National Aeronautics and Space Administration

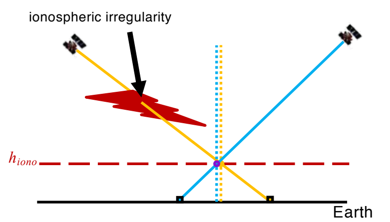
Innovation in Reducing Error in the Estimation of Ionospheric Total Electron Content

Principal Investigator: Lawrence Sparks (335G)

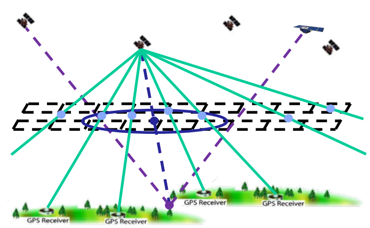
Program: Innovative Spontaneous Concepts

Project Objective:

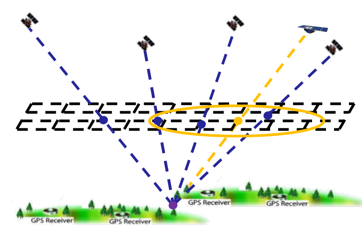
The objective of this task has been to optimize a numerical methodology for removing obliquity error in the estimation of the delay experienced by a radio signal travelling through the ionosphere along an arbitrary raypath. The standard thin-shell model of the ionosphere allows calculation of a simple geometrical factor to convert a slant TEC measurement into a vertical TEC estimate at the point where the raypath intersects the shell. It is well-known, however, that, under disturbed conditions or at low latitude where the ionospheric structure is complex, this approximation can be a significant source of TEC estimation error. Previous work at JPL introduced the multi-cone estimation algorithm (NTR-40931) designed to eliminate obliquity error as a source of estimation inaccuracy. The present task has sought to define the optimal fit parameters needed to render this error-reduction algorithm of value to current and future applications that are adversely affected by ionospheric delay.



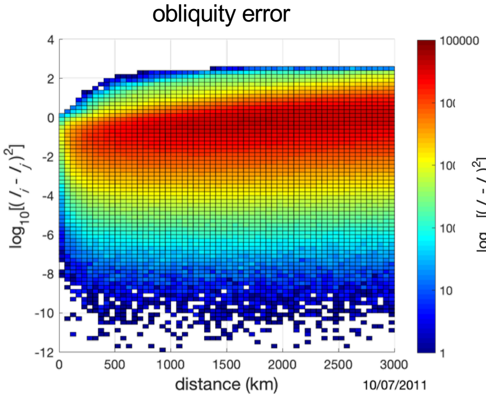
Vertical TEC estimates differ due do obliquity error



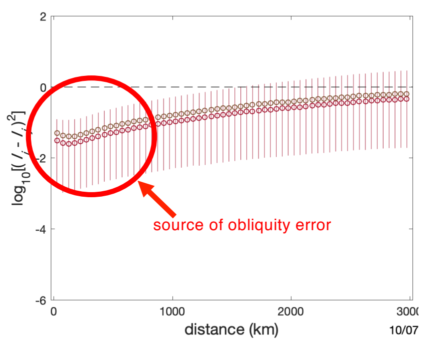
Phase 1 of multi-cone estimation



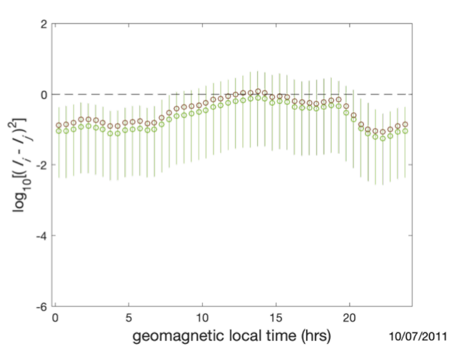
Phase 2 of multi-cone estimation



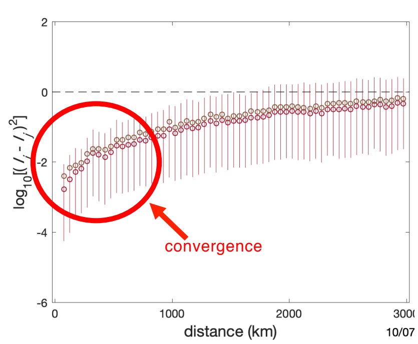
Spatial decorrelation of equivalent vertical TEC



Mean and median decorrelation for *distinct* satellite measurements

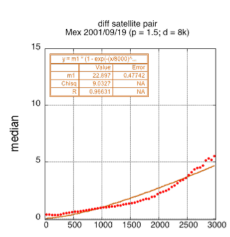


Diurnal mean and median squared difference of equivalent vertical TEC



Mean and median decorrelation for *same* satellite measurements

Example of a fit to the median to determine optimal fit parameters:



FY18/19 Results:

Phase 1 of the multi-cone algorithm uses a conical fit domain to estimate the TEC associated with raypaths (*pseudo-observations*) that connect any earth intersection point of interest to the emitting satellites visible locally. Phase 2 inverts conical domain estimation, placing the earth point at the vertex of a cone of pseudo-observations used to estimate the TEC connecting the earth point in question to any visible point beyond the ionosphere.

Optimal fit parameters have been determined from fits of the median spatial TEC decorrelation as a function of the distance separating pairs of ionospheric pierce points associated with signals emitted from a *single* satellite in common. Tabulating TEC differences as a function of local time has revealed a strong diurnal dependence, suggesting that optimal fit parameters should be specified as functions of time.

Benefits to NASA and JPL:

The results of this task are of potential benefit to any JPL project interested in reducing the error associated with the estimation of radio signal propagation delays through the ionosphere.

NASA's Cyclone Global Navigation Satellite System (CYGNSS) has recently begun exploring the possibility of using this methodology to correct for the ionospheric delay affecting its measurements.

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