Two dimensional modeling of sediment dynamics in braiding rivers

Braided rivers are self-induced forms of alluvial streams which are characterized by a multichannel network separated by ephemeral exposed bars. Prevailing sediment inflow, high stream power and erodible banks are necessary conditions for braiding. The complicated pattern of braided streams and their high dynamics make them challenging for both understanding and modeling. Several modeling works have been conducted in the case of braiding rivers. Here we investigated the robustness of a physical based 2-D model (TELEMAC2D coupled with SISYPHE) and its ability to reproduce the braiding dynamics from the initiation, starting from an initially flat bed with a central incision, to the evolution of the pattern resulting from different flow and sediment forcings and different sediment transport formulas. The idealized river model remained close, dimensionwise, to flume experiments. The boundary conditions of the simulation were chosen to reproduce braiding circumstances. The fact that, on the one hand, the initial condition was a flat bed and, that on the other hand, the choice of boundary conditions was taken as simple as possible, allows to state that the resulting landform is self-induced and therefore permits to directly link the result to the constitutive relations used. This permits an isolated analysis of the model capability to reproduce the morphology and the dynamic characteristic of braided streams. The 2-D simulations were performed using the finite element method for the hydrodynamics and the finite volume method for the morphodynamics. The scheme used for the advection of velocities and water depths were, respectively, the method of characteristics scheme and the mass-conservative distributive PSI scheme, in agreement with the default numerical parameter of TELEMAC. The bed slope effect, the deviation of the solid transport and secondary currents were also taken into account. The simulation results showed that the TELEMAC2D/SISYPHE model was able to successfully reproduce the initiating phase of the braiding pattern. The resulting landform was comparable to flume experiment results. The formation dynamics and bar shape compared well with those observed in both flume experiments and natural rivers. Nevertheless, passing the formation phase, the braiding pattern was not maintained and gradually tended to meander. This tendency of the system to converge to a single channel configuration might be explained by the lack of lateral variation of the inflow but also suggests processes controlling the bars and bank erosion may not be adequately represented and/or damped by the mesh's level of refinement. / Les rivières en tresses sont des cours d'eau présentant plusieurs chenaux qui se divisent, s'entrecroisent et se rejoignent. L'abondance de l'apport en sédiments, une puissance forte et des berges facilement érodables sont des conditions nécessaires au tressage. Dans ce travail, nous avons cherché à évaluer la robustesse d'un modèle 2-D à base physique (TELEMAC2D couplé à SISYPHE) et juger son habilité à reproduire la dynamique de tressage ainsi que l'évolution du motif résultante de différents forçages. La construction du modèle a été largement inspirée d'expériences en canal. Ce choix a été motivé par la disponibilité de données et de points de comparaison. De plus, le fait de prendre comme état initial un fond plat et des conditions aux limites les plus simples que possible, nous a permis de mener une analyse isolée de la capacité du modèle à reproduire un motif de tresses et maintenir son développement.

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