Degradation of satellite-based navigation performance observed from an anomaly crest location

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Equatorial ionospheric irregularity studies stem from the scientific community interest in the physics of plasma instabilities and from the technical interest in the effects of the ionosphere on communication and navigation system. Over the last decade, signals from Global Navigation Satellite System (GNSS) have been exceedingly exploited to monitor and characterize the ionosphere and related dynamics concerned with scintillations of trans-ionospheric radio signals. GPS amplitude scintillations in terms of the index S_4 and consequent errors in receiver positions have been extensively studied from Calcutta situated near the northern crest of the Equatorial Ionization Anomaly (EIA) and from other equatorial and low latitude stations. However occurrence of phase scintillations on GPS links have not been frequently reported from this sector, mainly due to non-availability of appropriate transmissions. Severe Space Weather events have the potential to cause serious damage to the technological infrastructure on which society relies. Associated with such events, which may occur even under geomagnetic benign conditions in the equatorial region, increasing number of satellite links may be disrupted leading to significant deviations in position.

Institute of Radio Physics and Electronics, University of Calcutta is a station under the **SCIntillation Network Decision Aid (SCINDA) program** of US Air Force Research Laboratory and operates dual-frequency GPS receiver at L1 and L2 frequencies since 2006 within the framework of this program. During the vernal equinox of 2014, 60 nights of intense ionospheric scintillations ($S4 \geq 0.6$) were observed on different GPS L band frequencies from Calcutta. The location of Calcutta being near the northern crest of the Equatorial Ionization Anomaly (EIA) in the Indian longitudes, signal outages from this location are amongst the most severe.

The present paper reports studies, spread over the equinoctial periods of 2014 and 2015, of amplitude and phase fluctuations of GPS signals resulting in loss-of-lock on a number of satellites and consequent degradation in position determination from the SCINDA station at

Calcutta. In March 2014, it is found that the number of satellites affected by intense amplitude and phase scintillations gradually increase from 4 around 13UT to a maximum of 10 during 15-16UT and thereafter falls to 2-3 around local midnight hours. Intense amplitude scintillations ($S_4 \geq 0.6$) are usually not found to affect any GPS satellite during post-midnight hours. It was found that for March 2014, the maximum cycle slip duration was found to be 145 seconds which corresponds to S_4 value of 1.31 and abnormally high value of σ_ϕ along with latitude deviation value of 85m during 15-16UT. During the time period when there was no loss of lock found, the maximum position deviation was found to be 10.87m. When there was no amplitude and phase scintillation observed, the maximum position deviation value is found to be 1m. An interesting observation noted in this study is the presence of good correspondence between amplitude and phase fluctuations which have not been extensively reported from the Indian longitudes. Characterizing phase fluctuations on GPS signals from an EIA crest location and studying its correlation with resultant degradation in navigation performance will provide new information for system designers.