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Effects of climate change on average and extreme streamflow in the Rhine basin

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Due to global warming, the hydrologic behavior of the Rhine basin is expected to shift from a combined snowmelt and rainfall driven regime to a more rainfall dominated regime. Previous impact assessments have indicated that this leads, on average, to increasing streamflow by 30% in winter and spring, and decreasing streamflow by a similar value in summer. In this study, high-resolution (0.088 degrees) regional climate scenarios for the Rhine basin are used to force a macro-scale hydrological model. Climate scenarios are based on model output from the ECHAM5-OM global climate model, which is in turn forced by three SRES emission scenarios: A2, A1B and B1. The Variable Infiltration Capacity model (VIC; version 4.0.5) is used to examine changes in streamflow at various locations throughout the Rhine basin. Average streamflow, peak flows, low flows and several water balance terms are evaluated for both the first and second half of the 21st century. The results reveal a distinct contrast between those periods. The first half is dominated by increased precipitation, causing increased streamflow throughout the year. During the second half of the century, a streamflow increase in winter/spring and a decrease in summer is found, similar to the previous studies mentioned before. This is caused by (1) temperature and evapotranspiration, which are considerably higher during the second half of the century, (2) decreased precipitation in summer and (3) an earlier start of the snowmelt season. Magnitudes of peak flows increase during both periods, that of streamflow droughts only during the second half of the century.