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Construction of a phase screen model based on one-dimensional satellite orbital in-situ electron density data

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Ionospheric plasma irregularities can cause interference with radio wave signals across the ionosphere, the signals received by receivers at the ground often show rapid fluctuations in both phase and amplitude, which are referred to as ionospheric scintillation. Phase screen theory has become a feasible handy tool for studying and modeling ionospheric phase and amplitude scintillation since its introduction [1, 2]. To achieve that, the three-dimensional (3D) power spectrum density (PSD) of electron density fluctuation (ΔN_e) is one of the key inputs to the phase screen. As we know, ionospheric irregularities are distributed along the magnetic lines of the geomagnetic field, with the result that the irregularities are elongated along the direction of the magnetic lines. When we assume that the semi-axis length ratio of the irregularities in three directions is a: b: 1, the form of the 3D PSD becomes Eq. 1, which leads to a change in the shape of the PSD. Consequently, obtaining the electron density (N_e) 3D PSD from the one-dimensional (1D) N_e satellite orbital data is almost impossible to acquire. As an alternative way, we propose in this study an approach to obtain the 3D PSD from the 1D N_e data along the low-Earth orbit satellite, e.g., ESA's Swarm satellite.

$$\Phi_{Ne}(q) = ab\frac{\langle Ne_3^2\rangle \Gamma\left(\nu+\frac{1}{2}\right) q_0^{2\nu-2}}{\pi^{\frac{3}{2}}[q_0^2 + a^2\kappa_x^2 + b^2\kappa_y^2 + \kappa_z^2]^{\nu+\frac{1}{2}}\Gamma(\nu-1)} \quad (1)$$

As a further test, the correction coefficients from 1D PSD to 3D PSD under conditions of anisotropy of ionospheric irregularities have been analyzed in our study, and further try to extend them to conditions under different magnetic inclinations.

1. C. L Rino, "A power law phase screen model for ionospheric scintillation: 1. Weak scatter," *Radio Science*, **14**, 6, 1979, 1135–1145, doi: 10.1029/RS014i006p01135.

2. K. C. Yeh & C. H. Liu, "Radio wave scintillations in the ionosphere," *Proceedings of the IEEE*, **70**, 4, 1982, 324–360, doi: 10.1109/PROC.1982.12313.