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RESEARCH ARTICLE

TEMPORAL AND LATITUDINAL VARIATION OF ELECTRON DENSITY DURING THE ASCENDING HALF OF THE SOLAR CYCLE 23 IN THE TOPSIDE F-REGION OF THE INDIAN LOW AND EQUATORIAL LATITUDES.

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Abstract

The effect of solar activity on local time, seasonal and latitudinal variation of electron density N_e measured by the SROSS C2 satellite over the Indian zone during the ascending half of the solar cycle 23 from 1995-2001 at the height of ~500 km is investigated. The SROSS C2 covered the latitude and longitude belts of 31° S - 34° N and 40°- 100° E respectively. Results show that average nighttime (20:00 - 04:00 LT) electron density varies between $0.92\times10^{10} - 1.62\times10^{12}$ m^{-3}, decreases to a low value of $0.44\times10^{10} - 2.65\times10^{11}$ m^{-3} before sunrise and after sunrise increases to an average daytime (10:00 – 14:00 LT) value that varies between $1.03\times10^{11} - 20.19\times10^{12}$ m^{-3}. There is an evening enhancement in N_e within 18:00 LT to 20:00 LT in the summer solstice. The daytime N_e is highest in the equinoxes with higher value in spring compared to that in autumn. In between the two solstices electron density is higher in winter. Both daytime and nighttime electron density increases with the increase of solar activity in summer, winter and equinoxes. However, annual average electron density appears to follow the ascent of the solar cycle with a time lag of about one year and at the peak of the solar cycle 23 the topside electron density over Indian low and equatorial latitudes exhibits a non-linear relationship with F10.7 cm solar flux. The non-linear relationship between electron density and F10.7 cm solar flux appears to have been caused by non-linear variation of the neutral densities at the bottom and top end of the solar cycle. The variation of the solar ionizing fluxes Lyman α and E10.7 EUV proxy indices have been found to be linear with that of F10.7 and, therefore, appear to have no effect on the observed non-linear variation of electron density with F10.7 cm solar flux.

Introduction:-

Almost perfectly horizontal field lines of the earth's magnetic field within a narrow belt of about ±3° geomagnetic latitude gives rise to the electrojet current between altitudes of 70 km and 140 km and it is transferred almost undiminished to higher altitudes, to affect deeply the entire low latitude region. The electrojet current gives rise to the equatorial ionization anomaly (EIA), the fountain effect; the post sunset equatorial anomaly (PEA), noon bite-out, spread F etc.

Equatorial anomaly was first reported by Appleton (1946) and Mitra (1946). As explained by Martyn (1947) the anomaly is formed through the combined effects of E×B drift and ambipolar diffusion. The electrojet current causes F region plasma to drift upward with a velocity of $E\times B/B^2$. At the same time gravitational and pressure gradient forces more ionization downward along the magnetic field lines transporting plasma away from the magnetic equator toward higher latitudes. Thus the ionization crests are formed north and south of the magnetic equator. This is the mechanism of fountain effect (Hanson and Moffett, 1966). The equatorial ionosphere has been studied theoretically and experimentally since long (Moffett, 1979; Anderson, 1981; Walker, 1981; bailey and Balan, 1996; Rishbeth, 2000; Abdu, 1997, 2001; Stening, 1992; Walker et al., 1994 and references therein). More recently, the equatorial F-region ionosphere has been studied using the data provided by the Japanese satellite Hinotori for a moderate (F10.7 ≥ 150) to high (F10.7 ≤ 220)solar activity period (Watanabe and Oyama, 1995, 1996; Su et al., 1996; Oyama et al., 1996; Balan et al., 1997). The Indian satellite SROSS C2 provides data from December 1994 to July 2001 over the equatorial zone. Using SROSS C2 data the variability of F region ionosphere has been studied (Bhuyan et al., 2002 a, b; Bhuyan et al., 2003; Bhuyan et al. (2006); Niranjan et al., 2003). Studies on equatorial plasma density have been done using the data from the Chinese satellite ROCSAT-1 (Burke et al., 2004; Lin et al., 2005; Kil and Paxton , 2006; Su, et al., 2002; Kil et al., 2004; Le et al., 2003; Yeh et al., 2001). Pavlov et al. (2004) have reported results of the study of electron density, electron and ion temperature measured by the ionospheric sounders and by the middle and upper atmosphere (MU) radar and compared with modeled data for geomagnetically quiet and moderate solar activity conditions at locations close to the geomagnetic equator and equatorial anomaly crests along 201° geomagnetic meridian.

The solar cycle variations of the most important ionospheric parameters have been studied extensively. Volland (1969) explained diurnal density variation and its dependence on solar activity with the help of a two dimensional model between 100 and 400 km height. Mendonca et al. (1969) have reported solar activity effect on TEC at Sao Jose Dos Campos between 1963 and 1968. Rajaram and Rastogi (1977) have reported the effect of season and solar cycle on equatorial electron density distributions. Huang and Cheng (2000) have obtained positive correlation between the 12 month running average of monthly mean TECs and sunspot numbers by using the ETS2 satellite beacon signal during the period from March 1977 to December 1990 at Lunping observatory around equatorial anomaly crest regions in East Asia. Rastogi (2003) have reported the effect of solar cycle variation on the equatorial spread-F in the American zone. Bhuyan et al. (2006) have reported the effect of solar activity on local time and seasonal variations of electron temperature measured by the SROSS C2 during the low to moderate solar activity period from 1995 to 1998 over the Indian subcontinent. They have found positive correlation of both daytime (10:00-14:00 hr) and nighttime (02:00-22:00 hr) electron temperature with solar activity. Truhlik et al. (2005) have found that the logarithm of the O^+, H^+, He^+ and N^+ densities in the topside ionosphere at a fixed altitude, latitude, and local time is in the first approximation, a linear function of solar activity characterized by the daily F10.7. Pandey and Mahajan (1985) observed that electron temperature increases with the increase of solar activity at 300 km. Brace and Theis (1981) found that at the altitude of 300 km, T_e measured by the ISIS satellite during daytime had significant decrease with increase in solar activity during the solar maximum period of solar cycle 20. They found positive correlation of nighttime T_e with F10.7 at 300 km. Mahajan and Pandey (1979) found that T_e at 1000 km increased with solar activity between 1965 and 1969.

Ionization and peak density as represented by ionospheric total electron content (TEC) and NmF2 normally exhibits a linear relationship with solar activity measured in terms of 10.7 cm solar flux index F10.7 and sunspot number R_z. However, there have been number of reports which indicate that the linear relationship does not hold good near the peak of solar cycles i.e. for very high values of F10.7 (Titheridge 1973, Bhuyan et al., 1983, Lakshmi et al., 1988, Kane, 1992, Rishbeth, 1993). Balan et al., (1993, 1994) have shown that during the intense solar cycle 21 when F10.7 frequently exceeded 300 and reached a maximum value of 367, the total ionospheric electron content and related solar F10.7 increase nonlinearly. The observed nonlinear variation of ionization density with solar flux has been theoretically investigated by Balan et al. (1994) using the Sheffield University Plasmasphere Ionosphere model. The relative importance of neutral winds, neutral densities and solar EUV fluxes on the observed nonlinear phenomenon has been investigated. It has been found that the saturation of ionization is caused by the saturation in production of ionization due to the nonlinear increase of solar EUV fluxes while nonlinear increase of neutral winds and neutral density seem to have no effect on the saturation. In other words, the ionosphere (and atmosphere) responds linearly to solar EUV (or UV) inputs and nonlinearly to F10.7 beyond certain high value of the flux and the expected linear relationship between the EUV (and UV) fluxes and F10.7 breaks down during solar maximum.

In this paper we present the results of the study of the effect of solar cycle variation on the diurnal, latitudinal and seasonal variation of N_e within ±10° of the geomagnetic equator over India during the period of low (1995) to high (2001) solar activity using the SROSS C2data.

Results:-

Diurnal, seasonal and latitudinal variation of electron density:-

The electron density measured by the SROSS C2 satellite during the period January 1995 to July 2001 has been studied over three latitudes ±10° of the geomagnetic equator and over the geomagnetic equator. The data are grouped into bins of ±2.5° in latitude and 1 hour in local time. Fig.1 shows the scatter plot of N_e against local time over 10° N of the geomagnetic equator for summer (May, June, July and August), winter (November, December, January, February) and equinoxes (March, April, September and October). In summer the average daytime electron density varied from a low value of ~16.20×10^{10} m^{-3} in 1995 to a high value of ~183.00×10^{10} m^{-3} in 2000. The average nighttime N_e varied from ~3.64×10^{10} m^{-3} in 1995 to ~47.60×10^{10} m^{-3} in 2000. The diurnal minimum in N_e is lowest in 1997 with a value of ~1.15×10^{10} m^{-3} and highest in 2001 with a value of ~16.10×10^{10} m^{-3}. In winter the average daytime N_e varies from ~10.80×10^{10} m^{-3} in 1996 to 156×10^{10} m^{-3} in 2001. The nighttime electron density is minimum in 1995 with an average value of ~0.98×10^{10} m^{-3} and is maximum in 2001 with an average value of ~74.50×10^{10} m^{-3}. The diurnal minimum in N_e rises from a low value of ~0.41×10^{10} m^{-3} in 1997 to ~18.20×10^{10} m^{-3} in 2001. In equinox average daytime N_e is minimum ~17.10×10^{10} m^{-3} in 1996 and maximum ~219×10^{10} m^{-3} in 2000. Average nighttime N_e varies from ~2.12×10^{10} m^{-3} in 1995 to ~162.00×10^{10} m^{-3} in 2001. In equinox the diurnal minimum of electron density has a minimum value of ~0.88×10^{10} m^{-3} in 1997 and a maximum value of ~23.20×10^{10} m^{-3} in 2001.

Over the geomagnetic equator (Fig.2) in summer average minimum and maximum daytime electron densities are ~16.00×10^{10} m^{-3} in 1995 and ~122.00×10^{10} m^{-3} in 1999 respectively. The nighttime N_e has a minimum value of ~1.26×10^{10} m^{-3} in 1997 and a maximum value of ~44.80×10^{10} m^{-3} in 2001. The diurnal minimum in N_e rises from a low value of ~0.31×10^{10} m^{-3} in 1997 to ~13.40×10^{10} m^{-3} in 2000. In winter daytime N_e is minimum with an average value of ~18.00×10^{10} m^{-3} in 1996 and maximum in 2000 with an average value of ~125.00×10^{10} m^{-3}. The nighttime N_e varies from a low value of ~3.76×10^{10} m^{-3} in 1995 to a high value of ~63.10×10^{10} m^{-3} in 2001. The diurnal minimum varies from ~0.75×10^{10} m^{-3} in 1995 to ~20.50×10^{10} m^{-3} in 2001. In equinox average daytime electron density is minimum in 1996 with a value of ~26.20×10^{10} m^{-3} and maximum in 2000 with a value of ~148.00×10^{10} m^{-3}. Nighttime N_e has minimum value of ~2.01×10^{10} m^{-3} in 1997 and maximum value of ~128.00×10^{10} m^{-3}. Diurnal minimum varies from ~0.49×10^{10} m^{-3} in 1997 to ~26.50×10^{10} m^{-3} in 2001.

Fig. 3 shows the scatter plot of N_e in summer, winter and equinox over 10° S of the magnetic equator. In summer daytime N_e varies in its average value from ~10.30×10^{10} m^{-3} in 1995 to ~151.00×10^{10} m^{-3} in 2000. Average nighttime N_e varies from 0.92×10^{10} m^{-3} in 1997 to ~64.40×10^{10} m^{-3} in 2001. Diurnal minimum rises from ~0.44×10^{10} m^{-3} in 1997 to ~11.60×10^{10} m^{-3} in 2001. In winter average daytime minimum and maximum values of N_e are ~19.49×10^{10} m^{-3} in 1997 and ~147.00×10^{10} m^{-3} in 2001 respectively. Nighttime N_e varies from ~2.64×10^{10} m^{-3} in 1995 to ~70.80×10^{10} m^{-3} in 2001 in its average value. The diurnal minimum in winter has a low value of ~0.54×10^{10} m^{-3} in 1995 and a high value of ~10.60×10^{10} m^{-3} in 1999 and 2000. In the equinoxes, average daytime electron density increases from 1995 to 2000 from minimum value of ~18.90×10^{10} m^{-3} to maximum of ~158.00×10^{10} m^{-3}. The nighttime N_e has its minimum value of ~1.41×10^{10} m^{-3} in 1997 and a maximum value of ~152.00×10^{10} m^{-3} in 2001. The diurnal minimum rises from a low value of ~0.53×10^{10} m^{-3} to a high of ~11.20×10^{10} m^{-3} in 2000.

Solar cycle variation:-

The effect of variation of solar activity on electron density is studied by plotting the daytime (10:00 – 14: 00 LT) and nighttime (22:00 – 02:00 LT) measured electron density within the region ±10° magnetic latitude against monthly mean sunspot number R_z and shown in Fig. 4. During the period 1995 to 2001 sunspot number varied from the minimum of 0.9 in October 1996 to the maximum of 170 in July 2000. Solar activity decreased from its peak level in 2000 and mean R_z in 2001 was 102. The N_e versus R_z plots are shown separately for the three seasons and for all data combined. Electron density bears a positive correlation with solar activity in all the three seasons both during daytime and nighttime. The relationship between N_e at the altitude of ~500 km and R_z can be expressed by the least square fit as

$$N_{e\,(day)} = 1.2612\, R_z + 7.156 \quad (1a)$$
$$N_{e\,(night)} = 0.3488\, R_z - 1.6033 \quad (1b)$$

The daytime and nighttime electron density increases with the increase of solar activity in all the three seasons and also over the three latitudes. The rate of increase of N_e with sunspot activity is faster during daytime than during the night.

Response of electron density to solar activity is further investigated plotting the average daytime and nighttime electron density against the F10.7 cm solar flux (Fig. 5) both during day and night and in all seasons. The linear relationship is expressed by the relations

$$N_{e(day)} = 1.3229\, F10.7 - 74.552 \quad (2a)$$
$$N_{e(night)} = 0.3946 F10.7 - 27.023 \quad (2b)$$

Similar to the variation of day and nighttime density with sunspot number, the rate of increase of electron density with increase in solar F10.7 cm solar flux is faster at day compared to that during nighttime.

In Fig. 6 the year to year variation of electron density averaged for all latitudes between ±10° separately for the three seasons are shown. The figure also shows the variation of average yearly F10.7 cm flux during the same period. It is seen from the figure that the average annual electron density exhibits retarded growth beyond the year 1999 when F10.7 continued to increase till 2000. Thus the electron density at the topside of Indian low latitude appears to respond nonlinearly to F10.7. The linear relationship does not hold good both at the minimum and maximum of the solar cycle.

The level of ionization and height of ionospheric layers are determined by solar ionizing radiations (EUV and X ray), densities of the neutral constituents and neutral wind. The measured value of Lyman α flux and solar EUV fluxes show good correlation with F10.7 only during rising and falling phases of the solar cycle and exhibits poor correlation at the peak and trough of the cycle (Hinteregger et al., 1981, Hedin, 1984). The solar Lyman α (1216 A°) and He I (10,830 A°) measured during the intense solar cycles increase non-linearly with F10.7 (Balan et al., 1993, 1994). Richards et al. (1994a, b) also showed that the values of EUV fluxes measured during solar cycle 21 are nonlinearly related to F10.7 flux.

In Fig.7 the month to month variation of Lyman α, E10.7 EUV proxy index as obtained from the SOLAR2000 Research Grade version 1.23 empirical solar irradiance model (Tobiska et al., 2000) as well as F10.7 cm flux is shown. During the ascending half of the solar cycle 23, the F10.7 cm flux varied from a minimum of 69 to a maximum of 237 and the solar activity was not as intense as seen in case of solar cycle 21 when mean F10.7 cm flux at the peak of the solar cycle reached a high value of 303. The solar ionizing radiations have good linear correlation with F10.7 cm flux during the period of observation (bottom panel). Fig.8 shows the variation of neutral density with F10.7 cm solar flux. The fitted curves show that the neutral densities vary non-linearly with F10.7 both at the bottom and peak of the solar cycle. The variation of the solar ionizing fluxes Lyman α and E10.7 EUV proxy indices which have been found to be linear with that of F10.7 could not have caused the observed non-linear variation of electron density with F10.7 cm solar flux. Saturation in the density of the neutral constituents and effect of neutral winds might have been responsible for the observed nonlinear variation of topside electron density measured by the SROSS C2 at the bottom and top of the solar cycle 23.

Solar cycle variation of afternoon secondary enhancement:-

A secondary enhancement of electron density has been observed in the afternoon hours of low solar activity summer months. There is little evidence of the afternoon enhancement in the equinoxes as well as in winter. The eastward electrojet current reverses in the nighttime causing the reversal of the ionization drifts to downward direction. Before the reversal, the vertical drifts at times show a post sunset enhancement believed to be caused by the F region dynamo. Post sunset enhancements are routinely observed in F2 peak density and total ionospheric electron content at low latitudes. These enhancements have seasonal and solar cycle variations. The **E**×**B** drift has seasonal and solar cycle variations. Fejer et al. (1979) have observed dependence of **E**×**B** drift at Jicamarca on season and solar cycle. They found that the evening pre-reversal enhancement is observed throughout the year during solar maximum, but its amplitude is smallest for summer. For solar minimum conditions this enhancement is almost completely absent except during the equinoctial months. Long term report on **E**×**B** drift over the Indian zone is not available. As the diurnal variation of **E**×**B** drift as observed over Jicamarca does not explain the occurrence of the afternoon enhancement in N_e in the Summer, variation in neutral wind within this time period and in the season may be one of the reasons for the observed enhancement. The effect of neutral wind on the afternoon enhancement being investigated using HWM (Hedin et al., 1991). In summer for low solar activity the neutral wind is equator ward in the northern hemisphere and pole ward in the southern hemisphere from morning till afternoon. The wind velocity is very weak in the afternoon to presunset hours in the northern hemisphere from equator to about 30° N. Equator ward wind movement is seen at latitude beyond 30° N while in the southern hemisphere the wind is relatively strong and pole ward. The high latitude equator ward wind may bring in ionization to low latitude thus raising the level of ionization in the afternoon to evening period. The latitudinal variation of the neutral wind in the moderate solar activity period is nearly similar to that in low solar activity. The effect of prereversal enhancement of **E×B** drift velocity as observed in the high solar activity years may not contribute significantly to the ionization at low and equatorial latitudes as the ambient ionization level is already high and would remain embedded within. The daytime N_e is highest in the equinoxes over all the three latitudes. Daytime electron density is higher in spring than in autumn over ±10° and over the magnetic equator. In between the two solstices, electron density is higher in winter then in the summer.

Discussion:-

The prime factors for local time, seasonal and latitudinal variations of equatorial ionosphere that have been reported are **E×B** drift and the neutral wind. The temporal and spatial variations of NmF2 and TEC at low latitudes have been studied by Huang et al. (1989), Abdu et al. (1990), Walker et al. (1994) among others. From studies of electron density variations at the topside for solar maximum, Su et al. (1996) have reported that the electron density at 600 km altitude measured by the Hinotori satellite has its highest value within a broad range of latitudes around the geomagnetic equator. At higher latitudes, the electron density was found to decrease with increasing latitude in both hemispheres and the density is higher in the summer hemisphere. They also observed that the highest daytime values of electron density occur earlier at high latitudes. Su et al. (1995) from the modeling study of electron density and temperature measured by the Hinotori satellite at 600 km have found higher asymmetry in electron density in the summer hemisphere and lower asymmetry in the winter hemisphere. This summer to winter asymmetry is caused principally by the meridional wind. The meridional wind carries the F region in the summer hemisphere to altitudes of higher chemical loss rate in the winter hemisphere. Bhuyan (1992, 1994) had studied the variability of time of diurnal maxima in NmF2 and TEC and found a winter to summer time delay in the Asian sector and summer to winter time delay in the American sector. Bhuyan et al. (2003) have studied temporal and latitudinal variation of electron density at 500 km altitude over the Indian zone for a period of low solar activity (1995-1996) using SROSS C2 data. They have seen asymmetric ionization anomaly in the equinox and winter while the EIA is not so well developed in the summer. The cause of this summer to winter asymmetry in electron density in the Indian zone is suggested to be asymmetric neutral winds. They have also reported that the time of diurnal maximum of electron density varies with season. Pavlov et al. (2004) have reported a comparative study of modeled NmF2 and hmF2, and NmF2 and hmF2 which were observed at the equatorial anomaly crest and close to the geomagnetic equator simultaneously by the Akita, Kokubunji, Yamagawa, Okinawa, Chung-Li, Manila, Vanimo, and Darwin ionospheric sounders and by the middle and upper atmosphere (MU) radar at Shigaraki during the 19-21 March 1988 geomagnetically quiet time period at moderate solar activity near approximately the same geomagnetic meridian of 201°. A comparison between the N_e measured by the MU radar and those produced by the model is presented for 19-21 March 1988. The equatorial daytime upward **E×B** drift resulting from the zonal component, E_Λ of the electric field, lifts upward the ionospheric electrons and ions, and this leads to the increase of hmF2 close to the geomagnetic equator. Ions and electrons then diffuse downward along the magnetic field lines leading to the plasma "fountain". The effect on NmF2 depends on the competition between the electron density reduction caused by the plasma outflow and the electron density enhancement caused by the decrease in the loss rate of O^+ (^4S) ions. From their study they have found that the decrease in NmF2 caused by the plasma outflow as a result of **E×B** drift is stronger than the enhancement in NmF2 caused by the decrease in the loss rate of O^+ (^4S) ions. The dependence of NmF2 on $[N_2]$ and $[O_2]$ is weaker than the dependence of NmF2 on [O] by day at low geomagnetic latitudes. The plasma drift along magnetic field lines due to the neutral wind can increase or decrease hmF2, leading to the decrease or increase in the loss rate of O^+(^4S) ions at hmF2, causing an increase or decrease in NmF2. A decrease in the production rate of O^+ ions by solar radiation caused by a solar zenith angle increase results in an NmF2 decrease with time during an evening time period. A pole ward wind forces the F2 layer to descend to low altitudes of heavy chemical O^+(^4S) ion losses, reducing N_e to low values before sunset. Due to this pole ward wind, the evening NmF2 decrease in time becomes strong. The decrease in the absolute value of the geomagnetic latitude leads to the weakening of the effect of the plasma drift due to the neutral wind on N_e. The north-south asymmetries in the observed NmF2 and hmF2 about the geomagnetic equator are mainly caused by the asymmetry in the neutral wind about the geomagnetic equator due to the displacement of the geographic and magnetic equators and the magnetic declination angle. The increase in the loss rate of O^+ (^4S) ions, due to the vibrationally excited N_2 and O_2, leads to the decrease in the modeled NmF2, up to a maximum factor of 1.16 and to the increase in the calculated hmF2, up to a maximum value of 5 km between -30° and 30° geomagnetic latitude at moderate solar activity.

The ionosphere is produced mainly due to the photo ionization process. The increase in solar activity gives rise to the increase in solar energy, which results in higher values of ion concentration. However, as observed earlier in this report, the variation of solar ionizing radiations with F10.7 cm solar flux had been found to be linear and therefore non-linear variation of electron density in the topside ionosphere might have been caused by the non-linear variation of neutral densities. The effects of neutral winds have not been investigated and needs to be taken into account through a theoretical simulation of the observed phenomenon.

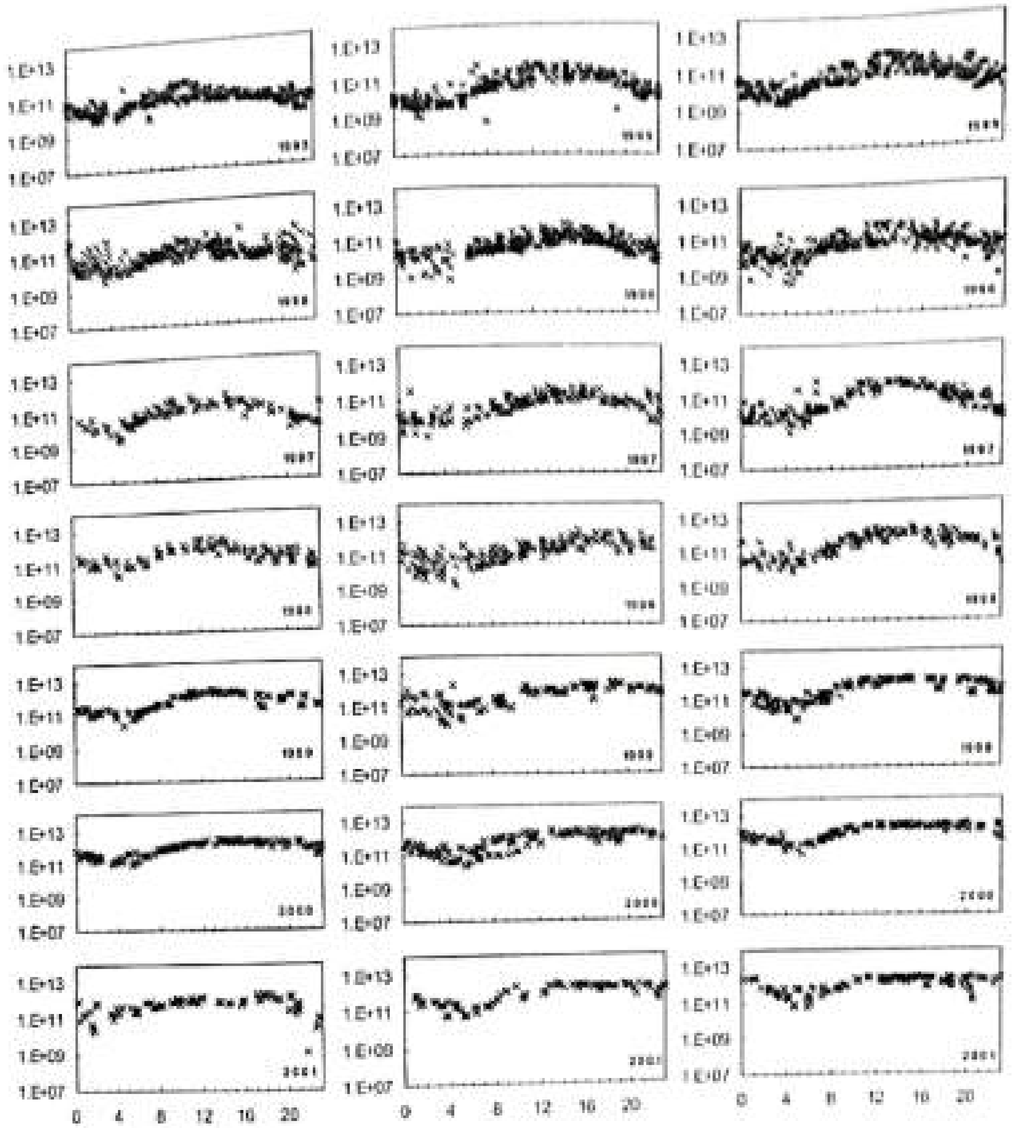

Figure 1: Diurnal and seasonal variation of electron density measured by the SROSS C2 at the altitude of ~500 km over $10^{\circ} \pm 2.5^{\circ}$ N magnetic latitude for the years 1995 to 2001.

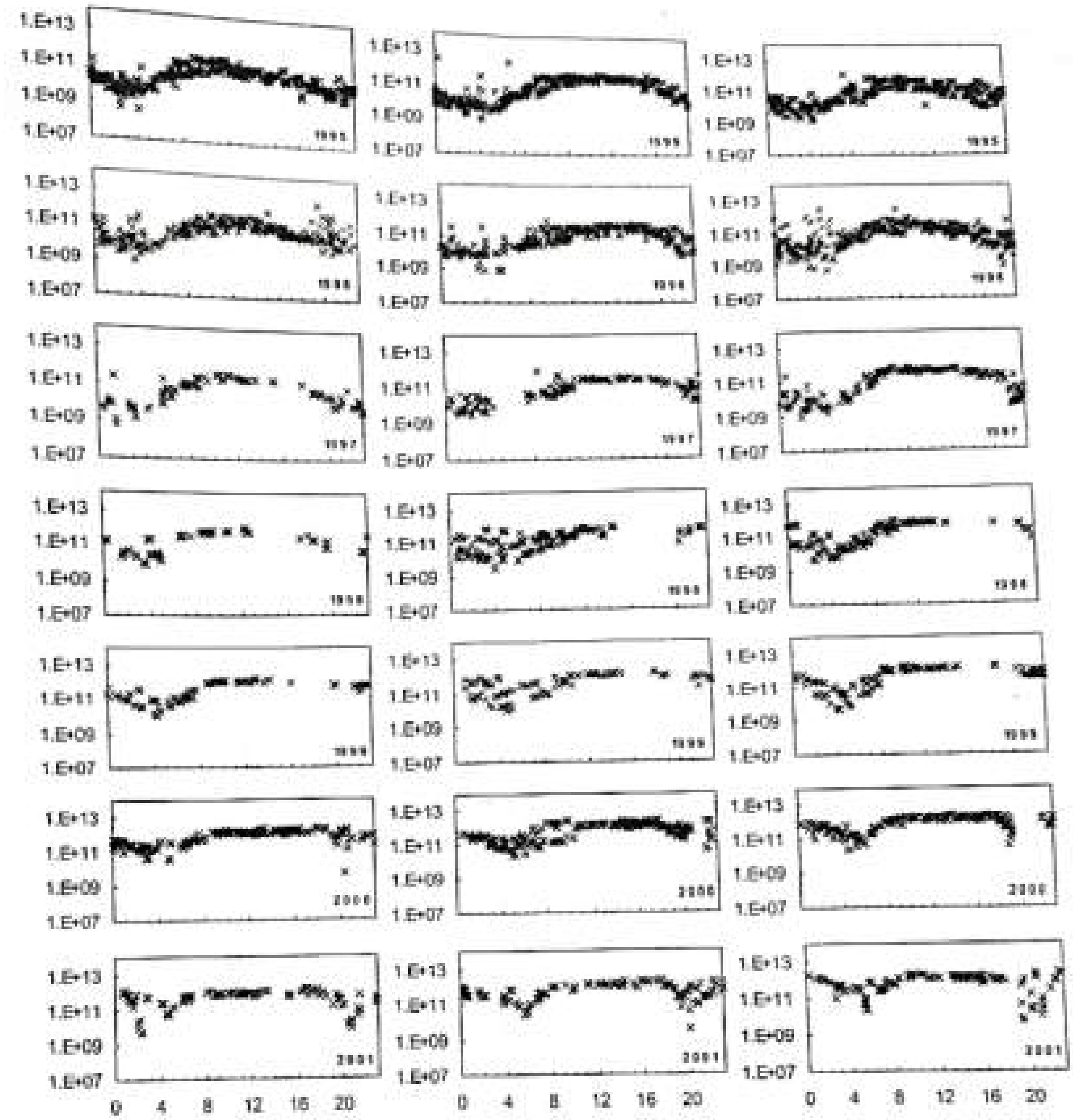

Figure 2: Local time and seasonal variation of electron density measured by the SROSS C2 at the altitude of ~500 km within ± 2.5° of the geomagnetic equator for the years 1995 to 2001.

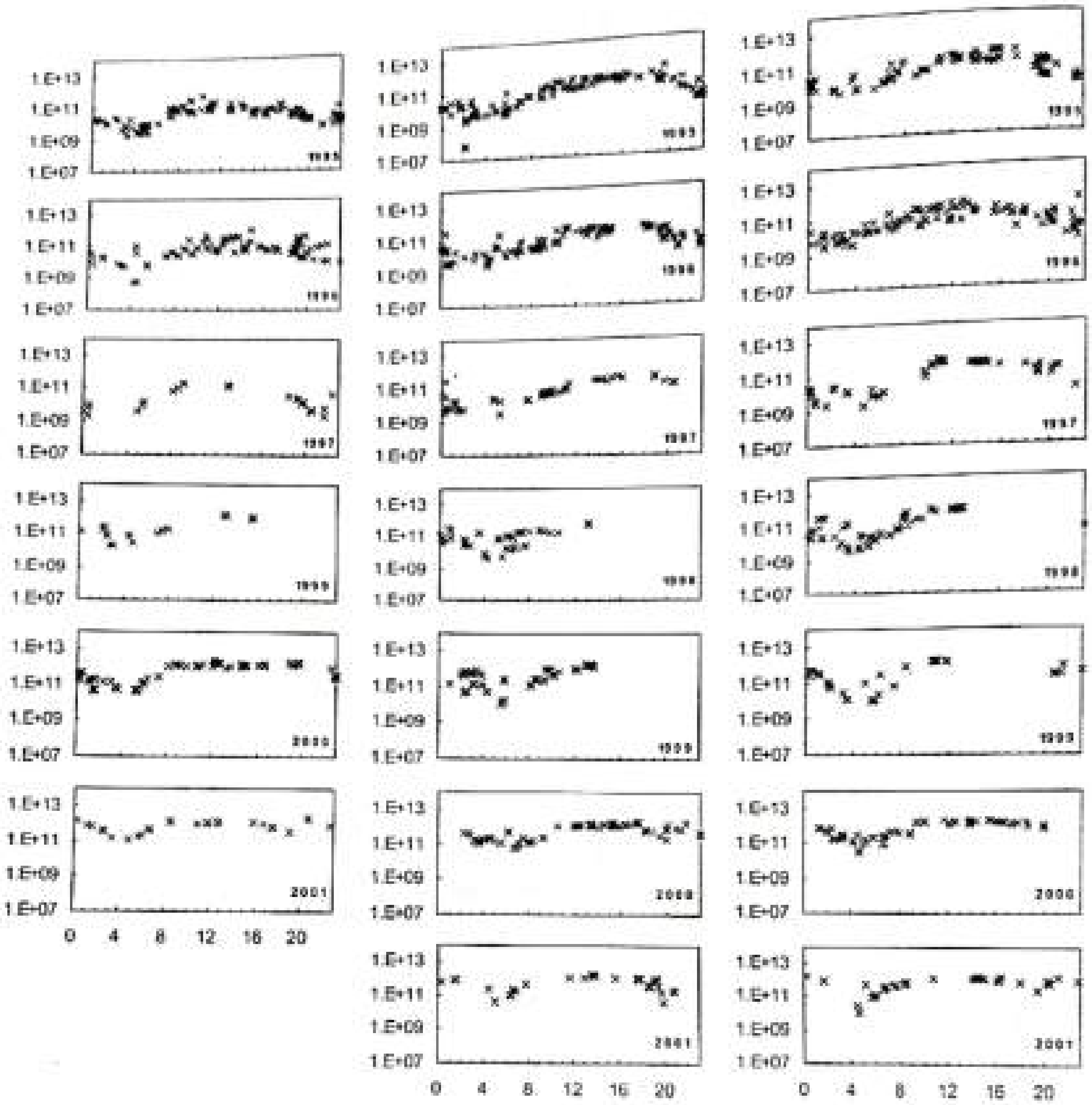

Figure 3: Diurnal and seasonal variation of electron density measured by the SROSS C2 at the altitude of ~500 km over 10° ± 2.5° S magnetic latitude for the years 1995 to 2001.

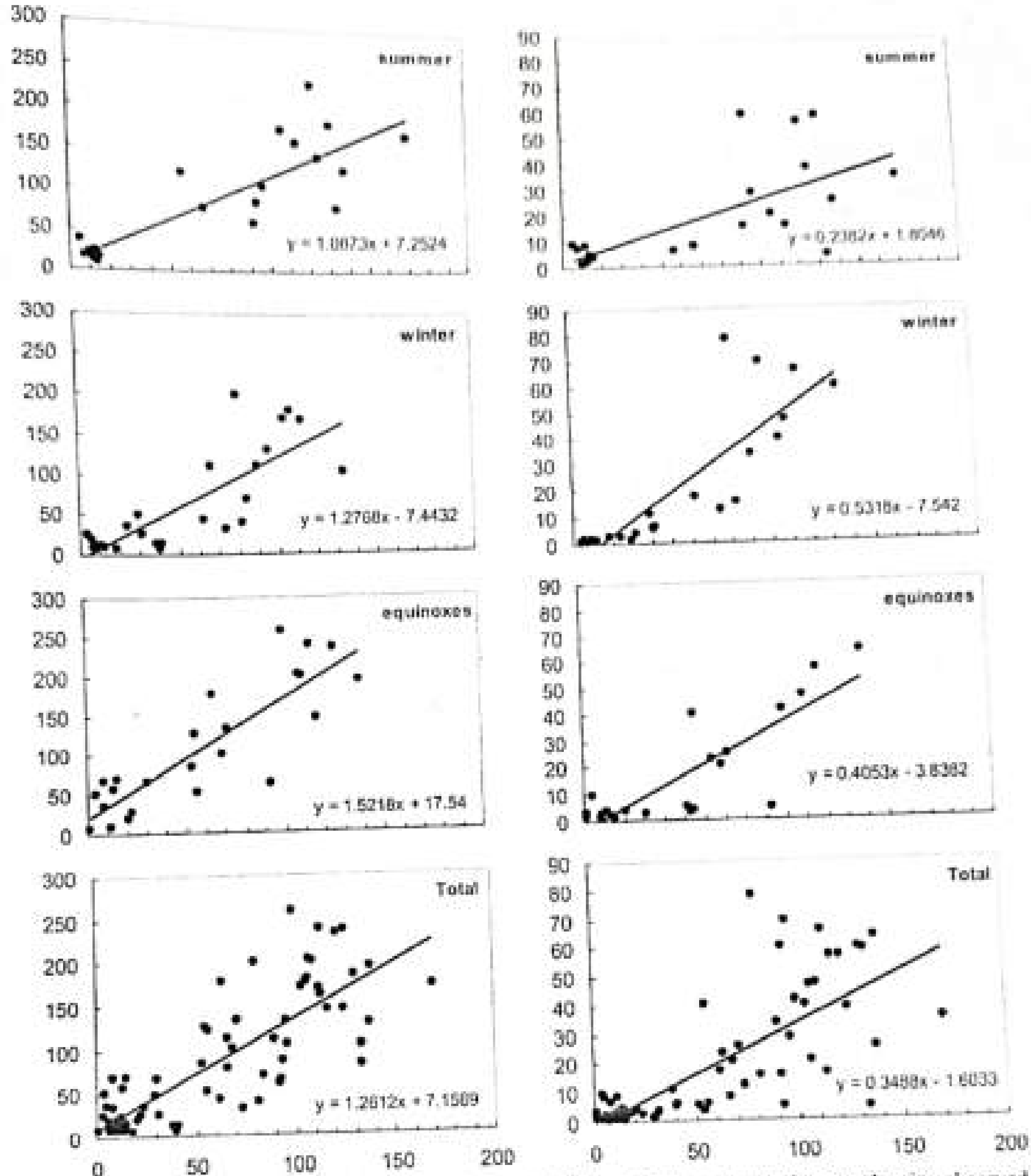

Figure 4:. Variation of average daytime (left column) and nighttime (right column) electron density observed by the SROSS C2 satellite with R_z within ± 10° magnetic latitude.

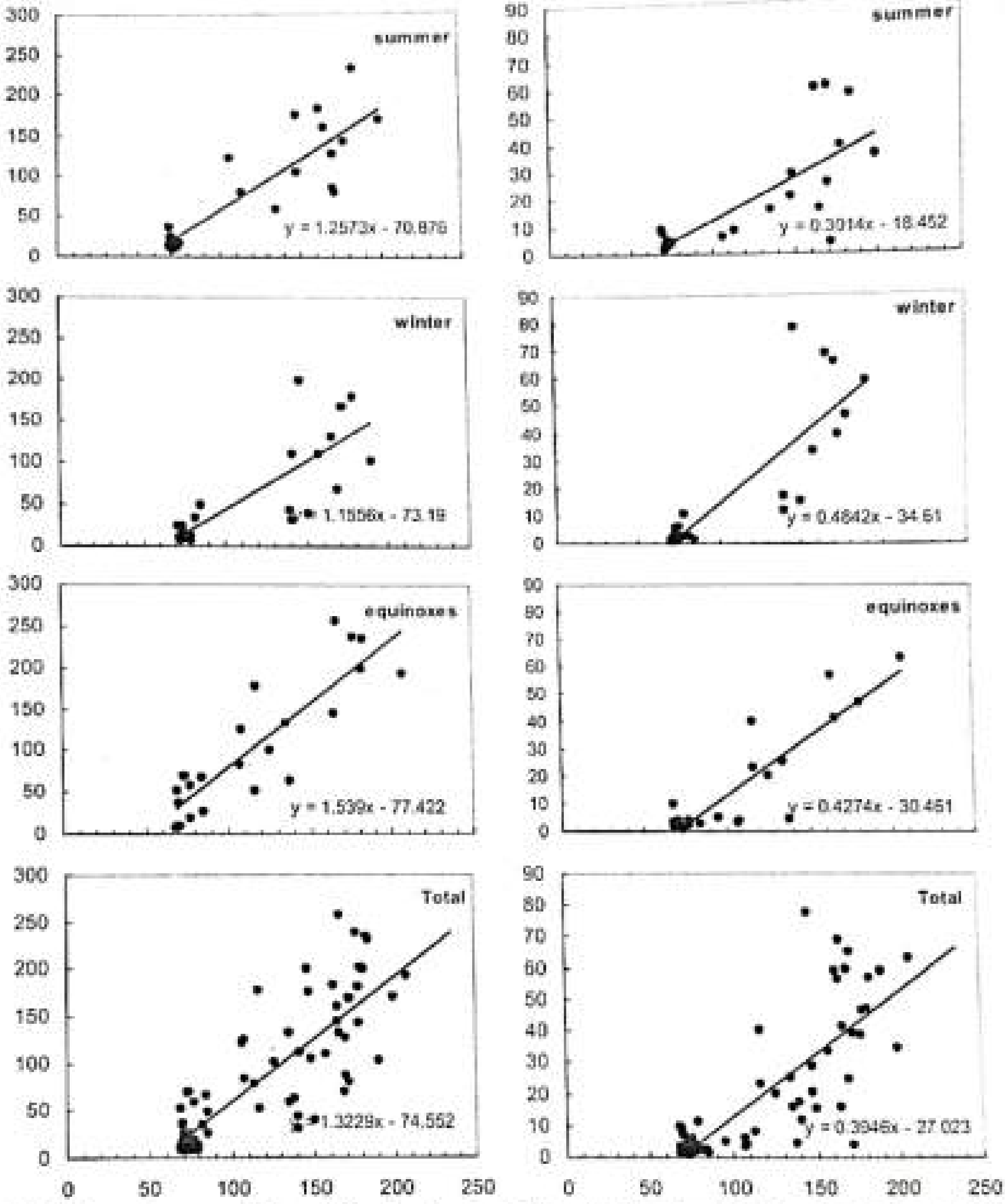

Figure 5: Variation of average daytime (left column) and nighttime (right column) electron density observed by the SROSS C2 satellite with $F_{10.7}$ cm solar ionizing flux within ± 10° magnetic latitude.

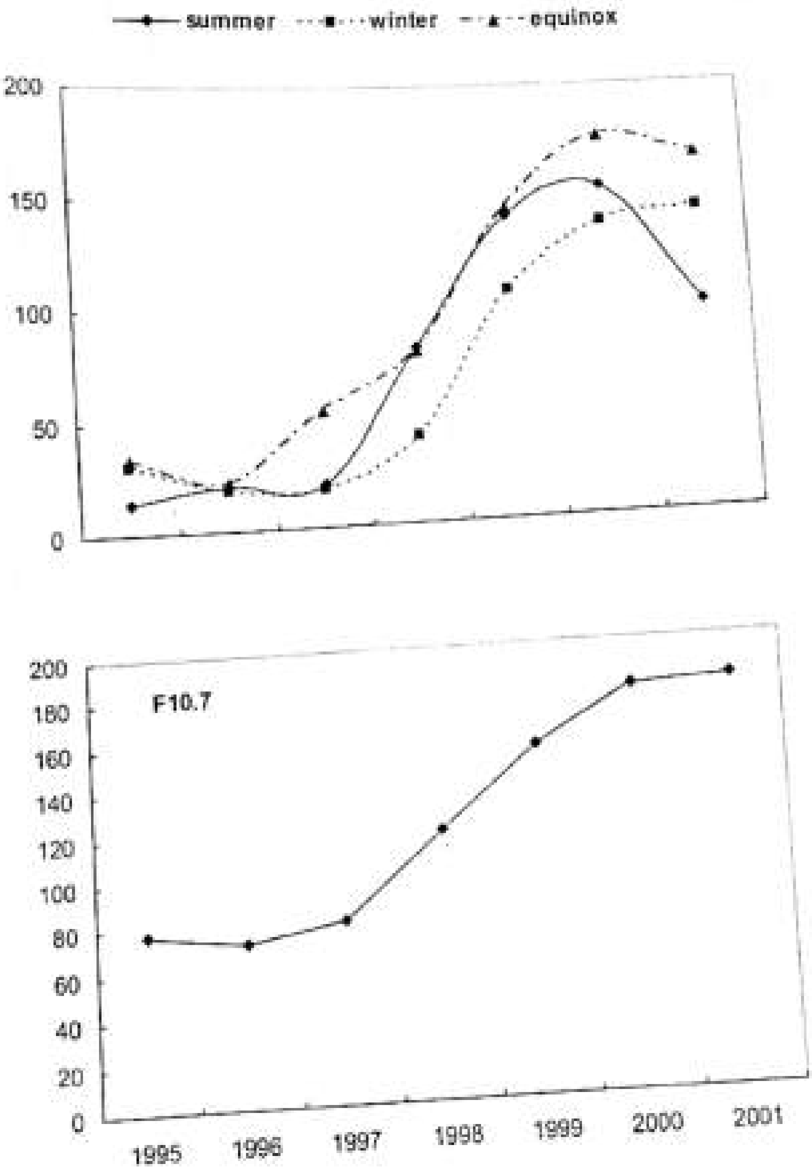

Figure 6: Variation of mean annual daytime (10:00 – 14:00 hr LT) electron density and F10.7 averaged for each year of observation from 1995 to 2001.

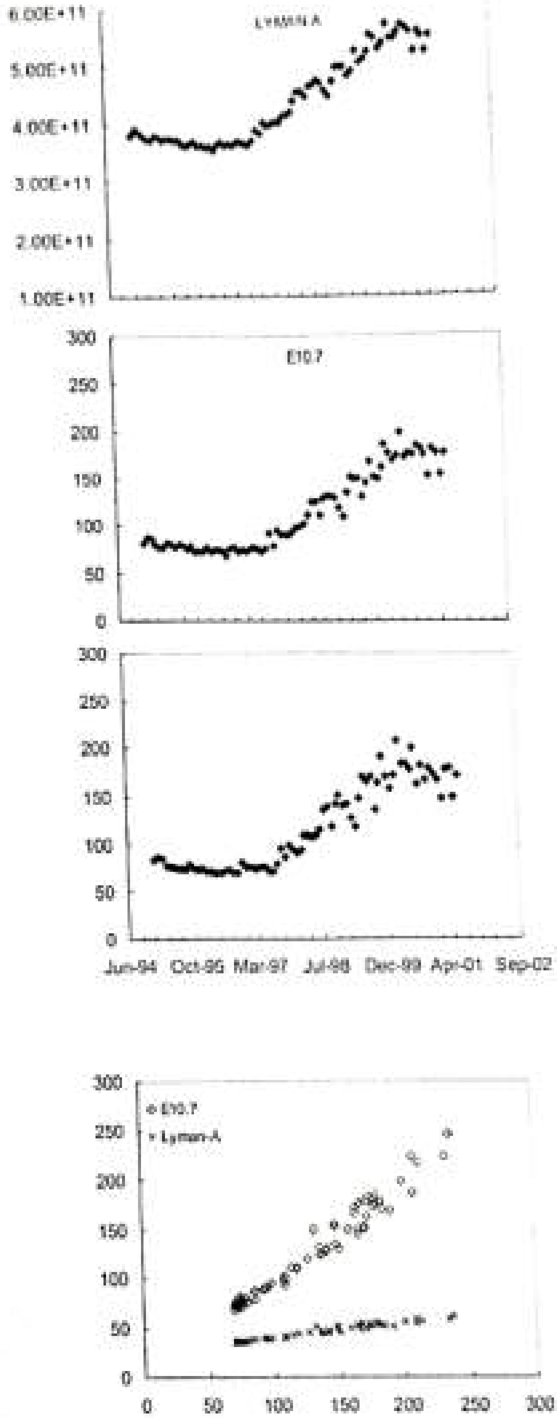

Figure 7: Month to month variation of Lyman-α, E10.7 and F10.7 during the period January 1995 to June 2001. The figure also shows plots of Lyman α and E10.7 against F10.7 cm flux.

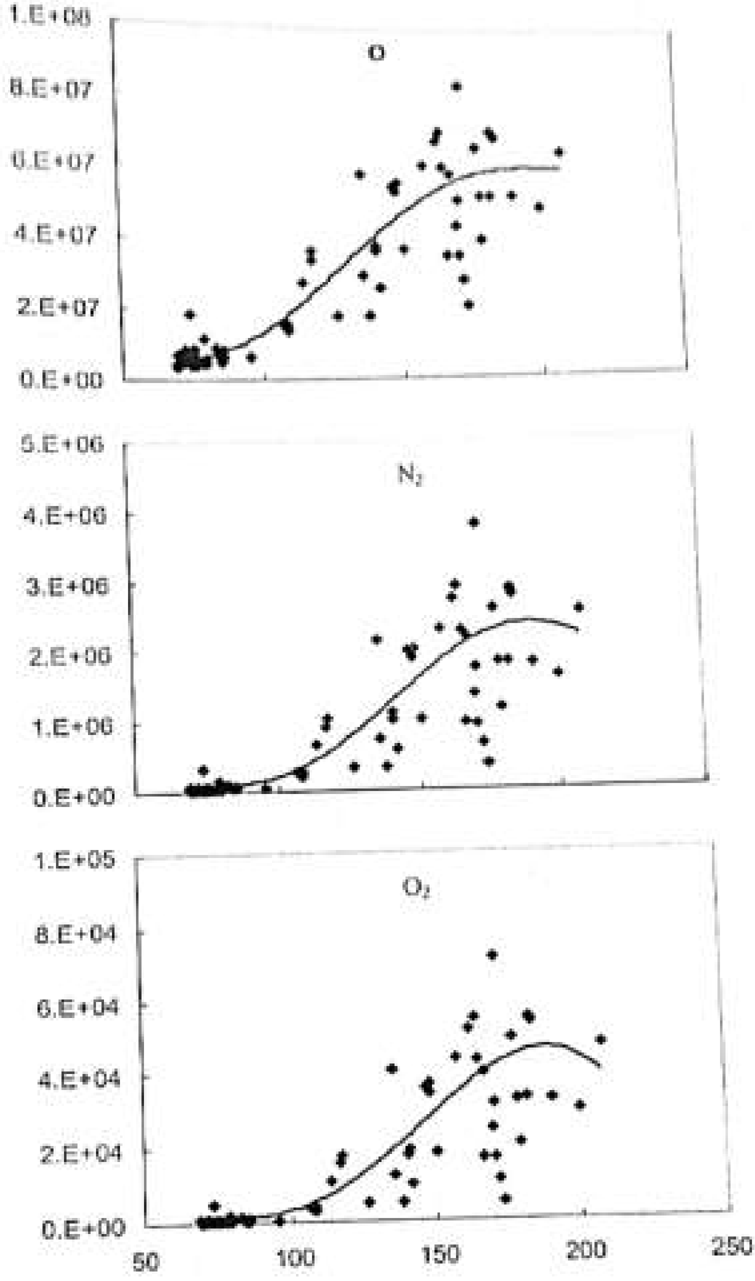

Figure 8: Scatter plot of neutral density of O, N_2 and O_2 against corresponding solar flux from the MSIS-86 model. The solid line in each block represents the 5[th] order polynomial fit to the data.

Conclusion:-

The effect of solar activity on the diurnal, seasonal and latitudinal variation of electron density for the period 1995-2001 is investigated. Results show that density is minimum before sunrise and maximum in the midday or afternoon hours. A secondary enhancement in the evening hours of summer has been observed for low solar activity. Both daytime and nighttime N_e increases with increase of solar activity. However, the linear relationship between electron density and F10.7 breaks down both at the minimum and maximum of the solar cycle 23 which is believed to have been caused by nonlinear variation of neutral densities at the minimum and maximum of the cycle.

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Electron temperature of topside ionosphere over the Indian subcontinent

Minakshi Chamua

1. Introduction:

India has a long and glorious history of ionospheric research. Since 1962, the year first satellite beacon receiver was set up at National Physical Laboratory (NPL), New Delhi till the present time Indian scientists have been doing ionospheric research. This author also got some opportunities to study upper ionosphere at Dibrugarh University of Assam, India while working in an ISRO (Indian Space Research Organisation) sponsored project. A set of aeronomy payloads, consisting of electron and ion RPAs (Retarding Potential Analyzers) and a potential probe (PP) designed at National Physical Laboratory (NPL), New Delhi, was flown onboard SROSS-C satellite in May 1992 by ISRO. This mission yielded payload data for a limited period of 56 days only, at lower altitudes ranging from 350 km down to 200 km over the Indian region. As this mission faced partial failure another set of identical payloads was flown on board SROSS-C2 satellite from Shriharikota range of India. Initially the satellite was placed in an elliptical orbit of 938 x 437 km and after two months operation in higher orbit it was brought down to 630 x 430 km. SROSS-C2 was launched in May 4, 1994 and it worked for nearly seven years till 12th July 2001. The satellite covered periods from minima to maxima of solar cycle 23 and recording data for 3800 orbits over the Indian region. The RPA payload (Fig. 1) consisted of Ion RPA, Electron RPA, potential probes (PP) and associated electronics. The electron and ion RPAs were used for in-situ measurement of ionospheric electron and ion densities, their temperatures and other related parameters of plasma. The potential probe was used to estimate the satellite potential w.r.t. ionospheric plasma.

The scientific objectives of the NPL SROSS mission were –

a) To study the especial features of energetic of the equatorial and low latitude ionosphere.
b) To establish the response of the thermal structure to the dynamical effects
c) To study the effects of magnetic storms and spread-F on thermal structure
d) To study the behaviour of electron and ion density and temperature anomaly in the low latitude region.

In order to achieve these scientific objectives, the RPA was designed to measure the following parameters:

Electron temperature, Te
Thermal and suprathermal electron flux (up to 30ev)
Ion density, Ni
Ion temperature, Ti
Ion composition (O^+, O_2^+ / NO^+, H^+, He^+)
Thermal ion flux
Irregularity in ion density
Irregularity in electron density
Satellite potential w. r. t. plasma.