2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Comparison of propagation of GNSS signals from plasma instabilities generated using a plasma model combined with a configuration space model and a spectral model

Kshitija Deshpande (1), Matt Zettergren (1), Chuck Rino (2) and James Conroy (3)

(1) Embry Riddle Aeronautical University (ERAU), Daytona Beach, FL, USA

(2) Boston College, Boston, MA and University of Colorado Boulder, CO

(3) Virginia Tech, Blacksburg and JHUAPL, Maryland

Propagation of Global Navigation Satellite Systems (GNSS) signals is a problem of electromagnetic (EM) wave propagation in random media and has been a subject of interest for more than last 5 decades. GNSS signals experience phase and amplitude fluctuations in the form of scintillation. Many of the scintillation models employ phase screens and multiple phase screen approach [Rino (1979), Knepp (1983)]. The ionospheric irregularities in such models have been represented by different spectral models. Implementing these models in the study of ionospheric scintillations of radio signals at high latitudes is challenging since the path of satellite signal to ground has a variable angle of incidence, in addition to the complicated geometry of magnetic field lines at high latitude and polar regions, and complex magnetosphere--ionosphere coupling mechanisms creating the irregularities. Satellite-beacon Ionospheric-scintillation Global Model of the upper Atmosphere (SIGMA, Deshpande et al. 2014) is a model that simulates GNSS signal propagation through random media. In order to capture the closer-to-real propagation effects by plasma instabilities (from 20m to 100 km scales) we attempt a challenging task of combining a first principles based plasma model (Geospace Environment Model of Ion-Neutral Interactions (GEMINI, Zettergren et al. 2015)) and a configuration space model (small description ??, reference?) to generate irregularities with very high resolution (deca-meter) and large extent (F-region irregularities of a 50km or 100km-length cube).

Plasma processes responsible in the production of density structures in auroral and polar regions, some of which generate these phase scintillations, include gradient-drift instability (GDI) and Kelvin-Helmholtz instability (KHI). GEMINI is used to simulate the GDI and KHI instabilities in a confined region of ionosphere of 100 km x 100 km x 100 km or so with as small as 200 m resolution. This model can provide the ionospheric number density simulation as an input to SIGMA. We further extend it to include Configuration Space model to fill up GEMINI's space with small scale phase structures inside SIGMA. We compare the results of GEMINI-SIGMA combination to that of Config Space-GEMINI-SIGMA combination. Such a hybrid model approach can prove to be an excellent tool to investigate evolution of instabilities at small to medium scale sizes and thus could prove to be a unique way of studying the cascading phenomena. Finally, we compare the results with propagation using one of the most generic spectral models of the ionospheric irregularities - Sharkovsky model. Magnetospheric sources such as dayside or nightside reconnections can produce ionospheric instabilities through direct coupling in the cusp and polar regions. With the help of auxiliary observations, we can relate the instabilities producing GNSS scintillations to the type of instability (of KHI and GDI) using our modeling approach.