Added value of high resolution RCM simulations and comparison with Statistical Downscaling Methods within the EURO-CORDEX framework

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Thanks to:  
S. Herrera  
J. Fernández  
S. Kotlarski  
J.M. Gutiérrez

Formerly at:  
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www.meteo.unican.es
✓ Better resolved processes related to improved orography and land-sea mask (Pryor et al., 2012; Walther et al., 2013; Torma et al., 2015).

✗ No systematic/evident improvement of the high resolution (Kotlarski et al. 2014).

✗ Hi-res 0.11° simulations took ~ 100x the computing power of the standard 0.44° CORDEX resolution.

✗ There is no unique, best way to assess the added value (Prein et al., 2015).
What do we mean with “fair”? 

- Spatial representativeness:

  RCMs
  Areal averages
  
  VS
  
  SDMs
  Point stations
  Areal averages
What do we mean with “fair”? 

- **Spatial representativeness:**

  - **RCMs**
    - Areal averages

  - **SDMs**
    - Point stations
    - Areal averages

**Motivation:** fair comparison

- Unfair: RCMs vs SDMs
What do we mean with “fair”? 

- Spatial representativeness:
  - RCMs: Areal averages vs SDMs: Point stations
  - SDMs usually calibrate the mean.

- Metrics used for validation should not have been calibrated in the training/tuning phase.

Motivation: fair comparison
What do we mean with “fair”?  

- Spatial representativeness:

  RCMs  
  Areal averages  
  VS  
  x unfair
  ✓ fair

  SDMs  
  Point stations  
  Areal averages

- Metrics used for validation should **not have been calibrated** in the training/tuning phase.

SDMs usually calibrate the **mean**. Are other parameters indirectly adjusted?
✓ **SQ1:** Do the high resolution RCMs add value with respect to the coarse ones before and/or after bias correction?

✓ **SQ2:** Is it fair to compare RCMs and SDMs?
<table>
<thead>
<tr>
<th>RCM</th>
<th>Institution</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCLM</td>
<td>CLM Community</td>
<td>0.11° and 0.44°</td>
</tr>
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<td>DMI, Denmark</td>
<td>0.11° and 0.44°</td>
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<tr>
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<td>IPSL/INERIS, France</td>
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</tr>
<tr>
<td>WRF331G</td>
<td>UC, Spain</td>
<td>0.44°</td>
</tr>
<tr>
<td>HadRM</td>
<td>MOHC, United Kingdom</td>
<td>0.44°</td>
</tr>
<tr>
<td>ALADIN</td>
<td>HMS, Hungary</td>
<td>0.44°</td>
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The comparison is carried out at the 0.44° grid, i.e. the *skillful scale* of the high resolution.

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**Spain011/044 for Spain** (Herrera et al., 2015):
EURO-CORDEX compliant grids

**APGD** (Alpine Precipitation Gridded Dataset, Isotta et al. 2013)
- daily accumulated precipitation, period 1971-2008
- 0.05° resolution regridded into the EURO-CORDEX grids

**Observational data**

- **Spain011/044 for Spain** (Herrera et al., 2015):
  - EURO-CORDEX compliant grids

- **APGD** (Alpine Precipitation Gridded Dataset, Isotta et al. 2013)
  - daily accumulated precipitation, period 1971-2008
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**Wet-day mean precipitation**

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<tr>
<td>7.94</td>
<td>7.60</td>
</tr>
<tr>
<td>8.47</td>
<td>7.99</td>
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**Frequency of wet-days (above 1mm)**

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<th>0.11°</th>
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<tr>
<td>25.35</td>
<td>27.23</td>
</tr>
<tr>
<td>26.85</td>
<td>28.15</td>
</tr>
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</table>
Results: SDII Biases (DJF)

- Important biases for both resolutions.
- Depending on the RCM (and season, region, indicator), smaller biases are found in the 0.44° or 0.11AGG.
- Where should we look for added value?
Number of 011AGG improving on 0.44° (ALP, DJF)

Added value of the high-res. simulations in **spatial patterns** \((r, \text{RMSD})\).
Number of 011AGG improving on 0.44° (ALP, DJF)

No significant added value of high-res. after simple BC.
✓ SQ1: Do the high resolution RCMs add value with respect to the coarse ones before and/or after bias correction?

✓ SQ2: Is it fair to compare RCMs and SDMs?
Dynamical Downscaling:
ERA-Interim driven EURO-CORDEX simulations at 0.44°.

Statistical Downscaling over Spain (Perfect Prog):

<table>
<thead>
<tr>
<th>Label</th>
<th>Statistical Downscaling Method</th>
<th>Predictor Variables</th>
</tr>
</thead>
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<tr>
<td>S1</td>
<td>Nearest neighbor (1 analogue)</td>
<td>SLP, T850, Q850</td>
</tr>
<tr>
<td>S2</td>
<td>100 WTs (k-means) simulation from Bernoulli + Gamma</td>
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</tr>
<tr>
<td>S3</td>
<td>GLM (Bernoulli) + GLM (Gamma) with 30 PCs</td>
<td>SLP, T850, Q850</td>
</tr>
<tr>
<td>S4</td>
<td>GLM (Bernoulli) + GLM (Gamma) with 4 nearest grid boxes</td>
<td>SLP, T850, Q850</td>
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<tr>
<td>S5</td>
<td>S4 conditioned on 10 WTs (k-means)</td>
<td>T850, Q850 (SLP for WTs)</td>
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ERA-Interim predictors
Spain044 predictands
5-fold cross-validation (1989-2008)
San-Martín et al. (2016)

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Pursuing a fair comparison

- **Mean** usually calibrated

- **D1** CCLM
- **D2** HIRHAM
- **D3** RACMO
- **D4** RCA
- **D5** HadRM
- **D6** ALADIN
- **D7** WRF 331F
- **D8** WRF 331G

- **S1** ANALOG
- **S2** WT-WG
- **S3** GLM (PCs)
- **S4** GLM (nns)
- **S5** GLM-WT (nns)

**DJF**

- **Correlation Coefficient**
- **MAE (mm)**
- **RMSD**

- **Standard deviation**

- **Mean** usually calibrated
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**90pWET:**
Indirectly corrected by the mean
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http://www.meteo.unican.es

- Mean usually calibrated
- 90pWET: Indirectly corrected by the mean

Pursuing a fair comparison

**Local Scaling (LS)**

| D1  | CCLM   |
| D2  | HIRHAM |
| D3  | RACMO  |
| D4  | RCA    |
| D5  | HadRM  |
| D6  | ALADIN |
| D7  | WRF 331F |
| D8  | WRF 331G |
| S1  | ANALOG |
| S2  | WT-WG  |
| S3  | GLM (PCs) |
| S4  | GLM (nns) |
| S5  | GLM-WT (nns) |
Mean usually calibrated

90pWET:
Indirectly corrected by the mean

CDD: time sequence dependent
(not calibrated for any method)
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Pursuing a fair comparison

- **Mean** usually calibrated
- **90pWET:** Indirectly corrected by the mean
- **CDD:** time sequence dependent (not calibrated for any method)

![Diagram](http://www.meteo.unican.es)
Conclusions

✓ SQ1: Do the high resolution RCMs add value with respect to the coarse ones before and/or after bias correction?
- **No**, in terms of *seasonal mean biases* in several climate indicators.
- **Yes**, there is added value in *spatial patterns*, BUT it is *not statistically significant* after bias correcting both simulations.

✓ SQ2: Is it fair to compare RCMs and SDMs?
- **No**, if the comparison is based on percentiles and intensity-dependent indicators due to their close relationship with the mean, usually affected by the *methods calibration*.
- **Yes**, if the comparison considers *non-optimized parameters* by either RCMs or SDMs, such as dry spells.
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References:


Acknowledgements:

- Data providers: MeteoSwiss, AEMET and UC for the observational data provided for this work and the EURO-CORDEX modeling groups, as well as the Earth System Grid Federation.
