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Heterogeneous slip distribution on faults responsible for large earthquakes: characterization and implications for tsunami modelling

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The fact that ruptures on the generating faults of large earthquakes are strongly heterogeneous has been demonstrated over the last few decades by a large number of studies. The effort to retrieve reliable finite-fault models (FFMs) for large earthquakes occurred worldwide, mainly by means of the inversion of different kinds of geophysical data, has been accompanied in the last years by the systematic collection and format homogenisation of the published/proposed FFMs for different earthquakes into specifically conceived databases, such as SRCMOD. The main aim of this study is to explore characteristic patterns of the slip distribution of large earthquakes, by using a subset of the FFMs contained in SRCMOD, covering events with moment magnitude equal or larger than 6 and occurred worldwide over the last 25 years. We focus on those FFMs that exhibit a single and clear region of high slip (i.e. a single asperity), which is found to represent the majority of the events. For these FFMs, it sounds reasonable to best-fit the slip model by means of a 2D Gaussian distributions. Two different methods are used (least-square and highest-similarity) and correspondingly two “best-fit” indexes are introduced. As a result, two distinct 2D Gaussian distributions for each FFM are obtained.
To quantify how well these distributions are able to mimic the original slip heterogeneity, we calculate and compare the vertical displacements at the Earth surface in the near field induced by the original FFM slip, by an equivalent uniform-slip model, by a depth-dependent slip model, and by the two “best” Gaussian slip models. The coseismic vertical surface displacement is used as the metric for comparison. Results show that, on average, the best results are the ones obtained with 2D Gaussian distributions based on similarity index fitting. Finally, we restrict our attention to those single-asperity FFMs associated to earthquakes which generated tsunamis. We choose few events for which tsunami data (water level time series and/or run-up measurements) are available. Using the results mentioned above, for each chosen event the coseismic vertical displacement fields computed for different slip distributions are used as initial conditions for numerical tsunami simulations, performed by means of the shallow-water code UBO-TSUFD. The comparison of the numerical results for different initial conditions to the experimental data is presented and discussed.
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