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Vaia-event-based model calibration, design of hydraulic hazard mitigation measures using 2D simulations with bedload transport and validation to a physical model: a case study of the Sesto River, in South Tyrol (Italy)

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In the past the Sesto River, the Drava River and the Piccola Drava River have caused flooding in the residential zone of San Candido (BZ) and the surrounding plains. Several flood events have been recorded during the 1700s and 1800s and more recently in 1965, 1966 and 2018. In October 2018, the “Vaia” storm widely affected the northeastern part of Italy and in particular the Sesto River basin, at the border between South Tyrol and Austria. During this event, a cumulated rainfall amount of 363.3 mm was recorded in 72 hours, resulting in a flood along the Sesto River valley. The flood wave monitored at the gauge stations of Sesto, Sesto Pusteria dam, Versciaco and Arnbach along its course, flooded a good part of San Candido.

Because of the hydraulic hazard in San Candido, a project for the mitigation of the hazard of Sesto River has been started. This project consists in the diversion of part of the flood wave by means of a river dam and a lateral spillway. The derived flow is discharged through a hydraulic bypass into the Drava River, which flows eastward downstream from San Candido toward the austrian border. The bypass is drilled across the mountain which separates the Sesto river valley from the Drava valley.

The Sesto river drains a Dolomitic area where the sediment yield is potentially very high, therefore the sediment transport along the river can become important during storms. To evaluate the dynamics of deposition along the study reach, the model BASEMENT v3.0.2 was applied. The computational domain encompasses an area of 2 ha and the mesh is composed of more than 8100 elements whose maximum size is 3 m^2 in the riverbed and 20 m^2 in the floodplain. The 2D morphodynamical model was calibrated on the 2018 Vaia event, thanks to the surveys carried out by the Civil Protection Agency, through a comparison between the deposits obtained numerically and those detected in the field. The hydrogram used as boundary condition was derived through a robust statistical analysis of the discharge time series measured at the gauge stations of Sesto, Sesto dam, Versciaco and Arnbach. The transport capacity along the entire reach was evaluated by the Smart and Jäggy formula using a single-grain characteristic diameter determined by a grain size analysis.

The project main elements have been shaped in the computational mesh: the river dam, the lateral spillway on the orographic right, a new configuration of the bottom of the riverbed with a constant longitudinal gradient of 3%. In particular the river dam has been implemented in the hydraulic model using the INTERNAL BOUNDARY "wall_internal", the new morphology of the bottom has been built directly into the digital terrain model, while the lateral spillway has been modeled with the STANDARD BOUNDARY "weir_out_constant".

Different design configurations were simulated in order to find an optimal solution. The BASEMENT model was used to evaluate the amount of sediment deposited behind the river dam and along the lateral spillway and to define the following design variables: the geometry of the dam, the spillway height, the planimetric positioning of the barrage and the spillway, the longitudinal and transverse slope of the riverbed. The design configuration has also been verified with a physical model set up by the Free University of Bozen-Bolzano.

In conclusion, the results obtained with the model allowed to reproduce the deposits that occurred during the “Vaia” event and to provide useful figures for the optimisation of the design of the mitigation measures of the hydraulic hazard.