

In the future, a significant increase in rainfall can be found mostly in coastal areas during January-February-March (JFM). Moreover, a slight increase in rainfall is projected in most areas brought about by convective rainfall. Further investigation of projections for JAS is challenging because of the overestimation of JAS present-day rainfall. During October-November-December (OND), a reduction in orographic rainfall over Luzon and mountainous area of Mindanao is projected.

In all seasons, mean temperature will generally increase, but the largest increase is during the hot season of March-April-May (MAM).

It is important to thoroughly understand changes in tropical cyclones especially in Western North Pacific region in order to recognize the Philippines’ increased risk potential from natural disasters and to take effective countermeasures.
Model estimations of possible climate changes of surface solar radiation at regional scales over the South West Indian Ocean

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Solar radiation incident at the Earth’s surface is the ultimate energy source for life on the planet, and largely determines the climatic conditions of our habitats. It has also major practical implications, for example, for solar energy utilization. Changes in the amount of solar energy reaching the Earth’s surface can therefore have profound environmental, societal and economic implications. These changes can be either natural or anthropogenic in origin.

The overall objective of this work is to identify the possible effects of climate change on the solar resources, covering domain of South West Indian Ocean (SWIO).

For this purpose, projections under RCP8.5 scenario from 3 GCMs in Coupled Model Intercomparison Project phase 5 (CMIP5) are dynamically downscaled to regional scales by regional climate model RegCM-4.4.5. As the results by now (more experiments and analysis are under taken), a median change close to -1% in surface solar radiation by 2050 is found, and it may increase by average about 2% to the late 21st century.
PARALLEL SESSION B: FRONTIER DOWNSCALING TOOLS

PB-043

Participatory Landscape Planning- an Approach towards the Conservation of Ecosystem Services in the Protected Areas for Resilience to Climate Change

Uddin, M.S.

Winrock International

Abstract Biodiversity conservation in the protected areas through land-use planning has become a versatile tool for forest ecosystem management. Climate-Resilient Ecosystems and Livelihoods (CREL) Project is working with the forest dependent communities in Bangladesh to assist them in assessing the climate change vulnerabilities and adaptive potentials of their forest ecosystems and livelihoods. A Participatory Climate Vulnerability Assessment (PCVA) tool was developed by CREL to engage local people and key stakeholders in collectively analyzing drivers of changes (risks and vulnerabilities) for preparing comprehensive community and landscape-level plans for necessary adaptation. The tools used for the PCVA approach are spatial, temporal, quantitative and qualitative, including transect walks, resource and hazard mapping, vulnerability matrix, trends, timelines, seasonality analyses, as well as livelihood risk analysis and cropping patterns, and institutional linkages. There were used to assess ecosystem services, and climate-related threats and vulnerabilities in the protected areas. This paper outlines important findings from the application of the PVCA approach in the protected area of Dudpukuria-Dopachari (a wildlife sanctuary in Chittagong, Bangladesh) as well as solutions sought for better protection, management, and conservation of critical ecosystems and protected areas in Bangladesh.
PB-044

Observational data sets for Europe, Southeast Asia and South America

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Validation and bias correction for Regional Climate Model output requires access to high-quality and high-resolution observational datasets. For Europe, the gridded daily temperature and precipitation fields of the E-OBS dataset, based on the meteorological station data provided by the European National Meteorological Services (NMSs) to ECA&D (www.ecad.eu), has been used frequently for these purposes.

Using a similar approach, the Southeast Asian Climate Assessment & Dataset (SACA&D) has been developed in a collaboration with NMSs from the region. Based on the meteorological station data, a gridded dataset providing daily maps of temperature and precipitation has been developed. This data set, SA-OBS, is introduced in this presentation.

The spatial resolution of these maps are 0.25 x 0.25 degree, and data spans the period from 1980 onwards. The gridding techniques used for this data set are similar as for the European data set. The most recent developments are that for South America, in collaboration with NMSs in the region and the Climatic Research Unit (University of East Anglia, UK), a similar gridded dataset is developed of which first results will be presented.
Evaluation of two precipitation-downscaling methods from a multi-model ensemble in the eastern US

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Historical data and model projections suggest that climate change can induce increase in precipitation amounts and intensity in the eastern United States, with potential impacts on infrastructure, agriculture, and water resources. Statistical downscaling bridges the scale gap between climate model outputs and local precipitation, and is a useful tool for local managers in planning for climate-change adaptation.

This study evaluates a quantile-mapping method and a generalized linear model method, Rglimclim [Chandler and Wheater 2002, Water Resources Research 38(10), 1192], in downscaling precipitation from 16 global climate models (GCMs) in the Coupled Model Intercomparison Project Phase 5 (CMIP5) ensemble. Cross-validation was performed on 56 years of data at 12 stations along the eastern coast of United States. Except that quantile-mapping overestimated wet- and dry-spell lengths at the southern part of stations, the two methods performed similarly. Brier skill scores showed that Rglimclim estimated precipitation occurrences well compared to climatology, but the percentage explained variance on precipitation intensity was low.

Then, future precipitation at the same locations were downscaled. Bayesian Model Averaging was used to obtain posterior distribution of the downscaled changes in precipitation intensity and frequency. The two methods agreed on the seasonality of change, with intensities changes being more positive in winter than in summer, and frequency changes mostly being more positive in summer than in winter. But the magnitudes and signs of the estimated changes differed greatly in each month. The 95% confidence intervals of intensity changes, examined for 2040-2069 minus 1961-1990, mostly did not overlap between the two methods. Agreement on frequency was better, but separations were still often seen. The impact of adding temperature, geopotential height, or specific humidity into Rglimclim predictors were also explored. They were found to result in divergent future trajectories compared to the original models, suggesting that predictor choices is non-trivial for regression-based downscaling and significance of the regression coefficient is not a sufficient criteria for predictor choice. It was concluded that method-related uncertainty needs to be considered in statistical downscaling, and more evaluation is needed to quantify differences between various downscaling methods and their reliability in downscaling the climate-change signal.
PB-046

From daily to sub-daily time steps – Creating a high temporal and spatial resolution climate reference data set for hydrological modeling and bias-correction of RCM data

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The ClimEx project (Climate change and hydrological extreme events – risks and perspectives for water management in Bavaria and Québec) focuses on the effects of climate change on hydro-meteorological extreme events and their implications for water management in Bavaria and Québec. It builds on the conjoint analysis of a large ensemble of the CRCM5, driven by 50 members of the CanESM2, and the latest information provided through the CORDEX-initiative, to better assess the influence of natural climate variability and climatic change on the dynamics of extreme events.

A critical point in the entire project is the preparation of a meteorological reference dataset with the required temporal (1-6h) and spatial (500m) resolution to be able to better evaluate hydrological extreme events in mesoscale river basins. For Bavaria a first reference dataset (daily, 1km), used for bias-correction of RCM data, was created by combining raster based data (E-OBS, HYRAS, MARS) and interpolated station data using the meteorological interpolation schemes of the hydrological model WaSIM. Apart from the coarse temporal and spatial resolution, this mosaic of different data sources is considered rather inconsistent and hence, not applicable for modeling of hydrological extreme events. Thus, the objective is to create a dataset with hourly data of temperature, precipitation, radiation, relative humidity, and wind speed, which is then used for bias-correction of the RCM data being used as driver for hydrological modeling in the river basins. Therefore, daily data is disaggregated to hourly time steps using the ‘Method of fragments’ approach [Sharma and Srikanthan, 2006], based on available training stations. The disaggregation chooses fragments of daily values from observed hourly datasets, based on similarities in magnitude and behavior of previous and subsequent events. The choice of a certain reference station (hourly data, provision of fragments) for disaggregating daily station data (application of fragments) is crucial and several methods will be tested to achieve a profound spatial interpolation. This entire methodology shall be applicable for existing or newly developed datasets.

References

PB-047

RCMES: A Toolkit for Regional Climate Model Evaluation

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Evaluation of climate models is a crucial step towards the judicious application of climate model projections to climate impact studies. To facilitate evaluation of global and regional climate models and improve access to reference datasets from multiple sources, especially a broad array of spaceborne remote sensing, JPL and UCLA have collaborated to develop the Regional Climate Model Evaluation System (RCMES). RCMES provides convenient access to curated satellite observations, including obs4MIPS and ana4MIPS, and CORDEX and CMIP model runs from the Earth System Grid Federation. The RCMES toolkit has built-in capabilities for subsetting, regridding, interpolation, and a variety of statistical metrics for evaluating global climate models (GCMs), dynamically downscaled climate, and multi-model ensembles.

The core of RCMES is a set of high-performance algorithms and Python libraries that are available as the open-source Apache Open Climate Workbench (OCW). OCW provides operators to load datasets using readers (observations and multiple models), subset all datasets to a region, perform temporal and spatial regridding, configure and evaluate a set of statistical metrics for a list of sub-regions, and visualize the model evaluation metrics. Built-in metrics include bias, temporal standard deviation, standard deviation ratio, pattern correlation, temporal correlation, RMS error, Taylor diagrams, etc. A new metric can be added with a few lines of python code. OCW also contains a simple but sophisticated configuration file capability that automates the entire analysis workflow – preparing data and computing multiple metrics and plots in a single run.

The poster will describe the software design and the improvements in the recent OCW release, including: statistical downscaling of GCMs using satellite observations, enhanced regridding capabilities, seasonal metrics, a friendly command line interface (CLI) that leads new users through the configuration of a full analysis run, an enhanced configuration file format (YAML), a set of configuration files that reproduce CORDEX analyses on several continents, and new support for high-resolution models on an irregular grid (latitude-longitude mesh). Documentation and tutorials are available on the rcmes.jpl.nasa.gov web site. There will be an RCMES training workshop at the meeting to provide guided hands-on experience with using the CLI, authoring configuration files, and customization of model evaluations in python.
Vegetation is the main component of terrestrial ecosystem and has the potential to regulate every aspect of hydrologic cycle including water, energy and biogeochemistry. Here the spatiotemporal dynamics of Normalized Difference Vegetation Index (NDVI) in Ethiopia during 1983 – 2012 were analyzed and its coupling with climate explored. It was found that only <5% of the country's landmass is covered by vegetation with annual mean NDVI of over 0.8, while approximately 76% of Ethiopia is characterized by a value <0.6, of which, half of the area has even <0.4 index value. This is a clear indication of how the country has lost large area of its dense vegetation cover in 20th century due to different reasons. Our results showed that, compared to eastern Ethiopia, western part is 3 to over 4 times greener. This is mainly due to differences in the length of growing season related to rainfall. Time series of spatially averaged annual NDVI were also investigated in different moisture zones, and we found out neither increasing nor decreasing behavior over the past 30 years. However, years of strong browning (e.g. 1984) and greening (e.g. 1997/8) which coincided with rainfall extremes were noticed. In most parts, especially northwestern, western and southwestern Ethiopia, seasonal NDVI decreased from main rainy season through dry season towards the short rainy season. A positive NDVI-rainfall coupling was observed during dry and short rainy seasons with r2 value higher than 0.65 at 5% significance level. Nevertheless, at annual time scale and during main rainy season, this coupling is insignificant and poor. The seasonal cycle of monthly NDVI closely resembles that of rainfall; however, variability in the timing of observed lag between their peaks was noticed among selected sites. On the other hand, negative correlations were observed between NDVI and temperature for different time scales although these correlations are insignificant and poor. Our results demonstrate that the dynamics of vegetation activity in Ethiopia has both spatial and temporal dependence, and is mainly driven by rainfall characteristics.

Key-words: Climate; Ethiopia; NDVI; Spatiotemporal; Vegetation
PB-049

To evaluate the influences of land use and land cover changes on regional climate over East Asia and China with satellite-based data

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With the rapid economic development in East Asia, and especially China, over the past few decades, the land surface has been significantly impacted. It is challenging to evaluate the influence on regional climate due to land use and land cover (LULC) changes, and to reduce the uncertainties at regional and local scales. Using satellite-based LULC data for the years 1980, 1990, 2000 and 2010, the Weather Research and Forecasting (WRF) regional climate model is adopted to explore the impact of LULC changes on surface air temperature (SAT) and the precipitation over East Asia, as well as subregions in China. Simulated results with satellite-based LULC data show that SAT and precipitation biases can be decreased to a certain degree. In terms of the general effect of LULC changes between 1980 and 2010, the precipitation decreases across the simulated domain. In subregions of China, significant subregional characteristics are apparent, especially with respect to East Asian Summer Monsoon (EASM) related precipitation, which is decreased in northeastern China, while increased in the south and mainly occurs during EASM southward retreat. In terms of the radiative forcing (RF) at the surface and top of the atmosphere, the values are negative over East Asia, which results in decreased SAT. SAT and radiation budget changes in China, which present obvious subregional characteristics that are distinct from those of East Asia, are also detailed discussed. Furthermore, the impacts on regional climate show obvious seasonal, interannual and decadal variations. Although the impact of LULC change on SAT and the radiation budget in global terms is small compared to other factors, and even less on regional scales, the importance on local scales and the corresponding components is worthy of attention.

Keywords: land use and land cover change, East Asia Monsoon, precipitation, surface air temperature, radiative forcing
Climate change Impact Analysis on the Hydro-climatology of Upper Blue Nile Basin Using SWAT

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The main objective of the study is to assess the impacts of climate change on water resources, hydrologic flow pattern and future Hydropower generation of Great Ethiopian Renascence Dam of the upper Blue Nile river basin using hydrological modelling techniques. Blue Nile river contributes around 60% of the total mean annual flow in the Nile river, and most of this flow comes in the flooding season (July – October) generated by high precipitation received in the Upper Blue Nile. Irrigation and Hydropower schemes of the two downstream countries Egypt and Sudan mainly depend on the flow coming during this season. Ethiopia is located upstream of the basin its demand for irrigation and hydropower development increasing. However, recent observations show that climate has changed at an unprecedented rate during last decade, with evident increase in extreme precipitation events and temperature in many parts of Africa. This increases the vulnerability with an anticipated effect on widespread agricultural based economic activities. This research analysed climate change impacts in the upper Blue Nile basin for mid and late century by employing a hydrological model named Soil and Water Assessment Tool (SWAT), using spatial maps and synthetic weather data input. The model was calibrated at monthly time scale against observed discharge series at five stations of the basin. The climate change scenarios were constructed using outcomes of five Coordinated Regional Downscaling Experiment (CORDEX) namely CCLM4-8-17, HIRHAM5, RACMO22T, RCA4 and REMO for emission scenarios of RCP 4.5 and RCP 8.5, which were used to adjust the baseline climate scenario representing the current precipitation and temperature patterns. The scenarios were applied to the calibrated and validated hydrological model to generate runoff and investigate climate change impacts on hydrology and water resources. Overall, the study suggests that the water resources of the Upper Blue Nile river basin may not be adversely affected by climate change, the results also argues that the climate in most of the basin is likely to become wetter and warmer in the mid-century, this result agrees with similar previous studies in the basin.
Evaluation and implications of the bias of a regional atmospheric model in the Arctic CORDEX framework

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An assessment of the Arctic CORDEX simulation, forced with the ERA-Interim fields, is presented here. The simulation has been carried out with the WRF-ARW modeling system for the period 1979 – 2014 at a horizontal resolution of 0.44 deg. Preliminary evaluation against the CRU observations suggests that the model has a mean wet bias of 0–2 mm/day over most of the areas except for Greenland where it produces a dry bias of ~1 mm/day. For the near-surface temperature, the model is warmer (by 0–4 deg. C) in summer except for Greenland and Norway. In winter, the model generally appears to be colder by ~ -12 deg. C except for few points over Russia. The amplitude of the variability seems to be overestimated for temperature and precipitation on both the seasons. However, the temperature biases are lower than that for precipitation. The analysis is extended to investigate how these biases can affect the model performance in simulating the atmospheric circulation of the Arctic. Of particular interest for this study are marine cold air outbreaks, surface energy fluxes and processes associated with the Arctic amplification. The role of the biases in modulating the synoptic conditions and dynamical parameters conducive for the development of meso-scale, high-impact weather systems such as polar lows is also discussed.
Assessment of climate change impacts and uncertainty on hydrological extremes in the Koshi river basin, Nepal

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In this study, projections of temperature and precipitation in future periods and their impacts on hydrology and water resources of the Koshi river basin were investigated. The statistical downscaling model Long Ashton Research Station Weather Generator (LARS-WG) was used to downscale low resolution data from ten General Circulation Models (GCMs) and three IPCC SRES scenarios (B1, A1B and A2). The physically based hydrological model Soil and water assessment tool (SWAT) was used to analyze the impacts of climate change on hydrology. LARS-WG simulated the baseline period (1981-2000) climate quite satisfactorily. Changes in climate and hydrological variables are presented at monthly and annual scale for three future periods: 2011-2030, 2046-2065 and 2080-2099. The results indicate that the Koshi basin tends to become warmer in the future as projected by all GCMs under three SRES scenarios. Changes in precipitation and streamflow are not univocal and vary depending on the GCM, SRES scenarios. Difference in the projection of flow exists in all three future periods with highest range of -35 to 51% under A1B during the 2055s. Seasonal results indicate the highest increase in flow during spring season. The mean of all GCMs under A1B indicates an increase of 23% and 25% in the spring flow during 2055s and 2090s respectively. Similarly, the range of projections for all water balance components is very large. The water balance components: surface flow, base flow and water yield may decrease or increase in future, as GCMs do not agree on the direction of change. The potential ET and actual ET are projected to increase as projections from all GCMs and scenarios indicate, although large uncertainty exists in the magnitude of change. The potential ET is projected to increase in the range of 6 to 24% in 2090s. There is high variability among the models and scenarios for projections of hydrological and water balance components, and this variability increases with future time periods.
We used CORDEX data of Conformal-Cubic Atmospheric Model (CCAM) for the periods 1976–2005, 2006–2035, 2041–2070, and 2071–2100 with RCP4.5 and RCP8.5; and Regional Climate Model (RegCM) for the periods of 2041–2050 and 2071–2080 with RCP8.5 for climatic and hydrological projection of 21st century over mountainous region of Himalaya. The results show that CORDEX data can be used for future climatic change and after bias correction; the same data can be used as an input to the University of British Columbia (UBC) hydrological model for riverflow projections. There is a consistent increase in air temperature and precipitation. However, temperature and precipitation increase is more in first half of the century while low in last half. High latitude region experience more increase in precipitation and temperature in comparison to the lower. Moreover, the increase in minimum temperature is larger in both scenarios for all future periods. Future riverflow is projected by both models to increase in the twentyfirst century (CCAM and RegCM) in both scenarios. However, the rate of increase is larger during the first half while it is relatively small in the second half of the twentyfirst century in RCP4.5. The possible reason for high riverflow during the first half of the twentyfirst century is the large increase in temperature, which may cause faster melting of snow, while in the last half of the century there is a decreasing trend in riverflow, precipitation, and temperature (2071–2100) in comparison to 2041–2070 for RCP4.5. Generally, for all future periods, the percentage of increased riverflow is larger in winter than in summer, while quantitatively large riverflow was projected, particularly during the summer monsoon.

These results of future high temperature are an alarming indication for glaciers melting with increased inflow in the rivers and if there is any heavy rainfall event with this increased riverflow, then it may exacerbate flashflood risk in the future. Increase in temperature and precipitation over the study area indicates that the climate is changing rapidly and needs special attention of policy makers for mitigation and adaptation. Due to high riverflow and increase in precipitation, water availability is likely to be increased in the twentyfirst century and this may sustain water demands of the region. New reservoirs may be made to store the surplus water and combat the hydrological extremes (e.g. flooding) in the future.
In previous studies atmospheric cyclones have been investigated in terms of related precipitation extremes in Central Europe. Mediterranean (Vb-like) cyclones are of special relevance as they are frequently related to high atmospheric moisture fluxes leading to floods and landslides in the Alpine region. Another focus in this area is on droughts, affecting soil moisture and surface and sub-surface runoff as well. Such events develop differently depending on available pre-saturation of water in the soil. We investigate two time periods which encompass a flood event and a subsequent drought on very different time scales, one long lasting transition (2002/2003) and a rather short one between May and August 2013.

In this contribution we focus on high spatial and temporal scales and assess the currently achievable accuracy in the simulation of the Vb-events on one hand and following drought events on the other hand. The state-of-the-art regional climate model CCLM is applied in hindcast-mode simulating Vb-events in August 2002 and May/June 2013 as well as the droughts in summer 2003 and July 2013 respectively. Besides the conventional forcing of the regional climate model at its lateral boundaries, a spectral nudging technique is applied. This means that inside the model area the regional model is forced to accept the analysis for large scales whereas it has no effect on the small scales. The simulations covering the European domain have been varied systematically by changing the nudging factor, the number of nudged waves, the nudged variables and other parameters. The resulting precipitation amounts have been compared to E-OBS gridded European precipitation data set and a recent high spatially resolved precipitation data set for Austria (GPARD-6). For the drought events the Standardized Precipitation Evapotranspiration Index (SPEI), soil moisture and runoff has been investigated. Varying the spectral nudging setup helps us to understand the 3D-processes during these events, but also to identify model deficiencies.

The results show that both, increasing the number of nudged waves from 1 to 7, as well as the choice of the variables used in the nudging process, have a large influence on the development of the low pressure system and the related precipitation amount and patterns. On the contrary, the nudging factor or the definition of the uppermost pressure level for the nudging is of low impact on the results.
PRODUCING HIGH SPATIAL RESOLUTION CLIMATE SCENARIOS FOR TROPICAL AMERICA USING WRF MODEL

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The results of 30x30 kms spatial resolution dynamic downscaling of CMIP5 models for tropical America (the domain 30-120°W and 15°S-25°N that includes Northern South America, Central America and Caribbean) using WRF for the 1981-2010 period are presented. The progress in a project oriented to produce high spatial resolution (10x10 kms) climate change scenarios for northwestern of South America also will be exposed. This project is based on both the own research group modeling efforts and the downscaling of GFS reanalysis and the CMIP5 products to produce data in the mentioned resolution. A way for delivering the produced information for regional VIA community, is proposed.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-007

Projection of extreme temperature and precipitation conditions using RegCM experiments

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As a consequence of global climate change, various weather-related regional impacts occurred in the last decades throughout the Earth, including various extreme climatic conditions. Besides the heat waves, the other crucial impacts includes the modification of the continental hydrological cycle, which may result in environmental and ecological damages in forms of floods, flash floods, inland water events, and even droughts. In order to reduce the overall socio-economic impacts of these potential hazards, it is essential to assess the future climatic trends. For this purpose, the regional climate model RegCM (version 4.3) is used to provide climate simulations for the extended Mediterranean region of Europe (i.e., Med-44 CORDEX area) with 50 km horizontal resolution. RegCM is a limited-area, hydrostatic, compressible, sigma-p vertical coordinate model maintained at ICTP (Abdus Salam International Centre for Theoretical Physics), Trieste, Italy. In our analysis, ERA-Interim data (1981-2010) and HadGEM2 global climate model outputs (1951-2005) serve as initial and lateral boundary conditions (ICBC) for the recent past, and HadGEM2 outputs are used for driving future scenario runs (RCP4.5 and RCP8.5) for the 21st century. Then, the 50 km resolution RegCM-outputs serve as an ICBC input for further downscaling using 10 km as a horizontal resolution for a smaller domain covering Central Europe with special focus on the Carpathian Region. In order to take into account subgrid processes - being especially important from the hydrological point of view - our RegCM experiments activate the subgrid Biosphere-Atmosphere Transfer Scheme (BATS). Specifically, the land surface processes are modelled by BATS version 1e with the treatment for subgrid variability of topography, and land cover is determined using a mosaic-type approach. The presentation analyzes temperature and precipitation outputs with special focus on the projected changes of extreme conditions (both with 50 km and 10 km horizontal resolution).
This study measures household vulnerability of Maasai pastoralist in Kenya to climate change using biophysical and socio-economic indicators selected based on researchers observation, literature review and interaction with stakeholders (pastoralist communities, government official and researchers). In-depth interviews were conducted with a total of 250 households in the five different administrative wards (Oloosirkon/Sholinke, Kitengela, Kapetui North, Kenyawa-Poka and Ilmaroro) in Kajiado East. The study was conducted between October 2014 and January 2015. Vulnerability was measured as the net effect of adaptive capacity which is the ability of pastoralist to cope with the adverse effect of climate change and variability and sensitivity/exposure to climate change and variability (biophysical) When the adaptive capacity exceeds that of its sensitivity and exposure, the household becomes less vulnerable to climate change and the reverse is also true. Principal Component Analysis (PCA) was used to assign weights to the indicators and also to calculate the household vulnerability index. A map showing the levels of vulnerability in the five wards was produced using the GIS software package ArcGis. Results shows that gender of household head, Age of household head, educational level, access to extension agents, Herds size, livestock diversity and access to credit facility increased vulnerability of the Maasai pastoralists to climate change in Kajiado East. Kaputiei North had the highest number of highly vulnerable household (33%), followed by Oloosirkon (19%), Kitengela and Imaroro 15%, but this was least for Kenyawa-Poka (5%). Oloosirkon/Sholinke had the highest number of households in the moderately vulnerable category (81%), followed by Imaroro and Kenyawa-Poka with 75% each; Kitengela has 50% and least for Kaputiei North 39%. Kitengela had 35% of the households in the less vulnerable category, followed by Kaputiei North 28%, Kenyawa-Poka 20%, Imararo 10% and Oloosikon/Shilinke 0%. Interventions through women empowerment through provision of credit facilities, access to extension agents, provision of basic education, herd mobility and access to credit facilities will reduce vulnerability of Maasai pastoralists to the effect to climate change and variability.
PC-009

Estimating the representativeness of a subset of hydrological climate impact projections compared to a larger ensemble

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The number of available regional climate projections has tremendously increased during the last decade. Impact modelers often choose a smaller subset from all available climate projections which is partly due to limited resources, to the need of combinations with other scenarios and/or uncertainty sources, or to a lack of communication between the climate modelers and impact modelers. Up to now, the choice is usually made following some general recommendations (e.g. having various global and regional climate models represented in the subset), evaluating some key characteristics of the projections (e.g. temperature and precipitation changes), or by accessibility.

Here, we present results from a study on how to optimally select a representative subset of climate projections from a larger ensemble. We also address the question: How representative are subsets selected based on the input rather than on the output of a hydrological model? We use an ensemble of hydrological climate projections for Sweden (18 projections). The ensemble comprises 3 emission scenarios, 6 global circulation models, 6 regional climate models and 2 hydrological models. The subset selection is done once using seasonal mean climate change values for the input data to the hydrological models (here temperature and precipitation) and once for the target variable runoff.

The results show that the convergence of the representativeness with increasing subset size is different for the input and the target variables. In the snow dominated mountainous northern parts of Sweden, a high representativeness for runoff as the target variable can be reached with as few as four projections - something which is not seen for the input variables in the same areas. Overall, it is shown that one gets a setback in representativeness for the target variable when the subset selection is based on the input variables instead of the target variable itself. This setback is smaller the larger the subset size is. Also, the subset is smaller when the subset selection is based on precipitation instead of temperature statistics.
PC-010

Moisture recycling in regional climate simulations: Spatiotemporal analysis and impact on the precipitation regime

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Land-atmosphere interactions are known to play a key role on climate and are expected to be critical to understand its evolution as a consequence of climate change. These land-air feedbacks are of utmost importance in those regions and periods when the intensity of evapotranspiration is high and, at the same time, controlled by soil moisture availability. In the Mediterranean Basin, the amount of rainfall coming from evapotranspiration over land represents a relevant fraction of the total precipitation in the year. Furthermore, many of these areas are affected by water limitations and are expected to be more sensitive to the impact of climate change along the upcoming decades. In this work, the WRF model, is used to explore 3D land-atmosphere coupling over the different regions within the European CORDEX domain, at 50 km horizontal resolution and for a high resolution domain (9km) over the Iberian Peninsula (IP). We start our analysis by computing the recycling ratio, for the hindcast (1989-2009), through the method of Eltahir and Bras, as a first approach to quantify the intensity of land-atmosphere feedbacks and their impact on the rainfall regime. This method, much more accurate than analytical Integral Moisture Budget recycling models, allows us to explore the spatial distribution of recycling over IP and therefore focus our analysis on the most sensitive regions. Both historical (1971-2000) and future (RCP8.5) simulations (2006-2100) were carried out to assess to what extend climate change may have an impact on land-air fluxes and the subsequent recycling and amplification mechanisms.
PC-011

Future precipitation and extremes changes in several sectors of La Plata Basin projected by four regional models of CLARIS-LPB project

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The La Plata Basin (LPB) is an important region for social and economic sectors of South America, mainly regarding hydric resources and agriculture. Regional models have been used to analyze climate change over South America in order to give more details of the projected changes in specific regions. The possibility of using several models, which can show different results, provides a range of values that need to be taken into account regarding the uncertainties. In this study, results of four regional models from CLARIS-LPB project are analyzed over South America, using different methods to assess changes in future projections (2071-2098) compared to the base period (1961-1988), mainly for LPB region. The differences between the future and base period are analyzed considering the ensemble and the dispersion among the models obtained by the standard deviation among them. The percentages of changes in the upper, middle and low LPB are analyzed for each model. The frequencies of extremes are calculated in these regions through percentiles of 5%, 10%, 15% (dry cases) and 75%, 90%, 95% (wet cases) in the base and future periods. During austral summer (DJF), more precipitation in the whole basin and an increase of extreme wet cases are projected, with agreement among models. In austral winter (JJA) there is increase in frequency of dry cases in the upper and middle LPB. In SON the behavior is different in each region, with higher frequency of dry cases in the upper and middle LPB and increase of wet cases in the low LPB. During MAM, the middle and low LPB show increase of wet cases, while in the upper LPB the uncertainty is high, as there is large dispersion among the models. The patterns of austral summer and spring anomaly precipitation variability, obtained from EOF analysis, display in the future projections, the same opposition observed in the present, between LPB and tropical S.A. During austral autumn (MAM) and winter, there are more differences among the patterns projected by the models.
Extreme precipitation in the North American Monsoon derived from two CORDEX models

Tereza Cavazos*, Pamela de Grau, Ruth Cerezo, Ray Arritt, Grigory Nikulin, and Ramon Fuentes Franco

We analyse the mechanisms associated with daily extreme precipitation (> P95th of wet days) in the North American monsoon (NAM) region and in México derived from two regional models that are part of the CORDEX initiative (RCA and RegCM4) for the 1979-2005 period and during the 21st century. The two models were forced separately by ERA-Interim, and by HadGEM2-ES and MPI-ESM-LR GCMs.

During boreal winter (DJF), the mean observed P95 threshold in the NAM region ~15 mm/d according to USA-CLICOM and NARR. HadGEM and ERA underestimate this value, while MPI overestimates it. As expected, the P95 threshold derived from the two regional models is much larger than their forcing GCMs. During JJA and SON, the mean observed P95 threshold from USA-CLICOM is ~20 mm/d, which MPI reproduces well. In contrast, NARR, ERA-Interim and HadGEM2 underestimate this value by almost half. Again, the regional models show much larger thresholds than their driving models. In general, the regional model forced by MPI tend to produce a stronger annual cycle of precipitation and larger P95 thresholds, with the largest values over the Pacific Ocean. During summer, MPI shows a very strong and northward-extended ITCZ over the eastern Pacific. Interestingly, RCA independently forced by ERA-Int, HadGEM, and MPI produce the largest P95 thresholds near the entrance of the Gulf of California, much farther north of the ITCZ. It is possible that RCA has a land-sea thermal contrast problem that needs to be Analysed. The historical results indicate that the main source of moisture during extreme events in the monsoon region is the Eastern Pacific.

Future scenarios of P95 show increasing values of P95 over the monsoon and in the Eastern Tropical Pacific close to Mexico during autumn (SON) at the end of this century (2075-2099) under the RCP4.5 and RCP8.5, and drier conditions in July and August. The circulation and humidity patterns associated with the composite of days above the historical and future thresholds will be discussed in this presentation for RCA and RegCM4.
Evaluation of extreme precipitation and drought in high-resolution EURO-CORDEX simulations over highly complex terrain

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Extreme precipitation events as well as droughts can cause severe social, environmental and economic impacts. The assessment of simulated extreme precipitation and droughts in changing climate conditions, such as those provided by the high resolution CORDEX regional climate modelling initiative, represents an important source of information for better planning hydrological and agricultural processes.

In this study we focus on the evaluation of the tails of precipitation distribution and drought events as simulated by the high resolution EURO-CORDEX regional climate models, driven by the ERA-Interim reanalysis. A non-parametric approach, suitable for cases when the right tail of distribution plays an important role, is applied in the evaluation. This method is based on a 2-sample modified Anderson-Darling statistic combined with the Kullback-Leibler direct divergence. Drought is evaluated using the standardized precipitation index for different seasons of the year. The analysis is performed over two regions in Europe with highly complex terrain features: the Alps and the Carpathians. Two high-resolution datasets of gridded observations (Alpine Precipitation Grid Dataset and CARPATCLIM) are used. In addition, gridded precipitation data from the E-OBS dataset (that has lower resolution and is based on lower station density) is also used over the study regions to better identify and understand the uncertainties that may arise from the selection of the observational dataset over complex terrain.
PC-014

Projections of daily extremes rainfall over Central Africa using CMIP5 models

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The ensemble mean of 11 state-of-the-art global climate models from the fifth Coupled Model Intercomparison Project is applied to evaluate model performance in the historical period and analyze future changes in heavy rainfall over the Central Africa, at the mid and the end of the 21st century following one greenhouse gas Representative Concentration Pathways RCP 8.5. We focus the analyses in the 90th and 99th percentiles of the total daily rainfall distributions for two 30-years periods (2036-2065 and 2071-2100). The models ensemble mean well reproduces the observed spatial distribution of both percentiles with some dry bias. The results of future changes show robust signal in the heavy rainfall response i.e., increasing amounts in central part of our region and the few areas in the northern and southern part characterized by a reduction of extreme rainfall or no trends.
Changes in Drought Characteristics over South Korea projected by Multi Regional Climate Models with the Standardized Precipitation Index

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In this study, the projection of future drought conditions is estimated over South Korea based on the latest and most advanced sets of regional climate model simulations under the Representative Concentration Pathway (RCP4.5 and RCP8.5) scenarios, within the context of national downscaling project of Republic of Korea. The five Regional Climate Models (RCMs) were used to produce climate-change simulations around the Korean Peninsula and to estimate the uncertainty associated with these simulations. The horizontal resolution of the each RCM is 12.5 km and model simulations are available for historical (1981-2010) and future (2021-2100) periods under forcing from the RCP4.5 and RCP8.5 scenarios. To assess the characteristics of drought on multiple time scales in the future, we use Standardized Precipitation Indices for 1-month (SPI-1), 6-month (SPI-6) and 12-month (SPI-12). The number of drought months in the future will be characterized by strong variability, with both increasing and decreasing trends among the scenarios. In particular, the number of drought months over South Korea is projected to increase (decrease) for the period 2041-2070 (Fut1) in RCP8.5 (RCP4.5) scenario and for the period 2071-2100 (Fut2) in RCP4.5 (RCP8.5) scenario. In addition, the percentage areas of drought condition are overall projected to gradually decrease over South Korea during the entire future period, except for SPI-1 in RCP4.5 scenario. Particularly, the drought areas for SPI-1 in RCP4.5 scenario show weak positive long-term trend. Otherwise, future changes in drought areas for SPI-6 and SPI-12 have marked downward trend under two RCP scenarios.

Acknowledgement

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Performance of CORDEX Regional Climate Models in Simulating Precipitation Climatology of Indian Summer Monsoon

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The performance of a set of 11 coordinated regional climate simulations performed in the framework of CORDEX-South Asia project in representing the characteristics of summer monsoon precipitation patterns over India has been evaluated for the period 1970-2005 representing the present climate. The precipitation climatology and interannual variability from each of these RCM simulations and the common features and differences among them has been assessed against observational datasets. Different kinds of statistical analysis like student’s t-test, spatial and temporal correlation, Taylor diagram plot etc. has been done to compare the model output with observations. Through bias plots and ensemble spread analysis an appraisal of the uncertainty of the models or the degree of agreement among them has also been carried out in this study. The better performing models are also identified and studied to find improvement if any. Further with the selection of a subset of better performing models (Best RCM experiments) the same exercise has been repeated over the monsoon core region of India. All the simulations were able to capture the main features of Indian summer rainfall climatology at regional scales except the poor capture in simulations which used a particular regional model (CSIRO-CCAM) . Compared to the observations almost all simulations show significant dry rainfall bias over a larger part of India. The biases and correlation of individual simulations with observation though vary considerably in space and time and among themselves as also confirmed by uncertainty analysis but their ensemble on an average outperform many of the individual models with bias of lesser magnitude and an improved correlation with respect to the observation. Though the ensemble is not able to capture the actual strength of year wise precipitation but it shows good ability in capturing the pattern of its variation as shown by spatial correlation values in each year. With the selection of better performing experiments over India the results improve in terms of agreement among experiments and bias. A major problem with the present set of CORDEX-South Asia experiments is that they are not able to simulate the interannual variations of precipitation. Over monsoon core region also, Best RCM experiments show an improved performance with lesser spread between experiments but dry bias and inability to simulate interannual variability still exists.
Recent climatic changes over Himalayan region: Previous studies and CORDEX-South Asia experiments

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The complex topography in the Himalaya region has its own implications in shaping the climate over the area; thereby giving rise to different sub-regimes of climate in the same region. In the present work, we have tried to summarize the observed changes in the climate system; which have taken place in the recent past over the Himalaya region using observation as well as the model datasets. This includes major findings from the previously done work by others as well as new studies based on the CORDEX-South Asia experiments. In the monsoon season, lower reaches of Himalaya receives higher amount of precipitation as compared to the higher elevation as indicated from the observation. Such kind of variation in the precipitation patterns give rise to a wide variety of the hydrological regimes in addition to different climatic sub-regimes. Attributed to this property, therefore different parts of the region may respond differently to the climatic changes. Corresponding to the global temperature rise; a significant warming trend over the western parts of the Himalaya have been reported in the recent past. The other parts of the region are also dominated by this positive trend of the temperature but their trend is not significant statistically. This may have implications for the hydrological cycle of this area, known as third pole of the world. Again, studies report that a significant decrease in the precipitation trend have been observed over the eastern Himalayan region, while for other parts in the same region a non-significant trend is dominating. It has also been noticed that the western Himalaya has experienced a positive trend of precipitation in the recent past in both JJAS as well as the DJF season; corresponding to the simultaneous increase in the snow cover over some parts. However a general decrease in the glacial mass have been reported by many studies which shows that glaciers have lost their mass while facing the menace of retreat. At the same time, for the central Karakorum part snow cover has found to be increased in recent times (also called Karakoram anomaly) which correlates with the cooling trend of temperature over this region thus defying the globally warming trend.
Impact of climate change on runoff timing over the Alpine region

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In this work we focus our attention on the snowmelt-driven runoff (SDR) on the Alpine region. We use the Regional Climate model output from Med-CORDEX simulations and in particular the ICTP regional climate model RegCM4 and the ALADIN regional climate model at 2 different resolutions (12km, 50km) and the output from other 3 EURO-CORDEX Models (RACMO22E and HIRHAM5, both driven by EC-EARTH and CCLM4-8-17, driven by MPI-ESM-LR; all of them at 44 and 11 km resolutions).

Comparison with the European Water Archive (EWA) observed runoff dataset (242 stations) over Alps show a good performance of all the models in the present day representation of the SDR at the highest resolution. The low-resolution simulations are less accurate in representing the runoff timing.

For the future projection we analyzed the RCP 8.5 scenario for the whole ensemble. All the models show a temperature increase up to 4 degrees in the Alps and this leads to a change of SDR timing that can span from 1 to 3 months depending on the model space resolution. These large changes are probably due to the snow-albedo feedback that is amplified over the complex Alpine topography.

There is a clear spatial difference between the high and low resolution simulation. The 11km show a reduced change of SDR on the top of the mountains and this is attributed to an increase of convective precipitation in spring and summer.

Such a change in runoff timing can be really important for water storage regulation rules for energy production, irrigation and therefore agriculture, and domestic use.
Regional climate simulation over Southeast Asia using NHRCM

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The vulnerability of Southeast Asia to climate change and extreme events necessitates reliable climate projections for appropriate preparation and action. For this purpose, we will use the non-hydrostatic regional climate model (NHRCM) developed at the Meteorological Research Institute of Japan, to generate high-resolution climate information over the CORDEX-Southeast Asia region. Prior to downscaling climate projections, we conduct hindcast simulations from 1989 to 2008 over Southeast Asia at 25 km resolution using boundary conditions from the ECMWF ERA-Interim dataset to evaluate the skill of the model in capturing climate means and extremes. Comparison of mean temperature with APHRODITE and CRU datasets indicates an overall cold bias in the model of -0.64°C and -0.82°C, respectively, with warm biases over parts of Indochina from December to May. In terms of precipitation, results indicate a mean wet bias (22.4%) relative to APHRODITE but a dry bias (-16.7%) with CRU, with seasonal and spatial variability. We also note a slight dry bias over areas with high elevation; however, this may also be related to uncertainties in the observation data. Correlation is relatively high (above 0.8) for temperature over the northern half of the domain but can be low and negative for precipitation over the Maritime Continent where the density of observation stations is relatively low. Interannual variability of temperature and precipitation in the model also tend to be slightly higher than observed over most areas. We will further examine the model output to determine its skill in representing climate extremes during the simulation period, as well as explore the factors contributing to model performance.

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Projected changes in tropical cyclone activity in the Philippines

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The Philippines is highly exposed to tropical cyclones. In recent years a number of very strong landfalling tropical cyclones have caused considerable damage and loss of life in the region. With uncertainty about the impacts of climate change on tropical cyclone activity, there is a growing need for improved knowledge and relevant information on the changing risks of tropical cyclones to guide decision makers and inform adaptation planning. We will present the results of downscaled regional climate model simulations for a domain that includes the Philippines and the main development region of tropical cyclones in the Northwest Pacific Ocean. Multiple global climate model simulations from the CMIP5 generation of models are downscaled to a 12km horizontal resolution using the Met Office Hadley Centre regional model, HadGEM3-RA. Model experiments are run for a historical period (1971 to 2005) and a future period (2035 to 2064) using the RCP8.5 greenhouse gas concentration trajectory. The analysis aims to build on current understanding of how tropical cyclones and the relevant drivers of tropical cyclone activity in the Northwest Pacific Ocean are projected to change by the mid-21st century. The findings will be related to the broader aims of the project to inform resilience building to tropical cyclone risks in the Philippines.
Predictability of Pre-Monsoon Heavy Rainfall Events over Bangladesh using WRF under the Changing Climate

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During the pre-monsoon season (March to May) of 2006 to 2014, three hundred fifty one cases of squalls were reported over Bangladesh. Maximum number of cases (76) was reported at Chittagong followed by 52 cases in Sylhet. Out of the 12 cases of squalls studied in the present paper which is related to flash flood and heavy rainfall over Bangladesh. This study examines the ability of the cloud-resolving weather research and forecasting (WRF) model to reproduce the convective cells associated with the flash-flooding heavy rainfall over Bangladesh on pre-monsoon season.

Mesoscale convective systems (MCS) are responsible for majority of the squall and flash flood events and related natural hazards that occur over Bangladesh and surrounding region in pre-monsoon season. In this study, meteorological observations of Bangladesh Meteorological Department (BMD) are used during flash flood events in order to update the initial and boundary conditions through the Advanced Research WRF model (WRF-ARW). For the purpose of simulating the flash flood events the model was run on single domain at 4 km resolutions with 40 vertical levels using initial and boundary conditions data obtained from NCEP FNL (Final) Operational Global Analysis. Several sensitivity experiments were conducted with different combinations of physical parameterization schemes of the model and found that the best skill scores were obtained by the combinations of Milbrandt, no cumulus and YSU schemes for the simulation of pre-monsoon weather events over Bangladesh and neighborhood region. This combination of physics has been used in the present study. The simulated precipitation, mean sea level pressure and 950 hPa wind fields from the experiments are presented in this study in order to analyze the observed and simulated features of the flash flood events. The model results are also compared with the Kalpana-1 satellite imagery and the Tropical Rainfall Measuring Mission (TRMM) observed results. Further, the intensity of the events, generated from the simulations is also compared with the BMD observations in order to evaluate the model performance. This study also examines long term changes of flash flood event under the changing climate.

Keywords flash flood, WRF-ARW, TRMM, climate change.
Response of a hydrological model to two rainfall scenarios from RegCM4 regional and MIROC3.2 global models

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This work aims to simulate numerically the inflow in the 21st century in the Rio Grande Basin (BHRG), located in southeastern Brazil. For this, SMAP (Soil Moisture Accounting Procedure) hydrological model was used using rainfall from RegCM4 regional climate model and MIROC3.2 global model numerical simulations for South America, under A1B and B1 climate change scenarios of IPCC. This is the second stage of a work that originally consisted in simulating present climate and inflows in this basin. Atmospheric simulation were carried out from 2011 to 2100 with a 50 km grid spacing in RegCM4 and 125 km in MIROC3.2. Boundary conditions for RegCM4 are derived from MIROC3.2 model, also using IPCC scenarios. In present climate simulations, RegCM4 was able to simulate the main temperature and rainfall patterns for South America, both in summer (DJF) and winter months (JJA). In terms of rainfall, RegCM4 showed better performance for the southeast region, where BHRG is located. A bias removal technique based on simulated and observed rainfall during control simulations was also used in order to obtain a better representation of rainfall by RegCM4 and MIROC3.2. Regarding inflow simulation, SMAP was calibrated using observed rainfall during the period from 1971 to 1986, in which it was adjusted and the best parameters were obtained for the inflow simulation. For the period from 1986 to 2000, it were compared observed inflow in the BHRG, simulated inflow using observed rainfall, and simulated inflow using simulated rainfall from RegCM4 and MIROC3.2 models (with and without bias removal). As hydrological model was able to simulate the observed inflow in BHRG in this period, this methodology was employed using IPCC scenarios. Results were compared to present-day climate simulations and showed that RegCM4 predicted a decrease in precipitation over RGB in all seasons, while MIROC3.2 forecasted a little decrease in dry season and a increase in rainy season. These precipitation scenarios were used by SMAP to generate inflow scenarios for the 21st century. When using RegCM4 rainfall, SMAP predicted around -25% in inflow for this century. With MIROC3.2 rainfall, SMAP predicted an increasing of 5% over the entire century. In the future, this methodology can be applied to other basins in order to have a broader vision of future rainfall and inflow over much of Brazil and thereby help the country to manage more adequately and effectively the use of national water resources.
Wind Energy Potential over the Black Sea: Current representation and projections

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We have quantified the ability of a current regional climate model (SMHI-RCA4) to simulate the wind energy potential in the Black Sea region (within EUR-11) using 5 global climate models for the boundary conditions. These data are publicly-available through the CORDEX project archives. The regional climate model results are compared to the ERA-Interim reanalyses over a common period, 1979-2005, and we use Taylor plots to demonstrate the effect of different global climate models on the regional climate simulations. Wind energy potential is calculated from the 3-hourly resolution, hub-height (120 m) wind speeds by extrapolating the available 10 m wind speeds using a power-law wind profile approximation. In general we find that the regional climate model produces stronger surface winds over the Black Sea region as compared to the ERA-Interim reanalysis, which we relate to the difference in model resolution.

Here we also assess the projected changes to the wind energy potential in the CORDEX EUR-11 region from the current period to the near future (2021-2050), and late 21st century (2061-2090). In order to assess the robustness of the projected changes, these are compared to model-uncertainty related to the choice of global climate model used to drive the regional simulation. To understand the context of the changes in wind energy potential in the region, we include the changing climatology of the upper level (850 hPa) winds over these periods.
PC-024

Performance of CORDEX Regional Climate Models in Simulating Precipitation Climatology of Indian Summer Monsoon

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The performance of a set of 11 coordinated regional climate simulations performed under the framework of Coordinated Regional Climate Downscaling Experiment in South Asia (CORDEX-South Asia) project in representing the characteristics of summer monsoon precipitation patterns over India has been evaluated for the period 1970-2005 representing the present climate. The precipitation climatology from each of these RCM simulations and the common features and differences among them has been assessed against corresponding observational datasets.
Evaluation of simulated decadal variations over the Euro-Mediterranean region from ENSEMBLES to Med-CORDEX

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Med-CORDEX simulations over the period 1970-2011 are evaluated with regard to their capability to represent observed decadal variations over the Euro-Mediterranean region and improve upon previous generation simulations from the ENSEMBLES project in their various experimental set-ups. Such an evaluation is needed to inform the use of these simulations and also future model development.

For temperature, both Med-CORDEX and ENSEMBLES simulations tend to provide comparable results: they generally capture the sign and timing of the anomalies but not the amplitude. In general, no clear stratification appears when considering different types of regional modeling systems. Rather, it is remarkable that certain periods are poorly represented by all systems with a general underestimation of the observed long-term temperature trend, mostly in the summer season, even with respect to the corresponding global drivers. For precipitation, the Med-CORDEX simulations are closer to observations than the other datasets, with some improvement with respect to ENSEMBLES dataset. In general, all the systems experience difficulties in representing anomalies during specific periods or for specific regions. For instance, in the second part of 1980s, the spatial patterns of surface air temperature during DJF/MAM are generally poorly represented, as well as the surface air temperature decadal climate anomalies for MAM/JJA averaged over the Mediterranean region.

Overall, the evaluation suggests limited improvement in Med-CORDEX simulations compared to ENSEMBLES with persisting problems likely related to the representation of surface processes that could also affect the viability of future projections (e.g. the estimation of temperature trends). A set of decadal variability evaluation metrics, as applied in this study, could be useful in the context of a broader evaluation framework.
Sensitivity of Indian summer monsoon simulations to cumulus and microphysics parameterization schemes in WRF model

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Indian Summer Monsoon (ISM) accounts for 70% of the annual total rainfall over India and has a huge impact on the agricultural and economic activities of the country. The monsoon rainfall shows large spatial variability over the country and reliable predictions are necessary for planning and management of agricultural activities. Indian monsoon is a complex system where the atmosphere-land-ocean interactions play an important role and these interactions are not fully understood yet. Regional climate models (RCMs) may have the ability to capture these interactions and their application for ISM simulations need to be explored. The use of RCMs require parameterization schemes to model certain physical processes and ISM rainfall simulations have been found to be especially sensitive to the cumulus parameterization scheme used.

This study examines the sensitivity of monsoon simulations to cumulus and cloud microphysics parameterization schemes in an RCM- the Weather Research and Forecasting (WRF) model. WRF model forced with ERA-Interim reanalysis data is run at 30 km resolution over a domain covering the entire subcontinent and equatorial Indian Ocean, for three contrasting monsoon years. The simulations are performed for 9 different cumulus-microphysics parameterization combinations. The use of spectral nudging for improving the rainfall simulations is also tested. All aspects of the simulated monsoon rainfall are evaluated against observations for various sub regions of the country, to understand the impacts of change in parameterizations. The study identifies sub-regions where RCMs are found to consistently improve simulated monsoon rainfall characteristics and provides guidance on the choice of cumulus-microphysics parameterizations for these sub-regions.
Effect of bias-adjustment on the projection of temperature and precipitation extremes from an ensemble of EURO-CORDEX RCMs

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In order to be used as an input for process based impact models, output from climate models are usually post-processed in order to reduce their systematic biases.

Amongst several techniques, bias-correction, or bias-adjustment, employs a transfer function to match the cumulative distribution functions of modeled and observed data.

However, as bias-adjustment affects directly the PDF of the climate variable, both in the present and future, the bias-adjusted climate change signal may be different than the ‘original’ one.

Climate models show temperature-dependent biases that can alter the climate change signal (Boeberg and Christensen, 2012). Recently, Gobiet et al (2015) discussed the effect of bias-adjustment on projected mean temperature and argue that, by removing the intensity-dependent errors, the adjusted mean climate change signal can be regarded as an improvement compared to the original one.

However, impact models are significantly dependent not only on the mean climate but also on the occurrence and frequency of extreme events, which in turn depend on the value and evolution of the tails of the PDF. The effect of bias-adjustment on the projected occurrence of climate extremes is less commonly investigated and it is the focus of this study.

In this work the outputs of an ensemble of RCMs from the EURO-CORDEX initiative has been bias-adjusted. A number of ETCCDI climate indices have been calculated for the present (1981-2010) and future (2071-2100) climate.

Indices include absolute thresholds indices (e.g. days when TX > 25C), percentile-based indices (e.g. days when TX > than the 90th percentile of the reference period), and indices based on the duration of an event (e.g. consecutive dry days).

Results show that absolute threshold indices are the ones most affected by bias-adjustment, as they depend strongly on the shift of the mean value of the variable, which is usually largely biased in the original RCMs. Threshold-based indices are less affected, however some differences emerge when bias-adjustment affects not only the present-day PDF, but also its evolution in the future. For instance, the resulting PDF of bias-adjusted climate change signal may be different (e.g. more skewed) than the original one. As a result, despite a decrease in the mean value of the temperature signal, the value of extreme climate indices can remain constant, or even increase locally.
Scaling of precipitation extremes with temperature in the Mediterranean: past climate assessment and projection in anthropogenic scenarios

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Expected changes to future extreme precipitation remain a key uncertainty associated with anthropogenic climate change. Extreme precipitation has been proposed to scale with the precipitable water content in the atmosphere. Assuming constant relative humidity, this implies an increase of precipitation extremes at a rate of ~7 %/°C as indicated by the Clausius-Clapeyron relationship. In this study, the scaling between precipitation extremes and temperature is investigated by assessing against observations the regional climate simulations performed in the frame of the HyMeX and MED-CORDEX programs. Despite differences in quantitative precipitation simulation between the various models, the change in precipitation extremes with respect to temperature is robust and consistent between the models. This study highlights the spatial variability of the temperature-precipitation extremes relationship over the whole Mediterranean basin, with large differences between mid-latitude and arid regions. Finally, the study shows an evolution of this relationship in future climate scenario consistent with a constant relative humidity.
PC-029

Station level downscaled temperature over the Western Himalaya region of India

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Present study is based on the analysis of 16 numbers of temperature stations randomly distributed over the Western Himalayan region of India with less than 30% missing values for the period 1969-2009. Missing values of the station data is replaced by the MICE (Multiple Imputation Chained Equation) technique and the distribution and quality of complete data set after missing value replacement is checked through qq (Quantile-Quantile) plots. Analysis of station data indicates the winter warming is higher and faster than other three seasons. Mean annual warming over the Western Himalayan region is ~0.84°C in 41 years during 1969-2009 while the whole earth surface has warmed 0.85°C during 1880-2012 indicating Himalayan warming is almost the double of global warming.

For the purpose of empirical statistical downscaling, suitable predictors are selected by the step-wise linear regression while the predictor domain is identified through the Canonical Correlation Analysis (CCA) between the Principal Component Analysis (PCA) of station data and Empirical Orthogonal Function (EOF) of predictor field. Downscale model was calibrated and validated for the period 1979-2005 using the EOF of the combined predictors of reanalysis field and each historical run of the CMIP5 GCMs with station temperature as predictant. The downscaled results were verified using the R2, d index and scatter plots between predicted values and observation. Station level future downscaled temperature time series was developed from four different available Representative Concentration Pathways of RCP2.6, RCP4.5, RCP6.0 and RCP8.5. Multi-model ensembles using commonly available GCMs in each RCPs indicate that downscale time series of all 16 stations are not satisfactorily generated but the stations Gulmarg, Kukernag and Manali provide reasonably better results. Gulmarg, which is the highest altitude station, is projected to be highest temperature change with a range of 0.72-6.05°C and 1.15-6.55°C in the winter and monsoon season respectively. The station Kukernag will also show a warming by 0.81-4.73°C, 0.47-4.96°C, and 0.13-1.67°C for winter, pre monsoon and monsoon respectively. The tourist station Manali will experience a higher temperature change of 0.73-3.90°C and 0.79-5.44°C during winter and pre monsoon seasons at the end of 21st century.
Future Changes in Extreme Rainfall Events and African Easterly Waves over West Africa

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This study examines the relationship between African Easterly Waves (AEWs) and extreme rainfall events over West Africa and investigates how climate change could alter the relationship in the future. Satellite observation, reanalysis, and regional climate model (RCA4) simulations (forced with eight global climate simulations) were analysed for the study. The study used 95th percentile of daily rainfall as a threshold to identify extreme rainfall events and applied spectral analysis to extract 3-5 days and 6-9 days AEWs from 700 hpa meridional wind component over West Africa. The capability of RCA4 to reproduce the rainfall climatology, extreme rainfall events, characteristic of AEWs, and contribution of AEWs to extreme rainfall events over the region during the past climate (1971 - 2005) was examined and quantified using statistical analysis. The future changes (2031 - 2065) in these parameters were projected for RCP4.5 and RCP8.5 climate change scenarios.

The results of the study show that RCA4 gives a realistic simulation of West African climate, including the annual rainfall pattern, AEWs, and the African easterly Jet that feeds AEWs. The bias in the simulated threshold of extreme rainfall is within the uncertainty in the observed values. The model also captures the link between the structure of AEWs and rainfall pattern over West Africa, and shows that the percentage contribution of AEWs to extreme rainfall events over the region ranges from 20 to 60% as depicted by reanalysis data. For RCP4.5 and RCP8.5 scenarios, the RCA4 ensemble mean projects a future increase in annual rainfall and in frequency and intensity of extreme rainfall events over the sub-continent, but the increase is generally higher for RCP8.5 scenario. It also projects a decrease in the frequency of rain days, no changes in the structure of the AEWs, and an increase in variance of the waves. However, the simulations from ensemble mean shows no substantial changes in the contribution of AEWs to the extreme rainfall events, suggesting that the increase in the frequency and intensity of the extreme rainfall events may not be attributed to the changes in AEWs. The study has application in reducing the impacts of climate extremes over West Africa in the future.

Keywords: Extreme rainfall events, African easterly waves, Climate change, Downscaling, West Africa
This study presents an overview of changes in the extreme events that are most likely to affect East Africa in the forthcoming decades. This study assesses, heavy precipitation and drought and winds at 700 and 850hPa levels change between present (1970–2000), near future 2035–2065 and future (2071–2100) climate on the basis of regional climate model simulations produced by the CORDEX project, Africa. A summary of the main results follows. rainfall, temperature and wind changes in three time slices. Very heavy rainfall is increasing in the near future while decreasing in the far future scenarios. Surface temperature changes is projected to increase in all CORDEX models used likewise wind changes in all levels. By the end of the twenty first century, countries in northern Kenya, western Tanzania more warming is projected in the near and far future scenarios. This warming seem to be associated with increase in evaporation which resulted into decrease in heavy rainfall over most regions in East Africa.

Key words: climatic extremes, East Africa, CORDEX
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-032

Using dynamical downscaling to force a glacier surface energy and mass balance model

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Most tropical glaciers are Peru, where they are key water sources for communities in mountain environments and beyond. Thus, their sustained shrinkage portrays these glaciers as archetype of global warming impacts on the local scale. However, there is still no deep understanding on the mechanism connecting temperature and these glaciers. Among others, the effect of temperature on the glacier surface mass balance (GSMB) can be expressed within accumulation regimes and hence in surface albedo, or in ablation dynamics through incoming longwave energy (LE). Here, we report a study in which a dynamical downscaling using the WRF model at 2 km spatial resolution is used to force a glacier mass balance model to simulate the mass balance during the period 2004-2005. Our goal is to mechanistically understand climate change impacts on these glaciers. Results suggest temperature as the main factor controlling GSMB changes through the lapse rate (LR). Correlations of GSMB with LR, humidity and zonal wind point to vertical homogenization of temperature, causing LE to increase, despite this flux always remaining negative. This “less negative” LE multiplies the impact of the seasonal fluctuation in albedo, thereby enhancing total ablation. As this mechanism only needs a relative increase in temperature, it may even occur in subfreezing conditions. Model output also indicates that turbulent fluxes are small, largely cancelling out. This suggests that the impact of LE is more likely to occur compared to either turbulent fluxes changes or shifts in the proportion of sublimation versus melt, which we find to be regionally stable. These findings imply that glaciers in north-central Peru are sensitive to subtle changes in temperature. We discuss the potential of using the dynamical downscaling and the GSMB to understand glacier-climate interactions in the Andes. We also examine the implications of our results for process-based understanding and how this non-linear and somewhat hidden effect of temperature reduces the skill of temperature index models to simulate GSMB in the Tropics.
It is well known that economic in Morocco is widely based on agriculture such as many countries in the Mediterranean area. Given the vulnerability of Morocco, this study discusses climate extremes based on daily temperature and precipitation over northern Morocco using four regional climate simulations to evaluate their ability to simulate extremes indices over Morocco. The indices were calculated on the basis of daily observations of maximum and minimum temperature and the daily amounts of precipitation. The calculations are performed with RClimDex and the R package climdex.pcic. Trends in these indices were calculated at 20 weather stations from 1970 to 2012. A large number of stations have significant trends and confirm an increase in temperature. In general, the trends for the precipitation indices are much less significant than for temperature indices and show more mixed spatial patterns of change. Significant increases in heavy precipitation events have been noticed at a few locations in the north and central parts of Morocco, with a general tendency towards drier conditions.

Four different RCMs participating in EuroCORDEX (KNMI, IPSL and CLM) and MedCORDEX (CNRM) have been used in this study. All simulations are performed at 12 km resolution and they cover the northern part of Morocco, where most of the selected stations are located and where the population density is the highest. For each model we analyzed both the evaluation and historical runs. To assess model performance, we use metrics such as Taylor diagrams to quantify the overall correspondence between simulated and observed fields and the portrait diagram to provide a visual framework for comparing model results to observations.
Sensitivity of Tropical Cyclones to Resolution and Convection Scheme over Eastern Tropical Pacific and Tropical North Atlantic Oceans in RegCM4 Model

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The sensitivity of simulated tropical cyclones (TC) to resolution and convection scheme parameterization is investigated over the CORDEX Central America domain. The performance of the simulations, performed for a ten-year period (1989-1998) using ERA-Interim reanalysis as boundary and initial conditions, is assessed considering 50 km and 25 km resolution, and the use of two different convection schemes (Emanuel [Em] and Kain-Fritsch [KF]). By comparing with observations, for the whole period we assess the spatial representation of the TC, and their intensity. At interannual scale we assess the representation of their variability and at daily scale we compare observed and simulated tracks in order to establish a measure of how similar to observed are the simulated tracks.

In general the simulations using KF convection scheme show higher TC density, as well as longer-duration TC (up to 15 days) with stronger winds (> 50ms-1) than those using Em (<40ms-1). Similar results were found for simulations using 25 km respect to 50 km resolution. All simulations show a better spatial representation of simulated TC density and its interannual variability over the Tropical North Atlantic Ocean (TNA) than over the Eastern Tropical Pacific Ocean (ETP). The 25 km resolution simulations show an overestimation of TC density compared to observations over ETP off the coast of Mexico. The duration of the TC in simulations using 25km resolution is similar to the observations, while is underestimated by the 50km resolution.

At daily scale, in general all simulations capture the density of cyclones during highly active TC seasons over the TNA, however the tracks generally are not coincident with observations, except for highly active seasons. Over the ETP the observed daily scale variability of TC is higher and models in general fail to reproduce the observed TC density and tracks. As for interannual scales, at daily scale, the 25 km resolution and those using KF, show an improvement regarding the TC density and tracks than the 50 km resolution and those using Em respectively.
**PC-035**

Multi-model analysis of the impact of high resolution and ocean-atmosphere coupling on the simulation of medicanes with RCMs

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Tropical-like cyclones, also called medicanes, are sometimes observed over the Mediterranean Sea. These are intense cyclones with a rather small size compared with similar atmospheric structures over wider oceans, and where the sea-atmosphere interaction plays a fundamental role. These characteristics are rather challenging for the simulation of such cyclones in climate models. High-resolution (0.11º) and ocean-atmosphere coupled RCM simulations, nested in ERA-Interim reanalysis, are being performed in EURO-CORDEX and Med-CORDEX projects over a domain including the Mediterranean Sea. The availability of corresponding lower resolution and uncoupled runs allows us to analyze the impact of high horizontal resolution and ocean-atmosphere coupling on the simulation of medicanes. Through comparison to an observational database of medicanes, we examine the ability of the different setups of the models to reproduce the observed frequency, intensity and location of the medicanes. The results of these evaluation runs can give an indication of the reliability of the climate change projections for this special type of cyclones, whose negative impacts might be large.
PC-036

Analyzing RCM outputs as benchmark for climate change impacts on the hydrology of selected river basins under conditions of water scarcity.

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Within the GLOBAQUA project, scenarios will be provided to assess future changes on aquatic ecosystems and effects on multiple stressors existent in these ecosystems. Water scarcity can be considered as one of the most crucial stressors on aquatic ecosystems, as it not only represents a single stressor, but can also trigger further stressors such as concentration of pollutants. Four large and medium scale river basins are chosen as test sites to perform the required sampling and modelling activities: The Ebro located in Spain (80,000km²), the Sava, crossing Slovenia, Croatia, Bosnia – Herzegovina and Serbia (100,000km²), the Adige in Northern Italy (12,000km²) and the Evrotas basin in Greece (2,600km²).

To assess changes on the water balance on the large scale in a spatially explicit manner the total runoff (mrro), evaporation (evspsbl) and precipitation (pr) are derived from climate model simulations of the Coupled Model Intercomparison Project Phase 5 (CMIP5) to serve as a benchmark to assess the impact of climate change on hydrological quantities. These variables are available for an ensemble of regional climate model (RCM) simulations, provided through the EURO-CORDEX initiative.

Twelve different combinations of general circulation models (GCMs) forcing different RCMs are available at 0.11 degree spatial resolution. This allows a thorough investigation of the impact of GCM and RCM on the resulting hydrological output. The hydrological quantities are then analyzed for a reference period under current conditions (1980 – 2010) and climate change impact is investigated based on the 2050s period (2040 – 2070). Projections are available for two Representative Concentration Pathways (RCPs), rcp 4.5 and 8.5 representing different radiative forcing.

In a first step, the water balance will be calculated for the reference period for each RCM-GCM-combination to determine the portioning of the three components. Previous studies revealed major differences among the RCMs of previous simulations for the Coupled Model Intercomparison Project Phase 3 (CMIP3). In the next step future simulations are used to assess climate change impacts on the components of the water balance and reveal possible surpluses and deficits. In this way spatially explicit information of potential drought risks are derived to serve as a large scale.
Self-Organizing Maps Analysis of CORDEX Simulation of Extreme Daily Precipitation in Alaska

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We analyze daily extremes of precipitation produced with a polar-optimized version of the Advanced Weather Research and Forecasting (ARW-WRF) model that used ERA-Interim reanalysis to simulate 19 years on a domain that encompassed the CORDEX Arctic domain. Analysis focuses on Alaska, because of its proximity to the Pacific and Arctic oceans, both of which provide a large moisture fetch inland. Alaska's topography also has an important impact on orographically-forced precipitation. In order to understand the circulation characteristics conducive for extreme precipitation events, we use Self-Organizing Maps (SOMs) to find general patterns of circulation behavior. The SOM algorithm employs an artificial neural network in an unsupervised training process. In our analysis, we use mean sea level pressure (MSLP) anomalies to train the SOM.

We examine daily widespread extreme precipitation events, defined as at least 25 grid points experiencing 99th percentile precipitation. Using the SOM procedure, we map days with widespread extremes onto the SOM's array of circulation patterns. This mapping aids in determining which array members (nodes) are being accessed at higher frequencies, and hence, which circulations are more conducive to extreme events. We show that there are multiple circulation patterns responsible for extreme precipitation, differentiated by where they produce extreme events in our analysis region. Additionally, we plot composites of several meteorological fields for SOM nodes being accessed by both extreme and non-extreme events to determine what specific conditions are necessary for a widespread extreme event. Composites of individual nodes (or of adjacent nodes in SOM space) produce more physically understandable circulations as opposed to composites of all extreme events, which can include multiple synoptic circulation regimes and thus obscure the key physical behavior. We also trace the temporal evolution of extreme events through SOM space, highlighting development and decay of extreme events. Our analysis lays the foundation for diagnosing differences between widespread, extreme precipitation events, including differences that may occur from climate change228
Climate change is expected to become one of the most important threat in the future. The combined impacts of multiple threats are also diminishing the capacity of natural systems to cope with the effects of these changes. Yet, over the past decade most studies have assessed the future spatial distribution of these threats individually. The Caspian Sea and its lower tributaries are the most biologically productive, biodiverse and important transboundary habitats of the region. The modern Caspian Sea originated as part of an ancient, brackish Pontic Sea 5 to 7 million years ago. In the late Mesozoic and early Palaeocene, range of salinities varying from 0.1 to 13‰ provide different ecological niches which give rise to high species diversity. The highest number of endemic species is found in the middle Caspian while the greatest diversity is found in the northern part of the basin. Here, we propose to use two case studies at a global scale: biodiversity hotspot, and Caspian Sea to illustrate the need to consider multiple interactions between climate change and other threats. For instance, we will examine the effect of climate change including sea level rise and land use changes on biodiversity hotspot. We will discuss congruence between threats, species vulnerability and protected areas through the biodiversity hotspot. We will also discuss the potential impact of future interaction of climate change, land use changes, and invasive species for 196 endemic species across in Caspian Sea. To this aim, we took into account the spatial distribution of biodiversity vulnerable to these threats. In particular, we found high cumulative threat values (>2 threats) aggregated over the eastern part of the Caspian Sea, with lower values in the central and western parts. Cumulative impact analyses also suggested that the return on investments for conservation purposes may be low when high cumulative threat areas with low species diversity require protection from many threats. These analyses provide a useful means of identifying where conservation measures and monitoring programs that should consider multiple threats should be implemented in the future. Ultimately, we will further discuss why manager should consider multiple threats to mitigate the future effect of climate change.

Key words: Caspian Sea, Biodiversity, Climate change
Coastal waters are among the most productive natural systems on Earth. Freshwater draining from rivers and streams carry land-based nutrients that help support the diverse life of the coastal environment. River flows, and winds constantly mix these nutrients in many of the important commercial finish species which depend on coastal waters. In this paper, impact of climate change on the present status of the Sepidrud River (as one of the largest rivers in northern Iran) in recent years have been investigated. Data on research activities on various types of pollution in the Sepidrud River, Some of the data collected in the years 1975 to 2012 pertains to the research and scientific centers. On the basis of data available seven types of specific polluting sources have been identified in the Sepidrud River during different years. Sediments are major polluting sources that have entered the river ecosystem in large amounts as a result of the degradation of the catchment area. The amount of sediments entering the Sepidrud River sometimes exceeds 300 g l-1. Besides agricultural runoff and domestic wastes, urban, rural, industrial and agricultural sewage and sometimes hazardous wastes, empty large amounts of heavy metals into the Sepidrud River, whereby the levels of some of these elements such as Ni and Cr exceed the maximum permissible levels. Sand and soil removal also pose a potential threat to the Sepidrud River ecosystem. The removal of bottom sediments during dredging operations can disrupt the entire benthic community and eliminate a significant percentage of the feeding habitat available to fish for a significant period of time. Eventually, the annual temperature and precipitation time series in Sefid-rud basin were analyzed by using regression and Mann-Kendall and the following result were obtained that changes were typical short-term variations in weather conditions and are trends which are found in some years. The analysis of mean temperature revealed that changes have a significant falling trend and precipitation also has a falling trend. Recommended that we explore collaborative approaches to constantly monitor the Sepidrud ecosystem so that we can use the data obtained to develop the best management measures to conserve and restore the Sepidrud River ecosystem.

Key words: Climate change, Sepidrud River, IRAN
PC-040

Estimating the impact of an improved soil hydrology module on the simulation of the hydrological cycle of various river basins of the globe

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Soil-moisture feedback processes play an important role in defining climate characteristics over many areas of the globe. Therefore, it is important to correctly simulate soil moisture dynamics when applying climate models to project future climate changes.

In this study, we presented the application of an improved five soil layer hydrology module of the regional climate model REMO. In order to identify the performance of the new scheme, we conducted hindcast simulations over the CORDEX-Africa, CORDEX South America, and EURO-CORDEX domains using REMO with the standard single bucket scheme and the improved five layer soil hydrology scheme. Focus in the presentation will be given on the simulation of the hydrological cycle of various river basins distributed over the three CORDEX domains, thereby representing different climate characteristics and hydrological dynamics.
Society needs improved knowledge regarding possible impacts of climate change on hydrology. The embodiment of such perturbations includes floods and droughts of growing severity and frequency. Quantification of these threats is important as a base for sensible adaptation measures. This research will explore impacts of climate change on catchment discharge and will address the challenge of better characterizing and communicating their uncertainties. It will in particular focus on the integrated evaluation of CORDEX regional climate model simulations, using hydrological modeling at the catchment scale.

For the evaluation of the various RCMs combined with different bias correction operations there are two main approaches:

1. Separate evaluation of the statistical properties of each climate variable in terms of its statistical properties such as annual mean, seasonal variation, frequency of extreme events.

2. Combined evaluation of the different variables at the catchment scale; that is the evaluation is based on hydrological simulation results, which integrate the different variables (mainly temperature, precipitation and evaporation).

The first approach is straightforward to apply and prevails by far in the literature on RCM evaluation and bias correction. The second approach, although more time demanding because it requires hydrological modeling, presents a critical advantage in that it allows a focus on the statistical properties of the climate variables which are most important for catchment-scale runoff.

When the first approach is used, a wealth of parameters is usually considered, ranging for example from the frequency of wet days to the number of days with temperature above 0°C. It is however unclear which of these parameters are the most crucial for hydrological modeling, in particular because it depends on the catchment characteristic (e.g. evaluation, glacierization) and on the hydrological parameter of interest (e.g. floods or mean summer discharge). The second approach represents a solution to this issue, as it shifts the focus from the input parameters to the output discharge and hence enables the evaluation of RCM and bias-correction methods from a hydrological perspective and in an integrated way.
Mapping and Visualizing Vulnerability to Natural Hazards in Coastal Regions of Bangladesh

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Bangladesh is extremely disaster prone country and highly vulnerable to devastation of natural calamities. Its coastal areas are socio-economical and environmentally important for providing habitat and daily livelihood to over 30 million people. But these areas are projected as the highly vulnerable to multiple threats of climate induced natural hazards such as hurricanes, tropical storms, tornadoes, storm surges, salinization etc. This study is based on historical records of natural hazards which aiming to assess and create a geospatial mapping of their vulnerability to these areas. The methodology is consisting of composite indicators for overall vulnerability assessment, weighing and ranking of zones and finally geospatial mapping for visualization to make it easily understandable to all. As coastal areas are dynamic and urge to area-specific socio-economic vulnerability assessment, hence this compiled hazard map would be helpful to convey a composite snap for understanding of its risk, frequency and magnitude for these specific areas. Moreover, it would also be important for providing a precise location; easy understanding to all types of people, planners, decision makers as for vulnerability communication, building awareness as well formulating and developing more effective mitigation and adaptation strategies for this areas.
Assessment of Water Availability in the Ganges Basin inside Bangladesh using CORDEX Climate Projection

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The southwest region of Bangladesh depends on the flow of the river Ganges and is facing various environmental problems like decrease in fresh water flow, saline water intrusion etc. due to decrease of the flow in the dry season. This study has assessed the future water availability and water demand in the Ganges basin inside Bangladesh under climate change scenarios using CORDEX Downscale Climate Projection data.

Assessment of climate induced long-term water availability in the Ganges basin inside Bangladesh have been computed using the Soil Water Assessment Tool (SWAT). Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM), soil data of Food and Agriculture Organization (FAO), global land cover data from European Space Agency (ESA) have been used to set up the hydrological model. The Tropical Rainfall Measuring Mission (TRMM) rainfall product version 3B42V7 with spatial resolution 0.250 and temperature data from ERA interim by the European Center for Medium range Weather Forecasts have been used for calibration and validation of hydrological model. Relevant hydrological data like water level, discharge has been collected from Bangladesh Water Development Board. Regional Climate Downscale Data from CORDEX-South Asia has been used to assess the future water availability based on climate projection.

The model is calibrated and validated for periods of 1998 to 2008 and 2009 to 2014 respectively. The model performance is evaluated using several statistical parameters like Nash-Sutcliffe Efficiency (NSE), Coefficient of Determination (R2), percent bias, RMSE-observations standard deviation ratio (RSR). During the calibration period the NSE value is 0.93 and coefficient of determination is R2 0.97 whereas in validation period NSE value is 0.75 and coefficient of determination is R2 0.96. This calibrated and validated model has been simulated for the period of 2014-2040, 2041-2070 and 2071-2099 with one RCM (CCAM) output of CNRM-CM5 GCM model for scenarios RCP 4.5 and RCP 8.5. The model results show that the flow is likely to be increased for the months of April, May, June, and July for both the scenarios. On the other hand, model results show that the flow is likely to be deceased for the months of August, September and October for the second half of the century. At present, the model has been simulated with single RCM output, and model simulation is under process with other RCM results derived from GCM of ACCESS, CCSM, GFDL and MPI.
Challenge in current climate modeling

Samuel Ibitoye

www.nou.du.ng

This paper compresses the present condition of under-remaining as for the included quality (AV) not out of the ordinary from restricted settled high-determination territorial atmosphere simulations and projections. The reasons that prompt the improvement and the advancement of territorial atmosphere models (RCMs) are initially considered. The experimental premise supporting the RCMs mission is then quickly checked on.
Future changes in extremes of precipitation over South Korea projected by HadGEM2-AO and 5-RCM ensemble under RCP scenarios.

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The change of extreme precipitation is assessed with the HadGEM2-AO – 5 Regional Climate Models (RCMs) chain, which is a national downscaling project undertaken cooperatively by several South Korean institutes aimed at producing regional climate change projection with fine resolution (12.5km) around the Korean Peninsula. The downscaling domain, resolution and lateral boundary conditions are held the same among the 5 RCMs to minimize the uncertainties from model configuration. Climatological changes reveal a statistically significant increase in near-future (2046-2070) and far-future (2076-2100) precipitation properties related to extreme precipitation, such as precipitation intensity and average of upper 5 percentile daily precipitation, with respect to the reference period (1981-2005). Changes depending on the intensity categories also present a clear trend of decreasing light rain and increasing heavy rain. In accordance with these results, the change of 1-in-50 year maximum precipitation intensity over South Korea is estimated by the GEV method. The result suggests that the 50-year return value (RV50) will change from -32.69% to 72.7% and from -31.6% to 96.32% in near-future and from -31.97% to 86.25% and from -19.45% to 134.88% in far-future under representative concentration pathway (RCP) 4.5 and 8.5 scenarios, respectively, at the 90% confidence level. This study suggests that multi RCMs can be used to reduce uncertainties and assess the future change of extreme precipitation more deterministically.

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PC-046

The difference of climate change at East China Sea and adjacent Northwest Pacific Ocean from 1871

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CANCELLED

Using SODA Database (1871-2010), analysis temperature change rate and trend from surface to the deep in the East China Seas and adjacent waters to the Northwest Pacific Ocean (NPO), for past 140 years, the results showed a larger differentiation at space and time: on the surface, the warming has emerged at the whole studying area for last 140 years; the warming rates appeared that over the 25 years > 50 years > 100 years > 140 years. But the largest rate was at the layer around the depth of 50-70 m. In the continental shelf area of the East China Sea (ECS), the temperature was rising at upper layer to 100 meters, some area deeper than 120 meters has appeared cooling. In the Kuroshio of the ECS (the ECS Kuroshio) and the Okinawa trough region, from the entrance to export of the ECS Kuroshio, the sea was warming at upper 300 m, the warming rate decreased with depth; 500-700 meters in some areas appear to be cooling; the layer deeper than 700 meters appears warming trend again. At the NPO adjacent to the ECS, the upper 200 meters appear to warming, a little cooling trend at 300-1200 meters, not change or appear weak warming below 1200 meters.
PC-047

Recovery of a ultra-high resolution synthetic precipitation and temperature data and future projection in the Korean peninsula

Jai-Ho Oh, Hyung-Jeon Kang and Sumin Woo
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Recently, because of the weather forecasts through the low-resolution data has been limited, the demand of the high-resolution data is sharply increasing. Therefore, in this study, we restore the ultra-high resolution synthetic precipitation and temperature data for 2000-2014 due to small-scale topographic effect using the QPM(Quantitative Precipitation Model)/QTM(Quantitative Temperature Model). Also, according to RCP8.5 scenario, we project the precipitation and temperature data for 2015-2040 over the Korean peninsula through the linkage of the global model and QPM/QTM.

First, we reproduce the detailed precipitation and temperature data with 1km resolution using the distribution of Automatic Weather System(AWS) data and Automatic Synoptic Observation System(ASOS) data, which is about 10km resolution with irregular grid over South Korea. Also, we recover the precipitation and temperature data with 1km resolution using the MERRA reanalysis data over North Korea, because there are insufficient observation data. The precipitation and temperature from restored current climate data reflect more detailed topographic effect than irregular AWS/ASOS data and MERRA reanalysis data over the Korean peninsula. In the future projection over the Korean peninsula according to RCP8.5 scenario, the distribution of regional temperature increase is illustrated more detail than the global model and the variability of precipitation is also more largely reflected due to complex topographic features. Based on this analysis, more detailed prospect of regional climate is investigated.
Sensitivity study of convective cloud feedbacks on radiation and impacts on precipitation

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A sensitivity study is performed to investigate the impact of convective cloud-radiation feedbacks on precipitation in the European regional climate. Two 5-year long simulations have been performed with the WRF3.6.1 regional climate model, forced by the ERA-interim dataset, with a spatial resolution of 50 Km. In the “control” experiment WRF considers cloudiness only from grid-scale clouds. In the “feedback” experiment liquid and ice water condensates associated with the subgrid-scale cumulus clouds are added to corresponding adjusted grid-scale condensates and are considered in radiative transfer calculations. The RRTMG radiation scheme and the Kain-Fritsch cumulus parameterization are used in both control and feedback experiments. The convective-cloud/radiation feedback (cu_rad_feedback) parameter, has been switched off and on in the control and feedback simulations, respectively. The results indicate that taking into account subgrid-scale cumulus clouds in the radiation scheme, affects precipitation by altering convective available potential energy and downward radiation at the surface, mostly in spring (MAM) and summer (JJA) months. The climate simulations have been performed in the EGI/Hellasgrid infrastructure.
Regional climate projections of changes in the monsoon, droughts and rainfall extremes for SE Asia

Jack Katzfey and Kim Nguyen
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To assist the government of Vietnam in its efforts to better understand the impacts of climate change and prioritise its adaptation measures, detailed climate change projections at 10 km resolution across Vietnam were produced for the High-resolution Climate Projections for Vietnam (HCPV) project. Six of the latest available global climate models (GCMs) from the Coupled Model Intercomparison Project Phase 5 were downscaled using the Conformal Cubic Atmospheric Model (CCAM) to 10 km and RegCM to 20 km over SE Asia. Simulations were performed for historical (1970-2005) and future (to 2099) time periods using two representative concentration pathways: RCP4.5 and 8.5.

The simulation of the monsoon for the current climate is validated for onset and end date, as well as for mean monsoon intensity. The projected changes in show decrease in duration (earlier end date) and a decrease in intensity (amount of rainfall) during the monsoon. Droughts are projected to generally increase in length, changes in frequency are more complex. Similarly, extreme rainfall is projected to decrease in some areas, but increase in other areas as well. The inter-connectedness of these changes will be discussed.

The implications of these changes will be discussed, with a focus on using a risked-based approach to assess the possible impacts and adaptation responses.
Future changes in extreme snowfall in Japan projected by large ensemble regional climate experiments

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Future changes in extreme snowfall are investigated analyzing the large ensemble regional climate experiments. Dynamical downscalings are conducted by Non-Hydrostatic Regional Climate Model (NHRCM) with 20 km from the global climate projections using Meteorological Research Institute-Atmospheric General Circulation Model (MRI-AGCM). Fifty ensemble experiments are performed in the present climate and ninety ensemble experiments are performed assuming the periods when 4 K rise in global-mean surface air temperature is projected.

The accumulated snowfall in winter decreases in the most parts of Japan except for the northern parts of Japan. Especially, the inland areas in the Sea of Japan side, which is famous for the heaviest snowfall region in the world, shows the remarkable decrease in snowfall in the future climate. The experiments also show increased number of days without snowfall and decreased number of days with weak snowfall due to significant warming in the most parts of Japan. On the other hand, the extreme daily snowfall, which occurs less than once ten years, would increase at mountainous areas in the Sea of Japan coast. This means that extreme daily snowfall in the present climate would occur more frequently in the future climate. The composite analysis of extreme daily snowfall indicates that the extreme precipitation occurs when the convergence line appears in the Sea of Japan. Since the warmer ocean could supply more water vapor than that in the present climate, the cumulus convections would stronger around the convergence line in the future climate. Since the surface air temperature at higher elevations is still lower than 0 degree Celsius, which could result in the increased extreme daily snowfall.
Changes in extreme precipitation indices by climate change over South Korea

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Recently, natural disasters have increased due to climate changes. Over the Korean Peninsula, most damages of natural disasters are related to extreme precipitation. To reduce these damages of future disasters, reliable projections of future changes in extreme precipitation are in high demand. In this study, changes in extreme precipitation indices over South Korea, which were provided by high-resolution climate change scenarios from 5 RCMs (HadGEM3-RA, RegCM4, SNURCM, WRF, and GRIMs), were analyzed. We used precipitation core indices provided by STARDEX (STatistical and Regional dynamical Downscaling of EXtremes for European regions). Differences in extreme precipitation between 25-year (1981-2005) historical experiment and 25-year (2076-2100) RCP 8.5 experiment were compared. Using the bilinear interpolation method, simulated precipitation data were interpolated to 230 sub-regions in South Korea and then, the core STARDEX indices of precipitation were calculated for each region. In late 21C, both precipitation intensities (e.g., 90th percentile of rainday amounts) and maximum number of consecutive dry days tended to increase. This indicates that heavy precipitation as well as drought could more frequently occur in the future climate compared in the present climate. Particularly, the occurrence of heavy precipitation more prominently increased in spring and winter, while that of drought more robustly increased in autumn. These changes in extreme precipitation are associated with the changes in low-level moisture and monsoon circulation. Through this study, the projection of extreme precipitation can be used as important information for policy decisions related to climate change adaptation and mitigation.
Due to the global warming, the amount of the snowfall has decreasing trend in the Korean peninsula in the recent years. However, the exceptional and longest severe snowfall events more frequently occur, which result in significant socioeconomic losses such as traffic congestion and damage of the crop cultivation. In general, not only the propagation of the Siberian High eastward, also the appearance of low pressure over the southern part of the Korean peninsula has a significant impact on the severe snowfall in South Korea. In particular, the region of heavy snowfall is expended when the low pressure passes over the southern part of Korea.

In this study, we numerically simulate the longest heavy snowfall over the Korean Peninsula from February 06 to 18 in 2014 and perform various numerical experiments to explain the cause of the severe snowfall occurrence by using high-resolution WRF model. Various experiments consist of SST (Sea Surface Temperature) experiment and topographic experiment. The control experiment was evaluated with the observations and it reasonably simulated heavy snowfall well. In numerical simulations, they showed relatively small amount of snowfall. Analyses of SST experiment demonstrate that the anomalous warm SST in 2014 winter led to cyclonic circulation over Korea and then the convergence zone between anti-cyclonic circulation by Siberian High and cyclonic circulation by warm SST anomaly appeared over Yeong-dong region. For the topographic experiment showed that dynamical lifting by mountain effect enhanced severe snowfall in that region.
Relationship between the Tropical South Atlantic SST and drought over West Africa from CORDEX

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Droughts in West Africa are not only an environmental problem but also a social and economic concern. However, droughts research has not obtained the necessary attention in West Africa. Moreover, the dynamics of West African drought are not fully understood and among the studies that have considered droughts of West Africa, only a few have considered the role of the Tropical South Atlantic (TSA) Sea Surface Temperature (SST) on drought over West Africa. In this study, we look at how 10 CORDEX models represent the relationship between the TSA SST and drought, precipitation and temperature over West Africa. Previous studies on drought over West Africa used only precipitation in Standardised Precipitation Index (SPI) to measure drought index. The use of precipitation alone is inadequate to give information about drought as evapotranspiration has a direct influence on drought. We recognize that evapotranspiration is an important process of water loss. Hence this study uses the Standardised Precipitation Evapotranspiration Index (SPEI) where evapotranspiration is included in the calculation of the drought index. We found that some models show close relationship with observation, others struggle and RegCM3 misses it most of the time. The other nine models show that both warm and cold phases of the TSA have influence on precipitation and temperature of West Africa but for drought, CRCM also disagrees.
Land atmosphere coupling in EURO-CORDEX evaluation experiments

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Interactions between the land surface and the atmosphere play a fundamental role in the weather and climate system through their influence on the energy and water cycles. Here we present results of summertime land-atmosphere coupling strength in a subset of the ERA-Interim driven EURO-CORDEX model ensemble (1989-2008) including an evaluation of the coupling related variables soil moisture and surface energy fluxes of latent heat (LE) and sensible heat (H). Most of the regional climate models (RCMs) reproduce soil moisture and surface fluxes for the different European climate zones reasonably well. However, for some regions and models differences are identified, also compared to FLUXNET surface flux measurements used as observational reference.

To quantify the coupling strength the H-LE-correlation method has been confirmed as useful and valid for the comparison of different RCMs. An important advantage of the method is that it can be applied to standard RCM output variables (H, LE) as well as to observations, although long time series of high quality flux measurement data are needed, which are available only for a few locations across Europe. For the full 20-year period of summer seasons the EURO-CORDEX simulations agree in the large-scale patterns, with strong coupling in Southern Europe and weak coupling for Northern Europe, also in agreement with the FLUXNET observations. For large parts of Central Europe, however, the model ensemble diverges between strong and weak coupling strength. Compared to the FLUXNET measurements more models tend to overestimate than underestimate the coupling strength. Higher model resolution leads to more small-scale heterogeneity but not necessarily to a change in the large-scale patterns. Diversity in the ensemble can be both explained by the different characteristics of the individual land surface models (LSMs) as well as different climate conditions in the models.
Boreal Summer Intra-seasonal Oscillations in CORDEX-SA Models

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The outputs from a suite of CORDEX-SA models have been analysed to examine the simulation of characteristic features of boreal summer intra-seasonal oscillations (BSISO) over the south Asian domain.

The daily precipitation data over the period 1986-2005 have been used for the models COSMO-CLIM, EC_EARTH, IITM-RegCM4-GFDL-ESM2M and IITM-RegCM4-LMDZOR which have been archived at Center for Climate Change Research, Indian Institute of Tropical Meteorology, Pune, India. The projected changes in the prominent features are examined under RCP4.5 scenario towards the end of the century (2081-2100).

The model outputs have been validated against the CMAP precipitation. All the four models show large discrepancy in simulating the annual cycle of summer monsoon (June-through September) rainfall over South Asian domain. Except COSMO-CLIM no model simulates the rainfall north of 25°N. Also all the models simulate maximum rainfall in the zone 5-10° N during summer monsoon season which may be the main reason for strong dry bias. These models have the difficulty in simulating BSISO properly. The northward propagation and the spatial pattern of BSISO variance have been examined. They fail to capture the peak centers of BSISO variance over Indian summer monsoon region. The behaviour of BSISOs in the extreme wet and dry monsoons have also been examined. The added value to simulation of BSISO by high resolution regional CORDEX models would be discussed with respect to parent global models.
Understanding the future changes in climate extremes over Qatar and the Arabian Gulf region

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A critical aspect of human-induced climate change is how it will affect climatological mean and extremes around the world. Summer surface climate of the Qatar and Arabian Gulf region is characterized by hot and humid conditions. The global warming can have profound impact on the mean climate as well as extreme weather events over the Arabian Peninsula that may affect both natural and human systems significantly. Therefore, it is important to understand the future changes in the seasonal/annual mean of temperature and precipitation and also the extremes in temperature and wind events for a country like Qatar. In this study, we assessed three CORDEX-MENA simulations downscaled using later boundary data from three CMIP5 GCMs (EC-EARTH, CNRM-CM5 and GFDL-ESM2M) to understand the behavior of regional climate extremes for the present and future climate. The downscaling of the GCM simulations has been performed with the latest version of the Rossby Centre Regional Climate Model-RCA4 for the MENA domain at 0.44° resolution. The changes in climate extremes are assessed for three future periods 2016-2035, 2046-2065 and 2080-2099 with respect to 1986-2005 (baseline) under two RCPs (Representative Concentrate Pathways) - RCP4.5 and RCP8.5.

We analyzed the projected changes in temperature and precipitation extremes using several indices including those that capture heat stress. The observations show an increase in warm extremes over many parts in this region that are generally well captured by the models. The results indicate a significant change in the frequency and intensity of both temperature and precipitation extremes over many parts of this region which may have serious implications on human health, management of urban infrastructure, water resources and the onshore/offshore operations related to energy sector in this region. Data from a high-resolution (20km) AGCM simulation from Meteorological Research Institute of Japan Meteorological Agency for the present (1979-2003) and a future time slice (2075-2099) corresponding to RCP8.5 have also been utilized to assess the impact of climate change on regional climate extremes as well. The scenarios generated with the high-resolution model simulation were compared with the coarse resolution of CORDEX-MENA and CMIP5 model scenarios to identify relative merits of resolution in simulating region specific features.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-057

Understanding the Variability and Predictability of West African Seasonal Climate using a Dynamically Downscaled GCM

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Understanding of seasonal climate over West African sub-region, as well as the ability of climate models to predict them, has focused on the agreement of simulations of dynamical models of the climate system, rather than considering outliers as potentially vital contributors to understanding and predictability. This work uses discrepancy in a large ensemble of climate simulations as a tool to investigate variability in dominant seasonal rainfall and temperature patterns (i.e. classes) over West Africa and to examine the capability of climate models in reproducing the variability.

The climate model examined adequately reproduces the dominant classes of seasonal climate (rainfall and maximum temperature) over West Africa. The sequences in which each class occurs cannot be linked simply to a single common index of global scale atmospheric circulation anomalies, implying that the chaotic regional atmospheric circulations that modulate the global scale modes of variability are indispensable. Some simulations perform substantially better and others substantially worse than the average of all the simulations, but the best simulations for a particular variable may not be exceptional for another variable. While identification of the best simulations in an array of simulations can provide substantial improvement over usage of the average of all the simulations, the possibility of misidentifying those simulations poses a serious risk to seasonal forecasting. The study however indicates that there may be limits to the extent to which year-to-year variations in the predictability of seasonal climate forecasts might be understood.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-058

Evaluation of a RCM ensemble performance to simulate heat waves over the Iberian Peninsula

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Several studies have reported an increase in the frequency, duration and/or intensity of heat waves in Europe, and models estimate further increase in these characteristics by the end of the 21st century. Hence there is a growing recognition in the fields of bio-climatology, epidemiology and environmental health that increasing heat risk is a problem, and proper adaptation measures should be developed in national, regional and local scales. Therefore, RCMs have become important tools for providing detailed and reliable estimates of current and future climatic conditions, to support a range of studies concerned with the regional impacts of climate change on natural ecosystems, society and even government and large utility planning.

This study is the first step in using the EURO-CORDEX ensemble simulations to assess the projected changes in the heat related climate extremes and risks over the Iberian Peninsula. To this aim, we test the ability of a regional climate model ensemble to represent the current heat wave conditions relevant to different sectors interested in heat risk. A variety of heat wave indices are calculated and analysed from different aspects, such as the yearly number of heat waves, the average daily magnitude across all heat wave events within a year, the hottest day of the hottest yearly event, the length of the longest yearly event and the sum of participating heat wave days per year. The ERA-Interim driven simulations of the high-resolution version (12 km) of RCM ensembles are analysed for the period 1981-2010. The uncertainty of the model ensemble to capture temporal and spatial variability of heat waves over the Iberian Peninsula is evaluated using a number of metrics ranging from daily to climatology scales against E-OBS and CRU TS3.10 observational reference as well as against ERA-Interim reanalysis datasets.

The preliminary results show that the regional climate model ensemble captures the important climatic patterns based on the comparison of the heat wave indices derived from observational/reanalysis data and model simulations for the reference period. The highest bias is found in high mountainous areas over the Pyrenees, probably amplified by the relative lack of high-elevation observing stations involved into the reference datasets and the scarcity of fine-scale modelling over complex terrain.
Scenarios of future changes in small scale precipitation extremes for The Netherlands are presented. These extremes mainly originate from convective cloud systems, which are not represented optimally in present-day hydrostatic regional climate models. Therefore, the scenarios are not only based on information from regional climate models, but also take into account information from observed relations as well as short integration with non-hydrostatic atmospheric models. This is done using a new approach whereby changes in precipitation extremes are set proportional to the change in water vapor amount near the surface as measured by the 2m dew point temperature. This simple scaling framework allows the integration of information derived from: i) observed relations and trends, ii) a new unprecedentedly large 16 member ensemble of simulations with the regional climate model RACMO2 driven by EC-Earth, and iii) short term integrations with a non-hydrostatic model Harmonie. Scaling constants are based a subjective weighting (expert judgement) of the three different information sources. In all scenarios local precipitation extremes increase with warming, yet with broad uncertainty ranges expressing incomplete knowledge of how convective clouds and the atmospheric mesoscale circulation will react to climate change.
PC-060

A multi-model and multi-scenario analysis of climate change impacts on marine storminess along the coast of the Mediterranean sea

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Because of mesoscale and sub-regional features, which are produced by the combination of complex morphology and strong contrast in air masses, the Mediterranean Sea represents a well-known test case for exploring the improvement caused by high resolution in the modelling of surface winds and sea level pressure fields. Quality of these two fields is essential for that of the wind waves and storm surges that they produce. This study uses a cascade of models for assessing an important aspect of regional climate change: the effect of extremes storms (waves and surges) on the complicated Mediterranean coastline, which is already affected by heavy exploitation and large demographic pressure.

The analysis is based on three sets of simulations carried out with regional climate models. The first set consists of former A1B “CMIP3” projections carried out within the fp6 CIRCE project. The two recent sets are the RCP4.5 and RCP8.5 projections produced within the MedCORDEX component of CORDEX. Some of MedCORDEX and CIRCE’s simulations include the coupling to a high resolution model of the Mediterranean Sea circulation. The regional climate simulations have been used for driving a storm surge model and a wave model focusing the analysis of the results along the Mediterranean coastline, in terms of changing sea level extremes, extreme significant wave height, wave direction and frequency. This large set of data allows to explore uncertainty related to the emission scenario, model and decadal variability for a time range reaching the end of the 21st century.

Results quite consistently show a progressive future reduction of marine storminess along most of the Mediterranean coastline, whose intensity decrease along the 21st century and with the emission level, being largest for the RCP8.5 scenario at the end of the 21st century. Further this study is capable of a comprehensive approach, where also local steric effects are included, thanks to the availability of temperature and salinity projections produced by the coupling to a high resolution ocean circulation component included in some regional climate models. Data, therefore, allow to consider the superposition of the effect of storm surges, waves changes and mean sea level rise. It is shown that the future increase of mean sea level compensates for the attenuation of storminess, so that the hazard posed by marine storms will affect a part of the coastal areas that will be larger in the future than presently.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-061

ClimEx – Climate change and hydrological extreme events – risks and perspectives for water management in Bavaria and Québec

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The recent accumulation of extreme hydrological events in Bavaria and Québec has stimulated scientific and also societal interest. In addition to the challenges of an improved prediction of such situations and the implications for the associated risk management, there is as yet no confirmed knowledge whether and how climate change contributes to the magnitude and frequency of hydrological extreme events and how regional water management could adapt to the corresponding risks.

The ClimEx project investigates the effects of climate change on the meteorological and hydrological extreme events and their implications for water management in Bavaria and Québec. It comprises three major components: climate, hydrology and high performance computing.

(1) The climate module builds on the development of a large ensemble of high resolution data (12km) of the CRCM5 RCM for Central Europe and North-Eastern North America, downscaled from 50 members of the CanESM2 GCM. The dataset will additionally contain the available data from the Euro-CORDEX project to account for the assessment of both natural climate variability and climate change. The large ensemble with several thousand model years provides the potential to catch rare extreme events and improve the process understanding of extreme events with return periods of 1000+ years.

(2) The hydrology module focuses on modeling the major catchments in Bavaria and Southern Québec in high temporal and spatial resolution using physically based models. The simulations form the basis for in depth analysis of hydrological extreme events based on the inputs from the large climate model dataset. A new method for ‘virtual perfect prediction’ will be developed to assess climate change impacts on flood risk and water resources management. This method shall identify patterns in the data which induce hydrological extreme events using different lead times and provide the opportunity to simultaneously analyze different scenarios of control measures for damage reduction.

(3) In order to enhance efficiency for these analyses the third project component deals with the consolidation, coupling, and optimization of the two previous modules. Therefore, the LRZ provides its expertise in high performance computing and data management to consolidate all available software tools in a common interface. The great demands of computation power for modeling climate and hydrology in parallel are met by the application of the LRZ's HPC SuperMUC.
Analysis of the influence of sea surface temperature representation in downscaled regional climate using the SEACLID/CORDEX-Southeast Asia simulations

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Climate variability over Southeast Asia is affected by variability in sea surface temperatures (SST). However, the spatial pattern and temporal variability of SST and its influence on regional climate may not be well represented in climate models, especially if the atmosphere is uncoupled from the ocean (i.e. SST is only prescribed in the model so no feedbacks), resulting in biases in the downscaled climate output. Recently, simulations of near-recent climate over Southeast Asia have been generated from the Southeast Asia Regional Climate Downscaling (SEACLID)/CORDEX Southeast Asia (CORDEX-SEA) project. Comparison with observed data indicates model biases in the simulation of temperature and rainfall over the region. It is therefore important to examine the representation of SST in climate models in order to address its associated uncertainties. The objective of this study is to assess the importance of SST in simulating regional climate over Southeast Asia. An expected outcome of this study will be a deeper understanding on the SST-climate relationship over Southeast Asia, particularly the Philippines, to aid in the improvement of regional climate simulations for better future climate projections that can be used in adaptation and impacts studies.
The performance of land surface and cumulus convection scheme in the simulation of Indian Summer Monsoon using RegCM4

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Indian Sumer Monsoon (ISM) is the most dominant tropical circulation process in the Atmospheric General Circulation System. It contributes about 70% of the total annual precipitation during June-September over India. Summer rainfall has substantial effect to the agriculture and economy of the country. ISM is dominated by convection and land surface processes also play important role through transfer of energy and moisture. These processes must be well represented in the numerical models for better simulation of ISM. Therefore it is important to investigate the performance of various land surface and cumulus schemes in simulating ISM. In this study, performance of the convection and land surface schemes in simulating ISM are investigated using RegCM 4. The performance of two land surface [BATS, CLM 3.5] and five convection [MIT, Kuo, Grell and Grell over land and MIT over Ocean (GL_MO), Grell over ocean and MIT over Land (GO_ML)] schemes are tested. The model at 30 km resolution covering (30˚E-120˚E, 15˚S-45˚N) is integrated for the period of 1st May-30th September during 2007, 2008 and 2009. The initial and boundary conditions are derived from NNRP1 data at 2.5˚×2.5˚ resolution. The Sea Surface Temperature is taken from NOAA Optimum Interpolation weekly mean data at 1˚×1˚ resolution.

Some important features of ISM simulated by the model; viz. Somaly jet, Tropical easterly jet (TEJ), Heat low, Tibetan high etc. are analyzed with NCEP reanalysis. Heat low is well produced by the model with MIT, GO_ML and GL_MO schemes. The Somaly jet is usually weak but better simulated with MIT scheme. Although the model is able to reproduce the TEJ and Subtropical westerly jet, the location and strength of the jets are varying scheme-wise and is better simulated by MIT scheme. The model is also able to simulate the stronger easterly jet in 2007 compared to 2009 with MIT scheme. The rainfall over Central and North West India is significantly under-predicted by the model with all these schemes. The monthly and seasonal precipitation is better simulated by the model with the combination of MIT convection scheme and CLM compared to the other combinations although it over-predicts rainfall over heavy precipitation zones. Considering overall performances, RegCM4 shows better skill in simulating ISM with MIT convection scheme using CLM.
Climate change could harshly affect cities, especially metro cities in India, as they become the hub of livelihood opportunities. It results in growing population density from the neighboring areas. At the same time, the city’s population will continue to increase and require housing, transportation, and other city services. Except the city can manage growth in a more sustainable manner, flood depths will increase and waterlogging will last longer due to the projected climate change impacts on rainfall and current urbanization process of India. Addressing climate change in urban areas requires building resilience to deal with the enduring impacts of climate change. Urban climate change resilience planning is closely linked to urban development processes. Urban resilience plan against climate change uses participatory approaches and bottom-up development planning. In metro city of India, situated in the flood-prone foothills of the Nepal Himalayas, the key urban systems, agents and institutions that enhance the risks of climate change impacts are linked to natural settings, behavioral patterns and weak governance. This research paper describes how local communities in metro city of India have used participatory approach to facilitate local resilience and adaptation planning.
Water is a primary medium, by which climate change will influence to people, ecosystems and economy. So, water resources management as a way to adopt to climate change must be in center of attention.

Taking account all this and the role and significance of Aghstev river in development of economy of the republic, the aim of the work was to discover, analysis and estimate the dynamics change of annual runoff of river in the context of global climate change, estimate the vulnerability and risk of runoff, work out ways of productive using and protection, management and regulation.

For solving these problems as a theoretical base were appropriate studies mainly the works about climate change and softening of its influences reports. As an raw material have used the results of actual observations of Armstatehydromet. As a methodological base in the work have used general scientific, characteristics, analysis, statistical analysis, mathematical, extrapolation, correlation methods.

For estimation of vulnerability of water resources have analyzed the tendency of river runoff, water temperature, air temperature and atmospheric precipitation changes for period 1929-2014 as well as have estimated climate change of basical period 1961-1990 by A2 scenery of PRECIS model predicted changes of river runoff up to 2030, 270 and 2100.

In the result of studies became clear, that the annual runoff of Aghstev river has a tendency of increasing, as well as a tendency of increasing has water temperature. In study river basin increases both of annual air temperature and annual number of atmospheric precipitation. At the other side, according to second national message about climate change, in case of predicted change of climate in the territory of Armenia the total river runoff of basical period 1961-1990 at 2030 will decrease for 6,7 %, at 2070 - 14,5 %, 2100 - 24,4 %.

So, the influence of climate change on actual river runoff as well as on precipitation in different river basins of Armenia is different. So, in mountainous countries the problems with climate change is necessary to discuss by river basin principe.

For softening the effects of climate change on water resources and adapt the economy to natural new conditions is necessary to realize measuring in sharp evaluation, technological, institutional and legal-organization spheres.

It means the climate change not only negative but also positive influence can be have on river runoff.
Forecasts allow to make the most efficient use of water resources of country, also in good time get ready for dangerous hydrological phenomena and alarm or appreciably decrease the damage which caused to national economy.

The aim of job is to study, analysis and forecast the volume runoff one of the main rivers of republic in water period. Toward this end were collected, worked out and analyzed the data of observations of hydrological and meteorological stations and points of basin, which have been kept in Armstatehydromet and have been used according literary sources and mathematic-statistic, geographic, mapping, analyze and correlation methods.

The river Vedi is the left tributary of Araks. In middle and lower flows the waters of river are used for irrigation completely. To Vedi river is characterized spring-summer flood, summer-autumn and winter low water level stages. In the basin the annual runoff character with one spring maximum (April-June). Second, small increasing of expense observes during autumn rains. So, in the period of spring floods by river passes 65-70 % of annual runoff. And in this time often observed maximum expense of river water. Usually is forms in the April - in the beginning of May but especially in the first part of May. So, for economic productive using of water of river is necessary to organize rightly regulation and management of river runoff. The role of it is increases more in conditions of climate change, depending on dynamic change of river runoff. For more productive organization of regulation and management of runoff is necessary scientific knowledge, that means, it need to forecast.

So, in work have been made methods of long-term forecasting of monthly runoff. The monthly forecast is being published in 23-24 of previous month. As a result of study have been got multifactor correlation links. In of runoff forecast are used by links between average monthly values of runoffs of predicted and preceding months, air temperatures, atmospheric precipitation.

So, these methods of long-term forecasting of monthly runoff give possibility one month earlier calculate the value of predicted runoff of Vedi river in Urtsadzor hydrological point. And due to this is possible to manage the runoff of Vedi river, and also to plan the problems of water consumption, know the runoff of next month before.

These methods of forecasting is possible to apply for operative forecasts.
Climate change: potential impact on coffee rust

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In this work, some meteorological variables from a regional climate model are used to characterize the dispersion of coffee rust (a fungal disease) from Central America to Mexico during the 20 Century. The climate model consists of the REgional atmosphere MOdel REMO coupled to the MPI-OM global ocean model with increased resolution in the Atlantic Ocean. Lateral atmospheric and upper oceanic boundary conditions outside the coupled domain were prescribed using ERA40 reanalysis data. In addition to the historical simulation, a projection of the evolution of the coffee rust for the 21 Century was obtained from a REMO run using MPI-ESM data for the lateral forcing.
Large Ensembles of Regional Climate Projections

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Projections of regional climate change have great utility for impact assessment at a local scale. The CORDEX climate projection framework presents a method of providing these regional projections by driving a regional climate model (RCM) with output from CMIP5 climate projection runs of global climate models (GCM). This produces an ensemble of regional climate projections, sampling the model uncertainty, the forcing uncertainty and the uncertainty of the response of the climate system to the increase in greenhouse gas (GHG) concentrations.

Using the weather@home project to compute large ensembles of RCMs via volunteer distributed computing presents another method of generating projections of climate variables and also allows the sampling of the uncertainty due to internal variability. weather@home runs both a RCM and GCM on volunteer’s home computers, with the free-running GCM driving the boundaries of the RCM. The GCM is an atmosphere only model and requires forcing at the lower boundary with sea-surface temperature (SST) and sea-ice concentration (SIC) data. By constructing SST and SIC projections, using projections of GHG and other atmospheric gases, and running the weather@home RCM and GCM with these forcings, large ensembles of projections of climate variables at regional scales can be made.

To construct the SSTs and SICs, a statistical model is built to represent the response of SST and SIC to increases in GHG concentrations in the CMIP5 ensemble, for both the RCP4.5 and RCP8.5 scenarios. This statistical model uses empirical orthogonal functions (EOFs) to represent the change in the long term trend of SSTs in the CMIP5 projections. A multivariate distribution of the leading principle components (PC) is produced using a copula and sampled to produce a timeseries of PCs which are recombined with the EOFs to generate a timeseries of SSTs, with internal variability added from observations. Hence, a large ensemble of SST projections is generated, with each SST projection having a probabilistic definition, as it occurs at a percentile in the distribution of warmings due to GHG increases in the CMIP5 ensemble.

This talk will present the statistical model of SST and SIC, the weather@home model and some initial results from the regional climate projections achieved by computing a large ensemble of weather@home models using the SST and SIC projections for RCP4.5 and RCP8.5.
Determining the Suitability of Evacuation Centers to Increase Accessibility of Aid Distribution: Lesson Learnt from ‘Bah Kuning’ 2014

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Located outside the ‘Pacific Rim of Fire’, Malaysia is basically non-visible to severe natural disaster and calamities but prone to flood, severe haze, land slide and other man-made disaster. The effects of global extreme weather and climatic events have hit Malaysia as bad as neighboring regional countries. In December 2014 worst flood in decades has hit her causing 250 000 families has lost their homes and 21 people have been reported dead. Continuous precipitation with high density had raised water levels that submerged few states. Victims were evacuated in scattered or trapped with low life support on water, food, energy and healthcare supply. Emergency aid provided by related agencies has very low accessibility to reach to the evacuation centers and third force volunteers have limited information and resources to support aid distribution efforts. Therefore an integrated assessment of flood management in the river basin is important for more effective response. To increase preparedness and reduce the risk, this study intent to improve accessibility to evacuation centers based on flood risk map. Digital Elevation Model (DEM) data, GPS data, Flood Model data and land use data will be use in the production of flood risk and vulnerability map for the study area. Site selected is along Lebir River in Kelantan State, Malaysia. From this flood risk map, the suitability of evacuation centers will be assessed. This map and plan able to assist the authorities and stakeholders to provide emergency assistance and aid to victims based on severity of affected areas. Location for additional evacuation centers will also be suggested and accessible route will be map
PC-070

Analysis of the longest dry spells phenomenon in a Ghézala dam (Tunisia)

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CANCELLED

This contribution focuses on an analysis by event of dry event, according to a predetermined threshold, from series of observations of the daily rainfall. The accent has been put on the modeling and computation. The approach has been illustrated on a case study of the Ghézala dam localized to the North of Tunisia where the average rainfall is 680 mm. The dry events are constituted of a series of dry days framed by the rainfall event. Rainfall events are defined themselves in the form a uninterrupted series of rainfall days understanding at least a day having received a precipitation superior or equal to a threshold of 4 mm. The rainfall events are defined by depth and duration, which are found to be correlated. An analysis of the depth per event conditioned on the event duration has been undertaken. The negative binomial distribution appears the best overall fit for the depth per event. The duration of the rainfall event follows a geometric distribution while that the dry event follows the negative binomial distribution. The length of the climatically cycle adjusts to the Incomplete Gamma. A procedure of stage simulation by stage by the method Monte Carlo has been executed to generate a synthetic sequence of rainfall events and dry with correspondent lengths of rainy season.
PC-071

Representation of Arctic Temperature Extremes in the Arctic CORDEX RCM ensemble

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Capturing Arctic temperature extremes in RCMs in present-day climate is essential to have some confidence in their projection. In this study, we use two climate extreme indices: Cold Spell Duration Index (CSDI) and Warm Spell Duration Index (WSDI). Evaluated were 7 RCM ERA-Interim driven runs on the basis of the model forcing data (ERA-Interim reanalysis) and over land on the basis of the station data set Global Summary of the Day. We focus on the two extreme seasons, on winter where Arctic amplification is greatest and thus we might expect pronounced changes in extreme weather events, and on summer where Arctic amplification is modest in contrast.

Both warm and cold spells are interesting measures for model evaluation, because: (i) Their calculation is based on relative temperature thresholds. CSDI for example is based on Cold Nights, which are defined as days with daily minimum temperatures below TN10 (10% percentile of the daily minimum temperature distribution in a reference period). Thus, even if a model shows biased daily minimum temperatures, cold nights could still be represented well. (ii) Whether calculated cold nights cluster “correctly” (which is necessary for a good representation of spells) depends on a well-represented circulation, i.e. on the occurrence of blocking events and cyclones (depending on season and geographical location).

The analysis of cold spells shows that biases in the model runs are largest over the ocean for both winter and summer in comparison with ERA Interim, and located in areas with high cold spell occurrence. Six out of seven models overestimate the cold spell maximum along the ice edge on the Atlantic side of the Arctic Ocean, and these biases are more pronounced in summer than in winter. Five out of seven models underestimate the cold spell maximum in the northern Baffin Bay, with higher biases in winter. The cold spell maximum in the Baffin Bay is associated with cold air outbreaks from the inner Arctic, which suggests a connection to biased circulation in the models.

Similar analysis is performed for warm spells, where we discuss the biases in the models in association with the temperature distribution itself and the atmospheric circulation by analyzing the distribution of warm daytimes and atmospheric conditions leading to high warm spell occurrences.
UnLoadC3: Climate change modelling as part of an uncertainty assessment coping with modeling the future of hydrological regimes and chemical pollution loads within two pre-alpine river catchments.

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One of the UnLoadC3’s goals is the establishment of mathematical tools needed in the analysis of uncertainties inherent in regional scale climate change projections. Their application is intended to draw on future developments pertaining to water-availability and water-quality within the catchments of the river Schwechat and the river Raab under changed climatic conditions. Changes in climate forcings are realized on the basis of EURO-CORDEX RCM projections driven with the scenarios RCP 4.5 and RCP 8.5, which cover the 21st century. A well-known problem that comes with RCM projections (dynamical downscaling) is that they fail to reproduce observed climate conditions across the European Alps and hence future projections generated by RCMs cannot be regarded as a sensible estimate of climate change. To escape this problem a technique called ‘bias correction’ has been often applied to RCM scenarios in the recent past. The application of this method means to apply the corrections required to transform RCM results towards observations to the scenarios. Thereby the dynamically generated information is empirically corrected and overall the result corresponds to statistical downscaling. To accomplish the state of the art, we consider ensembles of dynamically produced regional projections, apply ‘bias correction’ and analyze the impact of change in terms of percentiles of probability distributions regarding minimum, maximum and daily averaged temperature as well as precipitation totals at grids spanning the catchment areas with a spatial resolution of 1 km. This approach, which obviously comes closer to the natural behaviour of climate than base statements on one or a few projections only, will be presented as maps displaying the amount and frequency of change on the example of the aforementioned climate parameters. Furthermore a qualitatively discussion of how this part of analysis fits into the overall uncertainty analysis, that covers the whole project from the selection of a particular RCP scenario to impact-modelling focusing on the catchments, incorporating land use, growing plants and modelling the hydrological behavior of the rivers under investigation.
PC-073

Performance of RegCM4.1 in simulating extreme precipitation events of Pakistan

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The objective of this study is to explore the capability of the Regional Climate Model (RegCM) version 4.1 in simulating the extreme rainfall events in Pakistan with particular reference to monsoon season (July, August and September). We analyzed the quantitative impact of different resolutions and domain sizes on simulation of precipitation characteristics by RegCM and found a best suited parameter setting for the region of Pakistan. After selection of spatial resolution, we simulated an extreme precipitation event of July 2010 and compared it with the observed data of selected five stations to analyze the performance of RegCM quantitatively. One of these extreme rainfall events was during July 2010 when countrywide total precipitation during July–September 2010 was the highest since 1994 and the sixth highest in the last 50 years (PMD 2010). The criteria of 50mm/day rain was adopted as extreme in selected 5 stations among the potential monsoon dominated regions with slightly different geographical locations, which are Balakot, Islamabad, Lahore, Murree and Muzaffarabad. In this study we presented extreme rainfall events of July 27-30, 2010, simulated by RegCM and compared with the GPCP dataset and PMD observed station data. Using ERA Interim boundary conditions, RegCM4.1 well captured the extreme rainfall events of July 2010 as well as monthly mean value and 4 days averages were well in-accordance with the GPCP and observed station data.
Mechanisms of future changes in extreme precipitation over Northeast Asia and South Korea: A multi-RCM study

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In this study, we examine future changes in extreme precipitation over Northeast Asia and Korea using five Regional Climate Models (RCMs) simulations driven by single GCM under two RCP emission scenarios. Focusing on summer season (June-August, JJA), RCM performances in simulating extreme precipitation are first evaluated in comparison with observations for the present period (1981-2005). Then RCM outputs in future period (2071-2100) is analyzed relative to the present to study spatio-temporal patterns of extreme precipitation changes. Physical mechanisms are examined using linearized moisture budget analysis at 850hPa. It is found that RCMs can simulate heavy rain events (> 80 mm/day) over Korea similar to observations, which are not well captured by GCM, providing added value of dynamic downscaling. RCMs consistently project increases in the frequency of heavy rains (>50 mm/day) and also the intensification of extreme precipitation (measured as 95th percentile). Thermodynamic effect (moisture increase due to warming) on extreme precipitation change is confirmed by inter-RCM and inter-scenario relationship. However, dynamical effect (atmospheric circulation change) also affects local scale changes, resulting in nonlinearity and uncertainty in precipitation responses, which represents differences in RCM dynamics and physics.
A Comparative Flood Hazard Assessment with Regional Climate Model Projections for India

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An increased intensity and duration of extreme precipitation, have led to devastating flood events, which is regarded as the most frequently occurring natural disasters in India. The CO-ordinated Regional climate Downscaling EXperiments (CORDEX) projections have been widely used globally for understanding the nature and magnitude of possible extreme precipitation events. However, these CORDEX projections should also be aptly utilized to analyze flood hazard at regional and local scales under changing climatic conditions. In the current study, a flood hazard map is derived for Jagatsinghpur District located in the lower Mahanadi River deltaic region, which is regarded as one of the highly flood prone areas in India. A statistical relationship is established between the CORDEX rainfall output (1988-2005) and observed daily stream flow for the entire study area, which is further refined using Variable Infiltration Capacity (VIC) model simulated runoff and routed stream flow under a Bayesian Statistical framework. The derived relationships are applied further to project future stream flow pattern using CORDEX rainfall projections under RCP 4.5 scenario for the expected extreme events till 2030. The projected rainfall projections under MIKE FLOOD (a widely used 2-D dynamically coupled hydrological flood model), utilizing fine resolution LiDAR DEM and a set of precise GIS data sets for flood inundation mapping. A set of flood inundation maps were discerned for the extreme events for the near future (up-to 2030). The derived flood inundation projections will facilitate planning process, and also help in strategizing suitable adaptation policy to minimize losses.
Assessing the potential impacts of climate change and reforestation on rainfall onset and cessation over West Africa

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Two observations (GPCP and TRMM) and two RCMs RegCM and WRF forced respectively with HadGEM and ECHAM (historical 1971-2004 and future projection 2031-2064 under rcp45 conditions) were used to investigate the potential impacts of climate change and reforestation on the rainfall onset and cessation over West Africa. Four definitions of rainfall onset dates (RODs) and one of rainfall cessation dates (RCD) based on rainfall threshold are used in this study. The results show that both observations produce similar results of ROD/RCD in each climatic zones of West Africa (Guinea, Savanna and Sahel respectively). The two GCMs fail to simulate the spatial distribution of ROD/RCD and produce later/early ROD/RCD in all definitions as observed. However, the two RCMs perform better than their driven GCMs in simulating the ROD/RCD over the region. The potential impacts of climate change due to elevated greenhouse gas (GHGs) show that the temperature would likely increase over West Africa in both RCMs and GCMs but more consistently over Sahel. However, elevated GHGs would lead to a decrease in rainfall in both RCMs and GCMs again much more over Sahel. For the future ROD, increase in GHGs indicates that regardless of the definitions used, northern Nigeria would have delayed RODs. The vertical structure of the monsoon dynamics in the areas of highest impacts of climate change (i.e. latest ROD areas) shows that for each definition the elevated GHGs in the future would shallow the monsoon flow essentially over Sahel. No agreement is observed between the RCMs on the potential impact of climate change on the RCDs. While RegCM indicates delayed RCDs over the Sahel and early RCDs over Savanna, WRF produces early RCDs in all the areas. From both models, the projected impact of reforestation over Savanna indicates that West African climate would likely be cooler in most areas with more rainfall during the rainy season especially over the reforested zone. The cooling effect is more consistent and higher over Savanna but reforestation would induce a warming over some surrounding areas. Regardless of the definitions used, reforestation would induce early ROD over most areas in West Africa as obtained from both models, except over north of Nigeria. The potential impact of reforestation on the RCDs shows no agreement results between the RCMs. While RegCM indicates delayed RCDs over the reforested area and early RCDs over Sahel, WRF produces delayed RCDs over all the climatic zones.
PC-077

Future projection of precipitation extremes linked to temperature with multi-model ensemble downscaling over Japan

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Recent studies have argued that the intensities of extreme precipitations are increasing in many regions across the world due to atmospheric warming. This argument is based on the principle of Clausius-Clapeyron (CC) relationship which states that the moisture holding capacity in the atmosphere increases by \(~7\%\) per degree raise in temperature. Though a number of studies have been conducted to investigate the precipitation extremes linked to temperature over different regions, but they are mostly based on observation datasets while few studies are conducted with GCM and RCM experiments. In our study, we analyzed multi-model ensemble experiment by three RCMs (NHRCM, NRAMS, WRF) forced by JRA25 as well as three GCMs (CCSM4, MIROC5, MRI-GCM3) to investigate the individual model behavior as well as the model uncertainty in reproducing the precipitation extremes linked to temperature and its future changes due to regional/ global climate change in late 21st century (2081-2100, RCP4.5) over Japan. In our methods, the precipitation intensities of wet days (defined as \(\geq 0.05\) mm/d) are stratified to different bins with 1°C temperature interval. Then we calculated the precipitation extremes (75th, 90th, 95th and 99th percentile) in each temperature bin. Our results indicates that model simulated precipitation extremes linked to temperature over Japan are consistent with observation (APHRODITE). Extreme precipitations increase with temperature up to 20°C in current climate, while it increases up to 22°C in future climate. The intensities of extreme precipitations are significantly increased by \(5\) mm/d in future climate for temperatures roughly above 21°C. Results also indicate that the rate of change of extreme precipitation intensities is found in the range of 3-5%/°C in the current climate which is increased to 4-6%/°C in the future climate. Each individual model also shows increasing rates in the future climate. The increase of extreme precipitation intensities and its rate in future climate is due to the increase in temperature under RCP4.5 (\(~2°C\)). Increase in temperature causes more evapotranspiration and subsequently increases the water vapor in the atmosphere. Our analysis of multi-model ensemble downscaling experiments also shows that specific humidity is increased in future climate for higher temperatures.
In the tropics, intense heating of the earth surface and an influx of moisture may lead to the formation of tropical lows, resulting in intense rainfall and flooding over land areas. This work examines the nature, characteristics and impacts of tropical lows over Botswana. Whilst Botswana lies under the descending limb of the Hadley cell resulting in a semi-arid climate, anomalous tropical lows can produce very high rainfall amounts over this region. Daily ECMWF ERA Int. rainfall and sea level pressure data and satellite imagery were used to identify recent anomalous tropical lows from 2008-2013. The meteorological structure and propagation characteristics of the tropical lows are analyzed via composite analysis and also as individual case studies. During the late summer, tropical easterly trough edges into the region, allowing for the anomalous evolution of tropical lows. The Limpopo valley provides a conducive avenue for propagation resulting in extensive floods affecting southern Mozambique and South Africa’s Lowveld. It appears the SSTs of the SWIO and La Niña may have a significant influence on the landfall of tropical lows from the Mozambique Channel. It is also found that the Botswana High is weakened and displaced southwards, allowing for tropical easterly flow at the steering levels in the mid troposphere.
PC-079

Heavy Daily Rainfall Characteristics over agro-ecological zones of Ghana

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This study investigates the trends in heavy daily rainfall characteristics among the six rainfall-sensitive agro-ecological zones of Ghana. Time series of the daily rainfall data from 1980-2011 was used to identify trends in the amount and temporal distribution of rainfall, occurrence of extreme daily rainfall events and the onset of rains. Data were quality controlled, and processed into indices of climate extremes, and the indices were calculated using RClimDex, which is based on R software and is developed and maintained by the Climate Research Branch of Meteorological Service of Canada. The indices are based on the number of heavy rainfall days (≥10 mm), number of very heavy rainfall days (≥20 mm), number of extremely heavy rainfall days (≥25 mm), consecutive dry days (<1 mm), consecutive wet days (≥1 mm), daily maximum rainfall, five-day maximum rainfall, annual wet-day rainfall total, Simple Daily Intensity Index, very wet days, and extremely wet days. The indices were simulated by calculating different extreme characteristics according to wet and dry conditions, frequency, and intensity. It was observed that there is a significant increase in the intensity of rainfall per rain day and a reduction in length of rainy days. The precipitation indices showed an increasing but not significant trend in the total rainfall amount. The results of other precipitation indices indicated an unstable trend in the intensity of rainfall in all agro-ecological zones. However, a significant decrease in the number of rain days and consequently the probability of continuous dry days of up to seven and eleven days in the first four weeks of the planting season is revealed. Furthermore, in all agro-ecological zones, more intense rainfall is observed over short periods.
The potential of CORDEX models to capture present extreme events of the Guinea Coast

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We analyze the performance of a group of two regional climate models (RCMs) driven by four global circulation models (GCMs) from the cordex set of models in simulating long term extreme events in daily precipitation and temperature over the Guinea Coast for the present period of 1961-2010. A comparison made with observation data demonstrates that the models perform well in simulating the frequency and intensities of daily precipitation events but struggle to give a reasonable representation of the guinea highlands. Clear differences are seen in the influences of the GCMs on the RCMs outputs in the analysis of the daily extremes. The substantial differences observed among the simulations called for a further investigation on the value added by the RCMs. High values are observed in the daily extremes precipitation events. High resolution simulation has high implication on the studies of precipitation extreme events over the Guinea Coast.

Keywords: Cordex, Guinea Coast, extreme, RCMs, GCMs, temperature, precipitation
PC-081

Assessment of short-duration precipitation extremes in 12.5 km Euro-CORDEX projections by RCA4: historical performance and future changes

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Recent observational analysis have highlighted the importance of studying precipitation at high temporal resolution, in order to properly resolve the true nature of precipitation (Eggert et al., 2015). Further, modelling efforts have identified the importance of resolution in simulating the response of short duration rainfall to a warming climate (Prein et al., 2015). Here, we present an historical evaluation and a future analysis of an RCA4-Euro-CORDEX ensemble at 12.5 km resolution for time resolutions down to 7.5 min. In the historical period, the projections are compared with both 15-min gauge observations, as well as a newly created 15-min dataset of gauge-adjusted radar observations covering most of Sweden at 2×2 km2 (based on the method by Berg et al., 2015). Particularly, we focus the evaluation on the simulation of the diurnal intensity cycle and convective rainfall extremes in order to assess the ability of RCA4 to reproduce observed properties. Additional to standard point based analysis, we investigate spatial characteristics of contiguous rainfall regions and their evolution in time. We then apply the methods to future scenario simulations and focus the analysis on short-duration rainfall extremes with the aims of not only describing future changes over Sweden in an overall sense but also assessing the expected changes in spatio-temporal properties of individual storms. Relative future changes are compared with previous estimates from less high-resolution RCM projections.

References:


Extreme Summer Precipitation Increase in the Med-CORDEX Simulations: Analysis of The Evaluation Period

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In this study, extreme precipitation in August and September has been analyzed by using regional climate model outputs with 50-km horizontal resolution from ICTP-RegCM4. The simulations driven by ERA-Interim (period: 1979-2012) and NCEP/NCAR (period: 1982-2012) have been applied to solve complex feedback mechanisms and processes over the Mediterranean Basin. Due to the importance of the air-sea interaction in the region, the processes linked to the extreme summer precipitation events have been investigated using the atmosphere-ocean coupled regional climate model (only forced by ERA-Interim) to reveal the effects of the Mediterranean Sea on the regional climate system. The results show that the number of extreme daily precipitation (>50 mm) for August and September has increasing trend in the recent decade over the domain (excluding Eastern Mediterranean). The maximum precipitation simulated for the same months reaches their maximum values in the second half of the simulation period. Available observational gridded datasets are compared with the RCM simulations and similar signal has been also found in the TRMM dataset in term of the inter-annual variability of the extreme precipitation events for the period of 1998-2012. These signals are weaker in the coupled simulation driven by ERA-Interim and the standalone simulation driven by NCEP/NCAR, both simulations have been forced by different SSTs, which indicates the significance of the sea surface temperature over the region. The surface heat fluxes produced by simulations have been also analyzed to investigate extreme precipitation increase in the recent decade. This study provides the information to identify simulation capability of RCMs in precipitation extremes which can be valuable for ensembles of future simulations.

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This study presents an overview of changes in the extreme events that are most likely to affect East Africa in the forthcoming decades. This study assess, heavy precipitation and drought and winds at 700 and 850hPa levels change between present (1970–2000), near future 2035–2065 and future (2071–2100) climate on the basis of regional climate model simulations produced by the CORDEX project, Africa. A summary of the main results follows. rainfall, temperature and wind changes in three time slices. Very heavy rainfall is increasing in the near future while decreasing in the far future scenarios. Surface temperature changes is projected to increase in all CORDEX models used likewise wind changes in all levels. By the end of the twenty first century, countries in northern Kenya, western Tanzania more warming is projected in the near and far future scenarios. This warming seem to be associated with increase in evaporation which resulted into decrease in heavy rainfall over most regions in East Africa.

Key words: climatic extremes, East Africa, CORDEX
Projected changes of hydrological extremes (floods) in the 21st century in selected catchments in Poland

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The aim of the study is an estimation of changes induced by climate variability on floods in ten chosen catchments in Poland. We apply simulation approach to derive series of daily flows in catchments under changing climatic conditions, following the RCP4.5 and RCP8.5 emission scenarios. The climate projections are obtained from the EURO-CORDEX initiative, in the form of time series of precipitation and air temperature derived from different RCM/GCMs for the periods: 1971-2000, 2021-2050 and 2071-2100. Conceptual HBV and GR4J rainfall-runoff catchment models are applied to estimate future flow time series. The models are calibrated using the available precipitation, air temperature, and flow observations from the period 1971-2000. The models are verified using the 2001-2010 observation data. Subsequently, we verify performance of the models using the EURO-CORDEX simulations for the reference period (1971-2000). We also compare the results obtained with and without bias correction (quantile based mapping method) of the RCM/GCM outputs. Finally, the models are run for the future climate scenario simulated by RCM/GCM models for the years: 2021-2050 and 2071-2100. We derive mean annual maximum flows and flood frequency curves for annual maxima time series based on the obtained simulations. The results indicate substantial differences between climate models and catchments. The regional variability follows the flood regime type. The catchments where the extremes are expected to increase have a rainfall-dominated flood regime. In catchments where the flooding is mainly caused by spring snowmelt, a small change in extreme flows is projected.

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The Attribution of Extreme Weather Events and their Impacts to External Drivers of Climate Change

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It is now widely accepted that "extreme event attribution" is possible, albeit in a probabilistic sense and recognizing the role of multiple causal factors. Annual assessments of the role of climate change in individual weather and climate events are being compiled using a range of approaches. There is increasing interest in using event attribution in risk assessment, and public communication to address questions of rebuilding and relocation after disasters. In order for the science to inform the latter, only attributing the role of climate change on meteorological hazards is likely insufficient and the relative roles of hazard and vulnerability need to be included when assessing impacts. Using the very large ensembles of regional climate models over the CORDEX regions Europe and MENA as input into impact models on hydrology and biogeochemistry provides a starting point to develop the science towards end-to-end attribution of extreme weather events.

This approach requires a large ensemble of climate model simulations to provide results from which the statistical significance and the shape of the distribution of key variables can be assessed. The weather@home experiment within the climateprediction.net project provides such an ensemble, producing many hundred ensemble members per year via volunteer distributed computing. We use these output to feed into the impact models to assess the impacts of climate change now affecting vulnerable regions, societies and ecosystems. In order to do this bias correction of the regional model becomes particularly important as the absolute values are crucial for reaching biological thresholds and the interdependencies between variables need to be kept intact within the bias correction process. Here we present a method using new bias correction approaches towards realistically quantifying the link between climate change and extreme weather which is central to a realistic assessment of loss and damage associated with climate change.
Using of information GCM and RCM in the calculation of the maximal runoff of the rivers of Ukraine

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The process of global warming of the Earth, observed in recent decades, is associated with large-scale changes in the hydrological cycle, namely the increase of water vapor in the atmosphere; in change of water regime, and the intensity of extreme precipitation values; reducing snow cover and widespread melting of ice; changes in the number of soil moisture and runoff volume.

The many years research of the changes of atmospheric circulation and global warming, show that century observation period marked increase of the average temperature throughout the Ukraine. In particular, in Polesie and forest-steppe on to 0.7-0.9 °C, in the steppe zone - on 0.2-0.3oS. Most sensitive changes - in winter (up to 1.5 °C in Polesie and forest-steppe and 0.7 °C in steppe zone) and spring (through March) - a total of 0.8°C, ie the first months of the year[1].

Found that in modern global and regional climate changes in Ukraine observed: positive long-period trend to increasing average temperature in winter and spring months; downturn in the maximum freezing depth of soil from 80-90-ies; displacement to earlier onset dates of maximum snow supplies and dates of spring processes. Regression in time series maximum snow supplies and spring rainfall is less pronounced.

In such complex trends temporal changes of meteorological factors tends to reduce the slope layers and maximum water discharge of spring flood that must be take in account during the hydrological calculations and forecasts.

The authors of this study proposed methods accounting of climate change as part of genetic model formation of maximum flood runoff.

For the original version proposed to adopt a detailed model of isochronous channel. The components of this model are hydrograph of slope influx, function isochronous of channel lag and floodplain regulation.

The model makes it possible to introduce "climate amendments" directly to the maximum snow supplies and rainfall during the flood, as well as to runoff coefficients[2].


PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-087

DRY PERIODS IN SOUTHEASTERN BRAZIL: A NUMERICAL SIMULATION WITH CHANGES IN SEA SURFACE TEMPERATURE

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In a previous observational study we build a conceptual model of synoptic and dynamic patterns for dry periods in five precipitation homogeneous regions for southeastern Brazil in autumn, winter and spring for 1982-2009. The SST (Sea Surface Temperature) anomalies for South Atlantic Ocean (SAO) appear as an important factor in the occurrence of this kind of event and show a characteristic behavior: a tripole pattern (negative/positive/negative).

The dry periods where determined using the method of consecutive dry days, and counting the number of events in what this condition happens. In the analyzed period, 1990 is the year with the less number with dry periods and 2003 is the year with the bigger amount of this kind of events.

Numerical simulations where performed using RegCM4.3 model for CORDEX South America domain with 50km and using BATS, HOLTSLAG and MIXED1 for surface, PBL and convection parameterizations, respectively. Control simulations where performed for those two years, to investigate if the model can reproduce the behavior of the dry periods. The modified simulation where performed only for 1990, changing the SST pattern in SAO, to reproduce the characteristics founded in the conceptual model for the observational study and to investigate how these affect the dry events.

The number of events for the in control simulations where compared to those from the observational study and the results for the modified simulation where compared to those from the control simulation.

In both years two of the homogeneous regions show more events in simulations compared to the observations and another two the opposite behavior happens. For 2003, the control experiment reproduce well the biggest event of the year founded in observational analysis in three homogeneous regions, for one of the other two regions the model underestimate the duration of the event and in the other one region, the event was much longer than what was found in the observations. For 1990, the model didn't reproduce the longest event of the year, simulating the longer event of the year in different dates.

In the modified experiment the amount of dry periods were large than what was found in the control experiment only in two homogeneous regions. Also it seems that the longer events of the year in each homogeneous region were always found in the modified experiment. These results suggest that the SST modification does not necessarily produce driest periods but longer ones.
Freezing rain often affects North America during the cold season. Generally no more than a beautiful poetical touch glowing in the light (and much fun in schoolyard), it can lead to significant consequences, from people falling over sidewalk to road accident and severe power outages.

In Numerical Weather Prediction, freezing rain is parameterized in sophisticated microphysics schemes much too costly to be used in climate models. Thus, diagnostic’ methods, in-line or out-line, are the way to go.

The fifth-generation of the Canadian Regional Climate Model (CRCM5) uses the Bourgouin (2000) in-line diagnostic method to produce freezing rain. In addition, off-line methods such as Cantin and Bachand (1993) formulation are used. With Bourgouin, we explore horizontal resolution sensitivity and physical mechanisms of freezing rain in-line production through short simulations of documented events at 0.44°, 0.22° and 0.11° over Montréal area and the St-Laurent river valley. Results show that particularly at higher resolution freezing rain characteristics are well comparable to observations. In climate mode, we use CRCM5 0.11° simulations over Québec driven by ERA-interim to compare in-line and off-line results to Cortinas et al. (2004) climatology of freezing rain, thus revelling potential and limitations of Cantin and Bachand off-line method. We then apply this method to the forth-generation of the CRCM 45-km projections driven by CGCM3 and ECHAM5 from 1960 to 2100 to quantify climate change influence on freezing rain from simulations already completed (without in-line diagnostic). This method will also be applied to diagnosed ERA-interim and CORDEX freezing rain.
Simulating extreme hydro-meteorological events with DRIHM(2US) services

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From 1970 to 2012, about 9000 High Impact Weather Events (HIWE) were reported globally: all together, they caused the loss of 1.94 million lives and economic damage of US$ 2.4 trillion (2014 UNISDR report). Storms and floods accounted for 79 per cent of the total number of disasters due to weather, water and climate extremes and caused 55 per cent of lives lost and 86 per cent of economic losses. Predicting high impact weather events (HIWE) is still one of the main challenges of the 21st century, with significant socio-economic implications.

At the heart of this challenge, lies the ability to access hydro-meteorological data and models and to facilitate the collaboration between meteorologists, hydrologists, and Earth science experts for accelerated scientific advances in hydro-meteorological research (HMR). The EU funded DRIHM (Distributed Research Infrastructure for Hydro-Meteorology) and DRIHM2US (Distributed Research Infrastructure for Hydro-Meteorology to US) projects developed a prototype e-Science environment to facilitate this collaboration and to provide advanced end-to-end HMR services (models, datasets and post-processing tools). The DRIHM(2US) services will be presented and demonstrated for the Genoa 2014 flash-flood event, as a prototypical HIWE in the Mediterranean area.
Analysis of climate change impact on runoff characteristics in the Zagyva catchment located in Hungary

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Projected changes in regional climatological conditions are likely to modify the different processes of the whole hydrological cycle (especially runoff), and may result in various environmental and socio-economic hazards (e.g., floods, landslides, droughts, water scarcity, sustainability of food production). In order to decrease the overall exposure to potential future damages, it is essential to estimate and evaluate future climatic trends and prepare detailed assessments of hydrologic responses, with special regard to the runoff extremes. Thus, this study focuses on impacts of climate change on runoff extremes over a relatively small catchment area. The applied methodology is shown for the Zagyva catchment located in the northern part of Central Hungary. For the investigation the Distributed WAtershed (DIWA) hydrological model is used, considering several aspects i.e., topography, land use, soil type. Historical meteorological and runoff data are available for 30 years to analyze trends in the recent past. Future climate simulations are provided by the RegCM4 regional climate model (taking into account RCP scenarios) adapted for the Carpathian Region. First, calibration and validation of DIWA distributed hydrological model are completed for the joint watershed after the confluence of the two small Hungarian rivers (until the cross-section located in Jásztelek, Hungary at 47.5°N 20.0°E) using historical meteorological and runoff data. After that, characteristics of extreme hydrological events in the past and in two future time periods for 30 years are assessed. Finally, statistical analysis based comparison of observed-past, modelled-past and modelled-future runoff data is evaluated for the catchment of Zagyva.
PC-091

Extreme precipitation in a continental-scale convection-permitting climate model

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Convection-permitting regional climate models (CPCMs) have proven to be useful for downscaling large-scale climate information to regional and local scales. Especially the representation of precipitation extremes is improved by explicitly simulating deep convection and the more accurate representation of orography and land surface properties. Due to their high computational costs most CPCM simulations have been restricted to small domains on the order of a few 100 km. On such small domains CPCMs might not reach their full potential because they are restricted by the lateral boundary forcing and may not be able to spin up properly.

In this study we investigate the ability of a continental scale CPCM to simulate extreme precipitation in the Contiguous United States within the period 2000 to 2010. Therefore, we downscale ERA-Interim reanalysis data to a horizontal grid spacing of 4 km with the Weather Research and Forecasting (WRF) Model that allows an explicit simulation of deep convection. In addition, we analyze climate change signals in a corresponding 10 year long pseudo global warming simulation using a 100 year average climate change signals from 19 CMIP5 rcp8.5 scenario simulations as perturbation to the lateral boundary conditions of ERA-Interim.

We perform a scale dependent analysis focusing on hourly to weekly temporal scales and on point (station) to regional spatial scales. The goal is to find out how a continental scale CPCM simulates precipitation extremes and how it projects future changes of extremes on different spatiotemporal scales. In addition, we show an object based analysis focusing on the characteristics, distribution, and tracks of precipitation objects in the current simulation and their projected changes. This allows us to gain a more process and physically based understanding of how U.S. extreme precipitation events might change in a warming climate.
PC-092

Regional climate model based simulations of interannual rainfall variability over the Guinean Coast of West Africa

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Using the RCA4-SMHI regional climate model driven by ten individual general circulation models (GCMs) from CORDEX, the inter-annual rainfall variability of the ~peak monsoon over the Guinean Coast is investigated. The RCA4-SMHI simulations showed improved performance over the GCMs in depicting the rainfall variability over the Guinean Coast. Some simulations from the RCA4-SMHI as compared with observations show over-estimation over Guinea mountains. Further investigation on the cause of the over-estimation was explained with the main monsoon features such as the African Easterly Jet and Tropical Easter Jet over West Africa.
Rainfall and temperature scenarios for Bangladesh for the middle of 21st century based on RCP scenarios using RegCM

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Rainfall and surface temperature are the most important climatic variables in the context of climate change. Thus, these variables simulated from ICTP RegCM models have been compared against observed (rain-gauge) data and projected for the middle of twenty first century under the Representative Concentration Pathway (RCP) 4.5 emission scenario. Through calibration and validation of RegCM was adapted for Bangladesh for generating rainfall and temperature scenarios. The model generated rainfall was calibrated with ground-based observed data in Bangladesh during the period of 1981-2000. Better performance of RegCM obtained through validation process increased confidence in utilizing it in the future rainfall and temperature projection for Bangladesh. Rainfall, maximum and minimum surface air temperature projection for Bangladesh is experimentally obtained for the period of 2041-2060. This work finds that the RegCM simulated rainfall and temperature are not directly useful in application purpose. However, after validation and calibration, acceptable performance is obtained in estimating annual rainfall and maximum and minimum surface air temperature in Bangladesh. Change of rainfall is projected about 1.2 percent in pre-monsoon (MAM), -1.4 percent in monsoon season (JJAS), -1.90 percent in post-monsoon season (ON) and 0.46 percent in winter season (DJF) during the period of 2041-2060. Similarly, change of maximum and minimum surface air temperature is projected about 1.4 and 1.5 degrees Celsius for the same period.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-094

Mass balance processes of Chhota Shigri Glacier (Western Himalaya, India) assessed by point-scale surface energy balance as well as in-situ measurements

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Chhota Shigri Glacier is one of the best studied glaciers of Himalayan region but an understanding of physical processes governing mass balance of this glacier has not been established yet. In this study, a point-scale surface energy balance model was run using the in-situ meteorological data from the ablation zone of Chhota Shigri Glacier over two separate periods (13 August 2012 to 3 February 2013 and 8 July to 3 October 2013). The model provides the quantification of the surface energy fluxes and identification of the factors affecting glacier mass balance. Turbulent sensible heat and latent heat fluxes were calculated using the bulk method. The computed ablations were validated by stake observations. During Summer-monsoon period, net radiation was the primary component of the surface energy balance with 82% of the total heat flux which was complimented with turbulent sensible and latent heat fluxes with a share of 13% and 5%, respectively. A striking feature of energy balance is the positive turbulent latent heat flux, thus condensation or re-sublimation of moist air at the glacier surface, during summer-monsoon period which is characterized by relatively high air temperature and relative humidity, and almost permanently melting surface. We also assessed the impact of Indian summer monsoon on Chhota Shigri Glacier mass balance. Our analysis demonstrates that the timing and intensity of snowfall events during the summer-monsoon season play a key role on surface albedo, in turn on melting, and thus are among the most important drivers controlling the annual mass balance of the glacier.

Chhota Shigri Glacier experience a mass wastage between 2002 and 2013 with a cumulative glaciological mass balance of –6.45 m w.e. and a mean annual mass balance (Ba) of –0.59 m w.e. a–1 revealed through in-situ (glaciological method) measurements. The winter glacier-wide mass balance (Bw) between 2009 and 2013 ranges from a maximum value of 1.38 m w.e. in 2009/10 to a minimum value of 0.89 in 2012/13 year whereas the summer glacier-wide mass balance (Bs) varies from the highest value of –0.95 m w.e. in 2010/11 to the lowest value of –1.72 m w.e. in 2011/12 year. So, we conclude that the Chhota Shigri Glacier is losing mass, though less rapidly or quite similarly like mountain glaciers in other parts of the world.
Regional and global climate projections in South Asia

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In the present study we performed a systematic analysis of climate change over South Asia CORDEX region using a large ensemble of regional climate simulations available from the South Asia CORDEX activities. Utilising a number of well-established observational data sets we evaluate ability of RCMs and their driving GCMs to simulate various aspects of the observed climate in South Asia and document consistencies and differences between the RCM and GCM ensembles. Future climate projections under different RCPs scenario (2.6, 4.5 and 8.5) are analysed for both regional and global ensembles with focus on changes in precipitation statistics at a range of time scales, including: seasonal means, annual cycle and extreme events. Special attention in the study is given to physical processes leading to future changes in precipitation statistics over the South Asia region. Consistency of such physical process between the RCM and GCM ensembles is also addressed. Finally, we examine potential impacts of bias correction on projected climate changes in different aspects of precipitation statistics.
Climate change observed in recent years is usually associated with increasing global temperature, but there is also evidence that the hydrological cycle is affected as well. Many studies dealt with evaluation of precipitation characteristics in RCMs and analyses of projected changes. However, little attention has been paid to the analyses of convective and stratiform precipitation, although climate models simulate convective (subgrid) and stratiform (large-scale) precipitation separately through deep (precipitating) convection and large-scale precipitation parameterizations. In this study we analyse the output of four RCMs (CCLM, HIRHAM, RACMO2 and RCA4) from the EURO-CORDEX project. RCM simulations with two horizontal resolutions (0.44° and 0.11°) driven by reanalyses ERA-Interim are used for validation. Projected changes of precipitation characteristics (2071-2100 vs. 1971-2000) simulated by RCMs with 0.11° horizontal resolution driven by EC-Earth GCM are presented. Mean convective and large-scale precipitation amounts tend to increase in all seasons except summer where large-scale precipitation amount decreases, which could lead to decrease of total precipitation amount in summer. Extreme precipitation tends to increase for both convective and large-scale precipitation. These results suggest especially in summer more periods of droughts and more frequent flash floods.
Rice is the major and staple food crop in southern state of Tamil Nadu, India, and it contributes 25 percent to total rice production in India. Tamil Nadu receives about 80 percent of its annual rainfall during northeast monsoon (rabi season) from September through December. Our focus here is to assess the rice yield response to projected changes in rainfall and temperature over Tamil Nadu during rabi season. To accomplish the goal, a three-step procedure has been adopted. First, from the pool of CMIP3/5 models, two coarse-resolution global climate models (GFDL_CM2.1 and CCSM4) that realistically capture the mean monsoon precipitation and its variability are selected. Second, lateral and boundary conditions taken from these two global models and for various scenarios are employed to run a regional climate model (IPRC_RegCM) with a ~25 km horizontal resolution. Third, employing the current and future climate states simulated by the regional model, rice yield over Tamil Nadu is assessed through application of a panel regression statistical model. In addition, the regional climate model is also forced with lateral and boundary conditions taken from ECMWF Interim reanalysis products (ERA-INT) to assess the ability of the regional model with reanalysis forcing in representing the current climate. It is expected that the suite of high-resolution regional model integrations will provide guidance for assessing robustness in the projected climate as well as its impact on rice yield over the study area. The observed and regional model simulated daily rainfall and temperature climatology compared to IMD observations and ERA-INT, all the regional model solutions representative of the current climate capture the annual cycle realistically including the seasonal peak during rabi season. By utilizing daily climate variables, we attempt to understand the changes in the space-time evolution of rainfall on the different stages of rice growth such as vegetative, reproductive and maturity phases. The author predicts the rice yield for the RCP6.0 scenario under the CCSM4 model by employing the panel data regression model. The model estimates the impact of rice yield for the projected global warming on rice yield is expected to increase by 14 and 26 percent for the regression model 1 which includes rainfall and growing degree days and regression model 2 includes rainfall and maximum and minimum temperatures respectively during end of the century.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-098

Seasonal variations of surface duct conditions in Ngaoundere, North Cameroon

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CANCELLED

The seasonal variations of refractivity gradients from 104 to 3000 m above ground level in the troposphere layer are presented based on observations from the radiosonde station located in Ngaoundere (13.5E, 7.3N), a middle belt savannah region of Cameroon. Six years (2006–2011) of data from in situ measurements made by Agency for the Safety of Air Navigation in Africa and Madagascar (ASECNA) of the temperature, moisture, and pressure are used to determine the surface duct conditions over Ngaoundere region. Each time that a negative gradient from the Abel-retrieved refractivity profiles is seen, it implies the presence of a duct in this study. The occurrence of ducts strongly depends on the local climate and synoptic weather conditions which have an appreciable influence on the refractivity vertical profile, especially the seasonal north–south movement of the Inter Tropical Convergence Zone (ITCZ) which provides wet and dry seasons to the region. Monthly and seasonal variations of ducts were also determined from the measured data. The highest and the lowest occurrence rate of surface ducts were observed during the wet and the dry seasons, respectively. September appears as the month when most of the ducts occur at the rate of at least one duct per day. The median duct thickness and duct strength are high and strong during the wet season, whereas they are low and weak during the dry season. When the data are separated into stable and unstable atmospheric conditions, we noticed that surface duct characteristics show some seasonal differences. Surface ducts are found to be more frequent in a stable atmosphere than in an unstable atmosphere. Statistical results are discussed alongside with local meteorological conditions and weather systems affecting the town of Ngaoundere. Besides, comments are made on their prospective significance in the region.
PC-099

A review of procedures to compute climatological length of seasons based on CORDEX simulations over Europe and Southamerica

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Definition and determination of the start and end of seasons is a typically and widely known discussion from a non-technical point of view. When it is translated to a more rigorous and systematic procedure from a climatological framework, many definitions and locally-based criteria are obtained. Several proposals have been made, depending on fixed, percentile-based thresholds or physically-based phenomena, among others. In general, it is hard to find how the annual cycle of temperature seen in any location can be translated into an objective non-local definition about the start and end of seasons. At the same time, the heterogeneity of the different climates on relatively nearby regions adds another challenge to be able to make consensus about those definitions. It is usual that some seasons like the more extreme ones (summer or winter) could present a clearer procedure for its definition, but it seems to be more complex for spring or autumn if extreme thresholds are being looked for.

Here we propose to take advantage of the high spatial resolution obtained by the regional climate model simulations available at the CORDEX initiative over several domains to review and analyze different procedures to obtain the start and end of the four seasons that cover the whole year. Europe and South America domains seem to be suitable to study if some general or common definition can be made for those magnitudes. It could be also of high interest the effort to propose some objective or common way to obtain them, despite huge variety of the climatic conditions present at different regions. And a second challenging focus would be that how they could be modified, displaced, reduced or enhanced when increased greenhouse gases conditions are present.
Impact of climate change on extreme cooling of the Black Sea in winter period

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Warming of the Black Sea region on data of model INMCM4 in the winter will be at the end of the XXI century on 2 - 3 °C more, than nowadays. Therefore, the study of climate change at the end of the century is important and necessary. At the same time, the spatial resolution of global models, despite their continuous improvement remains insufficient to display a regional atmospheric circulation. Besides, the Black Sea basin is consisted of less than 10 points of calculation area in the current global climate models. Thus, the method of “dynamical downscaling” takes an additional argument in regions with underdeveloped network of meteorological stations, features of terrain and difficult coastal line, i.e. as in the Black Sea region. Experiment of downscaling of the Black Sea region is to estimating of climatic characteristics (turbulent heat fluxes) with the influence of regional factors. In this study, we used input data of global model INMCM4, which is a joint in international project CMIP5. Thus, for the Black Sea region were calculated turbulent heat fluxes of winter period for 2071-2100 (scenario RCP8.5) and for control period (1971-2000) with a spatial resolution of 0,2 x 0,2 °. The integral characteristics presented below are referred to the area of sea limited by 44°–47° N and 28°–34° E. Average heat fluxes of winter period will change as follows in the future: sensible heat flux will decrease by 3%, and latent heat flux will increase by 22% compared to the control period. Thus it appears that the extreme total (sensible + latent) heat fluxes $P = 95\%$ (5% of winter days with the highest values of total heat flux of the winter period) will rise by 15% compared with the control period. Also the most extreme events $P = 99\%$ will rise by 40% in the future. Composites of atmospheric fields of European region during of the extreme cooling ($P = 95\%$) of the north-western part of the Black Sea were built (for this purpose was used sea level pressure). Then, clustering of atmospheric fields in European region has been done. The number of extreme events $P = 95\%$ with cyclone in the district of the Caspian Sea will increased from 20% to 50% from all extreme events in the future winter period. So, quantitative and qualitative changes during extreme cooling of sea surface of the Black Sea at the end of XXI century have been obtained. These results require further verification and analysis of possible risks in the future for the economy of the Black Sea region.
Seasonal or agroclimatic droughts are widespread in Ukraine, which is the one of main agricultural region in East Europe. Three agroclimatic seasons were considered for vegetation period: spring-summer (April-June), summer (June-August), summer-autumn (August-October).

Spatial and temporal distributing of seasonal droughts for period of 1995-2012 was investigated using comparison of five drought indexes such as the Palmer drought severity index (PDSI), standardized indexes of precipitation and evapotranspiration (SPI, SPEI), Selyaninov hydrothermal coefficient (HTC), Ped’ index of atmospheric droughtyness (Sa). All indices were unified to one scale and a drought is determined, if at least four indices from five indicated a drought of any intensity.

An estimation of cross-correlation between the seasonal values of drought indices showed that the greatest Pearson’s coefficients (r) observed in the Steppe area, and also in spring and summer periods. The best statistical relationship is observed between the Sa and SPEI, when the r equals -0.96...-0.97 in Steppe in spring and summer and reduced to -0.78...-0.82 in the area of Mixed Forests in summer and autumn. The SPI has high correlation with the HTC in the Steppe during vegetation season and in spring and summer for other agroclimatic zones. The PDSI has the lowest statistical relationship with other indices.

According to catalog data in Ukraine prevailed the spring-summer droughts. In the Steppe area 7-8 droughts were occurred in every season. In the Forest-and-Steppe area the amount of spring-summer and summer drought reduced to 3-4. In the area of Mixed Forests the temporal distributing of spring-summer droughts differs from south regions. In summer the amount of droughts is halved, and in autumn the number of droughts compares with the spring.

Full vegetation period drought encompassed Ukraine in 2007, 2009 and 2012. The drought in 2007 appeared the most intensive and reached the extreme criteria in spring and summer. In 2009 the extreme indexes were marked only in summer period, and a drought in 2012 showed moderate intensity. Anomalyously intensive droughts were observed in autumn of 2005 and 2011. The significant crop losses of winter wheat and spring barley (10-43% from the trend) was observed in years with severe spring-summer drought such as 1996, 2003 and 2007.

Created catalog with combination of different indices can be a methodological base for the drought monitoring in Ukraine.
Features of the regional circulation of atmosphere and sea breeze development on northern Black Sea coast

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The study analyzed the conditions of regional atmospheric circulation in May-August of 2000-2007, using defined index BSOi (Black sea oscillation index). BSOi was used for selection of synoptic situations, which are corresponded to the sea breezes conditions in the northwestern of Black Sea and Azov Sea coast.

To determine the type of regional circulation were chosen two stations as the poles: Kyiv (Ukraine) and Sinop (Turkey). Given the features of the regional pressure field in the warm season, the northern Black Sea coast is mainly situated in the transition zone between the poles of the pressure dipole. The calculated procedure of BSOi is similar to WEMO index, which used for western Mediterranean, and determined by the difference in sea level pressure between the pole stations.

Time series of BSOi shows the prolonged periods of positive or negative phase. Continuous periods last an average 7-14 days, but in some cases reach up 26-28 days. Predominance of negative phase indicates to stationary anticyclone over the continent and prevailing of the eastern and north-eastern winds along the Black Sea cost. The positive phase is characterized by western and south-western winds and low pressure over the continent.

Analysis of sea breeze frequency in Odessa and Mariupol showed that the least number of days with breezes is observed in June. In July and August fixed the maximum number of sea breezes. On average for the summer months in Odessa there are 52 days and in Mariupol are 25 days with breezes. In Mariupol were some years, when there was no breeze during the some months.

It is shown that BSOi can be used as the first objective filter to determine the breeze situation. For Odessa the most revealing index interval is [-0.75, 0.75], which accounts for 68.5% of all days with breeze and about 50% of days without one. For Mariupol not found a single range for all months, because due to very warm Azov sea surface in late summer the breeze circulation significantly weakened even under favorable synoptic conditions.

Using the BSOi has been developed the forecast algorithm of sea breeze for Mariupol. BSOi as the initial filter weeds out synoptic situations, which is unfavorable for breeze. If regional circulation is conducive, the second filter is used, which consists the climatic values in particular month, such as the temperature difference between land-sea surface, wind speed in the morning, temperature of sea water etc.
Dangerous hydrological events in future climate as projected by a large ensemble of high resolution RCM for northern Eurasia

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The evidence of modeling projections of climate change impacts on floodings is important for water resources management and flood assessment by decision-makers. Impact models usually use climate projections provided by global and regional climate models. However, challenges in representing dangerous hydrological events over the river catchments suggest that decisions should be made depending on the degree of realism of runoff simulation by an RCM at high resolution. Given an RCM simulated surface and groundwater inflow to rivers, the river routing model can compute flow and volume of water everywhere across watersheds taking into consideration the multitude of feeders.

Here to simulate future changes in flood frequency and intensity over the northern Eurasia the CaMa-Flood river routing model (Yamazaki et al., 2011) is used. The model is driven by runoff derived from an ensemble of thirty decadal long RRCM (Shkolnik et al., 2000) simulations spanning 1990-1999 and 2050-2059 (30x2=60 simulations in total). Horizontal grid size of RRCM is 381x183 with a mesh width 25 km. All the simulations differ in the atmospheric initial and time dependent lateral boundary conditions, provided by an AGCM T42L25 ensemble projection for IPCC RCP8.5 scenario. All the experiments include SST/IC evolution as projected by the three most successful CMIP5 models for the same scenario.

Given that modeling runoff, being a small difference of the two large values (precipitation and evaporation), is prone to significant biases due to biases in water balance components. The quality of the simulated river discharge is evaluated through comparison of RCM-driven river routing model output with river discharge observations at 43 level gauges across watersheds of northern Eurasia.

Simulated changes in the mean and extreme water discharge over the river network in northern Eurasia at resolution 0.25°x0.25° are considered. Possible changes in the extreme river discharge are analyzed in the context of projection uncertainties.

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Indian Summer Monsoon Rainfall contributes to around 70% of the total annual rainfall in India and have major impacts on Indian economy supported by agricultural products. Changing pattern of Indian monsoon in a warming world necessitates future projections of ISMR for climate change adaptation and planning. General Circulation Model (GCM) provides large scale information about the changing pattern of synoptic scale circulations; however, region specific projections of ISMR needs Regional Climate Models (RCMs). Dynamic RCMs applied at a nested fine resolution, over the region of interest, are traditionally used for impacts and adaptation. Coordinated Regional Climate Downscaling Experiment (CORDEX) is such an application of dynamic RCMs and has one of its application domain as South Asia. However, the added value by the CORDEX models to their parent GCMs is still under debate and needs improvement. Here, we couple a statistical downscaling model to the CORDEX simulation for projection of Indian monsoon to understand, if such a method adds value. The statistical model will only consider the synoptic scale variables well simulated by CORDEX models and affect ISMR. These synoptic scale variables are known as predictors. Relationships are obtained between these predictors and rainfall at a location, which will further be applied to the RCM simulations. We perform this coupled dynamic statistical downscaling method at a resolution of 0.250. We evaluate the coupled output for simulating mean and extremes of Indian monsoon as well as the climatology. We also test if such an application of statistical model is valid in a non-stationary climate with the state of art evaluation procedures.
Transients and ocean-atmosphere coupling in the South Atlantic Convergence Zone

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During summer most of South America is influenced by the monsoon, which has as a dominant feature the South Atlantic Convergence Zone (SACZ) that dominates precipitation variability over eastern Brazil and Uruguay.

The synoptic activity of the SACZ is modulated by upper level Rossby waves that extend from the extratropical Pacific bending to the northeast over South America. Recently, it was shown that the propagation path of these waves varies among years and as consequence the synoptic SACZ activity is different. In particular, if the path of the wave bends to the northeast so that circulation anomalies are largest over the continent, rainfall anomalies over land are strongest. On the other hand, if the path is more zonal rainfall anomalies over land are relatively small and the oceanic extension of the SACZ is strong and anomalies persist longer. This latter effect was ascribed to the local oceanic forcing of the SACZ. Thus, the dynamics of the SACZ, and its interaction with the local ocean, as well as its predictability depends on the trajectory of the extratropical transients.

In this study we further analyze the path of the transients associated with the main modes of variability in the SACZ, which consist in two dipoles, one with centers over the continental portion of the SACZ and another located over the oceanic part. We compare results of the NCEP-DOE Reanalysis 2 with those of a regional coupled model that includes explicitly ocean-atmosphere interaction. The coupled model is the recently developed Regional Earth System Model (RegESM), composed by the RegCM4 in the atmosphere with CLM4.5 as land model, the Hydrological Discharge (HD) modeling rivers and the MITgcm as the ocean component. The model has 50 km and ~0.1 degree of horizontal resolution in the atmosphere and ocean, respectively. The model domain covers most of the South America CORDEX subregion and we focus our analysis over the period 1980-2000.
PC-106
Preliminary assessment of wind resources in Morocco
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For the economic development of the state of Morocco, in the first place, necessary to solve the energy problems in the production. One of the most perspective areas is the development of renewable energy sources, particularly wind energy.

Based of physical-statistical analysis of the observations for wind speed and direction at 26 stations in the period 2005-2015 were obtained average annual and monthly wind speeds for the central month of the season, and also repeatability of wind speed by gradations.

Analysis of the average annual wind speed showed that in Morocco is dominated the weak winds of 1-4 m•s\(^{-1}\), and only to south from 28 N wind speed is increasing up to maximum value of 7.7 m•s\(^{-1}\) at the station Dakhla. The minimum value of 1.5 m•s\(^{-1}\) is observed at the station Taza. Wind speed increases in coastal regions due to the formation of breezes.

Most of the territory of Morocco is covered by mountains, which favors the development of local winds. Wind speed and direction are significantly different at the nearby stations, such as Larache and Chefchaouen, Meknes and Fes. The central part of Morocco is a region with the lowest values of wind speed.

Time series analysis of the average annual wind speeds showed, that at stations is observed an increase of wind speed, especially in the period of 2011-2014. This may be caused by changes of intensity of the Azores anticyclone, which is the main pressure center defining seasonal variation of the wind field in Morocco.

Maximum annual average wind speed was observed in 2014 at the station Dakhla and amounted to 9.0 m•s\(^{-1}\). The minimum of annual wind speed equal to 2 m•s\(^{-1}\) was fixed in 2012 at the station Taza. Analysis of wind directions showed, that in areas where the orography does not significantly influence, the trade winds are the main factor in dominating of northeastern wind direction.

Thus, in Morocco there are several regions (Guelmim-Es Semara, Laâyoune-Boujdour-Sakia El Hamra, Dakhla-Oued Ed-Dahab) with steady wind speeds more then 5 m•s\(^{-1}\), in which the development of wind energy production can be a promising.
Characteristics of the future summer temperatures in Croatia obtained from a EURO-CORDEX ensemble

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It is of paramount importance to understand changes in summer temperature climatology at regional scales when the global temperature is, beyond any doubt, on the rise. The high temperatures of the present summers as well as more frequent and more severe heat waves and hot temperature extremes can seriously affect human health and activities.

In this study, simulations from the six regional climate models (RCMs) from the EURO-CORDEX initiative forced by ERA-Interim are validated by using the E-OBSv11 data. All simulations were made for the 30-year period, 1971-2000, at the two horizontal resolutions (50 km and 12.5 km) over the common EURO-CORDEX domain. In our spatial analysis we focus on the territory of Croatia. Characteristics of summer temperature are described by the number of days with temperature over different thresholds which are determined by absolute and percentile criteria. In addition, the modelled warm spell and heat wave duration indices are compared with gridded E-OBSv11 data and with observations from the Croatian Meteorological and Hydrological Service (DHMZ) archive.

The RCMs’ results are also analysed in the context of the RCP4.5 climate change scenario. The changes of temperature indices are analysed for the two periods: 2011-2040 and 2021-2050. The future climate indices indicate warming in both periods, with more pronounced extremes lasting longer periods. Although temperature changes in the two periods are smaller than those referred to in the IPCC documents for the end of the 21st century, they are by no means negligible.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-108

EURO-CORDEX regional climate models: evaluation of mean temperature and precipitation over the PRUDENCE regions and Croatia

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In this study, a set of experiments the EURO-CORDEX simulations are evaluated over the PRUDENCE regions (Jacob et al. 2007, Clim. Change) and over a region that includes Croatia and large parts of the neighboring countries. Our set of experiments include 6 regional climate models (RCMs) forced by ERA-Interim reanalysis and integrated at the 12.5-km and 50-km horizontal resolutions and 11 (14) RCMs at the 12.5-km (50-km) resolution forced by CMIP5 global climate models (GCMs). The performance of the RCMs is evaluated for monthly, seasonal and annual land-point averages of near-surface temperature and total precipitation. Special focus is given to the RegCM4 simulations performed at Croatian Meteorological and Hydrological Service (DHMZ-RegCM4). As a reference, we use the E-OBSv11 dataset which includes near-surface temperature and total precipitation at a regular 0.25° x 0.25° grid.

For each simulation over the historic period 1971-2000 (1989-2008 when RCMs were forced by ERA-Interim) commonly used evaluation metrics over the selected subregions are applied. They include: (1) spatially-averaged differences between RCMs and observations, (2) the spatial 95th percentiles of simulated and observed temperature and precipitation, (3) spatial correlation coefficients between models and observations, (4) the ratio of spatial standard deviations between simulated and observed fields, and (5) the Spearman rank correlations between simulated and observed time-series of spatially-averaged temperature and precipitation.

The results highlight that, in most simulations, the RCMs are able to capture the (observed) spatial variability of the European temperature climate. This is indicated by high spatial correlations with values larger than 0.9 for most subregions. As commonly found in other studies, the total precipitation in RCM simulations is often overestimated and spatial correlations are noticeably lower than for temperature. The results of this study would enable to decide with confidence which combinations of RCMs and GCMs could be used to investigate the impacts of climate change scenarios over Croatia.
Future changes in water availability and drought intensity over major West African rivers basins based on CMIP5 and CORDEX multimodel ensembles projections

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In this study, we investigate changes in water availability and drought characteristics over ten major river basins of West Africa using multimodel ensemble based on CMIP5 and CORDEX simulations. Water availability is defined as the ratio between precipitation (water supply) and potential evapotranspiration (water demand) while the WMO recommended standardized precipitation index (SPI) is used to characterize drought. The analysis reveals that during the late 21st century and throughout the annual cycle all basins will undergo an deficit in water supply and an increase in water demand leading thus to substantial water unavailability over most of river basins. Such conditions exhibit positive trends and strengthen as the greenhouse gas forcing increases, with Senegal river basin experiencing the worse conditions. These lead to decrease of moderate drought occurrences and substantial increase of severe and extreme drought conditions, especially in the basins or part of the basins located in the Sahel.

It is thus clear that anthropogenic climate change will decrease water availability over West African major river basins. Adding to this the stress due to riparian communities, West Africa will thus experience absolute water scarcity. Therefore, adaptation practices in water management, especially for agriculture, will need to be designed and implemented to cope with the increased water stress foreseen throughout the region whose increasing trend of population will intensify water resources and food security needs.
PC-110

DAILY CHARACTERISTICS OF CENTRAL AFRICA RAINFALL IN REMO MODEL

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Historical and scenarios (RCP2.6, RCP4.5 and RCP8.5) of regional climate model REMO forced with general circulation models EC-EARTH and MPI-ESM was used to study the spatial and temporal changes as well as the annual cycle, extreme and the frequency distribution of the intensities of rainfall in Central Africa. The calculation of the DPID (Daily Precipitation Intensity Distribution) in 05 subregions enabled us to see the contribution of each range to the total precipitation. However, we note differences at some places according to model. From the spatial representation, it comes out that, the models overestimate precipitation in any location. Projections at the beginning and the end of the century show that the rate of decline in precipitation frequency distribution is decreasing with increasing rainfall intensities. In addition, an analysis of the variations of the thresholds and maximums of 90th and 25th percentiles reveals a decrease of extreme drought and increase of extreme precipitation. The study of the monsoon shows that, despite the fact that models agree with the ITCZ migration, the "jump" of monsoon is absent. Studies done on a daily scale show that no significant change will be recorded in the 21th century on the daily precipitation intensity.
PC-111

Impacts of different cumulus physics over south Asia region with case study tropical cyclone Viyaru

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Tropical Cyclone Viyaru, formerly known as Cyclonic Storm Mahasen was a rapidly intensifying, category 01B storm that made landfall in Chittagong, Bangladesh on the 16th of May, 2013. In this study, the sensitivity of numerical simulations of tropical cyclone to cumulus physics parameterizations is carried out with a view to determine the best cumulus physics option for prediction of the cyclone's track, timing, and central pressure evolution in the Bay of Bengal. For this purpose, the tropical cyclone Viyaru has been simulated by WRF-ARW v3.4.1 in a nested domain with NCEP Global Final Analysis (FNL) data as initial and boundary conditions. The model domain consists of one parent domain and one nested domain. The resolution of the parent domain is 36 km while the nested domain has a resolution of 12 km. Five numerical simulations have been done with the same microphysics scheme (WSM3), planetary boundary layer scheme (YSU), NOAH land surface scheme but different Cumulus Parameterization scheme. Four cumulus Parameterization schemes are KF, BMJ, GF and Tiedtke and one simulations was done without any cumulus physics scheme. The results of model simulations are compared with corresponding analysis or observation data. For best result data provided by Joint Typhoon Warning Centre (JTWC) and NASA tropical cyclone centre was used as observed for comparison. After the study it was found that tracks, intensity, wind speed, precipitation, and central pressure of the cyclone have sensitive result with different cumulus physics schemes.
Impact of Monthly-Scale Global Sea Surface Temperature (SST) Patterns on the East African Long Rains

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The use of high resolution data is very critical in providing good diagnostics and reasonable solutions to problems associated with climate-sensitive socio-economic sectors. The East African long rains, which are key to socio-economic growth, have been extensively studied using different data. While the outcomes have benefited the East African societies, conscious efforts still will have to be made to ensure that high resolution data are a top priority in climate research, to bring more added-value to the societies. In line with this, the current study has sourced Climatic Research Unit (CRU; 0.5o x 0.5o resolution) and Extended Reconstructed Sea Surface Temperature (ERSST; 2o x 2o resolution) data for the analysis. The study explores the impact of monthly-scale global SST patterns on long rains over the region during the climatologically-active phase of El Niño Southern Oscillation (ENSO). Specifically, it identifies the sectors of the SST that influence the regional climate. The study utilized about 60 years of climate data. Empirical orthogonal function (EOF) analysis was performed on CRU data (1951-2008), to isolate the dominant modes of precipitation. The four leading modes that were statistically separate contributed to 34.2% of the total variance. The EOF 1, 2, 3, and 4 accounted for 10.1%, 9.1%, 8.2% and 6.8%, respectively, of the total variance. Their temporal patterns depicted interannual variability, but with distinct loadings. To identify the SST sectors and their impacts, lagged grid-point correlations were computed, in which standardized global ERSST anomalies (1950/51-2007/2008) at six time-lags, from December to May, were centered on the long rains season. The results showed that EOF 1, 3, and 4 precipitation modes exhibited different responses to the Pacific ENSO, the Atlantic and Indian Oceans. These are important as they contribute to the predictive understanding of the rainfall modes, which are vital for initiating appropriate climate change adaptation strategies. Practically, the EOF 2 was not related to the global ocean, which is consistent with recent literature. It appears that this mode is driven by complex systems that merit further studies using numerical modelling. Alternately, the current study is undertaking a confirmatory research on this via intercomparison of other high resolution data such as CORDEX, CMAP, TRIMM, and the University of Delaware terrestrial gridded data.
Rapid future intensification of hazardous thunderstorms over Lake Victoria

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Future climate simulations project an amplification of precipitation extremes and associated weather conditions, with harmful consequences for human societies. Already now on Lake Victoria (East Africa), presumably several thousands of fishermen die every year because of intense nighttime thunderstorms. Yet the potential future consequences of anthropogenic greenhouse gas emissions for these thunderstorms are still unknown. Here we show that Lake Victoria amplifies the projected increase in extreme precipitation. By combining new satellite-based observations and the first high-resolution climate projection for the African Great Lakes, we identify the drivers of extreme precipitation over Lake Victoria and understand their projected change. Land precipitation on the previous day exerts a strong control on nighttime occurrence of extremes on the lake by increasing moisture availability, but especially by favouring atmospheric convergence. The rapid future increase in extremes over Lake Victoria is entirely attributed to the higher moisture content of converging air masses, consistent with expectations from thermodynamic scaling found in ensemble climate projections but opposed to the average over-lake precipitation decline dominated by mesoscale circulation changes. Our results highlight a new major hazard associated with climate change over East Africa and underline the need for high-resolution projections to assess local climate change.
From GCMs to river flow in the midst of uncertainties: Can potential future plights could be alleviated with currently available forecasting skill?

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The northwest part of India (NWI) known as the “wheat bowl” of the country, receives 20% - 25% of its annual precipitation during winter season. This precipitation is very important for the wheat crop, as it supplements the moisture and maintains low temperature during the reproductive stages. Most of the winter precipitation in the region is in the form of snowfall over western Himalayas. This precipitation, in turn, helps in maintaining the glaciers, which serve as the vast storehouse of freshwater supply to millions of people downstream throughout the year through rivers of western Himalayan origin. Therefore, for a country like India that gets more than 70% of its wheat production and fresh water from NWI region, the question arises whether strategies of winter-time precipitation prediction that have proved useful elsewhere can they be adapted to the exceptionally complex terrain of Himalayas as well? The aim of the present study is in two-folds. Firstly, it attempts to assess the seasonal predictive skill of six general circulation models (GCMs) (out of which four of them are from IRI Columbia University, one form NCEP and one from NCMRWF India at 1-month lead), for a period of 31 years (1982-2012). Secondly, an attempt has been also made to reproduce the information of the GCMs at higher resolution using downscaling approaches (both dynamical and statistical downscaling). The first part of the study reveals that the GCMs in general underestimate the observed climatology and inter-annual variability of precipitation and temperature and their skill is not satisfactory even with multi-model ensemble techniques. The second part of the work shows that dynamical downscaling (at 30 km resolution) with customized RegCM significantly reduces GCM biases. Further a comparison between Canonical Correlation Analysis (CCA) based statistical downscaling and Quintile Mapping (QM) based bias corrected dynamical downscaling has been made. The results suggest that the QM based bias corrected dynamical downscaling further improves the skill over domain of interest compared to CCA based statistical downscaling approach. Furthermore, the study reflects the model’s robustness at the event scale and paves a path for using dynamic downscaling methods in basin-scale studies. Finally, the plausible reasons of model failure and how CORDEX framework has played a key role in addressing such issues is highlighted.
Advancing the simulation of land-atmospheric boundary layer feedback processes in regional climate models

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The verification of regional climate models reveals strong deficiencies with respect to the simulation of the hydrological cycle. For example, a strong windward-lee-effect occurs in low and high mountains, the seasonal precipitation bias can be of up to 40%, and extrema are underestimated. These results lead to a still quite limited exploitation of the results of regional simulations in hydrology and agriculture.

To a large extent, these errors are due to an insufficient simulation of the interactions in the land-atmosphere (LA) system including the atmospheric boundary layer. The incorrect simulation of the pre-convective environment causes also errors in the representation of clouds and precipitation. Therefore, the improvement of LS feedback processes should come first to improve the simulation of clouds and precipitation (Wulfmeyer et al. ROG 2015). Convection permitting simulations provide an excellent potential, but they require an optimization of land surface and convective boundary layer parameterizations (Milovac et al. JTECH 2015). Data sets of novel observing systems are urgently needed to develop new theoretical concepts and optimized chains of parameterizations of LA exchange, turbulence, and shallow convection (Wulfmeyer et al. JAS 2015). We introduce such a new concept for the new generation of regional climate models.

Particularly the Surface Atmospheric Boundary Layer Exchange (SABLE) campaign in August 2014 demonstrated active remote sensing systems provide simultaneously profiles in the surface layer, the mixed layer, and the entrainment layer, higher-order moments, and both sensible and latent heat flux profiles in the convective boundary layer what is to our knowledge for the first time but essential for improvements and tests of parameterizations. Furthermore, by a sophisticated combination of surface scans, surface momentum, heat, and latent heat fluxes can be determined. It is shown how these novel data sets can be used for advancing our understanding and the simulation of LA exchange. We expect that an improved representation of these processes will lead to significant progress in regional climate models at all scales.
Impact of the sea surface temperature bias correction on the moisture transport and precipitation pattern over southern Africa in a regional climate model

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Possible changes of the climate in southern Africa will affect the water availability and thus the lives of the people in this region. Therefore, a detailed analysis of the moisture transport and precipitation pattern using high resolution climate change projections are of particular importance. To obtain high resolution climate change information for the future, regional climate models (RCMs) are used to downscale climate change projections generated with general circulation models (GCMs). These GCMs are usually coupled with an ocean model providing ocean parameters such as sea surface temperature (SST) needed by GCMs. Though, the global ocean models often have deficiencies in resolving regional to local scale ocean currents, e.g. in the ocean areas offshore the south African continent. In the Atlantic Ocean the cold up-welling Benguela flows northward along the west coast of southern Africa whereas in the Indian Ocean the Agulhas current flows southward along the east coast. The precipitation pattern in southern Africa are strongly affected by the moisture transport from the Atlantic and Indian Ocean and, consequently, from their SSTs.

To analyse the impact of the SST bias correction on the moisture transport and precipitation pattern, several experiments were conducted with the regional climate model REMO using corrected SSTs. In these experiments a historical MPI-ESM-LR simulation was downscaled with REMO to a spatial resolution of 25 x 25 km² for southern Africa. In total, five experiments, each covering five years, were carried out with a) SST as given by MPI-ESM-LR historical, b) SST as given by ERA-Interim, c) SST of Atlantic Ocean with the Benguela current replaced by ERA-Interim, d) SST of Indian Ocean including Agulhas current replaced by ERA-Interim and e) as a), but with perturbed atmospheric conditions to assess the internal model variability of REMO. The results show a distinct impact of the corrected SST on the moisture transport and precipitation pattern in southern Africa, but also on the vertical circulation. In particular, the contribution of the bias corrected SST of the Atlantic Ocean is stronger, which should be taken into account for climate change projections.
Future change of East Asia summer monsoon with the high-resolution AGCM based on the RCP Scenarios

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The high-resolution (40-km mesh) atmospheric general circulation model (GCM) have been used to better understand the regional details in future climate projection due to the global warming. First, we have performed the present-day climate simulation during 1979-2009 using AMIP observed Sea surface temperature (SST) and Sea ice concentration (SIC). For the future climate projection, we have performed the current climate during 1979-2009 and subsequently the future climate projection during 2010-2099 with composite SST and SIC of four CMIP5 models due to the two RCP scenarios (RCP8.5 and RCP4.5) respectively.

In the present-day climate simulation, we have evaluated the model's reproducibility of precipitation climatology and extreme precipitation indices in East Asian Summer monsoon (EASM) comparing 28 CMIP5/AMIP models. For quantitative evaluation, all model and observation data are converted to the rainfall fraction considering the improved skills of those comparing raw precipitation. The model reflects the spatial distribution of JJA precipitation fraction and its seasonal march over East Asia. Additionally, it has reasonable simulation skill in extreme rainfall fraction (95th/99th percentile, PDF, ...) comparing high-resolution models in CMIP5/AMIP models. Based on these results, future change of climatological pattern and extreme climate over EASM region are also investigated by dividing the three future as near-future (2010-2039), mid-future (2040-2069), far-future (2070-2099). The model shows increases of precipitation and extensions of seasonal march in EASM from May to September and their variabilities are increased from near- to far-future. Also, intensities of extreme precipitation indices in future projection are also prominent.
PC-118

Change of in Extreme Climate Events over China Based on GCM and RegCM

Ying Xu, Jie Wu

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The changes in a selection of extreme climate indices (maximum of daily maximum temperature (TXx), minimum of daily minimum temperature (TNn), annual total precipitation when the daily precipitation exceeds the 95th percentile of wet-day precipitation (very wet days, R95p), and the maximum number of consecutive days with less than 1 mm of precipitation (consecutive dry days, CDD)) were projected using 5 GCM and RegCM (drived by same 5 GCM) simulations in the early, middle, and latter parts of the 21st century under RCP4.5 emissions scenarios. The results suggest that TXx and TNn will increase in the future and, moreover, the increases of TNn are larger than those of TXx. R95p is projected to increase and CDD to decrease significantly. The GCM and RegCM simulations show remarkable consistency in their projection of the extreme temperature indices, but poor consistency with respect to the extreme precipitation indices. The further analysis need be to do.
Extreme heat stress events as measured by the wet-bulb temperature require extraordinarily high air temperatures coupled with high humidity. These conditions are rare, as relative humidity rapidly falls with rising air temperature, and this effect often results in decreasing heat stress as temperature rises. However, in certain coastal locations in the Middle East recent heat waves have resulted in wet-bulb temperatures of 33-35 degrees C, which approach the theoretical limits of human tolerance. These conditions result from the combination of extreme desert heat and humid winds off of the warm ocean waters. It is unclear if climate models properly simulate these dynamics. This study will analyse the ability of the CMIP5 model suite to replicate observed dynamics during extreme heat events in major urban areas.
Ship accessibility predictions for the CORDEX Arctic Ocean based on IPCC CO2 emission scenarios

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Changes in the extent of Arctic sea ice, which have resulted from climate change, offer new opportunities to use the Northern Sea Route (NSR) and Northwest Passage (NWP) for shipping. However, choosing to navigate the CORDEX Arctic Ocean remains challenging due the limited accessibility of ships and the balance between economic gain and potential risk. As a result, more precise and detailed information on both weather and sea ice change in the Arctic are required. In this study, a high-resolution global numerical weather prediction model (GME) was used to provide detailed information on the extent and thickness of Arctic sea ice. The results were evaluated by comparison with observations from the Hadley Centre sea-ice and Sea Surface Temperature (HadISST) dataset, extending from 1979 to 2009. Furthermore, projections of marine access were estimated, using daily sea ice thickness data for 2010-2099, using both the Representative Concentration Pathway (RCP) 4.5 and 8.5 scenarios. Under both scenarios, ships classified as Polar Class (PC) 3 and Open-Water (OW) were predicted to have the largest and smallest number of ship-accessible days (in any given year) for the NSR and NWP, respectively. Based on the RCP 8.5 scenario, the projections suggest that after 2070, PC3 and PC6 vessels will have year-round access across to the Arctic Ocean. In contrast, OW vessels will continue to have a seasonal handicap, inhibiting their ability to pass through the NSR and NWP.
Numerical investigations about atmospheric features leading to flash flooding episodes over complex topography

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Three flash flooding episodes are numerically investigated over La Paz city. Large scale atmospheric water transport is dynamically downscaled in order to take into account the complex topography forcing and local features. Overall, the synoptic situations leading to extreme precipitation and flooding episodes are better represented by the WRF model. While previous studies have taken into account large scale dynamics over the Amazon Basin, the circulation dynamics of extreme precipitation over the tropical Andes is still poorly documented. This work tries to tackle this issue and offer new elements for extreme precipitation forecasting over the Bolivian Andes.
SPATIAL SCALING OF THE WATER, ENERGY AND CARBON BUDGETS ACROSS RIVER BASINS OF THE ANDES–AMAZON SYSTEM

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The Andes–Amazon system exhibits complex interactions and feedbacks between hydrological, ecological, biogeochemical and climatic factors in a broad range of temporal and spatial scales. We aim to understand the coupling existing between water, energy and carbon budgets in the Andes–Amazon system, by performing a systematic study of the system for river basins of increasing Strahler orders, from the headwaters of the Amazon River basin on the Andes (order 1 river basins) to the low-lying larger river sub-basins downstreams. To that aim, we use a 3° Digital Elevation Model (DEM), which allows defining river basins with Strahler orders from 1 to 10. The long-term water, energy, and carbon budgets are estimated for increasing values of the Strahler orders during the period 1998-2013. Data sets pertaining to the water balance were obtained from the following sources: precipitation (P), runoff (R) and actual evapotranspiration (AET) from IDEAM (Colombia), National Water Agency (ANA, Brazil), and ORE-HYBAM (France). Data for the energy budgets were obtained from the Global Energy and Water Exchanges Project (GEWEX), and the ERA-Interim Reanalysis, which allowed estimating the radiative and non-radiative fluxes of the surface energy balance and Potential Evapotranspiration (PET). Data for the Carbon budgets come from the AMAZALERT project, and to Flux Tower Data, corresponding to annual mean net primary productivity (ANPP), gross primary productivity (GPP) and respiration rates (Rr), as well as from the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). We construct a three-dimensional parameter space in which the results of the three balances are expressed as: \( \psi = \frac{AET}{P} \) for the water balance, \( \Omega = \frac{AET}{PET} \) for the energy balance and \( \phi = \frac{ANPP}{AET} \) for the carbon balance. A scaling function is fitted that couples this 3-parameter space linking the water, energy and carbon budgets and show their scale invariance throughout all the range of river basins of increasing Strahler orders in the Amazon-Andes system.
Applications of dynamical downscaling in studying Black Sea Region climate.

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Using surface wind data from the climate model RegCM we performed statistical study of intense mesoscale cyclones that formed in the Black Sea Region during the period of 1979 – 2013. Apart from theoretical interest, the study is of practical importance as intense mesoscale cyclones may lead to bad weather conditions and also influence surface currents in the Black Sea. In order to detect intense cyclones in the wind field we used method based on the Okubo-Weiss criterion. Various parameters of the mesoscale cyclones, such as lifetime, intensity, trajectories over the sea, place and time of origin etc. were considered. Also, monthly and diurnal distributions of the Black Sea cyclones were determined. The results were compared with the results of another statistical study of the Black Sea cyclones that was performed using PRECIS climate model. Differences between mesoscale cyclones reproduced by RegCM and PRECIS models were considered. Unlike RegCM model, PRECIS model doesn't reproduce intense cyclones near the Caucasian coast in winter. Probably, the main reason for the discrepancy is different representation of coastal orography in the models. Orography in RegCM model is over smoothed and coastal Caucasian mountains are lower than in PRECIS. As a result, surface air flow traverses the ridge rather than passing around the obstacle and surface wind speed over the sea near the Caucasian coast in RegCM model is higher than in PRECIS, which favors the development of intense Caucasian cyclones in winter. Another application of dynamical downscaling is reproducing climate precipitation fields for the Black Sea Region. Yearly amounts of precipitation and evaporation over the sea are used to determine the Black Sea water balance, in particular river stock. Reproducing of precipitation fields is one of the most difficult issues in numerical modeling. Usually it requires thorough validation of modelling results and correction of parametrization schemes. In this study RegCM precipitation fields were compared with available observation data from meteorological stations, re-analysis ERA-Interim data and PRECIS model results. It was found that RegCM overestimates precipitation in winter over the land. In order to improve the model performance a set of numerical experiments was performed, in which empirical coefficients in SUBEX and Grell parametrization schemes were corrected.
PARALLEL SESSION C: IMPACTS AND APPLICATIONS

PC-124

Extreme value analysis of 10 m wind speed in the CORDEX Arctic domain

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In this study peaks-over-threshold (POT) models were applied to hindcast simulations with COSMO-CLM (2002-2014) at 15 km horizontal resolution (C15), to CORDEX Arctic simulations (22-50km), and to ERA-Interim (~80km). It is aimed to analyse the reoccurrence and intensity of extreme 10 m wind speeds and how they depend on the horizontal model resolution. Preliminary results were calculated for return levels of return periods from 2 years to 30 years for C15 and ERA-Interim. Although both analyses show the highest return levels in the area of the Greenland and Norwegian Sea, there are two distinct differences: First, the highest return levels based on ERA-Interim occur over land in southern Greenland, while in C15 the most extreme wind speeds occur over the Irminger Sea, a region of frequent tip jets; second, the return levels based on C15 are considerably higher in the whole area of the Greenland-Iceland-Norwegian Sea. Although the analyses of the CORDEX simulations (horizontal resolution of 22-50km) is still to be completed, these results demonstrate a clear impact of the horizontal resolution on capturing extreme wind speeds from arctic mesoscale wind phenomena.
CONCLUSION ORGANISERS

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Bolin Centre for Climate Research
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CO-SPONSORS

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