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Validation of a combined sediment transport modelling approach for the morphodynamic simulation of the upper Hungarian Danube River

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The reliable numerical modelling of morphological changes of rivers is still an unsolved problem, particularly in non-uniform river bed. Several sediment transport formulas were developed for mixed bed materials, however, none of them works well for any general case. For instance, a given non-uniform transport formula is expected and proved to calculate the bed armouring process well. On the other hand, it might estimate the movement and settling of the eroded finer particles less accurately. In order to overcome this issue the authors have elaborated and presented a combined approach implemented in a 3D numerical flow and sediment transport model. The combined approach means that the model applies two models at the same time but spatially differentiated based on the bed material conditions. Here, we use the sediment transport models of van Rijn (1984) and the Wilcock and Crowe (2003). Recent numerical model validation using laboratory data demonstrated the benefits of this novel method (Török et al., 2017).

The main goal of this study is to prove the advantages of the combined approach for field environment. Thus, the upper Hungarian Danube River with non-uniform bed material was selected for morphodynamic modelling purposes. The morphological processes at this river reach are considerably complex, e.g. bed armouring process in the main channel, side gravel bar formation, silting up between the river training structures and sediment deposition in the floodplain caused by floods can be observed. Field measurement data provided hydrological and morphological data for the parameterization of a 3D CFD model. The effect of the historical flood wave in 2013 June was analysed.

The results show that the combined approach resulted in a more accurate simulation of the morphological changes, compared to the separate application of the sediment transport formulas. The Wilcock and Crowe formula calculated reliably the armored bed surface in the main channel which resulted in a quasi-stable bed level, as occurred in reality as well. In turn, the bedload transport model of van Rijn was able to better estimate the bed changes, where the bed composition was finer, e.g. in the vicinity of groin fields. Furthermore, the sediment transport model of van Rijn was able to quantify the bed aggradation in the floodplain caused by the deposition of suspended sediments.