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Reconstruction of the Initial Tsunami Waveform by SVD Technique

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An approach is proposed to the reconstruction of the initial tsunami waveform by the inversion of tsunami tide gauge records. It is well known that the above formulated problem is an ill-posed problem of mathematical physics. The mathematical description of the direct problem of tsunami wave propagation consists in a system of linear shallow-water equations in the rectangular coordinates with depth assumed to be an arbitrary function of two variables. This system is approximated by the explicit-implicit finite difference scheme on a uniform rectangular grid yielding a system of the linear algebraic equations. The ill-posed inverse problem is regularized by means of the least square inversion using the truncated SVD approach. The numerical simulating yields the so-called r-solution. The quality of the solution is determined by relative errors in the reconstruction of initial waveform.We would like to find out how accurately a tsunami source can be reconstructed using records at a given tide gauge network. The proposed approach makes it possible to control the numerical instability and, therefore, to obtain an acceptable result despite the ill-posedness of the problem. Numerical simulating was applied to the real bottom relief of the Peru coastal zone and the synthetic data were first perturbed by the background noise. As a model of the original tsunami source the bottom deformation due to the typical tsunamigenic earthquakes with reverse dip-slip or low-angle trust mechanisms was used. After reconstructing the initial tsunami waveform a smoothing procedure was performed in order to improve the result. Although only a part of the tide gauge network was used for the inversion, a good agreement was obtained between the synthetic marigrams and marigrams calculated from the reconstructed tsunami source for all points of the network which verifies the adequacy of the algorithm. The agreement of marigrams is very important for prediction of the water elevation based on the data provided by some tide gauges. It should be admitted that the results obtained strongly depend on the presence of the noise due to the ill-posedness of the problem. Numerical results were found to be highly sensitive to a spatial distribution of the monitoring stations relative to bathymetric features. The proposed approach provides to be extremely helpful for evaluating the feasibility of using a given network of tide gauges for the reconstruction of the initial tsunami waveform.