On application of GNSS-techniques for early tsunami warning in the Sea of Japan

*Grigorii Viktorovich Nechaev[1,2,3], Nikolai Shestakov[2,3], Hiroaki Takahashi[1], Mako Ohzono[1]

1. Institute of Seismology and Volcanology, Graduate Schooll of Science, Hokkaido University, 2. Far Eastern Federal University, 3. Institute for Applied Mathematics FEB RAS

Tsunami hazard threatens an extensive coastlines located in the seismically active areas. About 250000 persons were killed by tsunami only with the beginning of 21th century. Thus, the problem of reliable early tsunami warning is very important nowadays.
The most of working tsunami early warning systems (TEWS) are based on seismic methods that often cannot provide a reliable and accurate warning due to different reasons. The GNSS-based TEWS recently has been developed and they are free of many shortcomings of seismic methods. Such systems utilize coseismic shifts measured by onshore GNSS-networks for tsunami modeling. The TEWS operating now, for example, REGARD [Kawamoto S. et al., 2017], are mainly focused on detection of huge Mw8-9 class subduction zone earthquakes. They are not designed to process relatively small events, which can produce coseismic displacements less than 10 cm, despite on RTX-techniques or recently developed methods [Fratarcangeli F. et al., 2018], which can detect site position changes of 1-2 cm in horizontal and 3-4 cm in vertical components. However, devastating tsunamis regularly appear in the Japan Sea. They are caused by shallow thrust seismic events with magnitudes Mw6.2-7.8. These quakes generate tsunamis more effectively than Pacific ones with the same magnitude.The epicenters of tsunamigenic earthquakes are distributed along the western coast of Honshu, south-west of Hokkaido and Sakhalin Islands. Nevertheless, tectonics and seismicity of the Japan Seahaven't been sufficiently investigated still and tsunamigenic seismic events can occur along the north-western margin of the sea. For example, the potentially tsunamigenic Mw~6 shallow seismic event occurred near the northeastern coast of Primorye on Nov. 11, 1990.
In this work we explored: 1) the capacity of GNSS-based TEWS application using data about historical Mw 6.2-7.8 Japan Sea crustal seismic events. The appropriate coseismic displacement fields were calculated and analyzed. Possible hypothetic tsunamigenic seismic sources were also considered; 2) the optimal GNSS-site distribution for earthquake source parameters obtaining based on existing and prospective GNSS-networks configuration in the region.
We obtained, that historical tsunamigenic earthquakes occurred along the eastern margin of the Japan Sea induced coseismic displacements ranging from 1 cm to a few decimeters through the northern Honshu and western Hokkaido. Even 1964 Oga-oki, Mw7.0 event caused up to 4 cm surface offsets on the Honshu Island coast. Southwestern Sakhalin Island are also might be affected by centimeter level coseismic movement invoked by the shallow Mw 6.2-7.3 earthquakes appeared in the north of the Sea of Japan and Tatar strait. Hypothetical events with Mw > 7.5 and located in the north-west of the sea may excite displacement varying from 1 to 4 cm in Russian Primorye and Hokkaido Island. A set of inversion tests lead us to a conclusion that GEONET GNSS-network might be used to model tsunamigenic earthquake sources with Mw>7.0-7.8 distributed along the eastern margin of the Japan Sea. Working and prospective GNSS-networks located along the western coast of the sea and Sakhalin Island might be involved into processing of seismic events with Mw ≧ 7.3 appeared in the northern part of the sea.

This work was partially supported by the RFBR grant No. 17-55-53110 and JREX Fellowship.

Keywords: tsunami early warning, GNSS

