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Hydro-morphodynamic modelling of floodplains: the role of vegetation in suspended sediment transport

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Riverine environments are amongst the most complex ecosystems on the planet. As several anthropogenic factors have increasingly disrupted the natural dynamics of rivers, namely through stream regulation, the need for re-establishing the ecological role of these systems has gained relevance.

Of particular interest are floodplains in compound channels, primarily regarded for safety against floods, but which also comprise an extensive realm for ecological functions and establishment of various species. Floodplain vegetation affects flow resistance and dispersion, playing a fundamental role in erosion and deposition of suspended sediment.

The present work aims at quantifying the interaction between vegetation and suspended sediment transport on floodplains in compound channels by numerical simulations. The employed numerical tool is BASEMENT v3, a GPU-accelerated hydro-morphodynamic 2D model developed at the Laboratory of Hydraulics, Hydrology and Glaciology of ETH Zurich. In the context of the present study, the model is extended with turbulence and suspended sediment transport capabilities. The implemented closure models for turbulence pertain to three major groups, namely (i) mixing-length, (ii) production-dissipation and (iii) algebraic stress models. For suspended sediment transport, the main classical formulations from fluvial hydraulics were implemented in the numerical model.

Laboratory data from flume experiments featuring suspended sediment load and vegetation-like proxies are used for model validation. The numerical results are compared with the observed water depths, velocities and sediment concentrations for different sets of experiments with varying properties, such as density and submergence. The implemented closure models for flow resistance, turbulence and suspended sediment are then combined, calibrated and classified in terms of numerical output quality.

The obtained results from this modelling effort mainly contribute to understanding the applicability of 2D (depth-averaged) models to complex eco-morphodynamics scenarios. The calibration and rating of well-known closure models for turbulence and sediment transport provides relevant guidelines for both future research and practice in fluvial modelling.