Community tsunami inundation maps for selected ICG/CARIBE EWS member states

C. Sánchez-Linares¹ (csl@uma.es), Jorge Macías¹, Íñigo Aniel-Quiroga², Ignacio Aguirre-Ayerbe³, Mauricio González² & Bernardo Aliaga³

Introduction

The Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions, ICG/UNESCO, as part of its Tsunami Programme is currently implementing major initiatives aimed at reducing the vulnerability of its Member States in the Caribbean and adjacent regions to tsunamis and other coastal hazards. This project focuses on supporting the CARIBE EWS, coordinated by IC/CARIBE, to develop accurate products towards the reduction of the tsunami vulnerability and the advance of the global tsunami preparedness in the area.

- Strengthens the capacities of early warning and response for tsunamis in the Caribbean
- Develops of community-level tsunami inundation maps for select coastal communities
- Support community preparedness for and response to tsunamis

Tsunami-HySEA model implements in the same code the three phases of an earthquake generated tsunami generation (Okada deformation model), propagation and coastal inundation (non-linear shallow-water system).

Tsunami-HySEA numerical model

Okada deformation model

- In the generation stage, Okada’s fault deformation model (Okada, 1985) is used to predict the initial bottom deformation that is transmitted to the sea surface.
- Assumes that an earthquake can be regarded as the rupturing of a simple fault plane.
- The fault is described by a series of parameters, comprising dip angle, strike angle, rake angle, fault width, fault length, and fault depth.
- Tsunami-HySEA can combine several fault planes to model the complete seafloor deformation and each fault could be applied at different time steps to simulate the full rupture time.

Shallow Water System Equations

- Uses the well-known 2D transient nonlinear shallow water system

\[ \frac{\partial h}{\partial t} + \frac{1}{2} \frac{\partial (hu)}{\partial x} + \frac{1}{2} \frac{\partial (hv)}{\partial y} = gh_f \frac{\partial z}{\partial t} \]

\[ \frac{\partial v}{\partial t} + \frac{1}{2} \frac{\partial (hu)}{\partial y} + \frac{1}{2} \frac{\partial (hv)}{\partial x} = -gh_f \frac{\partial z}{\partial x} \]

- \(h, v\) denotes the thickness of the water layer at points \(O \in D \subset \mathbb{R}^2\) at time \(t\); \(D\) is the horizontal projection of the 3D domain where the tsunami takes place.
- \(h_f\) is the depth of the bottom at point \(O\) (measured from a fixed level of reference).
- \(\alpha\), \(\beta\) are coefficients that correspond to the free surface of the fluid.
- \(\alpha = \sqrt{\frac{M}{g}} - 1\) is the Manning coefficient.

Numerical Scheme

- Solves the two-dimensional shallow-water system using a high-order (second and third order) path-conservative finite volume method
- The numerical scheme is conservative for both mass and momentum in flat bathymetry, and, in general, is mass preserving for arbitrary bathymetry
- Implementation of Tsunami-HySEA has been performed on GPUs and it handles nested grids
- These facts allows to speedup the computations, being able to perform complex simulations, in huge domains, much faster than real time.

Tsunamiogenic sources characterization

- A specific seismotectonic study was carried out, based on the tsunami historical events and the available catalogue of tsunami scenarios.
- Numerous scenarios were simulated.
- Worst-case scenarios were selected to proceed with a deterministic analyses of the tsunami hazard.

Results

Inundation maps

Maximum height in selected events and locations using tsunami level in Caribbean and high resolution level in local communities

References