The Ramifications of Configuration-Space Models for GNSS Scintillation

Charles L. Rino*[(1)], Charles S. Carrano[(1)], and Keith Groves[(1)]
(1) Institute for Scientific Research, Boston College, Boston, Mass.

Configuration-space models generate ionospheric structure realizations from collections of randomly located field-aligned *striations*. By imposing power-law size distributions according to a bifurcation rule, configuration-space realizations support two-dimensional power-law spectral density functions (SDFs) in any plane that bisects the striations. The structure model can be formulated in the same curvilinear coordinate system used for physics-based simulations.

The geometric dependence of ionospheric scintillation, which results from cumulative path-integrated structure, is well known. Standard propagation models assume that the structure along any path can be characterized by a correlation function, albeit potentially with an arbitrarily long correlation length. More realistically, propagation paths that intercept a distribution of striation scales generate a non-coherent superposition, whereas paths that intercept striations along near-parallel trajectories generate coherent superposition. For the non-coherent paths the two-dimensional spectrum is obtained from the three-dimensional SDF by replacing the along-path wavenumber with zero. Although the standard theory predicts an amplification proportional to an assumed elongation ratio, there is an implicit assumption that there is no change in the correlation function itself.

Additionally, the extrapolation of structure using standard three-dimensional models is critically dependent on the assumed axial ratio. For low-earth-orbiting satellite observations, the standard model can be reconciled with measurements because field-aligned measurements are singular events. That is, only a single path can be field-aligned. Ground-based GNSS propagation paths can produce sustained field-aligned trajectories. That is, near parallel measurement paths can traverse multiple field lines. Translating paths are common for low-earth orbiting GNSS receiver occultation measurements.

This paper will summarize recent results that illustrate the ramifications. The measured structure itself does not betray the mix of coherent and non-coherent integration. Rather, interpretation against a configuration-space model provides a more consistent assimilation of measurements.