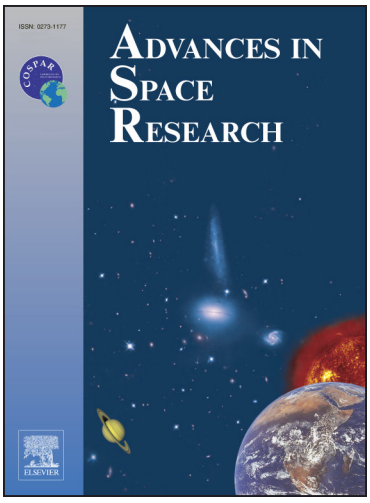

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Solar activity indices as a proxy for the variation of ionospheric Total Electron Content (TEC) over Bahir Dar, Ethiopia during the year 2010-2014

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Abstract

This paper was aimed at investigating the solar variations of vTEC as a function of solar activity parameters, EUV and F10.7 radio flux. The daily values of ionospheric vertical Total Electron Content (vTEC) were observed using a dual frequency GPS receiver deployed at Bahir Dar (11.6°N and 37.36°E), Ethiopia. Measurements were taken during the period of 2010-2014 for successive five years and analysis was done on only quiet day observations. A quadratic fit was used as a model to describe the daily variation of vTEC in relation to solar parameters. Linear and non-linear coefficients of the vTEC variations were calculated in order to capture the trend of the variation. The variation of vTEC have showed good agreement with the trend of solar parameters in almost all of the days we consider during the period of our observations. We have explicitly observed days with insignificant TECU deviation (eg. modeling with respect to EUV, DOY=49 in 2010 and modeling with respect to F10.7, DOY=125 in 2012 and the like) and days with maximum deviation (about 50 TECU). A maximum deviation were observed, on average, during months of equinox whereas minimum during solstice months. This implies that there is a need to consider more parameters, including EUV and F10.7, that can affect the variation of vTEC during equinox seasons. Relatively, small deviations was observed in modeling vTEC as a function of EUV compared to that of the variation due to F10.7cm flux. This may also tell us that EUV can be more suitable in modeling the solar variation of vTEC especially for longterm trends. Even though, the linear trend of solar variations of vTEC was frequently observed, significant saturation and amplification trends of the solar variations of vTEC were also observed to some extent across the months of the years we have analyzed. This mixed trend of the solar variation of vTEC implies the need for thorough investigation on the effect of solar parameters on TEC. However, based on long-term dataset, we came to conclude that the solar variations of vTEC is dominated by its linear pattern.

Keywords: Solar activity, TEC, linearity, quadratic fitting

1. Introduction

It is well understood that the primary energy source, which dominantly contribute to the dynamics of the upper atmosphere, the evolution of energetic particles as well as for the formation of ionosphere, is the solar radiation. This solar radiation varies in its magnitude with various time scale, which significantly affect the structure of the upper atmosphere, climate, and weather, inducing remarkable changes in the system of the terrestrial thermosphere and ionosphere (Gorney, 1990; Hedin, 1984). Our intension here is to characterize the effect of the regular solar activity variations in solar extreme ultraviolet (EUV) radiations on the ionosphere. Thus the regular variations in solar EUV radiations will strongly affect the Earth's ionosphere and the thermosphere (Afraimovich et al., 2008; Balan et al., 1993, 1994; Chen et al., 2008; Guo et al., 2007; Hedin, 1984; Huang, 1967; Liu et al., 2005). As a result, the most prolonged solar activity effects have been taken into account in ionospheric models, which are constructed for single stations, regions, and global as well, to reproduce the dominant patterns of ionospheric parameters. Indeed, as primarily ionizations for the ionosphere, solar EUV and X-ray radiation can vary by more than a factor of 2 from solar minimum to solar maximum and by as much as 50 % during a solar rotation (Belehaki et al., 2001; Bilitza, 2000; Zhao et al., 2005).

Considerable investigations have been conducted globally, with limited observations around East African region, so far to characterize the solar activity effects of several ionospheric parameters, such as electron density N_e and plasma temperatures at different altitudes, total electron content (TEC), and peak electron density (NmF_2) and peak height (hmF_2) of the F_2 layer, in terms of observations and theoretical models as well (Kane, 2003; Lei et al., 2005; Liu et al., 2007; Su et al., 1999). Significant achievement have been reported in the variability of the ionosphere in relation with solar cycle. As per these reports, the solar cycle variations of the ionosphere is complicated. Balan et al. (1993); Gorney (1990); Kane (1992) and Rishbeth (1993) reported that the relationship between foF_2, NmF_2 and TEC and solar indices such as sunspot number, solar 10.7 cm radio flux F10.7 or solar EUV fluxes is roughly linear, however, in reports such as Balan et al. (1994); Bilitza

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