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A 2D-3D strategy for resolving tsunami-generated debris flow in urban environments

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The incorporation of solids, either sediment from the natural environment or remains from buildings or infrastructures is a relevant feature of tsunami run-up in urban environments, greatly increasing the destructive potential of tsunami propagation. Two-dimensional (2D) models have been used to assess the propagation of the bore, even in dense urban fronts. Computational advances are introduced in this work, namely a fully lagrangian, 3D description of the fluid-solid flow, coupled with a high performance meshless implementation capable of dealing with large domains and fine discretizations. A Smoothed Particle Hydrodynamics (SPH) Navier-Stokes discretization and a Distributed Contact Discrete Element Method (DCDEM) description of solid-solid interactions provide a state-of the-art fluid-solid flow description. Together with support for arbitrary geometries, centimetre scale resolution simulations of a city section in Lisbon downtown are presented. 2D results are used as boundary conditions for the 3D model, characterizing the incoming wave as it approaches the coast. It is shown that the incoming bore is able to mobilize and incorporate standing vehicles and other urban hardware. Such fully featured simulation provides explicit description of the interactions among fluid, floating debris (vehicles and urban furniture), the buildings and the pavement. The proposed model presents both an innovative research tool for the study of these flows and a powerful and robust approach to study, design and test mitigation solutions at the local scale. At the same time, due to the high time and space resolution of these methodologies, new questions are raised: scenario-building and initial configurations play a crucial role but they do not univocally determine the final configuration of the simulation, as the solution of the Navier-Stokes equations for high Reynolds numbers possesses a high number of degrees of freedom. This calls for conducting the simulations in a statistical framework, involving both initial conditions generation and interpretation of results, which is only attainable under very high standards of computational efficiency.
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