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Impact of VHF irregularity dynamics on multi-frequency GNSS signal fading characteristics

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Transionospheric satellite-based communication and navigation links suffer significant degradation of performance in the equatorial region during intersection with ionospheric irregularities. These irregularities, of different scale sizes, primarily affect frequencies ranging from HF through VHF, UHF to L-band. Institute of Radio Physics and Electronics, University of Calcutta operates satellite beacon receiving systems, namely, Low Earth Orbiting (LEO) Coherent RAdio Beacon EXperiment (CRABEX) of Indian Space Research Organization at 150, 400MHz, SCIntillation Network Decision Aid (SCINDA) spaced-aerial VHF receiver of US Air Force Research Laboratory at 250MHz, and multi-frequency GNSS receivers at L1, L2 and L5 frequencies.
The present paper aims to understand decorrelation of multi-frequency GNSS signals at L1, L2 and L5 during periods of ionospheric scintillations with corresponding irregularity dynamics at VHF during the high-to-moderate solar activity period 2014-2015. The basic objective behind this study is to check if irregularity dynamics at VHF could be mapped to L-band scintillation indices, thereby developing predictive capability for L-band scintillation occurrence. During October 26-29, 2015, some cases of depletions in relative Total Electron Content (TEC) were observed by CRABEX on COSMOS2407 passes. SCINDA VHF link and GNSS links also noted patches of patches of scintillations on the geostationary FLEETSATCOM (FSC) link at 250 MHz. VHF zonal drift and characteristic velocities have been calculated from the SCINDA VHF spaced-aerial measurements. The decorrelation times of the VHF signals are provided by the VHF receiver. Functional relations have been developed to relate the VHF irregularity dynamics as mentioned above with GNSS S_4 indices. In addition, variations in the Position Dilution of Precision (PDOP) measured from GNSS have been found to degrade with smaller decorrelation times of the signals at VHF. Different nature of fading characteristics of the three GPS signals at L-band could possibly be attributed to different scattering mechanisms with respect to coherence distance. Scattering coefficients have been defined and calculated for each pair of GNSS L-band frequencies and their variations with irregularity zonal drift and characteristic velocities studied.