GNSS-TEC remote sensing of earthquakes, tsunami and volcano eruptions: modeling and observations

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Abstract

Large earthquakes and other energetic natural hazards such as volcano eruptions and tsunamis, strongly shake the neutral atmosphere, from the ground surface up to the ionosphere. Today, transient changes in ionosphere Total Electron Content (TEC) are routinely detected using dual-frequency GNSS receivers and linked to acoustic and gravity waves forced from below. In zones equipped with dense GNSS arrays, wave-like perturbations can even be imaged. Recent progress in numerical modeling of co-seismic TEC perturbations allow us to constrain the origin of the perturbations, which is a forward step toward making use of GNSS-TEC as an additional dataset for natural hazards mitigation.

In this presentation, we provide a report on our efforts to build a database of TEC waveform observations and numerical simulations. We present information regarding data storage and data format. We propose a data format that we feel will facilitate interdisciplinary collaboration across the natural hazard community (e.g., seismology, infrasound, ionosphere communities). The simulations are from the IonoSeis software and are based on acoustic ray tracing coupled with a 3D background electron density. A by-product of the waveform simulations are 4D electron density perturbations (1D in time and 3D in space), which enable creating TEC time series with any chosen satellite-receiver geometry (e.g. radio occultation geometries). We illustrate the database with two events: the 2010 Maule earthquake offshore Chile and the more recent 2022 Tonga volcano eruption that was observed with not only GPS and GLONASS constellations, but also Galileo, Beidou and SBAS satellites from ground and space.