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Modeling optimal initial conditions for propagation of seismotectonic tsunamis: a database of smoothed unit sources based on an efficient and accurate numerical integration

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The initial conditions for the numerical simulation of a seismically-induced tsunami are modeled by transferring the impulse produced by the co-seismic seafloor deformation to the sea-surface. In this process, the water column acts as a hydraulic filter for the smaller wavelengths. The numerical simulation of this process is computationally demanding; this makes the application of this filter unaffordable in studies that require a large number of simulations, such as the long-term probabilistic tsunami hazard assessment (PTHA). Here, we optimize the numerical modeling of the filter in the case of an instantaneous vertical seafloor deformation, given by an improper Fourier expansion integral in the wave number domain presented by Nosov and Kolesov (PAGEOPH, 2011); the contribution of elementary seafloor displacements can then be linearly combine to obtain a static tsunami initial condition. We first explore the convergence of the integral in one dimension, to identify the range of wavenumbers significantly contributing to the integral. We find that its support can be limited to $\frac{5}{H}$, being H the sea-depth. We then compare several quadrature formulae, selecting the optimal one in terms of accuracy and efficiency. We grid the domain into cells of equal size and constant depth, and verify that the nonlinear effects are negligible when we recombine them to obtain the initial sea level displacement. In two dimensions, the integral is solved with the optimal quadrature and the results tested on the tsunamigenic Kuril doublet sequence - a megathrust and an outer-rise - occurred in the Central Kuril Islands in late 2006 to early 2007. We also consider the horizontal co-seismic deformation projected on a slope and a simple model of the inelastic deformation of the wedge, on a realistic bathymetry. The approach proposed results accurate and fast enough to be relevant for practical applications, taking a few seconds for solving a single cell, depending on the local depth, and ~3min to recombine ~91k elementary initial conditions. We finally build a database of elementary initial conditions, as a function of the local sea depth, which can be linearly combined to obtain a discretization of any sea floor displacement globally.