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Morphodynamic simulations of complex river morphologies based on the results of the physical model of the Alpine Rhine

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The projected measures of the flood protection project at the Alpine Rhine River “International river stretch km 65 to km 91” include various adjustments to the riverbed geometry. The consequences of these changes are difficult to predict. Therefore, two physical model studies were conducted in Dornbirn (AT) with reach lengths of around 5.5 km each and a maximum width of up to 360 m. The riverbed was modelled as a mobile bed focusing on the development of the river morphology. Numerical models of both reaches were set up in Basement v3.1 to ensure correct upper and lower boundary conditions. During the project, each discharge scenario was first simulated in the numerical model and then in the physical model.

The calibrated hydrodynamic models were further extended with morphodynamical parameters. These numerical simulations aimed to reproduce the riverbed changes of the physical model. Four different initial riverbeds were chosen for the simulations. Two of them already had a quite developed morphology with alternating bars. The other two initial riverbeds reflected a state between the current trapezoidal channel of the Alpine Rhine River and a braided river system with multiple channels. The calibration of the numerical model has been done with the bed-forming discharge of 1’500 m3/s. Various parameters, such as the cell size, the downstream boundary height, the curvature effect and the gravitational bank collapse, were investigated. The model was validated with two flood events and a discharge hydrograph of a mean year.

The results show that the investigated morphology is independent of the changed parameter and didn’t change during the simulations. However, the precision of the morphology changed drastically with finer cell sizes. Due to the low slope of the Alpine Rhine River on the last 26 km before the inlet into Lake Constance, the choice of the downstream boundary condition had a widespread impact. Overall, the numerical model was able to accurately reproduce the bed changes and the morphological development of the physical model. The differences between the models had their origin in the different model setups, initial conditions of the riverbed and the model limitations.