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Coupled Eulerian-Lagrangian transport of large debris by tsunamis

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Tsunamis are notorious for the large disruption they can cause on coastal environments, not only due to the imparted momentum of the incoming wave but also due to its capacity to transport large quantities of solid debris, either from natural or human-made sources, over great distances.

A 2DH numerical model under development at CERIS-IST (Ferreira et al., 2009; Conde, 2013) – STAV2D – capable of simulating solid transport in both Eulerian and Lagrangian paradigms will be used to assess the relevance of Lagrangian-Eulerian coupling when modelling the transport of solid debris by tsunamis. The model has been previously validated and applied to tsunami scenarios (Conde, 2013), being well-suited for overland tsunami propagation and capable of handling morphodynamic changes in estuaries and seashores. The discretization scheme is an explicit Finite Volume technique employing flux-vector splitting and a reviewed Roe–Riemann solver. Source term formulations are employed in a semi-implicit way, including the two-way coupling of the Lagrangian and Eulerian solvers by means of conservative mass and momentum transfers between fluid and solid phases.

The model was applied to Sines Port, a major commercial port in Portugal, where two tsunamigenic scenarios are considered: an 8.5 Mw scenario, consistent with the Great Lisbon Earthquake and Tsunami of the 1st November 1755 (Baptista, 2009), and an hypothetical 9.5 Mw worst-case scenario based on the same historical event. Open-ocean propagation of these scenarios were simulated with GeoClaw model from ClawPack (Leveque, 2011).

Following previous efforts on the modelling of debris transport by tsunamis in seaports (Conde, 2015), this work discusses the sensitivity of the obtained results with respect to the phenomenological detail of the employed Eulerian-Lagrangian formulation and the resolution of the mesh used in the Eulerian solver. The results have shown that the fluid to debris mass ratio is the key parameter regarding the conservativeness of the model. This way, in highly resolved meshes and high quantities of debris, the model approaches full conservativeness only if the two-way coupling feature is present, an effect that is attenuated in coarse meshes or with small debris quantities.

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