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Tsunami run-up variability due to heterogeneous slip on the fault plane

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Most tsunami models apply dislocation models that assume uniform slip over the entire fault plane, and the standard analytical models based on Volterra's theory of elastic dislocations are propagated. Here, we quantify tsunami run-up variability for an earthquake with fixed magnitude but with heterogeneous rupture distribution in the assumption of plane wave propagation (i.e. an infinitely long rupture). A simple stochastic analysis over 500 slip realisations illustrates the expected variability in co-seismic slip along a fault plane and the subsequent run-up that can occur along a coastline in the near field. Due to the need for systematically analysing different geometries, grid resolutions, and hydrodynamic models, several 100 000 model runs are needed. Therefore, simple but efficient linear models for the the tsunami generation, propagation, and run-up estimation are used. The mean value and variability of the maximum run-up is identified for a given slope configuration and analysed for different dip angles. For a large number of cases it turned out the first positive waves did not break (by means of the breaking number discussed by Didulenkova et al., 2008), allowing validity of the linear models in terms of maximum run-up estimation. On the other hand, for the second positive wave after the first withdrawal most waves seems to break, thereby violating the model validity. Discussion on the run-up statistics are therefore limited to first positive wave. Based on the ensemble runs, non-hydrostatic effects are discussed, both with respect to its effect on the generation, but also for the near shore propagation and run-up. It is concluded that for the geometry and magnitude investigated, non-hydrostatic effects reduces the variability of the run-up, i.e. hydrostatic models will produce an artificially high variability. It is stressed that 3D effects (including variability in the strike direction) are expected to further reduce the run-up variability, however, such effects are not given emphasis here.