VARIATION OF D-REGION NITRIC-OXIDE DENSITY WITH SOLAR ACTIVITY AND SEASON AT THE DIP EQUATOR

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To study the solar control on electron-density(N_e) in the equatorial D-region, a program was initiated with Soviet collaboration in 1979. Total 31 rockets were launched during the high solar activity period, 1979-80 and 47 rockets during the low solar activity period, 1984-86 from Thumba(8°N) to measure the N_e profiles. Analysis of the data shows that the average values of N_e for the high solar activity period are higher by a factor of about 2-3 compared to the low solar activity values. It has been found that a single nitric oxide density, [NO], profile cannot reproduce all the observed N_e profiles. An attempt has been made to reproduce theoretically the observed N_e profiles by introducing variation in [NO] for the different solar activity periods and seasons.

INTRODUCTION

To study the solar activity variation in electron density at the equatorial region an Indo-Soviet collaborative program was initiated in 1979. Under this program total 47 rockets of type M-100 were launched during the low solar activity period(1984-86) and 31 during high solar activity period(1979-80) from Thumba (8.5°N, 76.8°E), India to measure the electron density of the D-region. All the observations were made for solar zenith angle (χ) = 70-80°. To measure N_e a d.c. probe method was used for all the above flights. This avoided any variability due to the different measuring techniques. The details of the technique can be obtained from SINELNIKOV et al (1980). Using these profiles, firstly the empirical models of N_e for low solar activity (LSA) and high solar activity(HSA) periods have been made. An attempt has been made to reproduce them theoretically. Analysis was also done for different months and seasons. To reproduce all the observed profiles it has been found that the nitric oxide density has to be varied both with solar activity and season.

ELECTRON DENSITY MODELS

All the profiles obtained during LSA period(1984-86) and HSA period (1979-80) have been averaged separately. Averaged profiles thus obtained for LSA and HSA periods are plotted in Figure 1. These electron density data were averaged in block of 5 km for the whole altitude range from 65-90 km. The values of standard error in mean have been calculated. These are shown at some altitudes(profile 1 and 2). For the sake of comparison, the N_e profiles obtained by MECHTLY et al(1972) from a mid latitude station for low and high solar activity conditions (χ = 60°) are also shown (profiles 3 and 4). Profile 5 was obtained by Langmuir probe experiment carried out from Thumba, India for LSA- period(SUBBARAYA et al., 1983). It is clear from Figuare 1 that the averaged values of N_e for the HSA period are higher by a factor of about 2 compared to the LSA values. The present HSA values are in agreement with the values of MECHTLY et al.(1972) below 75 km, but above this altitude the present values are higher. The N_e values (LSA) of SUBBARAYA et al(1983) agree well with the present LSA values below about 75 km.

Figure 2 show the electron density profiles obtained for the month of

April during LSA and HSA periods. It is interesting to note here that like in Figure 1, N_e values in April do not show any significant variation. A plot of N_e values for a fixed height does not show any systematic variation. It indicates that the factors other that solar zenith angle also control the electron density.

RESULTS AND DISCUSSIONS

A theoretical attempt has been made to reproduce the observed average electron density profiles of Figure 1 by introducing the variation in nitric oxide density for different solar activity periods and seasons. It has been found that a single nitric oxide density profile can not reproduce the observed N_e profiles of Figure 1. The nitric oxide density profiles which reproduce the observed N_e profiles are shown in Figure 3(profiles 1 and 2). In this figure, two measurements of [NO] at Thumba, one at HSA condition (TORKAR et al, 1985) and other at LSA condition (TOHMATSU and IWAGAMI, 1976) are shown (profile 3 and 4 respectively). The mid latitude profiles of BAKER et al (1977) and MEIRA (1971) are also shown in the same figure. It is clear from this figure that the nitric oxide density values (profile 2) needed to reproduce the high solar activity profile of N_e are higher by a factor of about 5 compared to the low solar activity values (profile 1). It is also to be noticed that, in general, the present [NO] values are higher compared to the observed profiles obtained from the same location. The derived [NO] values for LSA are greater than the measured values(profile 3) by a factor of about ten. The present HSA values of [NO] are greater than the measured HSA values of TORKAR et al(1985) by a factor of about five. One can also see from this figure that the present values are much higher compared to the mid latitude values of profiles 5 and 6.

It appears from Figure 2 and 3 that besides solar activity variation there could be a seasonal variation of [NO] also. To study these aspects, N_e data were analyzed for different seasons(winter, summer, autumn, and spring) for both LSA and HSA conditions. The nitric oxide density profiles required to reproduce these electron density profiles have been derived. These are shown in Figure 4 for LSA and HSA conditions. Lower scale represents the LSA values of [NO] whereas the upper scale represents the HSA values of nitric oxide density. From Figure 4, the following interesting points emerge:-(1) [NO] values show a seasonal variation during both LSA and HSA conditions. (2) for LSA period, [NO] values are minimum in winter and maximum in spring and autumn seasons. The spring value of [NO] at 75 km are higher compared to winter value by a factor of four. (3) For HSA period, trend of nitric oxide variation is almost in opposite phase compared to LSA period below about 77 km. The [NO] value for winter season is higher by a factor of three at 75 km compared to spring value of [NO]. Above 78 km, however, the spring values of [NO] became slightly higher compared to winter and summer values. (4) Both summer and winter values of [NO] show a minimum around 80 km for HSA period. Whereas the autumn and spring values show a constant value of [NO] above about 75 km. It should be mentioned here that the autumn values are based on one month observations only. (5) The LSA values of [NO] show a broad minimum ranging from 75 to 80 km for winter. It is also clear that the minimum in winter season is at 75 km which shifts to 80 km for spring season.

CONCLUSION

Analysis of electron density data obtained by 78 rocket experiments carried out at Thumba, India during the period 1979-86 have been done. In conclusion following points are made:-

(1) The average value of N_e for HSA is found to be higher by a factor

of 2-3 compared to the LSA values. When data were analyzed for a particular month (April), the N_e variation with solar activity was found to be insignificant.

(2) The above variation in N_e has been attributed to the variation in nitric oxide density. A theoretical analysis shows that the HSA value of [NO] is higher by a factor of about five compared to LSA value.

(3) To reproduce the N_e values of different seasons, a seasonal variation in [NO] density is needed.

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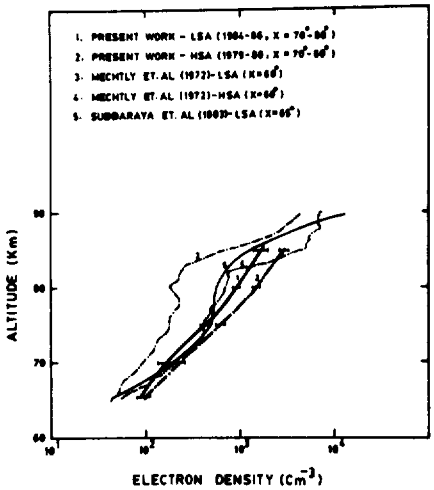

Fig.1. Empirical models of average electron density for LSA and HSA conditions obtained in the present work alongwith the profiles given by other workers.

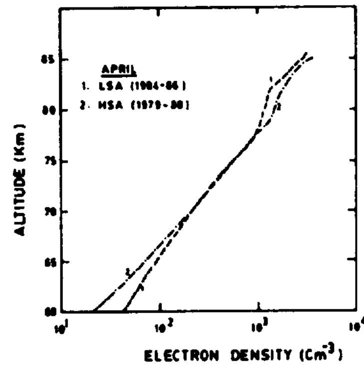

Fig.2. Empirical averaged electron density profiles for the month of April for LSA and HSA conditions.

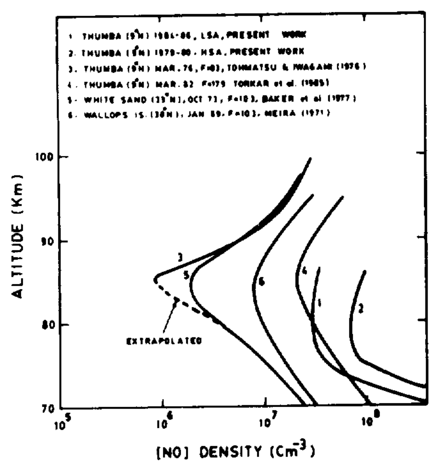

Fig.3. The nitric oxide density models obtained in the present work for LSA and HSA periods alongwith the profiles given by other workers.

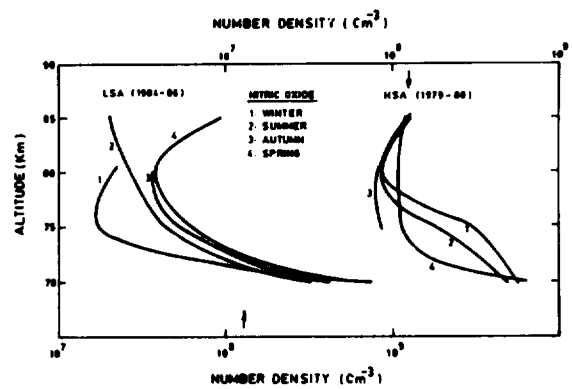

Fig.4. The nitric oxide density models derived for different seasons and solar activity periods.