Simulation models of electron density and Temperature variations in the topside ionosphere Plasma

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Abstract: The simultaneous variations of electron density and temperature in the topside ionosphere for low latitude have been investigated under various conditions of season, latitude, height and solar activity. With using the IRI data, models of the simultaneous variations of these parameters are presented and results are compared. The possible reasons for similarity or difference between variations are also discussed. [Z. Panahi, Z. Emami, S. Shafigh, R. Kuhi. **Simulation models of electron density and Temperature variations in the topside ionosphere Plasma.** *Life Sci J* 2013;10(5s):133-137] (ISSN:1097-8135). http://www.lifesciencesite.com. 24

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1. Introduction

Electron temperature (T_e) in ionosphere is measured by the heat balance between the heating by photoelectrons, cooling through coulomb collisions with ions, and heat conduction along the magnetic field lines (e. g., Watanabe et al. 1995; Kakinami and Watanabe, 2011). Since the photoelectron flux and natural density (e. g. Hedinand and Mayr, 1987), and plasma electron density (e. g., Lei et al., 2005; Kakinami et al., 2009) increase with increasing solar flux, it is not clear wether KT_e or T_e increases or decreases with an increase in solar flux. The energy distribution of ionospheric plasma has been studied extensively, theoretically thermal electron energy distribution (Hays and Nagy, 1973) and experimentally (Hays and Sharp, 1973).

Electron density (N_e) is produced by solar EUV radiation, since the solar photons have significant energy to ionize the natural atmosphere, Simultaneously photoelectron produced in this ionization process heat the local ambient electrons as well as remote electrons along the magnetic field (e. g., Watanabe et al. 1995; Kakinami and Lin 2011).

For relation between electron density and electron thermal energy as electron temperature, many studies have shown a negative correlation during daytime (Evans, 1971, 1973; Bitiliza, 1987; Bitiliza and Hoegy 1990; Zhang and Holt, 2004). A positive correlation was measured using incoherent scatter radar (Zhang and Holt, 2004). Theoretical study have also shown a positive correlation between N_e and T_e during of high solar flux (Lei et al. 2007). Further, results from comparison of measured and modeled electron density, and electron ion temperature for magnetically and solar activity conditions (Povlov et al., 2004). Also an exponential reduction of N_e above the F_2 layer peak leads to a decrease in the cooling by means of coulomb collisions, heat conduction along the field lines becomes important in the topside ionosphere (Bitiliza et al., 2007). In this paper, we present the seasonal, solar activity and latitudinal Simultaneous variations in the topside ionosphere from the height of 900km to 2000 km by using IRI data. The dependence of variations of N_e and T_e on different geophysical conditions is studied. The possible reasons for similar or different variations are also studied.

2. Annual variations of N_e and T_e

To study the annual simultaneous of electron density and temperature within $\pm 20^\circ$ latitude, a model algorithms are presented for the time period of 2011 months. As shown Figure 1, electron temperature diagrams in all months are u-shaped with the maximum of $1700\ ^\circ k$ at latitude -20° in March and October and the minimum of $1300\ ^\circ k$ at latitudes 10° in January and in 5° in July. As illustrated in the figures, the electron density variation trends are almost similar in January and February. In these two months N_e increases with T_e in the range of $20^\circ\_-10^\circ$ and between $-10^\circ\_0^\circ$ latitude N_e decreases with decreasing T_e and between $0^\circ\_10^\circ$ latitude, N_e also increases with decreasing T_e and between $10^\circ\_20^\circ$ latitude, N_e decreases with increasing T_e. To As we see N_e and T_e variation trends in March and April are similar within $-20^\circ\_-10^\circ$ latitude, electron density values increase with decreasing electron temperature. In May and January, in $-20^\circ\_0^\circ$ latitude, density increases with decreasing T_e and in $0^\circ\_10^\circ$ latitude N_e decreases with increasing T_e and within $10^\circ\_20^\circ$, except a reduction at 20° latitude in May.

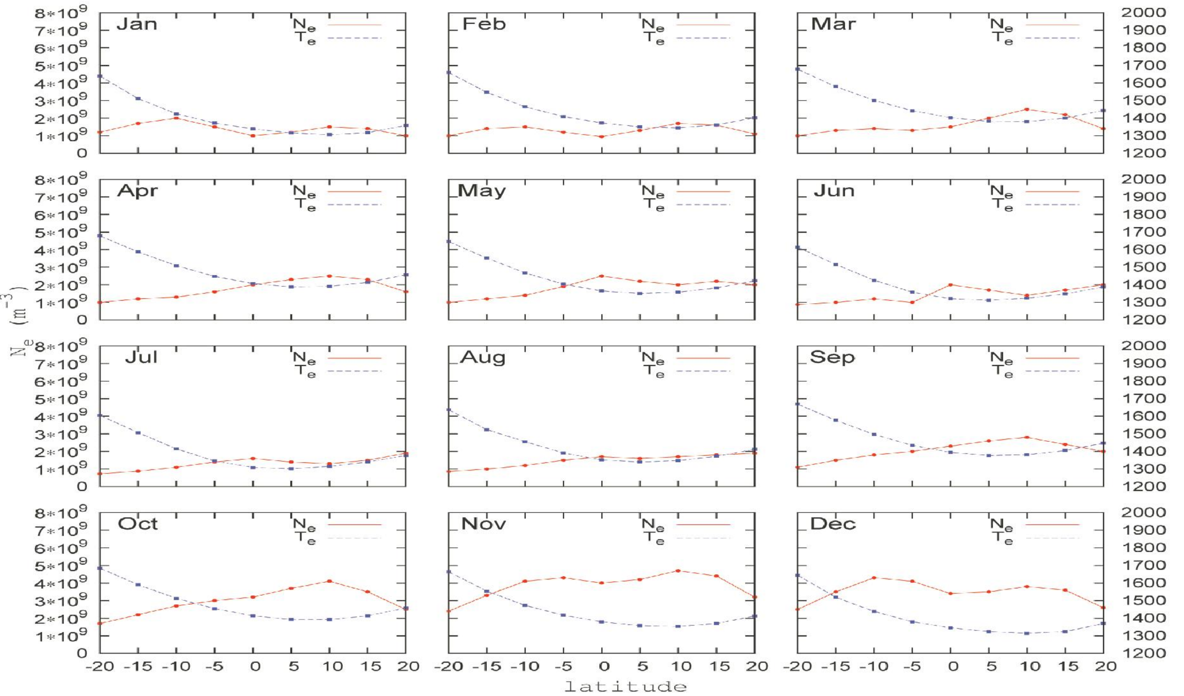

Figure 1. Annual variations of N_e and T_e in the topside ionosphere within ± 20 ° Lat for 2011,

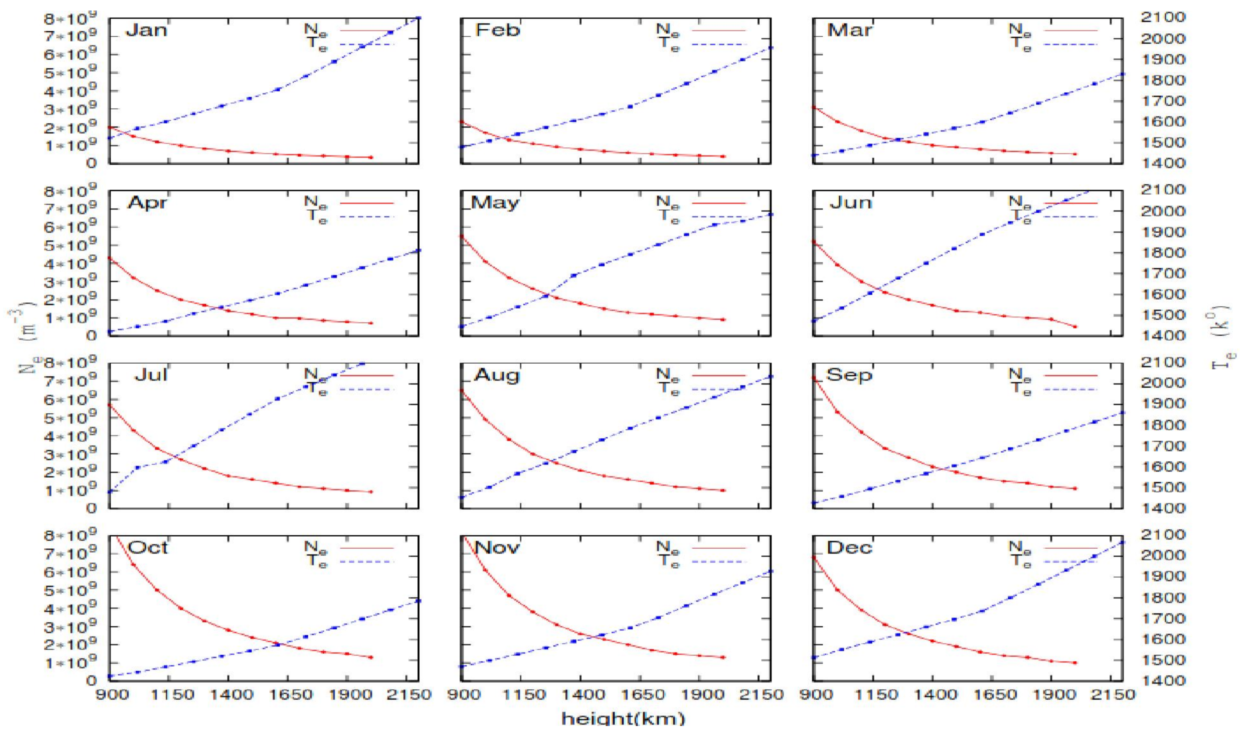

Figure 2. Annual variations of N_e and T_e in the using the IRI data topside ionosphere within the height 900km-2000km for 2011, using the IRI data

N_e in July and August is in the range of $-20^\circ\_0^\circ$ latitude that it increases with decreasing T_e and within $0^\circ\_5^\circ$, N_e decreases with decreasing T_e and in the range of $5^\circ\_20^\circ$, N_e values increase with increasing T_e. N_e and T_e variations in September and October are similar too. Within $-20^\circ\_-10^\circ$ latitude, N_e increases with decreasing T_e and between $10^\circ-20^\circ$, N_e decreases with decreasing T_e. In November and December, between $-20^\circ\_-10^\circ$ latitude, N_e increases with decreasing T_e and within $-10^\circ\_0^\circ$ latitude, N_e and T_e decrease together and in $0^\circ\_10^\circ$ latitude, N_e and T_e increase and at last in $10^\circ\_20^\circ$ latitude, N_e decreases with increasing T_e. Interestingly, in all months except with a small difference in January and December, minimum value of T_e corresponds to maximum value of N_e. To investigate the annual variation of N_e and T_e with height, presented figures are for the month for 2011 in low latitude from the height 90km to 2150km. As shown in Figure 2, a decrease in T_e and an increase in N_e with height is observed. During this period, the maximum and minimum of T_e are equal to $2100\ ^\circ K$ at height 2150km in May and $1420\ ^\circ K$ at height 900km in September and October. As can be seen in Figure, variations are totally opposed for N_e and T_e.

3. Solar activity variations of N_e and T_e

To investigate the solar activity variations effect on these parameters our calculations presented from height 900km to 2000km (Figure 3) and within $\pm 20^\circ$ dip latitude (Figure4). It should be noted that obviously the electron temperature didn't keep the same for both solar activity min and max, but these data selected for low latitude values, and solar wind in solar max more absorbed in magnetic poles. This in why electron temperature are the same in these two solar activities. Figure 3 shows simultaneous variations of T_e and N_e between $|Lat| \leq 20^\circ$. As is seen, in solar min electron density values are in the range of $10^8 m^{-3}$ and these values are lower than the solar max values in the range of $1\times10^9 - 4\times10^9 m^{-3}$. In addition, the figure illustrates a reduction of electron temperature from $2600\ ^\circ K$ at -20° to $2100\ ^\circ K$ at 15° and a small increase in the range of $15^\circ-20^\circ$ N. In solar activity min, similar to temperature trends is seen a reduction for the interval of -20° to 15° and an increase in the range of $15^\circ_20^\circ$N is obvious , in fact electron density and temperature variations are consistent in solar activity min. In solar max, for the interval of $-10^\circ\_0^\circ$ and $5^\circ\_20^\circ$, both electron temperature and electron density variations are following the same trends that means electron density decreases with decreasing temperature. However, within -20° to -15° and $0^\circ\_5^\circ$ electron density increases with decreasing temperature. Figure 4 illustrates solar activity dependence of electron density and electron temperature on height. As it is shown, electron temperature is from $2090\ ^\circ$k to $2600\ ^\circ$k, which the maximum temperature, $2600\ ^\circ$k, is located at the height 900km and the minimum temperature is located at the height 1100km. In addition, figure 4 shows a reduction within the range of 900-1100km height and also within 1500-1700km and an increase in the range of 1100km to 1500km and 1700km to 2000km. In solar activity min, electron density keep the range $10^8 m^{-3}$ and at heights 900km to 1000km electron density decreases with decreasing temperature. In the range of 1100km to 1500km electron density changes are reliable while temperature increases. Furthermore, from 1500km to 1600km to 1700km density decreases with decreasing temperature and in the next range between $1700\ ^\circ$K and $2000\ ^\circ$K density increases with increasing temperature. Solar activity max electron density variations which are shown in red correspond to temperature changes at heights between 1000km to 1100km and 1700km to 2000km. In these two ranges variations are similar together while in other ranges variations of N_e and T_e are opposite together.

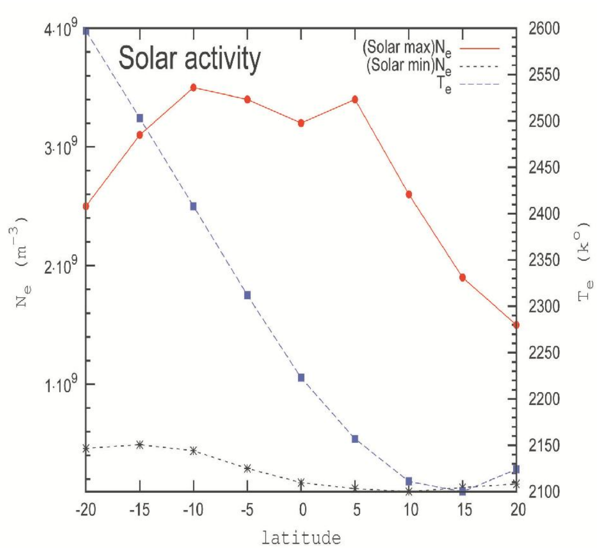

Figure 3. Solar activity variations of N_e and T_e in the topside ionosphere within $-20^\circ\_20^\circ$ latitude for 2011, using the IRI data

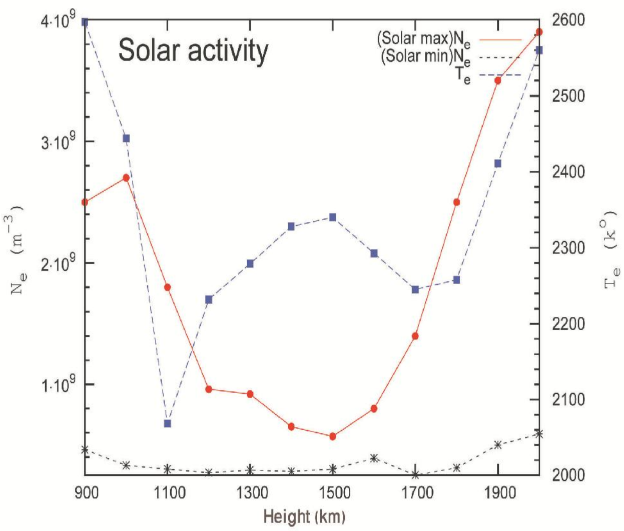

Figure 4. Solar activity variations of N_e and T_e in the topside ionosphere within 900km- 2000km for 2011, using the IRI data

Conclusion

We investigated the annual and solar activity variations of N_e and T_e in the topside ionosphere at magnetic dip latitudes within $\pm 20^\circ$ and also in the range of 900km to 2000km using the IRI data, All models except height annual variation model that only shows a similar trends for N_e and T_e in all months, increasing T_e and decreasing N_e with increasing height, illustrate both similar and apposite variations of N_e and T_e in different ranges. Since the cooling through coulomb collisions increases with the increase of N_e, an additional heat some is required for the ranges with similar trends. Therefore, these results show T_e in the topside ionosphere is controlled more by the integrated N_e along the magnetic field line (Kakinami et al, 2011).Although many factors such as the day time upward $\vec{E} \times \vec{B}$ drift, natural winds in the thermosphere, and waves of troposphere origin also affect the N_e in the topside ionosphere [Fejer, 1991; Oyama et al., 1996b; Watanabe are Oyama, 1996; Kakinami et al, 2011], our results explain that T_e in the low- latitude topside ionosphere is possibly controlled by photo electron heating and through coulomb collisions with ions that are related to N_e.

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