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Systemic Change in Hydrology: Spatio-temporal parameter variability of the PCR-GLOBWB hydrological model in the Rhine-Meuse basin

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Nowadays, a large part of hydrological research is focussed on hydrological modelling, both to improve system understanding and to simulate future systems to support decision making. Although the necessary simplifications in hydrological models such as empirical formulas or spatial and temporal discretisation can result in deviations in model predictions, hydrological models often perform well due to model calibration. However, fundamental changes in system behaviour can occur that are not represented by the used model structure. These changes can therefore not be simulated and can result in deviating model results. We refer to this situation as 'systemic change'. To detect systemic change, one can calibrate the model separately for different time periods, and evaluate whether thus-found parameter values change over time, which is an indication of systemic change (Verstegen et al., 2016). The aim of this study is to use this approach to detect possible systemic changes in the Rhine-Meuse basin when modelled with the PCR-GLOBWB hydrological model.

PCR-GLOBWB is run for Rhine-Meuse basin for 1901-2010 at a daily time step with a 30 arcminute resolution, after which a brute force calibration is performed for five parameters (degree day factor, Manning's roughness coefficient, soil thickness, saturated hydraulic conductivity and groundwater coefficient) using measured discharge data from the Global Runoff Data Centre (GRDC) at four locations in the catchment. To be able to identify the time stability of these parameters, the model is not only calibrated for the entire 1901-2010 period, but also for 10-year rolling calibration periods (i.e. 1901-1911, 1902-1912, 1903-1913, etc.). This results in a time series with 100 parameter values for each parameter, which is analysed for potential trends at the different calibration locations. First results indicate a decrease in the optimal parameter values for soil thickness and saturated hydraulic conductivity and an increase in the optimal parameter values for degree day factor and Manning's roughness coefficient through time, especially in the upstream areas such as Basel. If the calibration is performed more downstream, for example at Lobith, the optimal parameter values are less variable through time.

These results are used to determine the effect of potential systemic changes on the uncertainty of hydrological predictions by making three forecasts; one with stable parameter values and a

stationary climate, one with time-variant parameter values and one with a future climate scenario. The last forecast enables comparing the magnitude of change caused by the potential time-variant parameters with the change caused by time-variant climatic forcing. This way, the study gives more insight in both the occurrence of systemic change and its potential consequences, which can contribute to a better understanding of the behaviour of hydrological models under changing conditions.

Reference

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