4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

GNSS Radio Occultation Measurements of Sporadic-E

Daniel J. Emmons*(1), Dong L. Wu(2), Nimalan Swarnalingam(2,3), and Kenneth S. Obenberger(4)
(1) Air Force Institute of Technology, Wright-Patterson AFB, OH, USA, e-mail: daniel.emmons@afit.edu
(2) NASA Goddard Space Flight Center, Greenbelt, MD, USA; e-mail: dong.l.wu@nasa.gov
(3) The Catholic University of America, Washington DC, USA; e-mail: nimalan.swarnalingam@nasa.gov
(4) Air Force Research Laboratory, Kirtland AFB, NM, USA; email: kenneth.obenberger.1@spaceforce.mil

Sporadic-E (E_s) is characterized by an unusually high E-region ion density caused by metallic ions from meteor deposits and conducive neutral wind shears. Strong E_s can significantly impact High Frequency (HF) skywave propagation and perturb navigation & timing for Low Earth Orbit (LEO) satellites. Therefore, monitoring and characterizing global E_s occurrence is important both practically and scientifically. While modern ionosondes provide a direct method for probing local sporadic-E layers, there are many gaps in coverage including regions over the oceans and poles. Global Navigation Satellite System (GNSS) Radio Occultation (RO) provides an alternative method for monitoring sporadic-E, with truly global coverage.

However, the integrated nature of GNSS-RO provides indirect E_s measurements that can be difficult to invert and interpret. In this talk, we provide detail on improved models for estimating E_s intensity from GNSS-RO measurements [1]. These improved models use both L_1 and L_2 amplitude and phase perturbations from Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-I) to estimate intensities in terms of foEs, fbEs, foμEs, and fbμEs. In comparison with global Digisonde measurements, the new models show drastic improvement over baseline models that use only amplitude or phase.

Further, a statistical approach to modeling GNSS-RO scintillation from E_s is presented [2]. Sporadic-E layers are first modeled as simple Gaussian layers in altitude, where an analytic solution is used to calculate the resulting diffraction pattern at the LEO measurement plane. In comparison with midlatitude RO observations, the Gaussian lens simulations show similar trends with some substantial differences. To improve agreement, Kolmogorov turbulence is added to the layers and a phase screen model is used to simulate resulting diffraction patterns. The added turbulence increases agreement with observations, indicating that small-scale structure can have large impacts on RO observations of sporadic-E.

1. Emmons, Daniel, Dong Wu, Nimalan Swarnalingam, Ashar F. Ali, Joseph A. Ellis, Kyle E. Fitch, and Kenneth S. Obenberger. "Improved models for estimating sporadic-E intensity from GNSS radio occultation measurements." Frontiers in Astronomy and Space Sciences 10: 1327979.

2. Emmons, Daniel J., Dong L. Wu, and Nimalan Swarnalingam. "A Statistical Analysis of Sporadic-E Characteristics Associated with GNSS Radio Occultation Phase and Amplitude Scintillations." Atmosphere 13, no. 12 (2022): 2098.