GPS Stochastic TEC and Phase Scintillation

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GPS measurements, by design, have negligibly small intensity scintillation levels. Strong scintillation at GPS frequencies is observed only on propagation paths that intercept equatorial spread F (plumes, or bubbles). Diagnostic GPS receivers report intensity, phase, and pseudo, which are used for all subsequent processing. The pseudo-range measurement is used primarily to resolve the integer cycle phase ambiguity. Fresnel filtering suppresses large-scale intensity structure, whereas phase responds directly to the dominant source-receiver-range. Consequently, aggressive detrending must be used to extract phase scintillation estimates. Moreover, the cutoff that separates phase scintillation from TEC is arbitrary.

In a companion paper by coauthor Brian Breitsch dual-frequency measurements are used to construct range free-combinations that can be scaled to total electron content (TEC) units. The potential error terms involve scintillation and biases. With L1, L2, and L5 measurements L1-L2 and L1-L5 estimates provide redundancy with roughly the same frequency separation. It has been found that the TEC residuals differ by a fraction of one TEC unit, even when moderate scintillation is present. Under these conditions the phase scintillation frequency dependence is indistinguishable from the frequency dependence of the TEC component. In effect TEC is reflecting path-integrated structure over the entire measurable scale range. This suggests using TEC as the primary measure of intermediate scale structure rather than single-frequency detrended phase.

This paper explores this concept by using wavelet decompositions of TEC structure to identify a structure range identical to the detrended intensity structure range. Where the intensity scintillation is sufficient to support irregularity parameter estimation (IPE) developed by Charles Carrano, the TEC spectral decomposition can be compared to the equivalent-phase-screen structure that supports the IPE. It is noteworthy that several researchers are exploring various measures of TEC structure. The approach presented in this paper generalizes the concept. Computationally, TEC structure analysis is simpler and more definitive than detrending the phase. With L1, L2, and L5 measurements the assumption that the structure can be interpreted as a path-integrated measure can be checked.
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