A modeling system handling the wide range of time scales involved in sediment transport processes

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Introduction: Sediment related problems are of huge importance in most projects of costal and river engineering, where navigability is to be kept permanent and storage capacity maintained. Therefore, structures have to be designed considering sediment transport issues and sustainable operation rules need to be developed, both in short and long term perspectives. As a result of the complexity of the governing physical processes and the significant uncertainties affecting input data, modeling tools with a genuine predictive capacity, such as comprehensively validated numerical models, constitute key elements to provide quantitative decision-support in project design and developments. The present communication describes a modeling system dedicated to depth-averaged simulations of flow and sediment transport, as a support for sustainable management of sediments. The characteristics of the modeling system will be detailed, along with several examples of applications.

Characteristic time scales: A challenging issue in sediment transport modeling is the need to handle accurately and efficiently the wide range of time scales involved in the relevant phenomena. Indeed the time scales of interest extend from a few seconds or minutes (e.g. slope failures or rapid scouring) to periods as long as years or decades (long term sedimentation). Therefore, specific numerical modeling tools must be combined to handle reliably and at an acceptable CPU cost the processes characterized by time scales spanning over such a wide range.

Modeling system: The modeling system *WOLF*, developed for about a decade at the University of Liege, is based on a series of complementary numerical tools designed to be combined for covering the whole range of relevant time scales. It includes the following components [1]:

- steady flow and sediment transport model, computing bed equilibrium profile;
- unsteady model loosely coupling sediment transport and flow computation (quasi-steady);
- unsteady model tightly coupling sediment transport and flow computation (fully transient).

Besides, in cases where a direct coupling between sediment transport and flow computations turns out to be unnecessary, several post-processing tools (incl. a "Lagrangian"-type tracking of sediment particles) are available to analyze the results of the hydrodynamic depth-averaged simulations in terms of transport capacity or erosion risk.

Equilibrium vs. non-equilibrium models: Except for the Lagrangian approach, the two-dimensional models discussed above deal with *equilibrium* sediment transport, assuming instantaneous equality between solid discharge and local transport capacity [1]. Since lags between changes in flow conditions and changes in sediment transport may become significant for practical applications, especially as regards suspended load, the modeling system also deals with *non-equilibrium* sediment transport, thus generalizing its range of applicability. Besides, several turbulent closures are implemented, such as Smagorinsky type or k-ε [2], and play an important part since turbulence modeling directly affects predictions of sediment transport. Finally, an original treatment of locally rigid beds is presented, enabling a very general applicability of the models to real cases, often involving non-erodible areas.

Conclusion: A modeling system is presented, which succeeds in handling the wide range of time scales involved in practical sediment management problems. As a result of the flexibility offered in the levels of coupling between flow and sediment transport models, stable and accurate numerical solutions are obtained in a realistic CPU time for predictions of erosion and sedimentation patterns in the short, medium or long term, considering both bed load and suspended load.

References: [1] Dewals, B.J., S. Erpicum, P. Archambeau, S. Detrembleur, and M. Pirotton (2008). *Hétérogénéité des échelles spatio-temporelles d'écoulements hydrosédimentaires et modélisation numérique*. Houille Blanche-Rev. Int., **5**: 109-114. [2] Erpicum, S., T. Meile, B. J. Dewals, M. Pirotton and A. J. Schleiss (2009). *2D numerical flow modeling in a macro-rough channel*. Int. J. Numer. Methods Fluids: in press.