Geophysical Research Abstracts
Vol. 13, EGU2011-8418, 2011
EGU General Assembly 2011

Projections of hydrological extremes under climate change in Germany by combining three RCMs with a regional hydrological model

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More frequent and intense extreme events are expected as a consequence of climate change in many regions. In Germany, a general increase in precipitation in winter and a decrease in summer have been observed. There have been more frequent floods in Germany during the last two decades, some of which have been among the most destructive ones ever recorded. During the same period, some extreme drought events (like the 2003 drought) occurred endangering crop yield and water supply. Hence, the potential climate-driven changes in both extreme events are now at the focus of interest.

A study was performed for Germany with the aim to project the future flood and drought conditions accounting for various river regimes and under different emission scenarios: A2, B1 and A1B. All large river basins in Germany: Rhine, upper Danube, Elbe, Weser and Ems were included. Climate scenarios from two dynamical regional climate models (REMO and CCLM) and one statistical-empirical model (Wettreg) were used to drive the eco-hydrological model SWIM, which was previously validated for 15 gauges. At most of the gauges, the seasonal discharge and 95 and 99 percentiles of the simulated discharge using SWIM with observed climate data had a good agreement with the observed ones for the control period (1961 – 2000). However, the simulated discharge had a bias when using RCM climate as input for SWIM for the same period.

The Generalized Extreme Value distributions were fitted to the annual maximum/minimum series of river runoff for the control and scenario periods, and the changes in flood/drought generation over the whole simulation time were analyzed. Here only flood-related results are shortly described. The 50-year flood values estimated for two scenario periods (2021 – 2060 and 2061 – 2100) were compared to the ones derived from the control period using the same climate models (no bias correction). The results driven by two dynamic RCMs give various change directions depending on river basin, emission scenario and time period, whereas the results driven by Wettreg mostly show a declining trend in flood level. More specifically, the results driven by two dynamic RCMs suggest an increase of about 10 – 20% in the 50-year flood level in the rivers Weser, Rhine, Main, Saale and Elbe; whereas there is a likelihood of 20% decrease in the flood level for the Neckar. In contrast, the model Wettreg projects a downward trend for the northern basins Ems and Weser (10%), and Saale (20%), and no distinct trend could be found for the Main, Danube, and Neckar. It is not surprising that contradicting results were also obtained for projected drought indices using climate scenarios from three RCMs.

The uncertainty in estimating extreme events remains high. This is due to differences in regional climate models, emission scenarios and multi-realizations generated by RCMs. Nevertheless, adaptation strategy should account for a high probability of increase in flood intensity in many rivers in Germany, and increase in drought probability in some areas.