Study of the Accuracy and Spatial-Temporal Resolution of Ionospheric Data Assimilation due to Ingestion of RO Observations from Satellite Constellations

Bust, G. S., Johns Hopkins University, Applied Physics Laboratory
Dyrud, L., Johns Hopkins University, Applied Physics Laboratory
Fentzke, J., Johns Hopkins University, Applied Physics Laboratory
Datta-Barua, S., San Jose State University

There are currently plans for several different low earth orbiting (LEO) constellations of satellites carrying GNSS radio occultation (RO) sensors. COSMIC 2 and GEOScan are just two examples of such constellations. When these new constellations are considered in concert with existing LEO RO satellites and other 1-2 satellite missions such as the SMC SENSE mission, the ability of ionospheric data assimilation algorithms to ingest RO data and produce accurate, high spatial and temporal resolution of ionospheric state variables is becoming a realizable practical reality. Given the future availability of a large number of RO observations from satellite constellations, there are several important questions that need to be investigated regarding the accuracy and resolution limits of data assimilative techniques, as well as what are the optimal number of RO satellites, and in what kind of orbits?

This presentation will address these questions by generating cases of simulated test data from simulations of ionospheric and thermospheric state variables, ingesting the test data into the ionospheric data assimilation algorithms “Ionospheric Data Assimilation Four Dimensional” (IDA4D) and “Estimating Model Parameters from Ionospheric Reverse Engineering” (EMPIRE), and analyzing the output estimates of the state variables from IDA4D and EMPIRE.

In particular, we will use two different types of ionospheric state simulations. The first type will be a full, self-consistent, coupled ionospheric-thermospheric simulation using TIEGCM. This simulation will investigate the ability to accurately estimate the global, large scale (~ 500 km and larger horizontally) electron density from IDA4D and neutral winds and electric fields from EMPIRE, given a certain configuration of input satellite data. The second type of simulation will begin with a smooth background ionosphere from IRI or TIEGCM and will then artificially add small-scale structures such as Gaussian depletions and enhancements, polar cap patches, and equatorial bubbles. This second simulation allows investigation of the ability of IDA4D to resolve smaller scale, moving and evolving structures for various satellite configurations.

The output analysis of IDA4D and EMPIRE will be compared with the simulated “true” ionospheric state. A number of different performance metrics will be used to evaluate the performance of the data assimilation analysis as a function of satellite constellation configuration. The results of the analysis will begin to quantify important design questions such as given a desired accuracy, and spatial-temporal resolution requirement, how many satellites are needed and in what configuration to meet the requirements.