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Automated quality control algorithms for ionospheric scintillation measurements

Ionospheric scintillation is an important space environment / space weather parameter identifying regions of ionospheric turbulence for space environment researchers and providing indications of link quality for operators of communication, navigation, and other systems dependent on transionospheric radio propagation. Ionospheric scintillation is typically measured from fixed ground sites monitoring signals from one or more geostationary or moving satellites. Scintillation appears as fluctuations in the amplitude and phase of these signals and is characterized by various statistical indices such as S4 or sigma-phi. However, fluctuations in signal characteristics can also be produced by effects other than ionospheric scintillation, such as multipath propagation from nearby reflective objects or terrain or interference from nearby RF sources or noise, especially in urban areas.

Traditional scintillation measurement instruments typically have no internal quality control to provide confidence intervals or recognize non-geophysical effects on signal levels, and require post-processing by researchers familiar with the specific conditions at the measurement site to manually identify and filter out spurious non-scintillation events. Such manual filtering may inadvertently introduce bias and remove important geophysical observations that are more valuable precisely because they do not fit with standard climatology but are filtered out by researchers precisely because of this unexpected behavior.

In this paper we report on initial efforts to develop automated algorithms that use the statistical characteristics of signal fluctuations, resulting from the operative physical wave propagation processes, to provide quality control for scintillation measurements and identify non-geophysical impacts on the signal, especially multipath propagation. Discriminators investigated for use in automated quality control algorithms include the spectral shape of amplitude and phase fluctuations, decorrelation time, the statistical distribution of fluctuation magnitude, conservation of average signal power, and simultaneity of events between different links (for GNSS receivers monitoring multiple satellites).

Successful development of automated quality control algorithms for scintillation measurements can be expected to aid discovery of new geophysical phenomena, provide confidence in even unusual scintillation measurements, and allow removal of effects not related to ionospheric scintillation.