Impact of climate change on weather extremes in Rhineland-Palatinate

Assessment using COSMO-CLM simulations at convection-resolving scale

Christoph Knote

Universität Trier
Motivation

Why changes in extremes?

Extreme events have the most imminent effect on people.

Changes in mean do not tell the whole story: distribution and variability are also important!
Motivation

*Why high resolution climate modelling?*

Influence of small-scale features on atmospheric flow (orography, land use)

Convection resolving

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote
Setup

Positive extremes (maxima) are to be observed.

Time slice experiment:
10 years of summer months in 2 scenarios

---

IPCC AR4 simulations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
</tr>
</tbody>
</table>

Climatology of the 20th century

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
<td>JJA</td>
</tr>
</tbody>
</table>

A1B SRES
200 x 200 gridpoints
40 levels

$\Delta x = \Delta y = 0.012^{\circ}$
(approx. 1.3 km)

COSMO-DE Configuration
+bigger relaxation zone
Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote

COSMO CLM (2.4.11)
\[ \Delta x = \Delta y = 0.04125^\circ \]
approx. 5 km resolution

hourly forced

LandCaRe 2020
Check against forcing data:
Resolution increase from 5 to 1.3 km
Check against forcing:
Differences in 10 m windspeed histograms

Mean unchanged (+-)
Variability increased
Check against forcing:
Precipitation

in C20

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote

Universität Trier
Mean changes between scenarios

**Δ (A1B – C20)**

**Daily**
- **Temperature at 2m**
  - maximum: +2.1 K
  - mean: +1.77 K
  - minimum: +1.95 K
- **Precipitation**
  - very uncertain
- **Wind at 10m**
  - gusts: -0.05 m/s
  - mean speed: -0.03 m/s

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote
Peaks over threshold

How to get information about changes in extremes?

threshold $u$

fitted General Pareto Distribution (GPD)

Bias

Variance

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote
Extreme value analysis: Return levels

Maxima of daily minimum screen level temperature
Extreme value analysis: Changes in 30 yrs return levels

\[ \Delta (A1B - C20) \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>30 yr return value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature at 2m</td>
<td></td>
</tr>
<tr>
<td>daily</td>
<td></td>
</tr>
<tr>
<td>maximum</td>
<td>+4.3 K</td>
</tr>
<tr>
<td>mean</td>
<td>+3.3 K</td>
</tr>
<tr>
<td>minimum</td>
<td>+2.1 K</td>
</tr>
<tr>
<td>Precipitation</td>
<td>-24 mm/mo</td>
</tr>
<tr>
<td>daily</td>
<td></td>
</tr>
<tr>
<td>gusts</td>
<td>-0.05 m/s</td>
</tr>
<tr>
<td>mean speed</td>
<td>-0.03 m/s</td>
</tr>
<tr>
<td>Wind at 10m</td>
<td></td>
</tr>
<tr>
<td>mean speed</td>
<td>-0.21 m/s</td>
</tr>
</tbody>
</table>

very uncertain
Stability of 30 yrs return value for daily 2m temperature mean

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote

1000 iterations of “moving-block“ bootstrapping
Changes in 30 yrs return value of daily 2m temperature maximum

Impact of climate change on weather extremes in Rhineland-Palatinate – Christoph Knote
Changes in 30 yrs return value of 10 m wind gusts

Single events have (too) strong influence on return level calculation.
Conclusions

- **Resolution increase** added variability as expected
- **Mean changes** between scenarios in expected range (temperature, wind)
- **Extreme value analysis** stable
- Increases in **temperature extremes** exceed mean changes
- **Regional differences** visible, further investigation needed to assess consistency
- Mind the **error components**!
Thanks for your attention!

Changes in statistics of extreme values due to expected climate change

Christoph Knote
christoph.knote@empa.ch
2008
Error sources

Data
- Forcing data
  - One realisation of one GCM?
  - Nesting chain?

External Parameters
- Accuracy?
- Resolution?

Model
- (Cold / warm) biases?
- (Interdependence of) Parametrizations?
- Configuration errors?

Extreme value analysis
- Data preparation
  - Detrending?
  - Declustering?

EVT
- Threshold dependencies
- Return level theory
- Goodness of fit of GPD