Development of Ionosphere-Based Methods for Disaster Risk Assessment in Near-Real-Time

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Nowadays, the near-real-time (NRT) monitoring and prediction of tsunami propagation in both near-field (<500 km from the source) and far-field (>500 km away from the source and trans-ocean propagation) remain very challenging. The modern tsunami forecasts rely on 1) real-time and NRT estimation of earthquake magnitude from seismic data; 2) NRT estimation of the seismic source extent and the amplitude of the co-seismic crustal uplift, and 3) monitoring of tsunami propagation in NRT. The seismic source parameters can be rapidly estimated in NRT by using data from ground-based seismometers, accelerometers and Global Navigation Satellite Systems (GNSS)-receivers. However, even the most advanced seismo-geodetic methods still fail to correctly estimate the tsunami potential for large EQs (Mw>8) in real-time.

To resolve this fundamental challenge, an ionosphere-based approach has been suggested as an alternative or/and complimentary to the "classic" methods. The ionosphere is a part the Earth's atmosphere with the maximum of ionization located at 200-400 km of altitude. However, despite being high above the surface, the ionosphere is responsive to surface events such as natural hazards, explosions, rocket launches, etc. Earthquakes and tsunamis generate acoustic and gravity waves that propagate upward and trigger ionospheric perturbations that are often called co-seismic and co-tsunamic ionospheric disturbances (CSID and CTID, respectively). Such ionospheric disturbances carry the information about the source that generated them. Consequently, we can use ionospheric measurements in order to reconstruct information about the source. However, up to now there are no seismo-ionospheric methods that can perform in NRT.

This contribution aims to present recent advances in the area of ionospheric detection of earthquakes and tsunamis, and new developments toward NRT tsunami risk assessment from the ionosphere.

The future ionosphere-based system will be based on quasi-continuous observations of the ionospheric total electron content (TEC) by ground-based GNSS receivers. Data of some GNSS receivers are already available in NRT (e.g., https://www.unavco.org/data/gps-gnss/real-time/real-time.html; http://guardian.jpl.nasa.gov/). Once the data are collected, the following steps must be performed in order to assess the tsunami risk in NRT: 1) automatic detection of CSID/CTID and confirmation of their link with earthquakes/tsunamis; 2) inversion for earthquake magnitude and co-seismic crustal uplift from CSID (for near-field); 3) inversion of tsunami wave heights and the propagation speed based on analysis of features of CTID (for far-field).

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