JPL/USC GAIM:
Using COSMIC Occultations To Estimate Ionospheric State and Drivers

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Abstract

We are in the midst of a revolution in ionospheric remote sensing driven by the illuminating powers of ground and space-based GPS receivers, new UV remote sensing satellites, and the advent of data assimilation techniques for space weather. In particular, the COSMIC 6-satellite constellation launched in April 2006 and the satellites will soon be in their final orbits. COSMIC provides global coverage of GPS occultations (~5000 per day), each of which yields electron density information with unprecedented ~1 km vertical resolution. Calibrated measurements of ionospheric delay (total electron content or TEC) suitable for input into assimilation models are available in near real-time (NRT) from the COSMIC project with a latency of 30 to 120 minutes. Similarly, NRT TEC data are available from two worldwide NRT networks of ground GPS receivers (~75 5-minute sites and ~125 more hourly sites, operated by JPL and others). The combined NRT ground and space-based GPS datasets provide a new opportunity to more accurately specify the 3-dimensional ionospheric density with a time lag of only 15 to 120 minutes. With the addition of the vertically-resolved NRT occultation data, the retrieved density profiles will model the hour-to-hour ionospheric "weather" much more accurately.

The University of Southern California (USC) and the Jet Propulsion Laboratory (JPL) have jointly developed a real-time Global Assimilative Ionospheric Model (GAIM) to monitor space weather, study storm effects, and provide ionospheric calibration for DoD customers and NASA flight projects. JPL/USC GAIM is a physics-based 3D data assimilation model that uses both 4DVAR and Kalman filter techniques to solve for the ion & electron density state and key drivers such as equatorial electrodynamics, neutral winds, and production terms. Daily (delayed) GAIM runs can accept as input ground GPS TEC data from 1000+ sites, occultation links from CHAMP, SAC-C, and the COSMIC constellation, UV limb and nadir scans from the TIMED and DMSP satellites, and in situ data from a variety of satellites (DMSP and C/NOFS). RTGAIM ingests multiple data sources in real time, updates the 3D electron density grid every 5 minutes, and solves for improved drivers every 1-2 hours. Since our forward physics model and the adjoint model were expressly designed for data assimilation and computational efficiency, all of this can be accomplished on a single dual-processor Unix workstation. Customers are currently evaluating the accuracy of JPL/USC GAIM "nowcasts" and several-hour forecasts for ray tracing applications and trans-ionospheric path delay calibration.

In the presentation, we will discuss the expected impact of COSMIC occultation data, present results from assimilation of ground GPS TEC and COSMIC links into GAIM, and validate the retrieved GAIM density profiles by comparisons to incoherent scatter radar (ISR) profiles during June, September, and December of 2006.