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New method to determine initial surface water displacement at tsunami source

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Friday, March 11, 2011 at 05:46:23 UTC, Japan was struck by an 8.9-magnitude earthquake near its Northeastern coast. This is one of the largest earthquakes that Japan has ever experienced. Tsunami waves swept away houses and cars and caused massive human losses.

To predict tsunami wave parameters better and faster, we propose to improve data inversion scheme and achieve the performance gain of data processing.

One of the reasons of inaccurate predictions of tsunami parameters is that very little information is available about the initial disturbance of the sea bed at tsunami source. In this paper, we suggest a new way of improving the quality of tsunami source parameters prediction.

Modern computational technologies can accurately calculate tsunami wave propagation over the deep ocean provided that the initial displacement (perturbation of the sea bed at tsunami source) is known [4]. Direct geophysical measurements provide the location of an earthquake hypocenter and its magnitude (the released energy evaluation). Among the methods of determination of initial displacement the following ones should be considered.

- Calculation through the known fault structure and available seismic information. This method is widely used and provides useful information. However, even if the exact knowledge about rock blocks shifts is given, recalculation in terms of sea bed displacement is needed. This results in a certain number of errors.
- GPS data analysis. This method was developed after the December 2004 event in the Indian Ocean. A good correlation between dry land based GPS sensors and tsunami wave parameters was observed in the particular case of the West coast of Sumatra, Indonesia. This approach is very unique and can hardly been used in other geo locations.
- Satellite image analysis. The resolution of modern satellite images has dramatically improved. In the future, correct data of sea surface displacement will probably be available in real time, right after a tsunamigenic earthquake. However, today it is not yet possible.
- Ground-based sea radars. This is an effective tool for direct measurement of tsunami wave. At the same time, the wave is measured at a rather narrow area in front of the radar and does not include information about neighboring parts of the wave.
- Direct measurement of tsunami wave at deep water [2]. Today, this technology is certainly among the most useful and promising. The DART II® system consists of a seafloor bottom pressure recording (BPR) system, capable of detecting tsunamis as small as 1 cm, and a moored surface buoy for real-time communications.

We focus our research on improving the later method, direct measurement of tsunami wave at deep water. We suggest the new way to analyze DART data, modifying the methodology originally proposed by V. Titov. Smaller system of unit sources [3] should be considered to approximate all typical shapes of initial disturbance by several suitable basis functions. To successfully implement it, performance of data analysis should be dramatically improved. This could be done by using a signal orthogonalization procedure for considered system of unit sources and calculation of Fourier coefficients of the measured time series with respect to orthogonal basis. The approach suggested was used as a part of computerized workstation for tsunami hazard monitoring [5-6].

1. National Oceanic and Atmospheric Administration Center for Tsunami Research. URL: http://nctr.pmel.noaa.gov/honshu20110311/
2. National Data Buoy Center. URL: http://www.ndbc.noaa.gov/dart.shtml

3. National Oceanic and Atmospheric Administration Center for Tsunami Research. URL: http://sift.pmel.noaa.gov/thredds/dodsC/uncompressed/

4. National Oceanic and Atmospheric Administration Center for Tsunami Research. URL: http://nctr.pmel.noaa.gov/model.html

5. Alexey Romanenko, Mikhail Lavrentiev-jr, Vasily Titov, "Modern Architecture for Tsunami Hazard Mitigation" // Asia Oceania Geosciences Society (AOGS-2012), ISBN 978-981-07-2049-0

6. Mikhail Lavrentiev-jr, Andrey Marchuk, Alexey Romanenko, Konstantin Simonov, and Vasiliy Titov, "Computerized Workstation for Tsunami Hazard Monitoring", Geophysical research abstracts, Vol. 12, EGU2010-3021-1, 2010