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Rougerie, Sébastien: CNES
Béniguel, Yannick: IEEA
Yokoyama, Tatsuhiro: NICT
Serant, Damien, thalesaleniaspace;

Filling the gap between physical ionosphere models and scintillation models in equatorial region

The propagation of radio waves in the ionosphere can be addressed by the so called Multiple Phas. Screen technique (MPS). In this technique, the medium is divided into layers, each one of the. acting as a phase screen. The calculation alternates scattering and propagation calculations from on. screen to the next one to get the field transmitted through a turbulent medium. The phase screens are defined by a stochastic process. It is usually common to assume a Schkarofsk. spectrum, which has the shape of a low pass . st order filter in the wavenumber domain. The ITU-. P.531 section 4.3 (GISM model) proposes a scintillation model based on this spectrum shape for th. equatorial region [1], and similar approach existing in polar region [2].

These approaches have the advantage to propose a scintillation time series generator of the amplitude and phase on a very wid. frequency range. However, these approaches cannot reproduce the scintillation in a specific regio. at a specific time. On the other hand, a physical model of the ionospheric turbulence is in progress. In [3] – [5], a high resolution model of plasma bubbles is proposed based on the plasma density continuity equation. and the current continuity condition to obtain the electrostatic potential. The main advantage of this model is the possibility to tune the inputs from a space weather model, the earth magnetic model or any other empirical ionospheric (IRI, NeQuick). It also helps for a better understanding on the bubbles development which might be of interest for the forecast of ionospheric turbulence. To reproduce the effect the bubbles have on the propagation of an electromagnetic wave, the MPS. technique is used. To do so, the definition of the phase screens is now based on the outputs of the model [3] – [5].

The MPS technique requires however sampling steps of the phase screen smalle. than the Fresnel radius. Thus, the output of the physical model should provide the electron density data with grid spacing smaller than the Fresnel radius. For example, the Fresnel radius at L bands is close to 100m. The size of bubbles may reach more than 1000 km in the horizontal direction, an. 800km in the vertical direction. Thus, there is a computational challenge in order to provide physica. output of the ionospheric density data with such an accuracy and grid spacing.

The aim of this paper is to propose a solution when the grid spacing of the physical model is belo. the Fresnel radius. For this purpose, we have used one example of output of the High-Resolutio. Bubble model presented in [3], where the pixel size here is approximatively 1 km, much higher than the Fresnel radius at L band. To solve the scale issues, we have used phase screens based on th. Schkarofsky spectrum, and adjusted the strength of the spectrum (Cs parameter) in relation to the given electron density. To do so, we have meshed the medium with larger pixels corresponding to the phase screen size (phase screen must be larger than the irregularity size), compute the variance on the electronic density given by [3] and finally the Cs parameters.

Given the transmitter and receiver locations, the line of sight is determined, then the electron density along this line and the. phase screens parameters at the discretisation points on this line. This allows calculating the S4 and sigma phi parameters at receiver location for any particular line of sight. An attempt to validate the results was made using experimental data recorded in Africa with the SAGAIE network [6].

The global behavior seems to be in agreement with observations: an increase of S4 and sigma Phi corresponding to a decrease of the slant TEC. The S4 values obtained by simulation are in the same range than the mean S4 values observed during the one year of data.