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Balanced modelling of shallow slip amplification along subduction zones and its effects on near-field tsunami hazard

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Recent giant mega-thrust earthquakes (Sumatra 2004, Chile 2010, Tohoku 2011) have confirmed that the complexity of coseismic slip distributions may play a fundamental role in generation and coastal impact of the tsunami waves. In particular, shallow large slip patches, sometimes characterised by slow seismic rupture propagation within low rigidity zones, can contribute to the prominent increase of the tsunamigenic potential.
In the eastern Mediterranean Sea, all the coastlines are located within less then 1,000 km from any of three subduction structures, namely the Hellenic Arc at the boundary between the African and Aegean plates, the Calabrian Arc between the European and African plates, and the Cyprian Arc between the Anatolian and the Sinai plate.
To study the effects of heterogeneous slip distributions on the tsunami hazard in the Mediterranean region, we modelled a representative set of earthquake ruptures using discretized high-resolution 3D fault geometries with realistic variability of strike and dip angles.
In order to allow single events to release significantly more slip in the shallower part of the rupture without violating the expected long-time conservation of the total seismic/aseismic slip on a subduction zone, we define two slip probability-density functions (PDFs), both depending on rigidity/coupling variations with depth. The first PDF defines the expected spatial distribution of slip for a single event being inversely proportional to rigidity, and directly proportional to the seismic coupling. This will be referred to as slip PDF. The second PDF represents a probability of occurrence for a given event, it also depends on the rigidity (and coupling) at the average depth of a seismic scenario.
Individual k-2 stochastic slip distributions are generated using a kinematic model where we use the slip PDF to modulate the location of random sub-asperities (and hence slip) in order to account for shallow slip amplification.
In order to have a full coverage of the seismogenic portion of the subduction zones, we computed about 20,000 6.0 Mw 9.0 earthquakes source models and corresponding tsunami propagation in the Hellenic, Calabrian, and Cyprian Arcs.
For each scenario, tsunami propagation was computed using the HySEA numerical code, and tsunami inundation heights were recorded at a number of selected points of interest in the Mediterranean.
For hazard purposes, the probability of occurrence of individual seismic scenarios was used to modulate the probability of each inundation scenario.
Our model provides a simplified tool and examples to include slip heterogeneous distributions into the tsunami hazard assessment by taking into account the conservation of the total slip. We also show how shallow slip amplification may control the tsunami hazard and how significant this effect may be for the near-field hazard assessment. This approach has been used in the TSUMAPS-NEAM project hazard assessment (http://www.tsumaps-neam.eu/).