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

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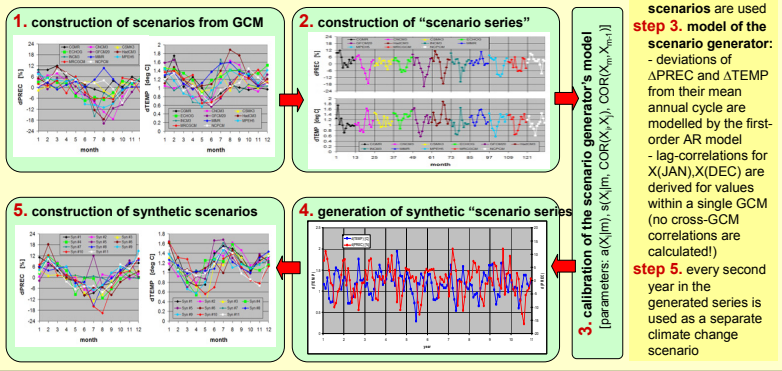
1. About this poster

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 such 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 www.climateprediction.net 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, dekadal, 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 10x11 scenarios 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 made 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"

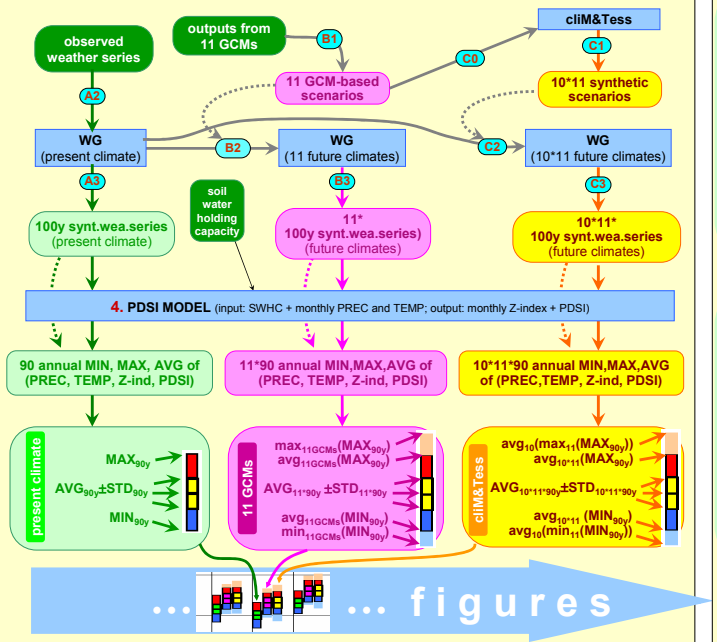


step 1. standardised scenarios are used

step 3. model of the scenario generator:
- deviations of ΔPREC and ΔTEMP from their mean annual cycle are modelled by the first-order AR model
- lag-correlations for X(JAN),X(DEC) are derived for values within a single GCM (no cross-GCM correlations are calculated!)

step 5. every second year in the generated series is used as a separate climate change scenario

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



notes:

A2. calibration of the M&Rfi weather generator (M&Rfi ~ Met&Roll generator described in Dubrovsky et al, 2004)

A3. generation of the synthetic monthly weather series representing the present climate

B1: derivation of the climate change scenarios using the pattern scaling method (Dubrovsky et al., 2005)

B2, C2. modification of WG parameters according to the GCM-based or synthetic (produced by climate scenario generator) climate change scenarios

B3, C3: generation of the synthetic monthly weather series (representing future climates) by the weather generator

C0: calibration of the climate scenario sampler/generator

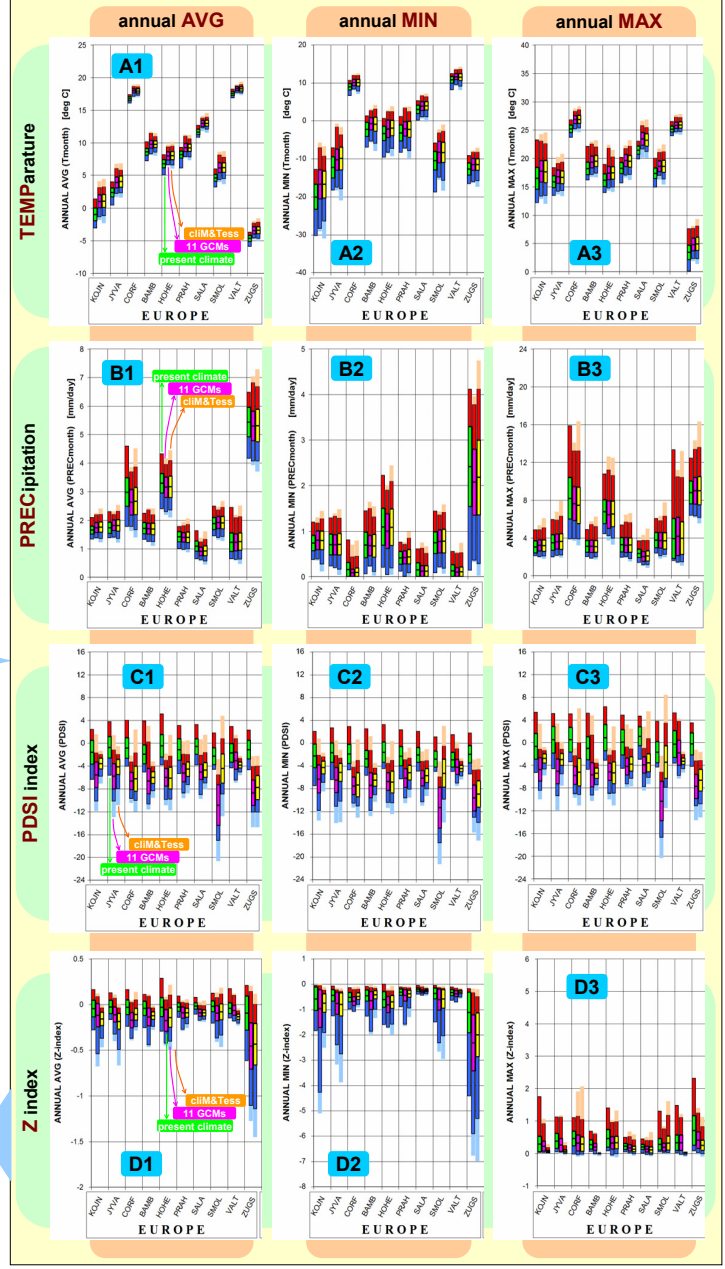
C1: generation of synthetic climate change scenarios

WG = Weather Generator M&Rfi (more flexible version of Met&Roll [Dubrovsky et al., 2000; Dubrovsky et al., 2004]

cliM&Tess = Climate Scenario Sampler based on AR model (see Box 2)

PDSI model = model for Palmer Drought Indices available from NDMC and modified by Dubrovsky et al., 2009

5. Results (results for the U.S. stations are on web version of the poster)



4.1 GCMs used to derive scenarios

(IPCC-AR4 dataset)

acronym	Center	res.x	res.y
CGMR	Canadian Center for Climate Modelling and Analysis, Canada	96	48
CNCM3	Centre National de Recherches Meteorologiques, France	128	64
CSMK3	CSIRO, Australia	192	96
ECHOG	Univ. Bonn Germany + KMA Korea + MPI-M Germany	96	48
GFCM20	Geophysical Fluid Dynamics Laboratory,USA	144	90
HadCM3	UK Met. Office, UK	96	73
INCM3	Institute for Numerical Mathematics, Russia	72	45
MIMR	National Institute for Environmental Studies, Japan	128	64
MPEH5	Max-Planck-Institut for Meteorology, Germany	192	96
MRCGCM	Meteorological Research Institute, Japan	128	64
NCPCM	National Centre for Atmospheric Research, USA	128	64

4.2 Station Weather Data [1961-1990; EC&D project]

Europe	station
BAMB	Bamberg, DE
CORF	Corfu, GR
HOHE	Hohenpeissenberg, DE
JYVA	Jyvaskyla, FI
KOJN	Kojnas RU
PRAH	Praha, CZ
SALA	Salamance, ES
SMOL	Smolensk, RU
VALT	Valentia, Ir
ZUGS	Zugspitze, DE

8. References

Dubrovsky M., Zalud Z. and Stastna M., 2000: Sensitivity of CERES-Maize yields to statistical structure of daily weather series. Clim.Change 46, 447- 472.

Dubrovsky M., Buchtele J., Zalud Z., 2004: High-Frequency and Low-Frequency Variability in Stochastic Daily Weather Generator and Its Effect on Agricultural and Hydrologic Modelling. *Clim. Change* **63**, 145-179.

Dubrovsky M., Nemesova I., Kalvova J., 2005: Uncertainties in climate change scenarios for the Czech Republic. *Clim Res* **29**, 139-156.

Dubrovsky M., Svoboda M.D., Trnka M., Hayes M.J., Wilhite D.A., Zalud Z., Hlavinka P., 2009: Application of Relative Drought Indices in Assessing Climate Change Impacts on Drought Conditions in Czechia. *Theor Appl Climatol.* **96**: 155-171.

6. 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 **MAX**ima and **MIN**ima of **TEMP** and for the **PREC** characteristics [A2, A3, B1-3]: the range between 90-year maxima and minima is mostly overestimated by the scenario generator (compare the overall lenghts of middle ("11 GCMs") vs. right ("cliM&Tess") bars within the bar triplets. The avg±std's are, however, mostly satisfactorily reproduced by the generator.
  - even worse misfit is manifested for **Z** and **PDSI** drought indices [C1-3, D1-3]: not only extreme values, but also avg±std are affected.
- **Climate change impacts (11 GCMs *vs* Present climate)** *(this assessment isn't main aim of the poster)*:
  - **temperature:** increase at all stations
  - **precipitation:** insignificant changes or slight decrease at most stations
  - **drought:** significant increase of drought risk (indicated by lower values of drought indices) at all stations

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.

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