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Scenarios of Socio-Economic and Climate Change and Their Impact on the Simulated Global Hydrological Response

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Over the past decade global hydrological models been applied increasingly at finer spatial resolutions and under more detailed scenarios to investigate the impact of global environmental change. Increasingly, scenarios do not only focus on anthropogenic climate change but also explore expected trends in water demand and land cover change. This provides more detailed information on future pathways and allows for the identification of areas under the elevated threat of hydrological hazards as floods and droughts. Yet, improved scenarios also lead to questions about their internal consistency and how the imposed changes filter and feedback through the simulated hydrology.

In this study, the large-scale water resources model PCR-GLOBWB (Sutanudjaja et al. 2017) was applied globally at a spatial resolution of 5 arc minutes on a daily resolution over the period 1970-2060. For the future, different projections were used that relied on likely combinations of RCP and SSP scenarios to capture the consensus on changes in climate and socio-economic conditions over the 21st century. These scenarios were conditioned on simulations with the integrated assessment model IMAGE of the Netherlands Environmental Assessment Agency (PBL; Stehfest et al., 2014) and translated into changes in land use and water demand that were applied to PCR-GLOBWB. As a further exploration of the possible effects, changes in land use intensity were translated into changes in soil properties via S-World (Stoorvogel et al., 2016). This leads potentially to a more detailed soil parameterization that can be consistently to linked to land use change over time and this adds a new level to existing scenarios.

In this study, we used the results of these simulations to investigate the sensitivity of a global-scale hydrological model to these different scenarios. This allows us to identify the separate and combined effects of climate and socio-economic change and investigate the effect of resolution and information on the outcome. Regionally, changing soil conditions have a small but appreciable effect on the median discharge that is of the same order as that of land use change. The influence of changing soil conditions becomes more important when considering low flows, i.e. under drought conditions. In general, climate change leads in many regions to a higher, yet more variable water availability and this often exceeds the effects of changes in soil and land use. However, there are regions where increased availability is countered by the increase in demand or where availability and demand get further out of phase. At such “hot spots” the interaction between the different components in scenario modelling becomes crucial while at the same time uncertainty in the imposed scenarios become more influential on projected pathways that explore adaptation. By evaluating these aspects critically, this study helps to understand weaknesses in current scenarios and their influence on impact modelling and to define new approaches to improve them.