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Modelling river bank erosion processes and mass failure mechanisms using 2-D depth averaged numerical model

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Bank erosion is a key process that may cause a large number of economic and environmental problems (e.g. land loss, damage to structures and aquatic habitat). Stream bank erosion (toe erosion and mass failure) represents an important form of channel morphology changes and a significant source of sediment. With the advances made in computational techniques, two-dimensional (2-D) numerical models have become valuable tools for investigating flow and sediment transport in open channels at large temporal and spatial scales. However, the implementation of mass failure process in 2D numerical models is still a challenging task.

In this paper, a simple, innovative algorithm is implemented in the Telemac-Mascaret modeling platform to handle bank failure: failure occurs whether the actual slope of one given bed element is higher than the internal friction angle. The unstable bed elements are rotated around an appropriate axis, ensuring mass conservation. Mass failure of a bank due to slope instability is applied at the end of each sediment transport evolution iteration, once the bed evolution due to bed load (and/or suspended load) has been computed, but before the global sediment mass balance is verified. This bank failure algorithm is successfully tested using two laboratory experimental cases. Then, bank failure in a 1:40 scale physical model of the Rhine River composed of non–uniform material is simulated. The main features of the bank erosion and failure are correctly reproduced in the numerical simulations, namely the mass wasting at the bank toe, followed by failure at the bank head, and subsequent transport of the mobilised material in an aggradation front. Volumes of eroded material obtained are of the same order of magnitude as the volumes measured during the laboratory tests.