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Prediction and uncertainty analysis of surface and groundwater exchange in a Rhine floodplain in south-west Germany

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Inundations and the resulting exchange between surface water and groundwater are of importance for all floodplain ecosystems. Because of the high groundwater level in floodplains and the groundwater dependence of floodplain vegetation habitat models of floodplains should include detailed information of groundwater and surface water dynamics. Such models can, for example, serve as a basis for restoration measures, focusing on the re-establishment of rare species. To capture these groundwater and surface water dynamics we use a distributed model approach to simulate the groundwater levels in a floodplain stream section of the Rhine in Hesse, Germany (14.8 km2). This area is part of the large nature reserve "Kühkopf-Knoblochsaue" and hosts rare and endangered flora and fauna. We developed a physical-deterministic model of a floodplain to simulate the groundwater situation and the flooding events in the floodplain. The model is built with the Catchment Modeling Framework (CMF) and includes the interaction of groundwater and surface water flow. To reduce the computation time of the model, we used a simple flood distribution scheme instead of solving the St. Venant equation for surface water fluxes. The floodplain is split into two sub-regions, according to the two nature reserve regions with the same model setup. Each model divides the study area laterally into irregular polygonal cells (270 - 400) with different sizes (114 - 480'000 m2), based on similar elevation and land use. For each sub-region the water level of the Rhine and the groundwater levels of three monitoring wells at the boundary of the model area are used as driving factors. As predictor variables we use observation data from four to six different groundwater monitoring wells in the sub-regions. For each model we run 5,000 simulations following a Latin Hypercube sampling procedure to investigate parameter uncertainty and derive behavioral model runs. We received RMSEs between 0.18 and 0.28 m for the different groundwater wells for the calibration period of 2.5 years and RMSEs between 0.16 and 0.23 m for the validation period of 9.5 years. Finally, we derived hydrological predictors (e.g. longest flooding period, amount of flooding days during the vegetation period, etc) from the model runs for following habitat models.