Geophysical Research Abstracts
Vol. 14, EGU2012-6448-1, 2012
EGU General Assembly 2012
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Evaluation of Regional Climate Models: Extremes important for Hydrological Projections

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Well parameterized precipitation-runoff models are often able to reproduce past hydrographs and other state variables quite satisfactorily. In general, extreme events like floods are often linked with heavy rainfall events, persistently long wet spells, rapid temperature increases in winter, among other extreme or rare situations. Getting information to force hydrologic models in future times is not a trivial task. A common approach is to downscale meteorological variables from Regional Climate Models (RCMs) to the desired spatial and temporal resolution required for these models. Therefore, it is crucial that extreme events are well represented in the RCM's outputs.

A significant effort on the evaluation of RCMs has been focused during the past decades to the mean behavior of RCM trajectories and foremost to the identification and correction of model biases. To compare RCMs with each other, it was common to rank them according to their performance. In more recent literature this procedure was enhanced by taking Multi-Model approaches into consideration, where the mean of an ensemble of RCMs is in general better than a single RCM output. Furthermore it has been of interest to evaluate extremes and to correct them. Most studies evaluating RCMs over Europe use either the EObs data set or reanalysis data as reference.

In this study, we also investigate the performance of RCMs with respect to extreme statistics relevant for hydrological projections. In addition to quantifying biases of the RCMs, we focus on the evaluation of the spatio-temporal structure of observed extreme statistics given below. Principal Component Analysis (PCA) was used to evaluate the dimensionality of the selected variables and a bootstrapping technique to test the null hypothesis that observed and simulated extreme values come from the same population. To the best of our knowledge, these techniques have not been used in this context. In addition to that, temporal trends and Taylor diagram for all statistics we considered.

Reanalysis data from thirteen different RCMs from the ENSEMBLES project covering Germany were chosen for the period from 1961 to 2000. A high resolution data set derived by the interpolation of a dense station network operated by the German Weather Service (DWD) was used as a reference (over 5500 rainfall gauges and 1100 weather stations). This study focuses on extreme variables derived from daily precipitation and temperature, such as 95 percentiles of annual and seasonal total precipitation, 95 percentile of daily temperature, frequency of heavy rainfall, cold and hot days per year.

Preliminary results showed that it is very unlikely that the RCM derived statistics and the respective observations are coming from the same populations with a p-values of 1%. PCA, on the contrary, showed that some RCMs are able to represent the overall variability of the observed field in a satisfactory manner (for example for summer and winter total precipitation). A preliminary conclusion of this study indicated that RCM outputs did not preserve the spatio-temporal structure of observed extremes to the level required for operational purposes in hydrological predictions.