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Computerized Workstation for Tsunami Hazard Monitoring

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We present general structure and functionality of the proposed Computerized Workstation for Tsunami Hazard Monitoring (CWTHM). The tool allows interactive monitoring of hazard, tsunami risk assessment, and mitigation – at all stages, from the period of strong tsunamigenic earthquake preparation to inundation of the defended coastal areas. CWTHM is a software-hardware complex with a set of software applications, optimized to achieve best performance on hardware platforms in use. The complex is calibrated for selected tsunami source zone(s) and coastal zone(s) to be defended. The number of zones (both source and coastal) is determined, or restricted, by available hardware resources.

The presented complex performs monitoring of selected tsunami source zone via the Internet. The authors developed original algorithms, which enable detection of the preparation zone of the strong underwater earthquake automatically. For the so-determined zone the event time, magnitude and spatial location of tsunami source are evaluated by means of energy of the seismic precursors (foreshocks) analysis. All the above parameters are updated after each foreshock. Once preparing event is detected, several scenarios are forecasted for wave amplitude parameters as well as the inundation zone. Estimations include the lowest and the highest wave amplitudes and the least and the most inundation zone. In addition to that, the most probable case is calculated. In case of multiple defended coastal zones, forecasts and estimates can be done in parallel. Each time the simulated model wave reaches deep ocean buoys or tidal gauge, expected values of wave parameters and inundation zones are updated with historical events information and pre-calculated scenarios. The Method of Splitting Tsunami (MOST) software package is used for mathematical simulation.

The authors suggest code acceleration for deep water wave propagation. As a result, performance is 15 times faster compared to MOST, original version. Performance gain is achieved by compiler options, use of optimized libraries, and advantages of OpenMP parallel technology. Moreover, it is possible to achieve 100 times code acceleration by using modern Graphics Processing Units (GPU). Parallel evaluation of inundation zones for multiple coastal zones is also available. All computer codes can be easily assembled under MS Windows and Unix OS family. Although software is virtually platform independent, the most performance gain is achieved while using the recommended hardware components.

When the seismic event occurs, all valuable parameters are updated with seismic data and wave propagation monitoring is enabled. As soon as the wave passes each deep ocean tsunameter, parameters of the initial displacement at source are updated from direct calculations based on original algorithms. For better source reconstruction, a combination of two methods is used: optimal unit source linear combination from preliminary calculated database and direct numerical inversion along the wave ray between real source and particular measurement buoys. Specific dissipation parameter along with the wave ray is also taken into account.

During the entire wave propagation process the expected wave parameters and inundation zone(s) characteristics are updated with all available information. If recommended hardware components are used, monitoring results are available in real time.

The suggested version of CWTHM has been tested by analyzing seismic precursors (foreshocks) and the measured tsunami waves at North Pacific for the Central Kuril's tsunamigenic earthquake of November 15, 2006.