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A novel method based on GPS TEC to forecast L band scintillations over the equatorial region through a case study

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ABSTRACT

Forecasting the occurrence of L-band scintillations has been a challenging task and, this challenge has been tackled by evolving a simple method using GPS-TEC data. For given background conditions, it has been shown that the fluctuations in the GPS-TEC truly represent the characteristic features of the perturbations that are responsible for the initiation of the plasma instability that finally culminates in to the observed irregularities. The close linkage between the perturbation features and the evolutionary pattern of the scintillations enable us to forecast '*when*', and '*for how long*' the L-band scintillations would occur, in addition to their 'occurrence pattern'. The first of their kind of results take us a step closer towards operational forecasting of L-band scintillations for real time navigational purposes.

1. Introduction

Very often, during post sunset hours, over equatorial and low latitude regions, the ground-satellite communication links experience both amplitude and phase scintillations due to the presence of plasma density irregularities in the ionosphere. The density irregularities are manifestations of the phenomenon of Equatorial Spread-F (ESF). The ESF that typically extends to $\pm 25^{\circ}$ in latitude centered over the magnetic dip equator refers to one of the turbulent conditions of the F region of the ionosphere due to the presence of the above plasma density irregularities that have scale sizes spreading several orders of magnitude (100's of km–10's of cm). These plasma density irregularities in turn manifest as, (i) spread in the reflected echoes from the F region (hence the name spread-F or ESF) as seen in an ionospheric sounder, (ii) phase and amplitude scintillation of satellite to ground communication links in the VHF and UHF frequency bands, (iii) as upward drafting plumes in the coherent VHF backscatter radar returns, (iv) as steep intensity bite outs in the thermospheric airglow images and (v) as steep density depletions in the satellite and rocket borne in situ measurements. Over the years this multi stage, multi parameter phenomenon has been unraveled to the extent of delineating the spatial and temporal variabilities and also to the level of identifying some of the most favorable background conditions that would support the generation and sustenance of ESF. Certain pre-requisites like the lifting up of the F region to great heights during post sunset hours (Pre-Reversal Enhancement—PRE) and its modulation by factors like, the alignment of the magnetically conjugate E regions with the sunset terminator have been reported in the literature (Abdu et al., 1992; Tsunoda, 1985). Further, the control of the equatorial ionization anomaly (EIA) over ESF through its associated temperature and wind anomaly (ETWA), the consequent meridional circulation cell that would manifest as vertically downward winds over the equator and the critical role of the additional forcings like the neutral winds in deciding the day to day variability of ESF have also been extensively studied (Raghavarao et al., 1988, Sekar and Raghavarao, 1987; Raghavarao et al., 1992; Raghavarao et al., 1999; Devasia et al., 2002; Jyoti et al., 2004). It had been shown that up to ~90 min, before the actual occurrence of ESF, it could be predicted through OI 630.0 nm day-glow measurements (Sridharan et al., 1994) or by monitoring the latitudinal variations of TEC through the navigational satellite beacons (Valladares et al., 2001). On the other hand, Thampi et al., (2006) have evolved a controlling parameter representing the background ionospheric/thermospheric conditions in an attempt to reach a level of deterministic prediction. The above results take us to a point, where it could be stated with some reasonable certainty, whether ESF would occur on a given day or not. These earlier predictions were totally based on the background ionospheric/thermospheric conditions with an inherent assumption of omnipresent perturbations. There had been fewer studies on the possible role of the initial perturbations in the ESF variability (Sreeja et al., 2009; Tsunoda, 2010). Out of the different manifestations of ESF, the one that has a crucial role in the VHF and UHF communication is the ionospheric scintillation.

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