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Simulation Study of GPS Phase Scintillation

The signal phase measured by GPS processors is crucial for high-resolution range measurement. The passage of GPS signals through the earth's ionosphere imposes a dispersive delay and phase advance proportional to total electron content (TEC). Dual-frequency measurements are used to correct the dispersive-phase error and for ionospheric diagnostics. While there many sources of phase/delay error that processors must contend with, phase scintillation is particularly challenging.

Recently developed theoretical results by Carrano and Rino, have provided a means of efficiently generating multi-frequency scintillation realizations over the complete range of observed GPS disturbance levels. A compact parameterization allows space-to-time translation consistent with observed coherence times and fade distributions. By incorporating geometric range and a slab TEC variation, the interplay between stochastic TEC and phase scintillation can be explored. We find that much of what might be identified as phase scintillation is stochastic TEC structure. The phase-screen model is initiated with stochastic TEC structure. Depending on the disturbance level, the stochastic phase structure maps directly onto the signal phase.

Many studies have shown that positioning errors with increasing scintillation. The simulations provide a means of comparing the errors with multi-frequency TEC calibration procedures. The scintillation errors are generally not the largest errors, but they increase rapidly as the scintillation transitions from moderate to strong. The simulations also provide improved scintillation diagnostics and bounds on how much phase change can be attributed to scintillation.

Ref: Carrano and Rino "A theory of scintillation for two-component power law irregularity spectra: Overview and numerical results,' doi:10.1002/2015RS005903