Evaluation of long term solar activity effects on GPS derived TEC

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Abstract. The solar activity hence the solar radiance follows a long term periodic variability with eleven years periodicity, known as solar cycle. This drives the long term variability of the ionosphere. In the present problem we investigate the long term behaviour of the ionosphere with the eleven year cyclic solar activity. Under the present study we characterize the ionospheric variability by Total Electron Content (TEC) using measurements made by Global Positioning System (GPS) and solar cycle variability by various solar activity indices. We make use of five solar activity indices viz. sunspot number (Rz), solar radio Flux (F10.7 cm), EUV Flux (26-34 nm), flare index and CME occurrences. The long term variability of these solar activity indices were then compared and correlated with the variability of ionospheric TEC, at a mid latitude station, Usuda (36.13N, 138.36E), of Japan, during the solar cycle 23 and ascending phase of cycle 24. From our study, we found that long term changes in the ionospheric TEC vary synchronously with corresponding changes in the solar activity indices. The correlation analysis shows that all the solar activity indices exhibit a very strong correlation with TEC (R =0.76 –0.99). Moreover the correlation between the two is stronger in the descending phase of the solar cycle. The correlation is found to be remarkably strongest during the deep minimum of the solar cycle 24 i.e. between 2007- 2009. Also we noticed a hysteresis effect exists with solar radio flux (F10.7 cm) and solar EUV flux (26-34 nm). This effect is absent with other parameters.

1. Introduction

The solar activity is characterised with a variation pattern of eleven years called solar cycle. During which there occurs periodic variation in the emission of radiation from the Sun. It has been now established that the primary source for the formation of the Earth's ionosphere are the solar extreme ultraviolet radiations (EUV) and solar X-rays [1]. The 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 i.e. these solar radiations follow the solar cycle variation [2, 3, 4, 5]. Therefore the regular or solar cycle variations in solar EUV and X-ray radiations will affect the variability and dynamics of the Earth's ionosphere. Since the variation of solar X-ray and extreme ultraviolet (EUV) radiations are the main cause for changes in the ionosphere, in the absence of continuous long term records of these fluxes, solar proxies have been used to represent solar emissions. Sunspot number (Rz), solar 10.7 cm