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Discrimination of Earthquake Precursors using Radio-Tomography of the Ionosphere

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This program relates to addresses lithospheric-ionospheric coupling during strong earthquakes (EQ). We discuss both the ionospheric implications of EQs, and the ionospheric precursors to EQ. the data are analyzed using the methods of satellite radio tomography (RT). Signals from both low-orbiting beacons ("LORT": Transit, Parus, Tsikada, etc.) and high orbiting global navigational satellite systems ("HORT": the GNSS satellites: GPS, GLONASS, Beidot, ...)are used for tomographic reconstructions.

Our resulting 2D and 3D tomographic images and their time flow (4-D RT) allow us to map spatio-temporal changes due to ionospheric perturbations induced by EQs and EQ precursors. Low-orbital RT (LORT) provides near “instantaneous” mappings, with a time span of 5-8 minutes, and 2-D graphics of the electron density over the seismically active region of interest. LORT supports 2D imaging of various anomalies, including wave structures such as ionospheric manifestations of acoustic-gravity waves (AGW), wave-like disturbances, and solitary waves with the gaps between images, depending on the number of operating satellites (currently, 30-100 minutes).

High-orbital RT (HORT) provides imaging of 4D distributions of ionospheric plasma (resulting in 3D snapshots every 20-30 minutes). Using this approach, one can reconstruct RT images of ionospheric irregularities, wave structures, and perturbations such as solitary waves. In regions with a sufficient number of GNSS receivers (California, Japan), 4-D RT images can be generated every 2-4 minutes. The spatial resolution of LORT and HORT systems is on the order of 20-40 km, and 100 km, respectively.

We present the results of a long-term study using HORT and LORT techniques for study of the ionosphere over California, Alaska, and Southeast Asia (Taiwan region). In particular, we established a ground station array extending from Washington to California, which we operated from 2011 to 2013 on a 24/7 basis. Reconstructions of the ionosphere using those data showed evidence of earthquake precursory processes from hours to days prior to earthquakes along the US West Coast. The system proved to be approximately 80% successful in discriminating unique signatures which correlated well with the eventual events in terms of geo-location of the eventual epicenters. Additionally, ionospheric waves arriving over the US West Coast as a result of Japan’s Tohoku event were recorded, arriving well ahead of the ocean waves, suggesting use of the ionospheric tomography technique for timely tsunami early warning and determination of wave heights.