Climate change scenarios for low carbon agriculture in Poland based on EURO-CORDEX (EUR-11) simulations

Małgorzata Liszewska, Krystyna Konca-Kędzierska, Maciej Sadowski

m.liszewska@icm.edu.pl
Support for low carbon agriculture
able to adapt to climate change in the perspective of 2030 and 2050
Support for low carbon agriculture able to adapt to climate change in the perspective of 2030 and 2050

The main objective of the project is to promote sustainable use of mineral fertilizers as the element of sustainable intensification for farms performance in Poland in order to reduce yield gaps while improvement resources use efficiency by implementation of innovative low carbon farming practices.

- to evaluate the carbon footprint in the life cycle for basic crops in Poland in current and future climate in perspective of 2030 and 2050.

Climate scenarios data and agro climatic analysis will be used to identify issues and risks related to climate change. Consequently the appropriate actions for incorporating low carbon practices for Polish agriculture also for future climate will be recommended. Issues of food security and the vulnerability of food production to climate change will be considered.

- to deliver series of daily projections of required climate parameters for the regions important for the project for the 2020-2090 period
Experimental farms

NOAA meteo stations
OBSERVATIONS

2 streams:

<table>
<thead>
<tr>
<th>Points</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1971-1999</td>
</tr>
<tr>
<td>23</td>
<td>1981-2010</td>
</tr>
</tbody>
</table>

Experimental farms (IUNG)  
NOAA meteorological stations

Variables:
minimum, maximum, mean daily **temperature**  
daily **precipitation**

**temperature**: *missing data* were replaced from the **E-OBS**  
**precipitation**: no replacement

*Other variables such as wind, humidity, sunshine duration* contain a lot of missing data and require more additional preprocessing work – it will be our next step.
EXPERIMENT 1.

EXPERIMENT 2.

Pulawy
CLIMATE MODELS

200 km

GLOBAL MODELS (GCMs)

10-50 km

REGIONAL MODELS (RCMs)

Statistical post-processing

points

LOCAL SCALES

Statistical post-processing

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CLIMATE MODELS

GLOBAL MODELS (GCMs)

REGIONAL MODELS (RCMs)

LOCAL SCALES

Statistical post-processing

points

200 km

10-50 km

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CLIMATE MODELS

EUROCORDEX

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>control (historical)</td>
<td>1971 - 2005</td>
</tr>
<tr>
<td>scenario (RCP)</td>
<td>2006 - 2100</td>
</tr>
<tr>
<td>RCP 4.5 + RCP 8.5</td>
<td></td>
</tr>
</tbody>
</table>

Horizontal resolution ~ 12 km (0.11 deg)

Domain Europe (EUR-11)
CLIMATE MODELS

2 ensembles **RCP4.5** i **RCP8.5**

<table>
<thead>
<tr>
<th>Global models</th>
<th>Regional models</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CNRM-CERFACS-CNRM-CM5</td>
</tr>
<tr>
<td>2</td>
<td>CNRM-CERFACS-CNRM-CM5</td>
</tr>
<tr>
<td>3</td>
<td>ICHEC-EC-EARTH</td>
</tr>
<tr>
<td>4</td>
<td>ICHEC-EC-EARTH</td>
</tr>
<tr>
<td>5</td>
<td>ICHEC-EC-EARTH</td>
</tr>
<tr>
<td>6</td>
<td>IPSL-IPSL-CM5A-MR</td>
</tr>
<tr>
<td>7</td>
<td>IPSL-IPSL-CM5A-MR</td>
</tr>
<tr>
<td>8</td>
<td>MOHC-HadGEM2-ES</td>
</tr>
<tr>
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<td>MPI-M-MPI-ESM-LR</td>
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quantile mapping, R, library(qmap)

- Statistical transformations for post-processing climate model output
- Empirical adjustment (bias correction) of variables originating from (regional) climate model simulations using quantile mapping.

Author(s)
Lukas Gudmundsson

References
**Post-processing**

**QMAP processing**

```r
fitQmap(obs, mod, method=c("PTF", "DIST", "RQUANT", "QUANT", "SSPLIN"), ...)
doQmap(x, fobj, ...)
```

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<td>Quantile mapping using parametric transformations</td>
</tr>
<tr>
<td>DIST</td>
<td>Quantile mapping using distribution derived transformations</td>
</tr>
<tr>
<td>RQUANT</td>
<td>Non-parametric quantile mapping using robust empirical quantiles</td>
</tr>
<tr>
<td>QUANT</td>
<td>Non-parametric quantile mapping using empirical quantiles</td>
</tr>
<tr>
<td>SSPLIN</td>
<td>Quantile mapping using a smoothing spline</td>
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**QMAP processing**

\[ \text{fitQmap}(\text{obs,mod,method=c("PTF","DIST","RQUANT","QUANT","SSPLIN"),...}) \]
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m.liszewska@icm.edu.pl
Results

1971-2090

temperature
precipitation

• series of daily values
• time aggregations (months, seasons, years)
• climate indices
Results

Climate indices

No. of days with Tmax>25, 30, 35 °C
Largest no. of consecutive days with Tmax>25, 30, 35 °C
No. of periods of more than 5 days with Tmax>25, 30, 35 °C
No. of TROPICAL nights, Tmin>20 °C
No. of ICE days, Tmax<0 °C
No. of FROST days, Tmin<0 °C
Largest no. of consecutive FROST days when Tmin<0 °C
No. of FROST periods of more than 5 days, Tmin<0 °C
Thermal growing season length, T>5, 10 °C
Thermal growing season start, T>5, 10 °C
Heating degree days, T<17, 20 °C

No. of WET days, prec>1mm/d
Mean precip amount at WET days (precip<1mm/d)
Highest 1 day precip amount
Highest 5 day precip amount
No. of days with precip >=10, 20, 30 mm
Longest WET period (precip>1mm/d)
No. of WET periods longer of more than 5 days
Longest DRY period (precip<1mm/d)
No. of DRY periods longer of more than 5 days
TAYLOR diagrams

1981-2015, RCP45 (x – direct, ♦ - post-processed)

Mean temperature [C]

Minimum temperature [C]
Precipitation [mm/d]
**Time aggregations**

black line – observations, dashed & blue area - percentiles p05 : p95 (90%)

Minimum temperature 1981-2010 Pulawy

Maximum temperature 1981-2010 Pulawy

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Time aggregations

black line – observations, dashed & blue area – percentiles p05 : p95 (90%)
ERRORS

TEMPERATURE, RCP85 (dark – post-processed, light -direct)

ME error 1995-1999 (test period)
- tas
- tasmax
- tasmin

MSE error 1995-1999 (test period)
- tas
- tasmax
- tasmin

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bars – observations, solid – post-processed, dashed - direct
CLIMATE DIAGRAMS


.. brief summaries of average climatic variables and their time course

1 Country name, station location and elevation, station name
2 Period of observation of temperature (77 years) and precipitation (55 years)
3 Annual average of temperature and annual precipitation sum
4 (red) Temperature curve
5 (blue) Precipitation time series
6 Indication of frost periods
7 Mean daily max. temperature of the warmest month
8 Mean daily min. temperature of the coldest month
An example for **Pulawy**
Time aggregations

Mean daily temperature

(black – OBSERVATIONS, dashed (red) – RCP85, green – RCP45, median & percentiles p10 : p90)
Time aggregations

Mean daily temperature

(black – OBSERVATIONS, dashed (red) – RCP85, green – RCP45, median & percentiles p10 : p90)

Precipitation
Seasonal aggregations

Minimum daily temperature (median)

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Time aggregations

Daily precipitation (median)

Precipitation [mm/d]
Statistics, deviation from the mean in 1981-1990 \([\text{s-mean(s)}*1981-1990]\)

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m.liszewska@icm.edu.pl
Climate Indices

dark – RCP85, light - RCP45

No. of FROST days, Tmin<0C

Pulawy

1981-1994

2011-2030

2031-2050

2051-2070

2071-2090

20 40 60 80 100 120

No. of SUMMER days, Tmax>25C

Pulawy

1981-1994

2011-2030

2031-2050

2051-2070

2071-2090

20 40 60 80

Largest no. of consecutive SUMMER days, Tmax>25C

Pulawy

1981-1994

2011-2030

2031-2050

2051-2070

2071-2090

0 5 10 15 20 25 30

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Climate Indices

bars – OBSERVATIONS, dashed (red) – RCP85, green – RCP45, median & percentiles p10 : p90 (80%)

Thermal growing season length, T>5C

Pulawy

Thermal growing season start, T>5C

Pulawy

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m.liszewska@icm.edu.pl
Conclusions

→ evident increase of temperature
  minimum temperature
  winter months
  well marked differences between RCP4.5 & RCP8.5 in the 2nd half of the century

the warming is visible in all climate indices dependent on temperature
Conclusions

→ evident increase of temperature
minimum temperature
winter months
well marked differences between RCP4.5 & RCP8.5 in the 2\textsuperscript{nd} half of the century

the warming is visible in all climate indices dependent on temperature

→ increase of precipitation is not so clear as in case of temperature
higher amount of precipitation
no relevant differences between RCP4.5 & RCP8.5
great need for credible climate scenarios for **various** applications
Summary

➢ great need for credible climate scenarios for **various** applications

➢ **quantile mapping** gave valuable results in our case
Summary

➢ great need for credible climate scenarios for various applications

➢ quantile mapping gave valuable results in our case

➢ always important issue: how to communicate/interpret the results to the users