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Weather Generators: Reviewing the State of the Art

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Algorithms for generating synthetic weather time series, especially precipitation and temperature, are important tools for hydrological modelling as well as for civil and agricultural engineering. There is very extensive and rapidly growing literature on the subject. The statistical models that generate this random sequences are called Weather Generators (WGs).

Basically there are single- and multi-site WGs. Since the later type is able to capture the spatial and temporal structure of a variable of interest, it has been recently expanded for the downscaling of Global and Regional Climate Models outputs. The range of techniques used in WGs is large: conditional distribution functions of variables of interest, times series models (ARMA), Markov chains, fuzzy rules, copulas, and combinations of them have successfully been used in the past. There are, however, still a number of open questions regarding the efficiency and robustness of WGs that need to be answered if these models should be used for climate change impact analysis.

In general we aim to define which are the minimum necessary conditions (i.e. statistical tests) that a WG should pass such that the synthetic and observed time series are statistically indistinguishable regarding their single-site values, their spatio-temporal variability, and their stochastic dependence. A sort of Turing test for WGs. In other words, if there is no perfect WG in a sense that it reproduces all statistical properties that one could ask for, we would like to know which is the expected frontier of a given WG. Specifically, we will consider:

1. How well a WG can reproduce monthly and annual totals, length of wet and dry spells, autocorrelation functions, etc.?
2. How well a WG can capture the spatial structure of the variables of interest (e.g. the joint first principal components of the precipitation and temperature fields)?
3. How well a WG can capture the extremes (e.g. percentile 95 of precipitation intensity and dry spell length)?
4. How many sites are necessary to estimate the spatio-temporal variability of the variables of interest?

At the begin of this study we have implemented two recent multisite-WG proposed by Hundecha et al. (2009, WRR) and Brisette et al. (2007, J. of Hydrol.) for the region within and around the Harz mountains, Germany, comprising the Bode River Basin. The area of the study ares is approximately 40000 km2. For this area 863 rain gauges operated by the German Meteorological Service during the period 1960-2010 are employed.

This study is work in progress. Currently the first WG simulating 863 stations lead to singular correlation matrices which, in turn, make the WG inoperative for such large problems. Further reduction to 179 stations (stations that have at least 1800 observations in every decade from 1960-2010) did not improve this situation. We are evaluating various numerical strategies to overcome this issue.