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A Comparative Study of Time-Domain and Time-Frequency-Domain Methods for Ionospheric Irregularity Drift Velocity Estimation from a GNSS Receiver Array during High Latitude Ionospheric Scintillation

The conventional spaced-receiver technique estimates ionospheric irregularity drift velocity through cross-correlating signal intensity measurements of a GNSS receiver array during amplitude scintillations [Ledvina, et al., 2004]. However, it is more suitable to use carrier phase measurements at high latitude regions, where phase fluctuations are more frequent and intense than amplitude scintillations. In our previous studies at Gakona, Alaska, the signal condition is not ideal for the conventional time-domain cross-correlation method. We have demonstrated an alternative approach that uses joint time-frequency analysis [Wang and Morton, 2015]. With our more recent GNSS receiver array establishment at Poker Flat, Alaska, the signal condition has been greatly improved. We discovered that the time-domain technique is also capable of resolving the time lag information across the receiver array [Wang and Morton, 2017].

In this study, both the time-domain and the time-frequency-domain methods are applied to the Poker Flat GNSS array data collected during a prominent phase scintillation event on 2015/12/20. The time lag results are compared and analyzed to study the characteristic of each method. To ensure the consistency in the drift velocity estimations, correlation coefficient thresholds are employed. The estimated irregularity drift velocities are further compared against the measured results from the co-located Poker Flat Incoherent Scatter Radar (PFISR).

Preliminary results show good agreement between the two methods in both time lag and velocity estimations under nominal correlation coefficient threshold (70%). However, the time-domain method shows inferior performance than the time-frequency-domain method towards higher threshold (90%) when comparing against the PFISR measurements. This is because the joint time-frequency-domain processing allows additional spectral filtering to increase the signal-to-noise ratio of scintillation signatures. On the other hand, the simple time-domain method cannot produce sufficient number of estimations towards higher thresholds to maintain good statistical performance. An obvious drawback of the time-frequency-domain method is that it is computationally expensive. These observations suggest that the time-domain method can be used to quickly identify the general irregularity drift velocity, while the time-frequency-domain method can be used to fine-tune the result.

References:

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