A Quantitative Comparison of Ground based L-band Scintillation and In situ F-region Irregularities From Swarm

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This study focused on observations of irregularity structures using the Swarm satellites in comparison with amplitude scintillation events recorded by the Global Positioning System - Scintillation Network and Decision Aid (GPS-SCINDA) receiver installed in Mbarara, Uganda (Geog. lat = -0.6°, Geog. lon = 30.8°, Mag. lat = -10.2°), roughly at the expected latitudinal location of the southern crest of the Equatorial Ionization Anomaly (EIA). Some distance in space and/or time between piercing points of the GPS signals and Swarm tracks had to be allowed, in order to obtain a sizable number of events. We find that for a large number of passes, amplitude scintillations were enhanced when the Swarm Langmuir probes also recorded density perturbations. But counter examples, i.e. irregularities but no scintillations, or no irregularities but scintillations, indicated that mismatches between observed irregularity structures and scintillations can occur over a few minutes and within distances of a few tens of kilometers. The number of matching observations was greater for Swarm A and C which were at lower altitudes of about 440-460 km compared to Swarm B at 510 km. The high resolution density estimates sampled at 16 Hz correspond to a spatial scale of 500 m, which is of the order of the Fresnel scale relevant for scintillations in the L band at GNSS frequencies. We modeled/predicted S4 from the in-situ 16 Hz data using the well-known phase screen model developed by Rino [1979]. The power law spectral index fitted to the observations was mainly in the range between 1.8 and 2.2, i.e. often < 2 where the phase screen model becomes not applicable. When using instead a spectral index of 2.5, which would qualitatively be expected for signal paths that are more perpendicular to the geomagnetic field than the Swarm satellite tracks, the range of predicted S4 agreed well with the observed one at Mbarara. The predicted S4 decreased drastically and was much below the observed one when using only 2 Hz density estimates corresponding to 4 km scales. Again, S4 predicted from Swarm B data was on average lower than for A and C, and agreed less well with the observed range. The relevant spatial scales for L band scintillations at the ground seem to be hundreds of meters, in agreement with Fresnel theory. Irregularities at about 450 km height contribute strongly to the L band scintillations while irregularities at about 510 km contribute already significantly less. Swarm A and C 16 Hz density estimates promise to provide a suitable statistical proxy for L band scintillations.