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Investigations of GPS-based total electron content (TEC) data at different low latitude IGS stations and its relevance to earthquake precursor studies

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ABSTRACT

In the present paper, IGS-TEC data of five low latitude stations which include Lucknow (26.9°N, 80.96°E), Bangalore (13.02^{0}N, 77.57^{0}E), Hyderabad (17.42^{0}N,78.55^{0}E), Port Blair (11.64°N, 92.71°E), and Lhasa (29.66°N, 91.10°E) are analyzed during high and low solar activity periods i.e. period-I and period-II, respectively to check its usefulness for earthquake precursory studies. The durational variations show that peak VTEC lies between 08:00 and 10:00 hrs (UT) at all the stations and ranges 25-50 TECU during period-I, it lies at the same time interval but within the range of 14-20 TECU during the period-II. The VTEC values are higher in the equinoctial months during both periods under consideration. In all seasons, seasonal peak VTEC values are noticed to vary between 14 and 42 TECU during period-I and 7 to 18 TECU during period-II. The influence of solar activity is studied on GPS-TEC in terms of sunspot numbers and solar flux index F10.7 cm and it is found that these solar indices are more fluctuating in the period-I than that period-II and attain peak values of ~ 175 and ~185 in period-I, and ~55 and ~85 during period-II. This enhanced solar activity causes more fluctuation in TEC data in period–I, compared to period -II. In addition, the effect of magnetic storms is also studied on GPS-TEC data and it is noticed that TEC is significantly affected in severe magnetic storms. This study provides a better understanding of the behavior of low latitude ionosphere during high and low solar activity periods.

Keywords: Ionosphere, IGS-TEC, Solar Activity, Solar Flux F10.7, Sunspot Numbers.

INTRODUCTION

In the recent era, the study of the ionosphere has become very important because of its wide area of applications, especially the low latitude ionosphere, which is affected by many geophysical phenomena such as magnetic storms, solar flares, and many anthropogenic sources which include nuclear explosions, dust storms, and volcanic activities. The ionospheric irregularities like Equatorial Ionization Anomaly (EIA), spread-F, and sporadic E, also affect the ionosphere which can be studied from the variation in ionospheric parameters (Pundhir et al., 2017a). So it is necessary to examine the effect of these factors on the ionosphere, which provides a better understanding of its structure and dynamics. For this, a diurnal, seasonal, and annual study of the ionosphere is inevitable. These studies are very important before examining the ionospheric data in earthquake precursory studies because the ionosphere is highly complex and variable and can be perturbed by a slight change in any of its parameters (Pundhir et al., 2017a).

Numerous researchers have studied the ionosphere morphologically by using TEC data that yielded remarkable findings (Natali and Meza, 2011; Wu et al., 2012; Akala et al., 2013; Huy et al., 2014). On account of the existence of EIA in India, extensive study of low latitude ionosphere is carried out by many workers using TEC observations based on global positioning system (GPS) measurements and have compared their findings with international reference ionospheric (IRI) models (Bhuyan and Borah., 2007; Mukherjee et al., 2010; Kumar et al., 2012; Prasad et al., 2012; Sharma et al., 2012; Chakraborty et al., 2014; Karia et al., 2015; Rathore et al., 2015; Pundhir et al., 2017b). The GPS-based TEC studies have succeeded in forecasting the ionosphere's behavior. In addition, these studies help detect the impact of solar activities on the ionosphere (Lastovicka, 2002; Dashora et al., 2009; Trivedi et al., 2011, 2013; Xu et al., 2012; Adebiyi et al., 2014). During space weather events like geomagnetic storms, the variation of TEC in the Indian region is studied at many low latitude stations namely; Rajkot (Bagiya et al., 2009), Varanasi (Kumar et al., 2012), Bhopal (Trivedi et al., 2011), Shimla (Rama Rao et al., 2009), and Agra (Pundhir et al., 2017a, b). The morphological studies by Kumar et al. (2012) have investigated the variations of vertical total electron content (VTEC) recorded during the low solar activity period extending from May 2007 to April 2009 at Varanasi (25.16^{0}N, 82.59^{0}E), located close to EIA crest and rest two International GNSS Service (IGS) stations Hyderabad (17.20^{0}N, 78.30^{0}E) and Bangalore (12.58^{0}N, 77.33^{0}E) in India. They have examined the diurnal and seasonal variations of TEC, and the effect of geomagnetic storms on it. It is reported that TEC is minimum during the winter months (November- February) and attains maximum during equinoctial months (March, April, September, and October) at all three stations. It assumed intermediate values during the summer months (May-August). Monthly, seasonal, and annual variability of GPS-TEC has been compared with those derived from the IRI 2007 model with three different options of topside electron density, NeQuick, IRI01-corr, and IRI 2001. Results of GPS-TEC and IRI 2007 TEC models are found consistent for monthly, seasonal, and