Handling very different time scales in numerical modelling of sediment transport and morphodynamics

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Sediment related problems are of a huge importance in most projects of river engineering and dam design. In the later case, they may have long term impacts, by decreasing the reservoir capacity, as well as short term ones, by damaging the turbines in the case of hydroelectric power plants. Therefore, the detailed analysis of sediment related aspects is increasingly present from the early stages of dam projects. The present communication covers a detailed description of a modelling system suitable for simulating flows and morphological changes in rivers and in the vicinity of hydraulic structures. The modelling system is next applied in the case of an Alpine hydropower project, involving reservoir sedimentation issues and long-term management of the sediments by means of periodic flushing operations.

A challenging issue in morphodynamics modelling is the need to handle accurately and efficiently the wide range of different 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 in the initial phase of a flushing operation …) to periods as long as years or decades (e.g. reservoir sedimentation …). Therefore, specific numerical modelling tools must be combined properly to handle reliably, and at an acceptable CPU cost, the processes characterized by time scales spanning over such a wide range.

The modelling system *WOLF*, developed at the University of Liege, includes a series of complementary numerical tools designed to be combined for covering the whole range of relevant time scales encountered in numerical modelling of sediment transport and morphodynamics. Therefore, the modelling system includes, among others, the following components related to sediment transport:

A. *steady model* computing bed equilibrium profile (fully static);
B. *unsteady model loosely coupling* sediment transport and flow computation (quasi-steady);
C. *unsteady model tightly coupling* sediment transport and flow computation (fully transient).

Besides, in cases where a direct coupling between sediment transport and flow computations appears not necessary, several post-processing tools (incl. a “Lagrangian”-type tracking of sediment particles) are available to analyze the results of the flow simulations in terms of transport capacity, erosion risk …

After a description of the three mathematical and numerical models mentioned above, including a comprehensive discussion of their respective ranges of validity, the presentation will detail the application of the modelling system for a real hydropower project. The study involves four successive steps:

- *step 1*: determination of the cut-off diameter of the reservoir, by means of the “Lagrangian”-type particle tracking technique applied to the flow field simulated with a k-ε turbulence closure;
- *step 2*: computation of the long-term equilibrium bathymetry of the reservoir, by means of *Model A* (*Model B* applies as well);
- *step 3*: simulation by means of *Model C* of the highly transient flows and morphodynamic changes during two distinct flushing operations in the reservoir, in order to evaluate their efficiency;
- *step 4*: application of *Model C* to simulate flushing operations in the river reach downstream of the dam, in order to wash out the deposits resulting from *step 3* (flushing in the reservoir).

The integrated approach provided by the modelling system presented above takes benefit at each stage of the most appropriate and efficient numerical coupling technique, depending on the relevant time scales.

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