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Session 9A Paper 2

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A Parameter Constraint Algorithm for the Generation of "All Clear" Forecasts of Equatorial Scintillation using Radio Occultation Data

Equatorial Spread-F Scintillation is an important space weather phenomenon in that it interferes with transionospheric communications and navigation. Some years ago, a model called the AFRL Scintillation Network Decision Aid (SCINDA) was developed to provide real-time alerts of the potential impact of scintillation on operational systems. This model uses data from ground station measurements of scintillation, coupled with empirical rules for the evolution of scintillation “bubbles” to map the regions where scintillation is likely to exist. An inherent limitation of the SCINDA model is that it can produce predictions only in regions where ground measurements are available. Although it provides information on the scintillation at the various stations and to the immediate east, where the scintillation structures drift with the nighttime ionosphere, it does not give the user a clear indication of what regions are likely to be free from scintillation effects.

The use of radio occultation (RO) data, in which scintillation is measured between a low Earth orbiting (LEO) satellite and GNSS satellites, has potential to address the issue of “all clear” forecasting since it samples wide regions of the active scintillation regions at a refresh rate of 90 minutes or so. We have performed several studies of RO data from the

Communications/Navigation Outage Forecasting System (C/NOFS) with the goal of developing a model to provide the user with a reliable forecast of “all clear” regions where scintillation is not present. Our model employs constraints in plasma density and apex altitude which are used to generate patches where scintillation would have been detected if present. For an “all clear” occultation, we can therefore predict that the region is free from scintillation effects.

Most previous studies employing RO scintillation measurements have relied on the tangent point (TP), usually taken at 350 km, to geolocate the region of interest, either clear or scintillating. Although valuable, we have found that such an approach guarantees an hour of clear conditions at a specific ground location with an accuracy of only about 80%. It is also difficult to estimate what is happening to the East or West of the tangent point using the this method. Our approach, which we call Parameter Constraint Analysis (PCA) can detect an “all clear” region of width up to 45o in longitude, depending on the geometry of the occultation. The combination of occultations from several LEO satellites, as in the COSMIC-2 mission, promises coverage of a virtually all longitudes within a relatively short time window. This approach would represent an important advance in the forecasting of scintillation.

We report here on the results of a TP analysis of “all clear” predictions that we use as a starting point for the development of our PCA scheme. We then describe the development of the PCA algorithm, including sensitivity studies that we have used to fine-tune the PCA parameters to arrive at maximum coverage with minimal uncertainty. Next, we report on various validation studies we have carried out to assess the PCA performance. Finally, we present results of PCA functionality applied to a simulated COSMIC-2 system, where we plan to apply the PCA technique to an operational system.