International Beacon Satellite Symposium BSS-2019
Olsztyn, Poland

Geolocation and Characterization of Ionospheric Irregularities using Radio Occultation Observations of Scintillation

Charles Carrano*[1], Keith Groves[1], Ronald Caton[2], Charles Rino[1], Paul Straus[3]

[1] Institute for Scientific Research, Boston College, Chestnut Hill, MA, USA (charles.carrano@bc.edu)
[2] Air Force Research Laboratory, Kirtland AFB, NM, USA
[3] Aerospace Corporation, El Segundo, California, USA

ABSTRACT

We present new techniques to geolocate and characterize ionospheric irregularities using radio occultation observations of scintillation. We analyze the scintillation time series to infer the Fresnel frequency, defined as the effective velocity at which the ray-path scans through the irregularity region divided by the Fresnel scale. Three different (but closely related) phase screen techniques can be used to measure Fresnel frequency. The first is a new theoretical result relating the scintillation index S_4 and the rate of change of TEC index (ROTI). The second is by fitting the spectrum of observed intensity fluctuations with a theoretical model, a technique we call Irregularity Parameter Estimation (IPE). The third is by back-propagating the complex signal until intensity variations are minimized. A geometric model for the effective scan velocity is used to map Fresnel frequency to Fresnel spatial scale, which yields the distance from the receiver to the irregularities. Once the irregularities have been geolocated, the horizontally integrated irregularity (turbulence) strength may be measured. At this point, forward propagation techniques, in conjunction with an empirical model relating horizontally and vertically integrated irregularity strength within an equatorial plasma bubble, may be invoked to predict scintillation along an arbitrary space-to-ground propagation path. We demonstrate these techniques using scintillation measurements from the CORISS instrument onboard the C/NOFS satellite. The figure at left shows a radio occultation event with dots, colored by the measured S_4 index, indicating the location of irregularities determined using the IPE technique. The figure at right shows predictions of S_4 for a geostationary AF-SATCOM signal at VHF, as viewed from a ground station at Kwajalein. These scintillation predictions (red dots) compare favorably with space-to-ground scintillation observations from the SCINDA VHF receiver at Kwajalein (black).

Key words: Scintillation, ionospheric irregularities, radio occultation, phase screen