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Complete workflow for tsunami simulation and hazard calculation in urgent computing using HPC services

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Tsunami urgent computing procedures quantify the potential hazard due to a seismically-induced tsunami right after an earthquake, that is from minutes to a few hours. The hazard is quantified by simulating the tsunami from source to shore, taking into account the uncertainty in the source parameters and the uncertainty associated with the wave generation, propagation, and inundation.

In the European eFlows4HPC project, an HPC workflow for urgent computing of tsunami hazard assessment is currently being developed, consisting of the following steps: 1) retrieval of parameters for the tsunamigenic earthquake (magnitude, hypocentre and associated uncertainties), 2) definition of a seismic source ensemble, 3) simulation of the tsunami generated by each scenario in the ensemble, 4) aggregation of the results to produce an estimate of tsunami hazard, which also incorporates a basic treatment of uncertainty modelling and 5) update of the ensemble based on incoming data.

Initially implemented on the Power-9 machine at BSC, the workflow has been fully embedded into a PyCOMPSs framework that enables parallel task execution and integrates full tsunami simulations for the first time. The tsunami numerical model (Tsunami-HySEA) computes the tsunami from the source to coastal impact using nested grids with resolution from kilometres to meters.

To limit the number of simulations and converge faster towards stable hazard estimates, new methods for defining the seismic source ensembles have been developed. When applied to several past earthquakes and tsunamis (e.g., the 2003 Boumerdes and the 2017 Kos-Bodrum earthquakes), our new sampling strategy yielded a reduction of 1 or 2 orders of magnitude for ensemble size, allowing a drastic reduction in the computational effort. This reduction may be exploited to improve tsunami simulation accuracy, increasing the computational effort available for each simulation for the same overall cost. The workflow also allows the integration of new incoming data (focal mechanism, seismic or tsunami records) for an “on the fly” update of the PTF based on this new information.

The improvement of the workflow through a well-defined ensemble of scenarios, realistic simulations and integration of incoming data, strongly reduces the uncertainty and yields to an update of the probabilistic forecasts without compromising theiraccuracy. This can be crucial in mitigating the risk far from the seismic source, and in improving risk management by better informing decision-making in an emergency framework.