Stochastic Climate Change Scenario Generator for Use in Probabilistic Climate Change Impact Assessments

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1. About this poster

Motivation: The ever increasing volume of GCM simulations available for climate change impact studies allows for better representation of uncertainties (between GCMs, between emission scenarios, between parameterizations, ...). However, the volume of available GCM outputs has become so large that it poses a strong requirement for more effective organization of the climate change impact analyses. In implementing the multi-model information for a given impact analysis, a scenario generator may be used.

The present scenario generator (cliM&Tess) is based on a multivariate parametric model (similar to that used in parametric weather generators, e.g. Dubrovsky et al., 2000, Dubrovsky et al., 2004), whose parameters are derived from a set of GCM-based scenarios (no limit on the size of the set, the model may also be calibrated with a very large perturbed-physics ensemble, e.g. that produced by the NCMRWF climate prediction project). Once calibrated, the generator may produce an arbitrarily large set of climate change scenarios representing the multivariate probability distribution function of the changes in relevant climatic characteristics: the generator reproduces mean annual cycle of changes in climatic characteristics, correlations between them as well as the intermonthly correlations. The scenarios consist of changes in monthly means and variabilities, and are easily linked with the stochastic weather generator M&Rfi, which produces daily (weekly, decadal, monthly) weather series to be used as an input to the impact models.

The main aim of the present experiment is validation of the scenario generator: the impacts obtained with a "classical" approach, which consists of pooling the results obtained with a set of 11 single-GCM-based climate change scenarios (the GCMs coming from the IPCC-AR4 database were run at SRES-A2 emission scenarios) are compared with results obtained using the set of 11th model produced by the scenario generator calibrated with the set of single-GCM-based scenarios. The comparison is made in terms of annual extremes and averages of monthly means of temperature (TEMP) and precipitation (PREC) and in terms of relative Palmer drought indices (Z and PDSI, Dubrovsky et al., 2009). The experiment is performed for a set of 10 European and 11 U.S. stations. The monthly weather generator (M&Rfi) is used to produce 90-year series of TEMP and PREC for present and future climates. In the latter case, the WG parameters are modified according to the climate change scenarios.

2. Scenario generator “cliM&Tess”

1. construction of scenarios from GCM
2. construction of “scenario series”
3. calibration of the scenario generator model parameters from present and future climates
4. generation of synthetic “scenario series”
5. construction of synthetic scenarios
6. generation of synthetic “scenario series”

3. Scheme of the Experiment (made for each of 21 stations)

observed weather series
11 GCM-based scenarios
110y synt. wea.series (present climate)
90 annual MIN, MAX, AVG of (PREC, TEMP, Z-ind, PDSI)
clIM&Tess
100y synt. wea.series (present climate)
11190y annual MIN, MAX, AVG of (PREC, TEMP, Z-ind, PDSI)
WG (1011 future climates)
WG (11 future climates)
WG (present climate)

4. PDSI MODEL (input: SWHC + monthly PREC and TEMP; output: monthly Z-index + PDSI)

5. Summary of results

- Quality of the scenario generator (clIM&Tess vs 11 GCMs):
  - the climate scenario generator works well for AVG(TEMP) [A1]: the means, variability and even 90-year extremes are very close to the values obtained with a set of GCM-based scenarios
  - worse, but still satisfactory fit is obtained for annual MAXima and MINima of TEMP and for the PREC characteristics [A2, A3, B1]: the range between 90-year maxima and minima is mostly overestimated by the scenario generator (compare the overall lengths of middle (“11 GCMs”) vs. right (“clIM&Tess”) bars within the bar triplets. The avg values are, however, mostly satisfactorily reproduced by the generator.
  - even worse misfit is manifested for Z and PDSI drought indices [C1, C2]: not only extreme values, but also avg values are affected.

- Climate change impacts (11 GCMs vs Present climate) this assessment isn’t the main aim of the poster:
  - temperature: increase at all stations
  - precipitation: insignificantly changes or slight decrease at most stations
  - drought: significant increase of drought risk (indicated by lower values of drought indices) at all stations
5. Results

The figures show annual average (AVG), minimum (MIN), and maximum (MAX) temperature, precipitation, PDSI index, and Z index for different climate change scenarios (A1 to D3). Each scenario represents a different climate change projection, with A1 being the present climate and B1 to D3 representing future projections. The graphs illustrate how these variables change over time in Europe and the USA for each scenario.

7. Conclusion

This poster brings the very first results obtained with the climate scenario generator. The results are not perfect (the impacts on selected climatic characteristics obtained with use of the scenario generator differ from those obtained with use of a set of single-GCM-based climate change scenarios), but we hope that improvements may be achieved by improving the model of the scenario generator. It is also assumed, that the quality of the generator may be increased by using higher number of scenarios for calibration.

8. References


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