Possible impacts of climate change on runoff characteristics of rivers in the Hessian part of the river Rhine catchment

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Research methodology

A study of 7 catchments in Hesse with catchment sizes varying between 500 km² and 27 000 km² was carried out to quantify the possible impacts of climate change on the hydrological behaviour. Climate data based on the general circulation model ECHAM5 were downscaled by the statistical downscaling method WETTREG (SPEKAT et al., 2006) in order to generate daily point values corresponding to meteorological stations of Germany's national meteorological service (Deutscher Wetterdienst). The resulting regional climate projections were provided by the German environmental protection agency (Umweltbundes-amt). These data were used to force the conceptual water balance model LARSIM (LUDWIG and BREMICKER, 2006) to simulate present (1961-1990) and future (2001-2100) streamflow for the area of the river Rhine catchment. To the period 2001-2100 three different IPCC emission scenarios (A1B, A2 and B1) were applied. LARSIM allows a process-based and spatially distributed simulation of the medium-scale mainland water cycle.

The model was validated comparing measured streamflow with streamflow resulting from simulation with observed hydrometeorological data. Climate change impacts were related to the differences between simulated streamflow driven by the WETTREG data for the reference period 1961-1990 and streamflow driven by WETTREG data for the period 2001-2100 based on the three different emission scenarios. Each simulation consists of ten statistical realisations with a time series of 20 years per decade. In the following, mean monthly values of mean discharge, low flow and flood values were calculated and compared. Extreme values on peak discharge result from a percentile statistics of 600 annual flood values for different 30-year periods.

Results (synoptic view over all examined catchments)

Annual **precipitation** amounts do not increase towards the middle of the century, whereas a clear disproportion towards increasing precipitation (+ 10 %) during the hydrological winter half year (i.e. November – April) and a corresponding decrease during the hydrological summer half year (– 5 %) have been observed. By the end of the century the climate projections reveal winterly increases in precipitation of about + 20 % and summerly decreases of about 10 %. Rising mean annual temperatures of about + 0.9 K towards the middle of the century and about + 2 K by the end of the century indicate also decreasing influence of snow cover on hydrological processes.

Mean monthly discharge changes to higher values during December to February whereas lower discharge is expected from June to November. This means an intensification of the existing hydrological regime with winterly high streamflow and summerly low flows. Corresponding to the decrease of discharge in summer the **mean low flow** value which is a common design value concerning surface water regulations decreases by about 10 % towards the middle of the century and 15 % up to the end of the century for all scenarios.

The mean monthly **flood values** are expected to increase by about + 10 % during December to February up to the middle of the century and about + 30 % by the end of the century. Behaviours of **extreme floods** differ significantly between the three IPCC emission scenarios. Highest changes are observed for the A1B scenario, starting with an increase in flood values in the middle of the century with an amount of + 20 %. Lower increased flood values are obtained for the B1 scenario but starting 30 years earlier than in case of the A1B scenario.

In order to provide "climate change factors" for design flood values for the period from now to the year 2050 it seems to be appropriate to consider also results from the period from 2050 to 2080 because of the high variability in floods caused by various possible emission scenarios. It should be pointed out that changes in peak flow are quite unsure because of multiple causes (modelled daily values, uncertain extreme rainfall data from the climate model and downscaling method, high influence of the highest (uncertain) peak flow value of the time series).

Literature:

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