Study of Ionospheric Response to Space Weather Disturbances in Three Dimensions Using the GPS Observation System

X. Pi, A. J. Mannucci, B. A. Iijima, and A. Komjathy

Jet Propulsion Laboratory, California Institute of Technology, California, USA
(Xiaoqing.Pi@jpl.nasa.gov / FAX: +1-818-393-5115 / Phone: +1-818-354-4257)

The Global Positioning System (GPS) satellites and global as well as regional networks of hundreds to thousands of ground-based permanent GPS receiver stations have become an unprecedented space weather observation system since the beginning of the new millennium. The GPS observables, namely carrier phase and pseudorange as well as signal power, can be processed to retrieve ionospheric measurements along the receiver-to-satellite line-of-sight, such as total electron content (TEC) and scintillation indices. Acquired simultaneously in various directions towards multiple satellites from a single site, such data provides ionospheric "weather" information in an area extending up to 2000 km distance from the station. Combining these global simultaneous measurements to produce time sequences of images, such as Global Ionospheric Maps (GIM), makes it possible to observe and understand space weather effects in the ionosphere on global-scales. This space weather observation system has also been augmented with space-borne GPS receivers on board low Earth orbiters (LEO's) including CHAMP, SAC-C, IOX, and GRACE. A new constellation of 6 LEO's of the COSMIC mission and an equatorial orbiter C/NOFS carrying space-borne receivers will be launched in this year. Space-borne GPS receivers are capable of acquiring in zenith-viewing geometry, as well as occultation geometry where GPS satellites rise or set behind the Earth's limb. Altitude profiles of ionospheric electron density can be derived from occultation measurements using inversion techniques, which can be combined with ground-based observations to extend GPS-based measurements of the ionosphere to three dimensions. Recently, space-borne GPS data have been assimilated together with ground GPS data into the 3-D Global Assimilative Ionospheric Model (GAIM) developed at the Jet Propulsion Laboratory and University of Southern California. Data assimilation allows adjustment of ionospheric density profiles computed by first-principles modeling, so that the model output can match real-world ionospheric weather conditions. In this paper, we will present ionospheric disturbances acquired from space-borne and ground-based GPS data at middle and low latitudes during space weather disturbances. The revealed three-dimensional structure provides insight into storm-time ionospheric electrodynamics and thermospheric variations, which drive various ionospheric perturbations at middle and low latitudes including triggering or suppression of ionospheric irregularities.