CODG TEC VARIATION DURING SOLAR MAXIMUM AND MINIMUM OVER NIAMEY

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Abstract

The present paper analyses the prediction of CODG model during solar maximum and solar minimum at Niamey station (Geo Lat 13°28'45.3"N; Geo long: 02°10'59.5"E). CODG TEC only shows dome time profile. The estimated TEC is higher during solar maximum than during solar minimum. Spring estimated TEC is the highest and summer one the lowest. The equinoctial asymmetry is only observed during solar minimum phase.

Keywords: CODG model, TEC, solar cycle phases

Introduction

Many study topics deal with ionosphere variability by means of GPS TEC (see Jin and Park, 2007; Chauhan and Singh, 2010; Ouattara and Fleury, 2011; Liu and Gao, 2001; Rama Rao et al., 2006; DasGupa, 2007; Spogli et al., 2009; Prikryl at al., 2010). Ouattara and Fleury (2011), Zoundi et al. (2012). Ouattara et al. (2013) have used CODG TEC, on the one hand to appreciate the accuracy of CODG estimation and on the other hand to put out ionosphere variability study ionosphere. The present study focuses on ionosphere variability by means of CODG model at Niamey in Niger. Our objective is to point out the seasonal variation of CODG TEC during the maximum of solar cycle 23 and during the deep minimum of solar cycle 24. This study is the first one that treats this variability. After data and methodology, we present and discuss the results. The paper ends with the conclusion.

Data and methodology

We determine the TEC at Niamey station by using the model of the coefficients of the ionosphere given by CODE i.e. Centre for Orbit Determination in Europe. The CODE is one of the centres of analysis of IGS. The TEC determination model is CODE GIM (Global Ionosphere Maps) or CODG. TEC is also determined by utilizing IGS stations through Global Ionosphere Maps. CODG TEC data used here come from IGS i.e. International GNSS (Global Navigation Satellite Systems) Service data base (http://igscb.jpl.nasa.gov).

Here, CODG TEC is estimated at Niamey station (Geo Lat 13°28’45.3”N; Geo long: 02°10’59.5”E) during solar cycle maximum phase (2000, 2001 and 2002) and during solar minimum phase (2006, 2007, 2008). For seasonal study, we consider the following classification: winter (December, January and February); spring (March, April and May), summer (June, July, August) and autumn (September, October and November).

Solar cycle phase CODG TEC ($TEC^{cycle\ phase}$) is obtained by applying the following formula: $TEC^{cycle\ phase} = \frac{\sum_{i=1}^{ny} TEC_{season}^{i}}{ny}$ with ny the number of years involved in the solar cycle phase and TEC_{season}^{i} the seasonal CODG TEC given by $TEC_{season}^{i} = \frac{\sum_{j=1}^{nm} TEC_{month}^{j}}{nm}$. In this equation, nm is the number of months per season and TEC_{month}^{j} the monthly arithmetic mean CODG TEC value. It is expressed as: $TEC_{month}^{j} = \frac{\sum_{k=1}^{nd} TEC^{k}}{nd}$ with nd the number of available data days per month and TEC^{k} the daily TEC value.

Results and discussion

Figure 1 gives the time variation of CODG TEC for solar minimum phase. Panel a concerns winter and summer, panel b is devoted to spring and autumn and panel c to all seasons put together. Figure 2 is the same as figure 1 but for solar maximum phase. Both figures show dome TEC profile independently of solar cycle phases and seasons.

Panel a of figure 1 shows that from 0800 LT to 1700 LT and from 2000 LT to 0400 LT winter TEC is superior to that of summer. In panel b, it can be seen that spring TEC is always superior to that of autumn. This result shows the CODG TEC equinoctial asymmetry. Panel c highlights that the highest TEC is observed during spring and the lowest during summer. Autumn TEC is superior to that of winter.

In figure 2a, one can see that except between 0300 LT and 0700 LT, winter TEC is superior to summer TEC. In panel b, there is no difference between spring and autumn TEC. These two seasons TEC show the same variability. There is no equinoctial asymmetry for this solar maximum. Panel c shows that the highest TEC is observed during autumn and spring and the lowest during summer.

The dome profile observed here can be attributed to the absence of electrojet (after Fayot and Vila, 1989). The only observed dome time profile over seasons and solar activity supposes that CODG does not reproduce the effect of all physical processes in equatorial region (e.g. noon bite out profile due to ExB effect: see Matuura, 1974; Fejer, 1981; Fejer et al., 1981; Fairley et al., 1986; Fejer et al., 1991 and nighttime peak due to the pre-reversal electric field signature: see Fairley et al., 1986; Fejer et al., 1991).

The equinoctial asymmetry observed during solar minimum has been previously noted by Gnabahou and Ouattara (2012), Ouattara et al. (2012) and Ouattara et al. (2013). Ouattara et al. (2013) attributed this asymmetry to McPherron mechanism. The absence of the equinoctial asymmetry during solar maximum maybe due to the following factor: Ouattara et al. (2013) show that for the years 2000 and 2002 there is more ionosphere in March/April than in September/October while in 2001 there is more ionosphere in September/October than in March/April. By merging together the years 2000, 2001 and 2002 as in the present study, the two kinds of equinoctial asymmetry effects annihilate themselves. The winter anomaly or annual asymmetry or non seasonal anomaly expressed as the presence of more ionosphere in winter than in summer. This kind of anomaly may be due to the presence of more ionosphere in January than in July (Rishbeth et al., 2006). Many speculations on the reasons of such observation exist (see Yonezawa and Arima (1959), Buonsanto (1986) and Rishbeth et al. (2000) and many references therein in the latter reference) but cannot explain the real amplitude of the annual asymmetry in all latitudes. Therefore the investigation of all physical processes involved in the manifestation of non seasonal anomaly remains necessary.

Conclusion

The present paper shows the equinoctial asymmetry during solar cycle minimum phase and it absence during solar cycle maximum phase. CODG TEC at Niamey exhibits non seasonal anomaly. The highest TEC is observed during spring and the lowest in summer. CODG TEC amplitude is also higher in solar maximum than in solar minimum. The TEC profiles given by CODG model is always dome profile.

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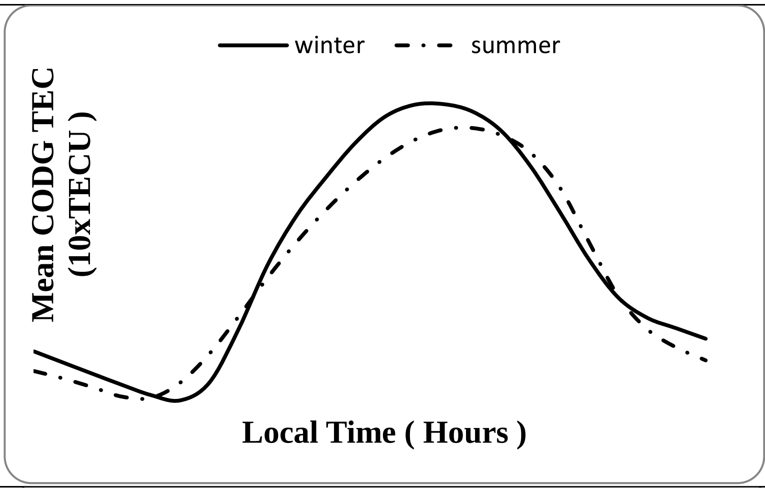
Figure captions

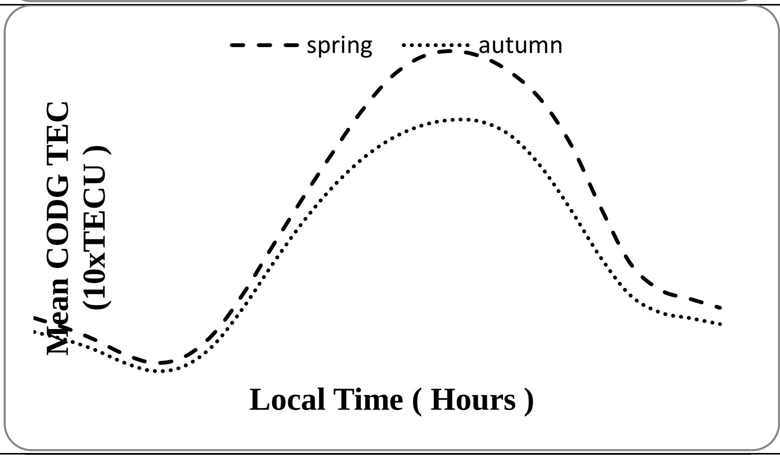
Figure 1: Time variation of CODG TEC for solar minimum phase. Panel a concerns winter and summer, panel b is devoted to spring and autumn and panel c to all season putting together.

Figure 2: the same as figure 1 but for solar maximum phase.

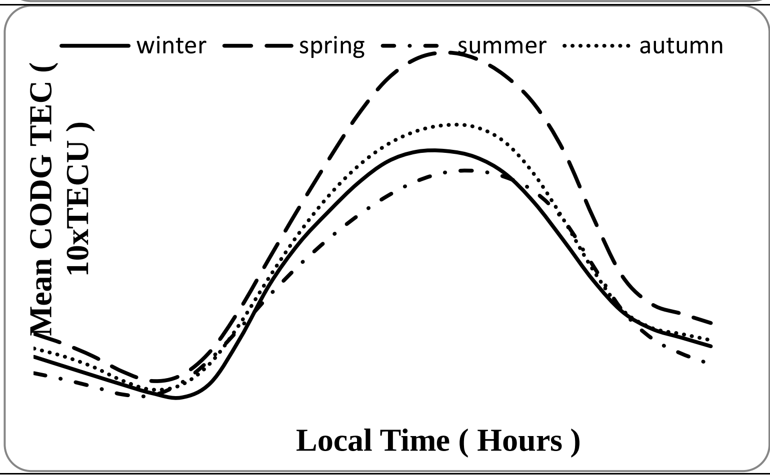
a


winter
summer
Mean CODG TEC (10xTECU)
Local Time (Hours)

b


spring
autumn
Mean CODG TEC (10xTECU)
Local Time (Hours)

c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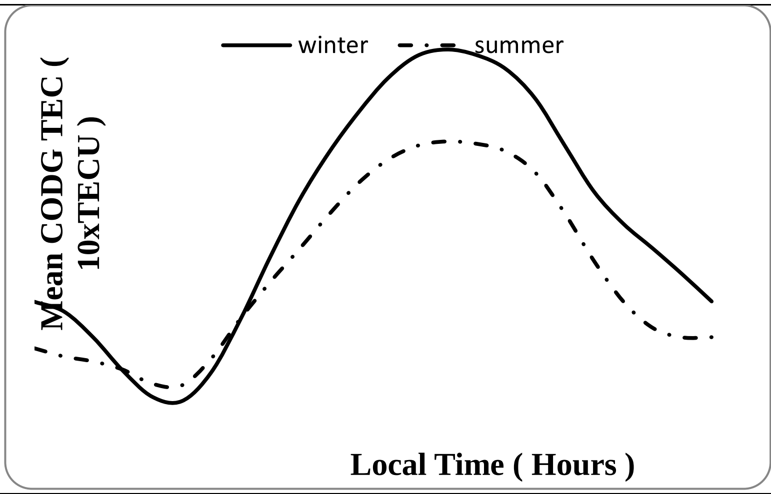
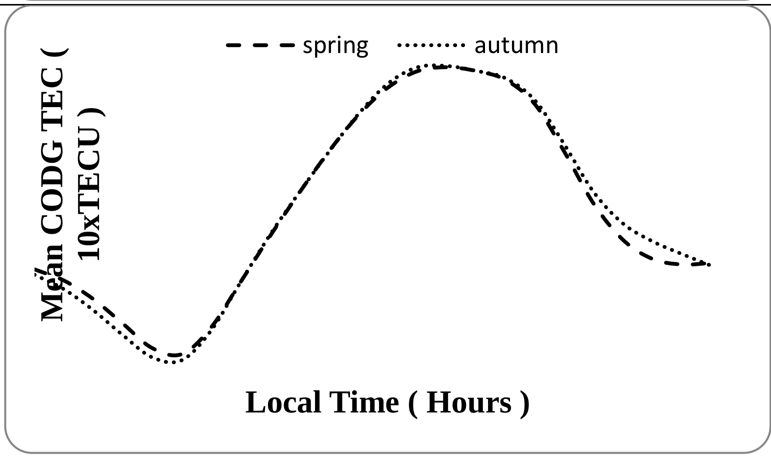
Mean CODG TEC (10xTECU)
Local Time (Hours)

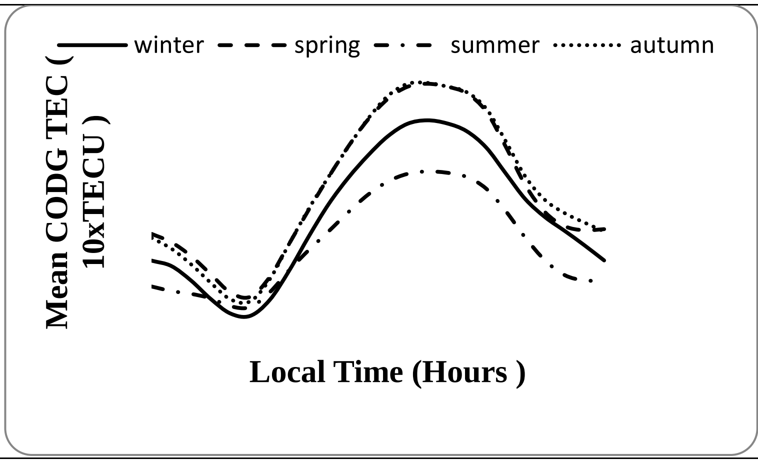
a


winter
summer
Mean CODG TEC (10xTECU)
Local Time (Hours)

b


spring
autumn
Mean CODG TEC (10xTECU)
Local Time (Hours)

c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