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Optimal source selection for local probabilistic tsunami hazard analysis

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Local hazard models for evacuation planning should accurately describe the probability of exceeding a certain intensity (e.g. flow depth, current velocity, etc.) over a period of years.

Computational-based probabilistic forecasting for earthquake-generated tsunamis deals with tens of thousands to millions of scenarios to be simulated over very large domains and with sufficient spatial resolution of the bathymetry model. The associated high computational cost can be tackled by means of workflows that take advantage of HPC facilities and numerical models specifically designed for multi-GPU architectures.

For the sake of feasibility, Seismic Probabilistic Tsunami Hazard Assessment (S-PTHA) at local scale exploits some approximations in both source and tsunami modeling, but uncertainty quantification is still lacking in the estimates. Here, we propose a possible approach to reduce the computational cost of local-scale S-PTHA, while providing uncertainty quantification.

The algorithm performs an efficient selection of scenarios based on the tsunami impact on a site.

The workflow is thought to take advantage of parallel execution on HPC clusters. Hence, as a first step, the whole ensemble of scenarios is split into a finite number of regions defined by the tectonic regionalization; then the procedure selects the scenarios mainly contributing to the hazard at an offshore point (in front of the target site) and for specific intensity levels. Finally, for each intensity level, the totality of synthetic tsunamigenic earthquakes is optimally sampled with replacement in a Monte Carlo Importance Sampling scheme.

The tsunamis potentially triggered by the selected scenarios are explicitly simulated with the GPU-based Tsunami-HySEA nonlinear shallow water code on high spatial resolution grids (up to 10 m) and subsequently the Monte Carlo errors are finally propagated to the onshore estimates.

This procedure allows for lessening the computational cost of local S-PTHA by reducing the number of simulations to be conducted while quantifying the epistemic uncertainties associated with the inundation modeling without appreciable losses of information content.