Initial tsunami signals in the lithosphere-ocean-atmosphere system

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Satellite and ground based instrumentations for monitoring of dynamical processes under the Ocean floor (3/4 of the Earth surface) and resulting catastrophic events should be adapted to unknown physical nature of transformation of the oceanic lithosphere's energy of seismogenic deformations into measurable acoustic, electromagnetic (EM), temperature, and hydrodynamic (tsunami) waves. To describe the initial (up to a tsunami wave far from a shore) stage of this transformation and to understand mechanism of EM signals arising above the Ocean during seismic activation, we formulate a nonlinear mathematical model of seismo-hydro-EM geophysical field interaction in the lithosphere-Ocean-atmosphere medium: from the upper mantle under the Ocean up to the ionosphere domain D. The model is based on the theory of elasticity, electrodynamics, fluid dynamics, thermodynamics and geophysical data.

On the basis of this model and its mathematical investigation, we calculate generation and propagation of different (see above) waves in the basin of a model marginal sea (the data on the central part of the Sea of Japan were used). At the moment $t=$0, the dynamic interaction process is supposed to be caused by weak (may be, precursory) sub-vertical elastic displacements (with the amplitude, duration and main frequency of the order of a few cm, sec and tenth of Hz respectively) at the depth of 37 km under the sea level, i.e. in the upper mantle. Other seismic excitations may be considered as well. The lithosphere EM signal is generated in the upper mantle conductive layer M (0.02 S/m, similar conductive structures are well-known in the case of tectonically active lithosphere zones). The horizontal component of seismic disturbance of the geomagnetic field replicates approximately the spatial structure of the seismic P wave (spatial modulation) started from M because of the initial displacements. The EM wave outruns the seismic P wave and arrives at the sea bottom at the moment $t=$3.5 sec with the magnetic signal amplitude of 50 pT. But propagation of the seismic EM signal occurred to be practically stopped (!) at the bottom because of a high electric conductivity of seawater (3.5 S/m). Fortunately, the delayed seismic P wave's shock into the sea bottom (at the moment t_p= 5.3 sec) generates a vertical flow above the area of the initial contact of the P wave front with the bottom. This flow of high conductive seawater in presence of the geomagnetic field along with the EM contact conditions at the sea surface causes EM emission into the atmosphere where the ULF

seismo-EM signal is spreading immediately. (Let us remember we described the visualization of our runs). The frequency spectrum of the EM signal above the sea is similar to the spectrum of the seismic excitation in the upper mantle under the sea floor. The amplitude of the computed magnetic signal (300, 200, 50, and 30 pT at the sea surface and at the height of 10, 30 and 50 km respectively, t = 10 sec), its main frequency (0.25 Hz), delay of the seismic P wave in regard to the magnetic signal (20 sec for receivers at the shore), parameters of a long (150 km) tsunami wave of a small amplitude (up to 15 cm) far from the shore, the seismic temperature disturbance (up to 0.02 K at the sea bottom) and other characteristics of the seismo-hydro-EM process correspond to observations. These results are typical by runs with different input data about the medium (e.g. compressibility and non-compressibility assumption on the hydrodynamic component of the model) and its seismic excitation. If the latter is strengthening then the computed signals' amplitudes increase proportionally (approximately). We describe a multilevel (sea bottom station, moored buoy and stratosphere balloon) multidisciplinary (e.g., sea bottom EM sounding and radio-tomography with satellites) lithosphere-Ocean-atmosphere monitoring system.