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3D long-wave runup with GPU-SPHysics

Robert Weiss (1), Andrew Munoz Munoz (1), Robert Dalrymple (2), Alexis Herault (3), and Guiseppe Bilotta (4)
(1) Texas A&M University (weiszr@tamu.edu), (2) Johns Hopkins University, (3) Istituto Nazionale di Geofisica e Vulanologia, (4) Universita di Catania

The dynamics of tsunami waves have been modeled in the last three decades commonly with two-dimensional approaches. The water-surface deformation is computed in two horizontal dimensions, which are often parallel to the geographical coordinates. The comparisons of such models with experimental data, field data, and analytical solutions resulted in a suite of computer models, often using different forms of the Shallow-Water approximation. These models have been proven to reliably and robustly simulate the runup and flow depth on land and surface dynamics near- and offshore. With the help of these models, fundamental knowledge of tsunami dynamics of the source could be gathered, including propagation and inundation. Furthermore, computational resources have improved so tremendously that real-time computations are possible and are used in the predictive frameworks of tsunami forecast systems.
With the installment of forecast systems, it is critical for communities to know how the local tsunami threat is characterized. For these hazard assessments to be carried out, quantifiable information on the local magnitude of past events is needed. Mostly, tsunami deposits are utilized as natural recorders of tsunami events. As the local hazard is dominated by the source as well as local geometric characteristics, evidence such as tsunami deposits ought to be understood as the result of three-dimensional processes, for which only three-dimensional models can be used to simulate the complex dynamics ranging over several spatial scales.
GPU-SPHysics solves the Navier-Stokes equations in three dimensions while utilizing the computational resources of the GPUs (Graphical Precessing Unit) on graphic cards. Our long-term goal is to employ GPU-SPHysics for simulation of three-dimensional and small-scale processes during tsunamis, i.e. sediment transport. To reach this goal, as a first step we present results of validation studies commonly used as benchmarks for two-dimensional models to show that GPU-SPHysics is capable of producing accurate results for tests in which two-dimensional models performed very well. The benchmark tests that we employ are the runup on a sloping beach and around a conical island. Both tests are part of the standard benchmarks for tsunami inundation models published by NOAA.