11 -- 2017-02-22 21:53:55

Session 5A Paper 2

Collett, Ian: Colorado State University
Breitsch, Brian: Colorado State University
Xu, Dongyang: Colorado State University
Morton, Yu

Statistical characterization of GNSS signal carrier Doppler frequency deviations during ionospheric scintillation

Ionospheric scintillation is the phenomenon when a radio signal propagating through electron density irregularities in the ionosphere undergoes random amplitude and phase fluctuations. Of particular interest is the negative effect that ionospheric scintillation has on Global Navigation Satellite Systems (GNSS) signals, which are primarily used to provide users on or near the surface of the Earth with precise navigation and timing information. These effects are the most pronounced in the equatorial and high-latitude regions.

Although scintillation is difficult to model, its effects can be statistically characterized using different metrics. The two most commonly used metrics are the amplitude scintillation indicator (S4), defined as the normalized standard deviation of the detrended signal intensity, and the phase scintillation indicator (sigma-phi), which is the standard deviation of the detrended carrier phase. The effect of scintillation on the Doppler frequency of the signal, on the other hand, is less commonly studied. Characterizing the fluctuations in the Doppler frequency of a GNSS signal is important because it directly impacts receiver carrier tracking operation.

This study utilizes data collected from two different locations at low and high latitudes (Ascension Island and Gakona, Alaska) to characterize Doppler frequency deviations under various conditions. The Doppler, obtained by differentiating the high rate carrier phase measurements taken by the receiver, is first detrended to remove the large scale variations due to the relative dynamics of the receiver and satellite. In equatorial regions, the two scintillation indicators S4 and sigma-phi are generally correlated, and the overall level of scintillation can be quantified by either. Distributions of the Doppler are produced for two different regimes: low level (0.3 _ S4 _ 0.6) and high level scintillation (S4 _ 0.6).

Furthermore, the standard deviation of the Doppler is determined for a larger amount of S4 bins and a positive correlation is observed. Qualitatively, this means that the magnitude of frequency fluctuations increases with the severity of scintillation. At low latitudes, lines of equal electron density generally lie in the East-West direction. To explore the effects of this, the distributions of low and high level scintillation are further subdivided based on whether the satellite signal scan velocity is more zonal or more meridional. At high latitudes, there are relatively low levels of S4. In this region, a similar procedure is followed to characterize the Doppler frequency fluctuations, except that the phase scintillation indicator sigma-phi is used instead to define the low and high level scintillation regimes.