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Scintillation Monitoring and Feature Analysis Using Multi-Frequency GNSS Receivers

Y. Jade Morton[(1)], Brian Breitsch[(1)], Charles Rino[(1)], Dongyang Xu[(2)], Rong Yang[(1)]
(1) University of Colorado at Boulder, e-mail: jade.morton@colorado.edu, brian.breitsch@colorado.edu, crino@comcast.net, Rong.Yang@colorado.edu,
(2) Colorado State University, email: dyxu@rams.colostate.edu

As the number of new operational GNSS signals continue to increase, there is the need to develop new means to utilize the new observables for scintillation monitoring and for ionosphere and space weather studies. In this presentation, we will discuss three distinctive yet inter-related effort aimed at achieving this objective. First, we will summarize our efforts in develop technologies that ensure robust operations and accurate capturing of the scintillation signal parameters at multiple frequency GNSS carriers. We will highlight an adaptive inter-frequency aiding algorithm. The algorithm utilizes the dispersive nature of ionospheric scintillation effects to adaptively adjust each carrier phase lock loop feedback process to optimize the control based on multiple carrier tracking loop outputs. It has demonstrated to be able to successfully maintain lock of strong scintillation signals at low latitudes.

Second, we will present time and frequency domain techniques that combines multiple frequency code and carrier observables. The objective is to detect and classify scintillation effects from ionospheric refractive effects and from receiver environmental multipath, all of them may share similar time-domain features. Ionospheric refractive effects cause GNSS signal group delay and carrier phase advances that are directly proportional to the total electron content (TEC). In the absence of diffractive effects, the refractive effects can be identified using appropriate dual frequency observables combinations in the time domain. And receiver environmental multipath effects have unique frequency-time features which are different from the ionosphere propagation effects. By analyzing multiple frequency carrier signals in the time and frequency domain, these different effects can be isolated, mitigated, or extracted for ionosphere and earth surface remote sensing applications and for improving the precision of navigation applications.

Finally, we will utilize a recently developed multi-frequency scintillation simulator to corroborate the analysis results derived from real data and observation. The simulator uses real scintillation measurements from ground-based receivers as an initializer to derive a phase screen capable of representing strong equatorial scintillation. A user can specify multiple frequency carriers and transmitting satellite orbits as well as receiver platform dynamics to define the signal propagation path through the phase screen. Example simulator scenarios such as a receiver on a LEO satellite will be highlighted to demonstrate scintillation effects that caused receivers to loss lock of signals.