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Novel Techniques for the use of GNSS Radio Occultation for Specification of the Ionospheric Scintillation Environment

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Typical methods used to characterize the ionospheric scintillation environment with data from Radio Occultation (RO) sensors involve the use of the tangent point (the point closest to the earth's surface) along the line of occultation for the localization of turbulent regions. While these techniques have been shown to statistically reproduce equatorial scintillation climatology, they lack the precision necessary for use of such algorithms in an operational sense. Long slant paths and sweeping horizontal geometries make precise geolocation of scintillation inducing irregularities a difficult task. A recent comparison of ground-based scintillation data from the AFRL Scintillation Network Decision Aid (SCINDA) with scintillation recorded on the Communication/Navigation Outage Forecasting System Occultation Sensor for Ionospheric Sensing and Specification (CORISS) sensor, found that use of the tangent point to geolocate the scintillation structures resulted in, at best, spatial uncertainties of a thousand kilometers or more and temporal uncertainties of +/- 30 minutes.

The coming launch of the FORMOSAT-7/COSMIC-2 mission has triggered an interested in the expanded use of RO from Global Navigation Satellite System Satellites (GNSS). With both fore and aft looking sensors and multi-GNSS capabilities, the 6 satellite constellation and its low inclination orbit is expected to provide up to 10,000 occultation measurements per day. In this paper, we will introduce a multipronged approach to identify and characterize GNSS RO observations from the low earth-orbiting (LEO) platform to more accurately geolocate ionospheric irregularities which can lead to degradation of communication and navigation systems.

As an improvement over the simple tangent point method, we have developed a quantitative technique to better pinpoint the location of irregularities. Referred to as Parameter Constraint Analysis (PCA), this method utilizes a set of physical parameters as a filter (or constraint) to the RO geometry to help better describe the sampled region. Through analysis of parameters such as local time, apex height, and local plasma densities, we can constrain the likely regions along the occultation path over which irregularities are most likely to be observed. Additionally, the

PCA technique provides an effective method for mapping ionospheric regions sampled during an RO event for use in regional All-Clear specifications. A prototype All-Clear tool based on the PCA method will be presented.

Additional methods to further refine the PCA results will briefly be discussed including Irregularity Parameter Estimation and Back Propagation techniques which benefit from a Configuration Space Model which addresses the issue of the changing propagation angle along an RO path with respect to the local geomagnetic field (B).