International Beacon Satellite Symposium BSS-2016
Trieste, Italy

Seismic and Ionospheric Signatures for the Study of Underwater Earthquakes: Modeling Developments

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ABSTRACT

In the last decade, it has been established that major earthquakes, volcano eruptions and tsunamis create waves propagating in the ionosphere that are observable as Total Electron Content (TEC) perturbations. We report here theoretical investigations and numerical modeling of TEC signals induced by ground and ocean motions aiming to a better quantitative understanding of these signals. Such development is needed to evaluate the benefit of incorporating TEC signals into tsunami early-warning systems. Recent studies show that current technology based on inland ground motions, geodetic measurement and tsunami gauges still needs improvement within 10 minutes after the earthquake/tsunami onset. In this study, we are using SPECFEM3D, a code based on the Spectral Element Method (SEM) to develop a numerical model of TEC perturbations. This model couples an elastic layer representing the Solid Earth to acoustic layers representing the ocean and atmosphere. Theoretical thermodynamics and physics considerations were used to develop an Earth atmosphere model parameterized for acoustic wave propagation. We will present results for different TEC events that show good fit with coseismic ionospheric observations; our model successfully predicts an acoustic pulse and fast-propagating (~3.5 km/s) Rayleigh-coupled waves as well as the acoustically resonant response of the atmosphere. This latter can be physically explained by multiple reflexions in the low atmospheric waveguide. Further quantitative examination aims to model attenuation effects, as well as finite fault effects (rupture history). We will also investigate how waves and TEC signal are affected by gravity (under the Cowling approximation), especially at low frequencies (~4mHz). Finally, we will present results for the Planet Mars where a lander with a microbarometer is planned to be launched in the coming couple of years.