Comparison of Simulated and Real-World Diffraction Effects In GNSS Phase Measurements Using the Geometry-Ionosphere-Free Combination

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The characterization of ionosphere scintillation-inducing irregularities is important for mitigation, prediction, and scientfic efforts. While weak scintillation causes mostly TEC-like phase structure (refractive effects), strong scintillation can cause uncorrelated fluctuations between phase measurements (diffractive effects). In particular, during deep-fade conditions, ionosphere-induced rapid phase changes can occur for individual phase measurements. Previous studies have investigated and simulated the decorrelation between GPS L1 and L2 carrier phase measurements as well as the occurence of half and full-cycle changes during scintillation-induced deep fades. (Carrano et al., "Scintillation Characteristics across the GPS Frequency Band," 2012) extends the comparison to the GPS L5 frequency.

In (Carrano et. al., "Direct Measurement of the Residual in the Ionosphere-Free Linear Combination during Scintillation," 2013), they investigate phase residuals due to scintillation diffraction in the ionosphere-free combination of GPS carrier phase observables. Using the ionosphere-free combination allows observation of phase scintillations without the added fluctuations of ionosphere TEC structures, although slowly-varying geometric doppler effects must still be detrended. By comparing the dual-frequency ionosphere-free combination from simulation and real data, the authors demonstrate and validate a correlation between scintillation S_4 index and ionosphere-free combination RMS residual phase.

In this work, we continue to investigate the diffractive effects of scintillation by comparing scintillation simulations to real triple-frequency GPS data. In particular, we use the geometry-ionosphere-free combination (GIFC) of triple-frequency GPS phase observables. This linear combination observable removes both geometric doppler and ionosphere TEC signal components, allowing for a more direct observation of the strong diffractive effects and rapid phase changes associated with scintillation. This means that agressive detrending is not needed in order to observe residual phase, although small effects such as multipath and inter-frequency bias variations do remain and must be accounted for. We also aim to tackle a looming disadvantage to this approach – that it may be difficult to determine on which signal rapid phase changes orginate when looking at the GIFC without reference to un-combined phase measurements.