Generating random waveforms for stochastic tsunami simulations

Luca Arpaia, Jeremy Rohmer, Anne Lemoine, Rodrigo Pedreros

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L. Arpaia[1,*], J. Rohmer[1], A. Lemoine[2] and R. Pedreros[1]

[1] French Geological Survey, Coastal Risk and Climate Change

[2] French Geological Survey, Seismic risk Unit

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Numerous near-field earthquake-induced tsunami simulations have shown that the spatial distribution of the fault slip can have a significant impact on the nearshore wave propagation and ultimately on the wave height in some sensitive areas. However fault rupture is a complex phenomenon which depends on pre-rupture stress condition, geometrical setting and frictional property of the fault, which are largely unknown. In the present study, we model the slip spatial field on the fault as a random field [Mai and Beroza, 2002]. Instead of resorting to the classical Gaussian assumption, random slip patterns are modeled using a joint lognormal distribution to account for the fact that the probability of negative values is zero. The Karhunen-Loeve (KL) expansion is used to generate the slip patterns [Gonzalez et al., 2016] while the free surface ocean displacement is computed by means of the Okada solution of an elastic dislocation problem. We investigate the relationship between the slip spectrum and initial waveform spectrum. We show that, in the context of Probabilistic Tsunami Hazard Analysis, we can effectively reduce the number of terms retained in the slip expansion. The interest is to compactly represent the mapping between a variable of interest at coast Y and the vector of the input random variables (the coefficients of the KL expansion) through the generalized Polynomial Chaos Expansion (gPCE) implemented in the Openturns software [Baudin et al., 2015]. The gPCE surrogate is tested on idealized one-dimensional benchmarks as well as on the historical event of the 1755 Lisbon tsunami.

[*] l.arpaia@brgm.fr, 3 Avenue Claude Guillemin, 45100 Orléans