Coupling shallow water models with three-dimensional models for the study of fluid-structure interaction problems using the particle finite element method

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ABSTRACT

In the risk assessment of natural disasters and in the territory management we can clearly identify two different areas of study: the local scale of the fluid-structure interaction and the large scale of the natural hazard [7]. The large scale is the flood prediction/forecasting which involves the use of precipitation data or storm surge in simplified models to forecast flow rates and water levels for periods ranging from a few hours to days ahead, depending on the size of the watershed or river basin. The local scale is the study of the fluid-structure interaction using the flood forecast as the external action or boundary conditions of the problem [5].

In the present work, the non-linear shallow water equations are solved with the PFEM2 semi-Lagrangian framework. PFEM2 combines a classic FEM discretization with fixed mesh for solving the flow equations, with a collection of moving particles that are used to transport the flow features in space [4]. This mixed numerical framework allows us to handle advective flows in a more accurate way when compared to traditional formulations [2]. A FIC-based stabilization method is used to prevent the instabilities induced by the Galerkin method [1, 6]. The wetting and drying areas are tracked implicitly allowing positive and negative values for the water depth [3].

The PFEM2 scheme for the shallow-water equations is coupled to the solution of the Navier-Stokes equations for 3D fluids and the equations of 3D solid mechanics, in order to solve FSI problems in environmental flow situations.

Some validation examples of the PFEM2 technique will be shown, as well as simulations of coastal floods and related FSI problems using data from digital models of the terrain.

REFERENCES