Anisotropic scintillation indices for low elevation angles

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In the phase-screen-based modeling of ionospheric scintillation of radio signals the flat-earth approximation is commonly used [1-3] This assumption is justified for large elevation angles, i.e., for the scenarios of interest in GNSS-assisted applications and services. In some user cases, such as reflectometry or limb-sounding, the calculation of scintillation indices at small elevation angles might be of interest. In this case the finiteness of the curvatures of the earth and the ionospheric shell should be considered. Additionally, as the scintillation-causing ionospheric irregularities are anisotropic, e.g., are asymmetric and field-aligned, the proper geometry of the irregularities should be fused into the scintillation model.

This contribution deals with the extension of the flat-earth model to a spherical one. The correlation properties of ionospheric electron density fluctuations responsible for scintillation occurrence are modeled conventionally as the ellipsoidal surfaces of constant value for the autocorrelation. The relative position of such ellipsoids and the radio-wave ray path modulates the scintillation strength and has purely geometrical origin [4]. The information on communication link geometry is used for proper generation of phase screens used further for simulation of wave propagation through randomly inhomogeneous ionosphere. For clarity and simplicity we have used also the single phase screen model and derived the analytic formulas for amplitude and phase scintillation indices following the approach of Ref. [3]. We show that the accounting of the finiteness of earth-/ ionospheric-shell-curvature yields the non-divergent values for scintillation indices at low elevation angles. Additionally to this, the regions of geometric enhancement of scintillation at low elevations appear to be displaced from the corresponding regions predicted within the flat-earth approximation. The found discrepancy is important for proper determination of regions of high scintillation activity at high latitudes, e.g., as regions mapped on sky plots for a certain ground-based receiver. Incorporation of the proposed geometric model in the scintillation climatological models such as the GISM [5] or the WBMOD [6,7] will be consistent with their extension to low elevation angles and, hence, will be useful for some aforementioned user-cases.

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