THE IMPORTANCE OF COSMIC OCCULTATION DATA FOR IONOSPHERE SPECIFICATION

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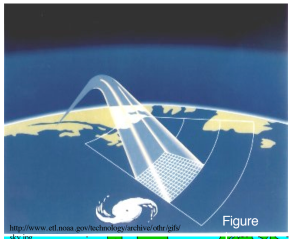


ABSTRACT

The lack of accuracy of ionospheric models in specifying the variability of electron density in the ionosphere has placed significant limitations on the performance of navigation, communication, and surveillance systems based on radio wave propagation. The existing operational data assimilation models that calculate the TEC and electron density distribution in the ionosphere use observations from networks of ground-based GPS receivers and a priori information from a model. Ground-based GPS data provide accurate information about the horizontal electron density gradients, but limited information about the vertical gradients. In addition, the ability of a network of ground-based GPS receivers to measure the detailed ionospheric structure critically depends on the density of the GPS receivers. On the other hand, radio occultation data obtained from the low-Earth orbit (LEO) satellites equipped with GPS receivers contain high-resolution information about the vertical gradients and entangled information about the horizontal gradients. In this paper we present preliminary results obtained from a test-bed for assessing the importance of different data sets, such as ground-based GPS and COSMIC occultation data, in the assimilation of measurements that specify the electron density distribution in the ionosphere.

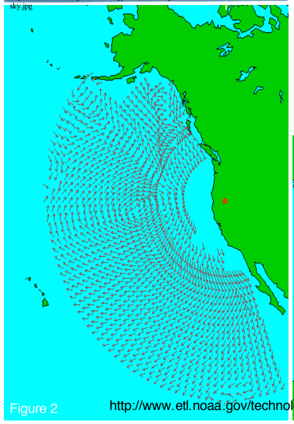
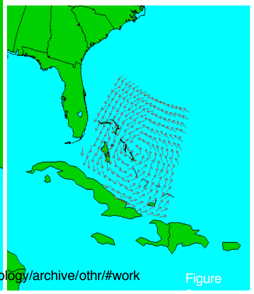


Figure 2



Figure

http://www.etl.noaa.gov/technology/archive/othr/#work

Motivation

OTH uses reflections off the ionosphere to image winds and other targets over the horizon (Figure 1). The uncertainty in the position of observed features depends critically on the knowledge of ionosphere structure. Ionosphere gradients determine the inclination of the reflection surface while small scale structure affect the sharpness of the image. Real-time estimation of the ionosphere is therefore essential for precise coordinate registration for OTH radar applications (Figures 2 and 3).
The ionosphere is very dynamic, changing on time scales of minutes, and there are no models, empirical or physics based, capable of providing the ionosphere structure with the required accuracy. Combining a model with measurements in a Data Assimilation scheme has become the method of choice of the ionosphere specification and forecast operational

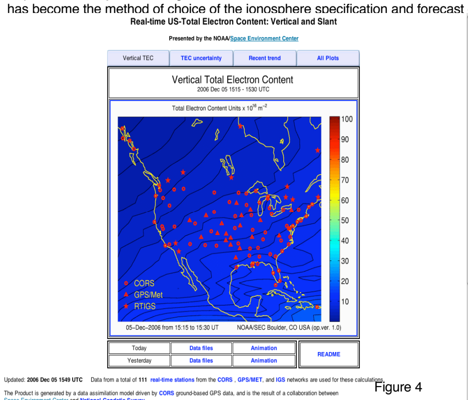


Figure 4

Tremendous progress has been made in specifying TEC from ground based dual frequency GPS receiver data. One such scheme is being transition into operations at the Space Environment Center in Boulder, Colorado. Significant validation and verification studies have shown that TEC can be specified with + - 2 TECU uncertainty (generally less than 5% of the value), most of the time over the US. However, the height profile of electron density cannot be specified with similar accuracy because of the lack of vertical distribution information in ground-based GPS data.

US-TEC Validation

Relative TEC

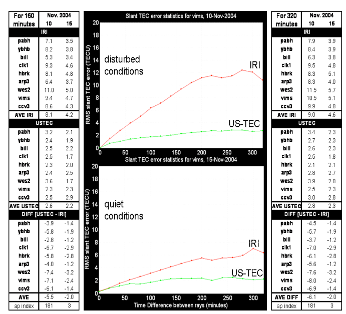


Figure 5

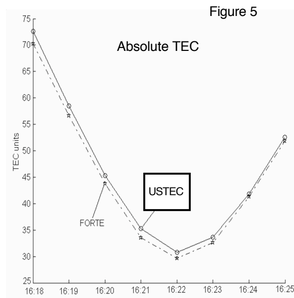


Figure 6

More validation information at:http://www.sec.noaa.gov/ustec/docs/USTEC_ValidationDocument.pdf

EOFs for Kalman Filter estimation

TEC EOFs

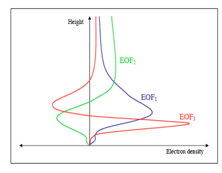


Figure 7

Electron Density Profile EOFs

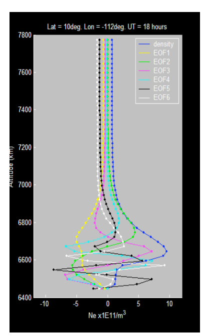


Figure 8

CONCLUSIONS

- **The electron density height profile cannot be accurately specified from ground-based GPS data alone.**
- **COSMIC GPS occultation data can provide the height distribution information needed to specify Ne.**
- **A Kalman Filter optimized for TEC specification does not provide the best solution for Ne and vice-versa.**
- **From this study we cannot tell how many LEOs are needed to specify Ne globally but plan to address the question next.**

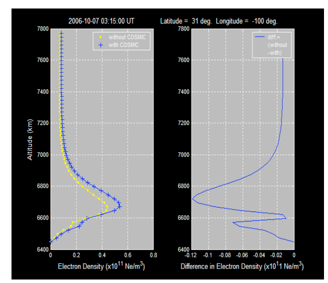


Figure 9

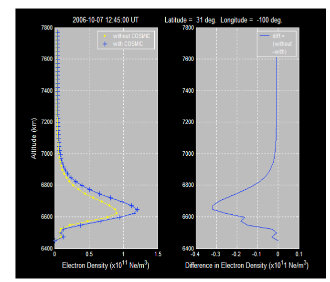


Figure 10

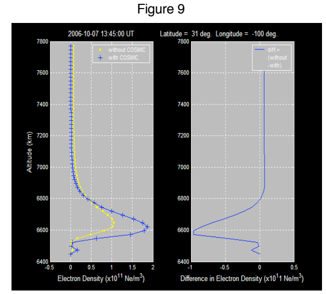


Figure11

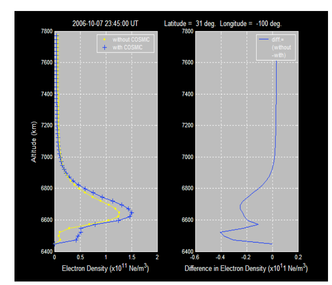


Figure12