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Climate Change Impact Assessment of the 21st Century Water Balance in the Mesoscale Fulda Catchment Area

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Numerous recent climate impact studies have shown that the anticipated change in the radiation balance of the atmosphere due to the increased anthropogenic green house gas emissions will also affect the global hydrological cycle. However, in spite of the ever-increasing resolution of the numerical climate models, a lot of controversy still exists to the extent of the impact of climate change on the regional, mesoscale water balance. Thus, even for a country as small as Germany different reactions of the regional meteorology and hydrology to simulated 21st century climate change have been predicted for various river basins of the country.

In this study the 21st century climate change impact on the water cycle in the 6930 km^2- mesoscale Fulda catchment area in central Germany is assessed in more detail. The objective is to evaluate the effects in central Europe for a better assignment and understanding of the water resources on the regional scale in a global context. For this purpose the future surface water budget in the study area has been simulated with the distributed hydrological model SWAT (Soil and Water Assessment Tool). The model is driven by high resolution climate modeling data for the years 2001-2100 assuming the IPCC-Scenarios A1B, A2, and B1. The comparison-, i.e. calibration and verification period is 1960-2000. The dynamic downscaling of the global circulation model ECHAM5 MPI-OM as carried out by the regional model REMO is the basis of the SWAT's water balance's projection. As for possible 21st century changes in the geographical data are assumed to be negligible.

The model is calibrated for the 1960-1977 and validated for the 1977-2004 time period using measured climate and hydrological data across the Fulda basin. A very good fit of modeled to the measured runoff data is obtained for daily, monthly, and yearly flows (RN^2= 0.89/0.94/0.97). Specific consideration had to be given during the SWAT calibration process to properly incorporate the managed water flows from the large Edertal reservoir. To that regard an artificial neural network approach has been used whereby flow output at a particular station is trained on SWAT's results to reduce the models systematic errors. The following results are found: Considering precipitation, there are periods were the mean yearly amount of precipitation is significantly higher in the forecast period than in the reference period 1960-2000. Although in the long term there is no observed trend in the yearly precipitation, as seasonal redistribution of the latter is obtained. Thus there will be more precipitation in the winter and, accordingly, less rain in the summer. Due to no change in the yearly precipitation the yearly flow rate will rise especially for the climate scenario B1.

The reason for this increase can be found in the increasing runoff amount during the winter half year. The runoff in summer does not change significantly. The evapotranspiration will decline between 2001 and 2100 in all the three scenarios simulated. The climate change impacts more in the distribution of the precipitation within the year and the change of other boundary conditions (e.g. temperature) that affect the system's processes. This study additionally shows how difficult it is to quantify the hydrological changes that indeed will happen in the unknown future. The chain of errors begins with the evaluation of emission scenarios and it ends with SWAT' systematic errors. Thus the most noteworthy result of the present investigation is that in the study area there is mostly certainly an effect on the precipitation distribution within a year and a rising runoff.