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Worldwide GNSS ionospheric response of the magnitude 8.8 2010 Chilean earthquake and tsunami: a revisit

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The third-largest earthquake of this 21st century ruptured the Andes subduction zone offshore of the Maule region in central Chile on 27 February 2010, in the middle of the night (3:35 am local time). This huge event triggered strong and destructive seismic motions accompanied by a devastating local tsunami and a significant transpacific tsunami. We investigate the impact of this earthquake on the ionosphere using Global Positioning System (GPS) satellites and other Global Navigation Satellite System (GNSS) data. Investigations related to ionospheric disturbances induced by mega-earthquakes accelerated with the Mw9.0 Tohoku earthquake of March 2011. The worldwide GNSS network, including the exceptionally dense Japanese GNSS network, observed a complex ionospheric response. With a better understanding of the physical mechanisms behind it and a more exhaustive data collection, we revisit the ionospheric wavefield triggered by the Mw8.8 Chile earthquake and tsunami.

When a large underwater earthquake occurs, the sudden shaking of an extended region of the sea-floor immediately transfers energy to the water column and the air above through an efficient solid-ocean-atmosphere coupling mechanism. The earthquake at depth thus excites seismic and tsunami waves in the ocean and acoustic-gravity waves in the atmosphere. In the lower frequency range (< 20 mHz), these atmospheric waves can propagate to the upper atmosphere, which shakes the ionosphere. During propagation in the rarefying atmosphere, the wave amplitude drastically increases by about four orders of magnitude. Typically, a tsunami with a height of the order of a meter in an open ocean puts the ionosphere into motion with peak displacement exceeding a kilometer at about 200 km of altitude. The shaken charged particles of the ionosphere plasma eventually induce fluctuations of propagation delays in radio signals, such as those emitted by GPS and GNSS satellites. We convert GNSS measurements into Total Electron Content (TEC) variations to study the ionospheric imprint.

We revisit the Maule earthquake with an in-depth analysis of the TEC data derived from a worldwide collection of GNSS records. We also compare the observed ionospheric responses to ground or ocean motions derived from high-frequency GNSS receiver data recorded onshore and

offshore. Doing so, we further characterize the filtering effect of the atmosphere on acoustic-gravity waves driven from the Earth's surface. Finally, we use numerical tools specifically developed to investigate the complex seismo-ionospheric wavefield triggered by large seismic ruptures. We focus on the resonant part of the seismo-acoustic response and the tsunami-induced ionospheric response and link them to waveguides in the solid-ocean-atmosphere system. This revisit intends ultimately to shed new and independent light on the 2010 Maule mega-earthquake rupture itself.