Satellite-Based TEC Inversion Technique to Estimate the Plasmaspheric Electron Density

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Tomographic algorithms are well-known inverse techniques to perform the estimation of electron density values based on Total Electron Content (TEC) measurements. In the last few decades, many tomographic algorithms were developed to describe the ionosphere based on observations given by ground-based stations of the Global Navigation Satellite System (GNSS). However, the electron density reconstruction at altitudes from 700 to 20000 km is a quite different scenario. The plasmasphere is much larger than the ionosphere (up to about 1000 km altitude) and is composed by very few electron densities at high altitudes. Any small TEC error or mis-modelling given by the background can effectively introduce artifacts in the final reconstructions. Therefore, obtaining stable and accurate estimations of the plasmasphere are a relevant challenging task for any TEC reconstruction system. Additionally, the space-based TEC data obtained from topside GNSS navigation measurements aboard Low Earth Orbiting (LEO) satellites excludes the ionospheric contribution below the satellite heights and more viable for plasmaspheric estimations.

In this regard, the present work will show results of a new tomographic method to estimate the plasmaspheric electron density using satellite-based TEC measurements. Figure 1 show a typical meridional cut obtained with the proposed tomographic method during the St. Patrick day of 2015 using TEC data from the Meteorological Operational satellite programme (MetOp).

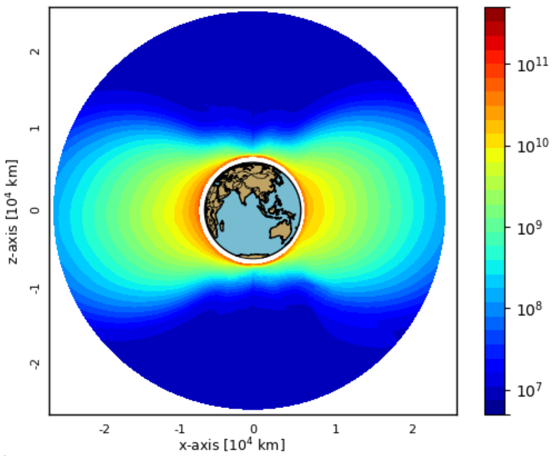

Figure 1. Typical 2-D electron density slice of the plasmasphere reconstructed in the Day of Year (DOY) 77 of 2015 using METOP-A data processed by the University Corporation for Atmospheric Research (UCAR). The color bar is in logarithmic scale and the unit is el/m^3.

The developed method employs independent grids geometries and imposes a set of constraints highly based on the background to stabilize the solution in the presence of noise and ill-conditioned geometry. Despite the imposed challenges, the developed approach was capable of representing the natural variability of the plasma ambient in terms of geographic/geomagnetic latitude, altitude, solar activity, season, and local time, when compared to two years of data obtained from in-situ measurements of electron density from spacecraft deployed by the Defense Meteorological Satellite Program (DMSP).