Deriving GWL-based products for modern climate services

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I) Scenario approach vs. II) Global Warming Levels

I) analyzing a **fixed** time period (end of the century)
II) analyzing a **variable** time period based on a **target temperature** (i.e. GWL)
Past and Future of national climate reports

Current national climate reports (Germany, Austria and Switzerland) are based on evaluations using the scenario approach.

- Stakeholders wonder if GWL-based results could be incorporated into these reports for an easier communication (likewise to AR6).

How do we adapt the GWL concept to regional climate models according to IPCC AR6?

- Which assumptions do we have to take into account?
- What are the limitations/constraints?
Estimation of a GWL period

GCM

- preindustrial period: typically 1850-1900 (but national institutes choose different baselines)
- averaging time window: IPCC AR6 uses 20 years (many national institutes use 30 years)
  - adjusting these ‘parameters’ changes the final model ensemble

RCM – main problems:

- no direct information on global surface air temperature
- no preindustrial period
- What is the best way of adapting GWL information for RCMs?
Estimation of a GWL period

Effects of PI period, time window and taking observations into account on reaching different GWLs (CMIP6 GCMs)

<table>
<thead>
<tr>
<th>method</th>
<th>PI period</th>
<th>time window</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCMonly-IPCC</td>
<td>1850-1900</td>
<td>20y</td>
</tr>
<tr>
<td>GCMonly-REF1880</td>
<td>1880-1910</td>
<td>30y</td>
</tr>
<tr>
<td>GCM+OBS-CH</td>
<td>1981-2010</td>
<td>30y</td>
</tr>
<tr>
<td></td>
<td>+0.71 °C</td>
<td></td>
</tr>
<tr>
<td>GCM+OBS-Vautard</td>
<td>1971-2000</td>
<td>30y</td>
</tr>
<tr>
<td></td>
<td>+0.46 °C</td>
<td></td>
</tr>
</tbody>
</table>
How does bias correction affect GWL analysis? (ongoing)

- analysis of CMIP5 model generation
  - reference ensemble of DWD
- use GCMonly-REF1880 method to get GWL periods
- comparison of RCP2.6, RCP4.5 and RCP8.5:
  - bias-corrected EUR-11 models (10 | 10 | 16)
  - original EUR-11 models (10 | 10 | 16)
  - driving GCMs (4 | 4 | 6)
- $\Delta$tas = tas@GWL - tas@reference period (1971-2000) for Germany
- CMIP5 GCM have higher temperature response over Germany than RCMs (up to 0.8 °C)
- bias-corrected (trend conserving) models show the same temperature change compared to original RCMs (as expected)
How does bias correction affect GWL analysis? (ongoing)

- perform bias correction (trend-conserving) on time periods with equal GWL (0.9 °C)

**SETUP (single RCM @ GeoSphere)**

<table>
<thead>
<tr>
<th>RCM (KNMI-RACMO22E_v1)</th>
<th>GWL 0.9 °C (30y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPI-ESM-LR r1i1p1</td>
<td>1984-2013</td>
</tr>
<tr>
<td>NorESM1-M r1i1p1</td>
<td>1998-2027</td>
</tr>
<tr>
<td>HadGEM2-ES r1i1p1</td>
<td>1994-2023</td>
</tr>
<tr>
<td>IPSL-CM5A-MR r1i1p1</td>
<td>1983-2012</td>
</tr>
</tbody>
</table>

results coming soon!
Prototypes of a new GWL-based scenario products

**Temperature**

deviation from the normal period 1981-2010

Switzerland
yearly mean

RCP2.6  
RCP8.5

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**Temperature**

deviation at Global Warming Levels (PI = +1.49°C)

Switzerland
yearly mean

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Prototypes of a new GWL-based scenario products

- mean over all RCP scenarios (RCP2.6, RCP4.5, RCP8.5)

- deviation from recent reference period: 1971-2000

increase in the amount of summer days (> 25 °C)

<table>
<thead>
<tr>
<th>GWL 1.5 °C</th>
<th>GWL 2 °C</th>
<th>GWL 4 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>#38</td>
<td>#28</td>
<td>#16</td>
</tr>
</tbody>
</table>

ensemble size
Challenges / Questions

➔ How do we deal with a mismatch between observed and simulated historic regional temperature trends using the GWL approach (e.g. Alpine region)?

➔ The GWL concept combines several scenarios and assumes that the way of reaching a target temperature is negligible for the results. Does this assumption hold for all variables that are of interest for impact modellers? Does this assumption also hold for the actual impacts of reaching a certain GWL?

➔ Which challenges arise with respect to the communication of GWL-based products?
Individual GCM simulations
EURO-CORDEX GCMs
GCM Mean
OBS Berkeley
OBS HadCRUT
Overall consistency between CMIP5 and CMIP6

GWLs reached slightly earlier in CMIP6
Underestimation of regional warming rate
... and EURO-CORDEX doesn’t really help 😞