Introduction

In assessing impacts of the forthcoming climate change, the climate change scenarios related to a specific time horizons and emission scenarios are required. These scenarios typically consist of changes in means (and, if possible, in variability) of the leading surface climatic characteristics (especially temperature and precipitation) and are mostly derived from outputs of Global Climate Model (GCM) simulations. Having the scenario, the future-climate time series (commonly with daily step) required as an input to the impact models (e.g. crop growth model) may be produced by the weather generator (WG) whose parameters were modified according to the GCM-based climate change scenario. Although the GCMs do not satisfactorily reproduce some important climatic characteristics, we assume here that the changes even in these features are of higher reliability and may serve in defining the climate change scenario. The present scenarios will be defined in terms of changes (defined as a difference or ratio of simulated future vs. presence) in selected parameters of M&Rfi weather generator, which is calibrated using GCM-simulated surface weather series representing future- and present-climate time slices. The parameters of interest also include those, which drive variability (both short-term and long-term). The purpose of deriving these “WG-friendly” scenarios is to allow for a more straightforward and effective employment of WG in preparing future-climate weather series, which fit the GCM-projected climate.

GCMs (run at SRES-A2 emission scenario; simulations for the IPCC-AR4)

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Model</th>
<th>Center</th>
<th>resolution $n_{lat} \times n_{lon}$</th>
<th>present</th>
<th>future</th>
</tr>
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<tr>
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<td>Bjerknes Center for Climate Research, Norway</td>
<td>124x64</td>
<td>1961-90</td>
<td>2081-2088</td>
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<td>CGCM3 (T47 res.)</td>
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<td>CM3</td>
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<td>2081-2100</td>
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<td>2081-2100</td>
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<td>ECHAM5 -OM</td>
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<td>NPCCM</td>
<td>PCM</td>
<td>National Centre for Atmospheric Research, USA</td>
<td>128x64</td>
<td>1961-90</td>
<td>2081-2099</td>
</tr>
</tbody>
</table>

A: 3 runs available

M&Rfi weather generator (www.ufa.cas.cz/dub/wg/marfi/marfi.htm) is the WGEN-like daily weather generator and a follower of Met&Roll:

- **precipitation occurrence** ~ Markov chain model
- **daily precipitation amount** ~ Gamma distribution
- **the non-precipitation daily variables** ~ 1\textsuperscript{st}-order AR model, whose parameters vary during a year and are conditioned on precipitation occurrence
- **daily WG linked to monthly WG**, which follows AR(1) model (Dubrovský et al., 2005)
- **many major & minor improvements over Net&Roll**
  - optional time-step
  - optional number of variables
  - variables may be non-parametrically transformed to become near-normally distributed
Present Experiment

Scenarios of changes in WG parameters for several European cities are derived from daily output of several GCMs.

Climate change scenario = (future-climate vs present-climate WG parameters). (difference in the case of temperature; ratio in the case of STDs and PREC) ratio. WG parameters are derived from detrended time series (within given time slice)

Climatic characteristics shown here:
- \(d[TAVG]\): change in the mean daily temperature
- \(d[DTR]\): change in the daily temperature range (\(DTR = TMAX - TMIN\))
- \(d[PREC]\): change in precipitation amount
- \(d[std(TAVG_{day})]\): change in standard deviation of daily average temperature
- \(d[std(TAVG_{month})]\): change in standard deviation of monthly average temperature; (changes in STD are calculated from detrended TAVG series)

Sampling errors in scenarios (shown for Prague) are estimated from 10 scenarios derived from 10 pairs of synthetic present-climate and future-climate weather series generated by M&Rfi calibrated from the GCM series

Comments on results

temperature changes:
- TEMP projected to increase everywhere / in all months / according to all models
- Oslo: greatest temperature increase is projected for winter,
- all other stations: the maximum projected increase in summer.
- south-European sites: the changes exhibit a significant annual cycle

precipitation changes:
- changes negatively correlated with TEMP
- inter-GCM uncertainty larger than for TEMP

changes in daily temperature range:
- significant increase in Madrid (nearly all months+all models);
- Oslo: rather decreases
- other stations: decreases in winter, increases in summer

changes in TAVG variability: positively correlated with changes in DTR

inter-model concordance:
- highest uncertainty for change in std(TAVG_{month}), which corresponds to highest noisiness of single-GCM scenarios as well as with the highest sampling errors

intra-GCM uncertainty (based only on CGMR model): lower than between-GCM uncertainty

noisiness in single-GCM scenarios + sampling errors \(\rightarrow\) smoothing could help!!!
(change in daily mean temperature)

(change in precipitation sum)
\[ d \ [DTR] \ [^\circ C] \]
(change in daily temperature range)

\[ d \ [\text{std}(TAVG_{day})] \ [%] \]
(change in TAVG variability)
\[ \downarrow \text{d \left[ \text{std}(TAVG_{\text{month}}) \right]} \text{ [%]} \downarrow \]

(change in monthly TAVG variability)

Oslo [10.7337 E, 59.9117 N]

London [0.1248 W, 51.5006 N]
(change in daily mean temperature)

(-change in precipitation sum)
\[ d \left[ DTR \right] \ [°C] \]

(change in daily temperature range)

\[ d \left[ \text{std}(TAVG_{day}) \right] \ [%] \]

(change in TAVG variability)
\[ d \ [\text{std}(\text{TAVG}_{\text{month}})] \ [%] \]

(change in monthly TAVG variability)
\( d \) [ \( \text{TAVG} \) ] [°C]  
(change in daily mean temperature)

\( d \) [ \( \text{PREC} \) ] [%]  
(change in precipitation sum)
\( d \text{ [DTR]} \) \( ^\circ \text{C} \)

(change in daily temperature range)

\( d \text{ [std(TAVG)]} \) \( \% \)

(change in TAVG variability)
\(\Delta \text{std(monthly TAVG)}\) [%] (change in TAVG variability)