Statistical Downscaling of EURO-CORDEX climate change scenarios: Projections of droughts and heavy precipitation along the 21st century

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1. Motivations and objectives

Climate change: current evidences

- Global mean surface air temperature has risen by about 0.74°C (1906-2005)
- 11 of the 12 warmest years on record have occurred in the past 12 years
- Important regional variations
- Redistribution of rainfall and other variables

Extreme weather events

Summary for Policymakers (IPCC)

- cold days and nights (99%)
- hot days and nights (99%)
- frequent and/or intense heavy rainfall events (90%) Longer and/or more intense droughts (66%)
- hurricane activity (50%) (western north pacific and north atlantic)
Tools for exploring climate change impacts

- **GCMs → RCMs**

  - **Regional scales:** Dynamical downscaling. Regional Climate Models (RCMs)
  - **Local scales:** Statistical downscaling and model calibration from RCMs
Statistical downscaling of RCM outputs

OBS 1981-2005

RCM calibrated 2025-2099

climate change signal

RCM 1981-2005 (control)

changes

RCM 2025-2099
Statistical downscaling of RCM outputs: Quantile-Quantile adjustment (Amengual et al. 2012)

\[ p_i = o_i + g \bar{\Delta} + f \Delta_i' \]

\[ \Delta_i = s_{fi} - s_{ci} \]

\[ \bar{\Delta} = \frac{1}{N} \sum_{i=1}^{N} \Delta_i = \frac{1}{N} \sum_{i=1}^{N} (s_{fi} - s_{ci}) = \frac{S_f}{N} - \frac{S_c}{N} \]

\[ \Delta_i' = \Delta_i - \bar{\Delta} \]

\[ g = \frac{\left( \frac{1}{N} \sum_{i=1}^{N} o_i \right)}{\left( \frac{1}{N} \sum_{i=1}^{N} o'_i \right)} = \frac{\bar{O}}{\bar{S}_c} \]

\[ f = \frac{\sigma_o}{\sigma_{S_c}} = \frac{\text{IQR}|_O}{\text{IQR}|_{S_c}} \]

\[ f = \frac{\sigma_{o_i}}{\sigma_{S_{ci}}} \]
2. Database and methodology

E-OBS gridded dataset (25 km)  
EURO-CORDEX (12.5 km)

**Validation task**

• Validation task

Perkins skill score (PSS) (Perkins et al. 2007)

PSS = 94.07%

PSS = 92.13%

PSS = 87.85%

OBS (1956-80)

Raw (1956-80)
• Validation task  Perkins skill score (PSS) (Perkins et al. 2007)

PSS = 94.07%

PDF

minimum temperature (°C)

OBS (1956-80)
Local (1956-80)
• Validation task  Perkins skill score (PSS) \((Perkins \ et\ al.\ 2007)\)

PSS under \(P_5\) for minimum temperature in winter

\[\begin{array}{l}
\text{Raw} \\
49.17\% \\
\text{Local} \\
67.07\% \\
\text{ENSEMBLE}
\end{array}\]
Climate change projections

Compute changes in calibrated CDFs between a 25-year past (i.e. control/observed; 1981-2005) and successive 25-year RCM time-slices (2021-2045; 2046-2070; 2071-2095) Future regional scenario rcp4.5 and rcp8.5

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<th>Driving GCM</th>
<th>RCM</th>
<th>Institute</th>
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<td>SMHI</td>
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3. Results

Mean annual precipitation

Observed

Future change (multi-model mean)

Std (future change multi-model)
Annual precipitation days

**OBSERVED**

**FUTURE CHANGE**
(multi-model mean)
Mean seasonal precipitation

OBSERVED

WINTER

SPRING

SUMMER

AUTUMN

Precipitation (mm)

- [0,50]
- (50,100]
- (100,150]
- (150,200]
- (200,250]
- (250,300]
- (300,400]
- (400,600]
- (600,900]
Future change (Multi-model mean)
P99 of daily observed precipitation

WINTER

SPRING

SUMMER

AUTUMN

Precipitation (mm)

[0,5] [5,10] [10,15] [15,20] [20,30] [30,40] [40,50] [50,60]
Events over P99 of daily precipitation

FUTURE CHANGE
Mean daily minimum temperature (WINTER)

Observed

Future change (multi-model mean)

Std (future change multi-model)
P1 of daily minimum temperature (WINTER)

OBSERVED

EVENTS UNDER P1:
Future change
(multi-model mean)
Mean daily maximum temperature (SUMMER)

Future change (multi-model mean)  Std (future change multi-model)
P99 of daily maximum temperature (SUMMER)

OBSERVED

EVENTS OVER P99: Future change (multi-model mean)
P99\_obs = 34.82 °C
P99\_fut = 37.08 °C
4. Future work

• Carry out an analysis of the temporal organization of the extreme events, in order to study the future incidence of droughts, heavy precipitation episodes, heat waves and cold spells.
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