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# Day-to-day variability of IEC at mid latitude during sunspot minimum

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**Abstract** : Study of day-to-day variability has been carried out by using hourly values of Ionospheric electron content (IEC) for two mid latitude locations, Boulder and Sagamore Hill during sunspot minimum activity (1985-1986). Both the locations show the maximum (30–40%) variability during evening and nighttime while minimum (10–20%) is seen during daytime. Variability is higher during equinox (1985) and summer (1986) at Boulder and during winter (1985) and equinox (1986) at Sagamore Hill. From a correlative study of variability in IEC with possible causative factor such as sunspot activity, magnetic activity and solar activity, it is seen that the magnetic activity has appreciable association with the variability of IEC. We have also compared the variability during quiet days and disturbed days.

**Keywords** : Ionospheric electron content (IEC), solar flux, magnetic activity.

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Ionospheric electron content (IEC) is one of the parameters of the solar terrestrial environment necessary for artificial satellite working system *e.g.* remote sensing, television relay, meteorological study and navigation *etc*. The study of day-to-day variability of IEC is of scientific interest and importance as looking towards its prediction capabilities. The day-to-day variability is best described by the ratio of deviation of daily value of IEC from monthly median to the monthly median value. Klobuchar [1] showed that the standard deviation from the monthly mean value is around 20–25% during day time and during night time it is higher than that for day time in solar maximum period (1968-1969), however the absolute value of IEC during day time is higher than that for night time. Kane [2] has studied the change in IEC at mid latitude stations (Stanford, Rosman and Clark Lake) which are few hundred km apart and concluded that the change in IEC value at all three locations were not always similar. Dabas *et al* [3] suggested that the main factor responsible for day-to-day variability at low latitudes (Indian sector) is equatorial electrojet strength and it is not influenced by solar or magnetic activity. Similar results were also shown for low and mid latitude stations [4,5]. Contrary to the above study, Mendillo [6] showed that the geomagnetic activity has strong influence on variability of IEC at mid latitudes.

In the present communication, we have studied the day-to-day variability of IEC, its seasonal dependence and the effect of solar-geophysical parameters on IEC at two mid latitude stations.

In the present study, hourly values or IEC from Faraday rotation measurements or 136.38 MHz signals at Boulder (40° N 254.7° E) and Sagamore Hill (42° N, 289.2° E) for the low sunspot activity period (1985-1986) are used. The total numbers of days of data for each year at the two locations are equal. Solar-Geophysical parameters such as 10.7 cm solar flux, sunspot slumber (*Rz*), $\Sigma Kp$ and *Ap* indices are obtained from A CATALOGUE OF SOLAR GEOPHYSICAL DATA 1982-1988, published by Radio Science Division, National Physical Laboratory, New Delhi, India. The standard deviation ($\sigma$) of hourly IEC value from monthly median value ($X$) is determined. The basic parameter ($\sigma/X$) in percentage, representing the day-to-day variability of

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IEC has been computed, for each hour of the each month. Similar parameter is computed for solar flux, sunspot number $\sum Kp$ and $Ap$ indices.

*Diurnal variation :*

Figure 1 shows the annual mean diurnal variation of day-to-day variability parameter in IEC during the low sunspot activity period (1985-1986) for Boulder and Sagamore Hill. It is seen that during both the years, the variation of the IEC parameter is almost same, although it is slightly higher during 1986 but the trend of variation is not similar for Boulder. Figure 2 shows the variability during night time (2200–0300 hrs) and day time (0900–1500 hrs). During 1985 and 1986, the daytime variability at Sagamore Hill shows same variation while at Boulder it does not follow the same variations for 1985 and 1986. Also the varibility is more for Boulder then for Sagamore Hill.

*Month-to-month variation :*

The month-to-month variation of variability parameter in IEC as well as for other solar geophysical parameters such as solar flux (*Sa*), sunspot number (*Rz*), $\sum Kp$ and $Ap$ indices are shown in Figure 3. The variability at Boulder during 1985 and 1986 is higher than that for Sagamore Hill. During 1986 variability in IEC and sunspot number are well correlated at Boulder. During the other period, which is considered in the present study, did not find any influence of the solar geophysical parameters on the variability of IEC. Figure 4 shows the seasonal variation of day-to-day variability parameter for Sagamore Hill during 1985 and

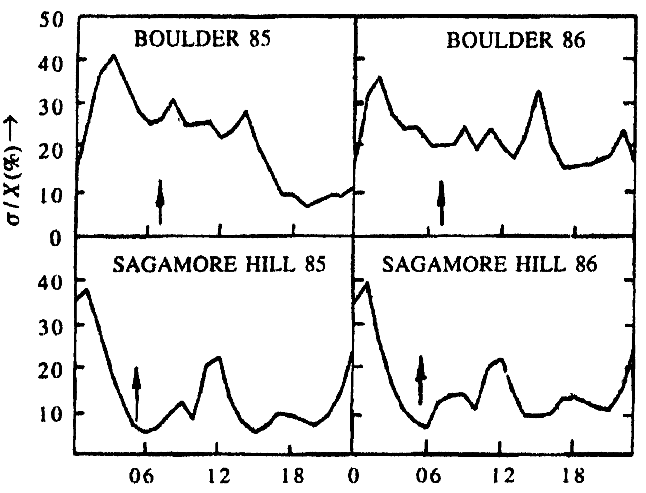


**Figure 1.** Annual mean variability of ionospheric electron content as a function of universal time. Arrow represents the local mid nihgt.

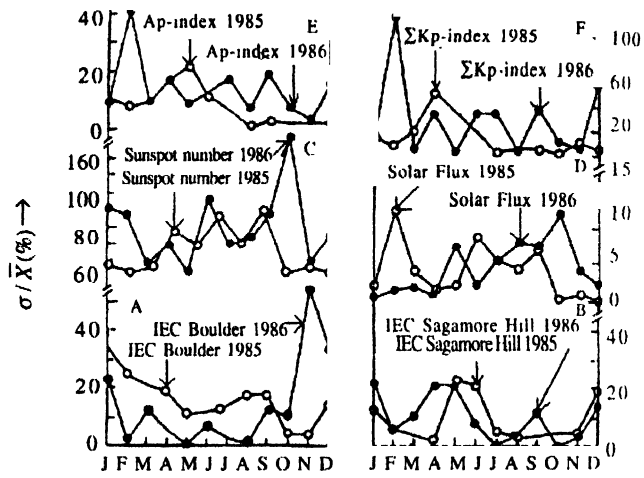


**Figure 3.** Month-to-month variation of variability for [A] IEC Boulder [B] IEC sagamore Hill, [C] sunspot number, [D] Solar flux, [E] *Ap* index, [F] $\sum Kp$-index. Blank circle for 1985 and dark circle for 1986

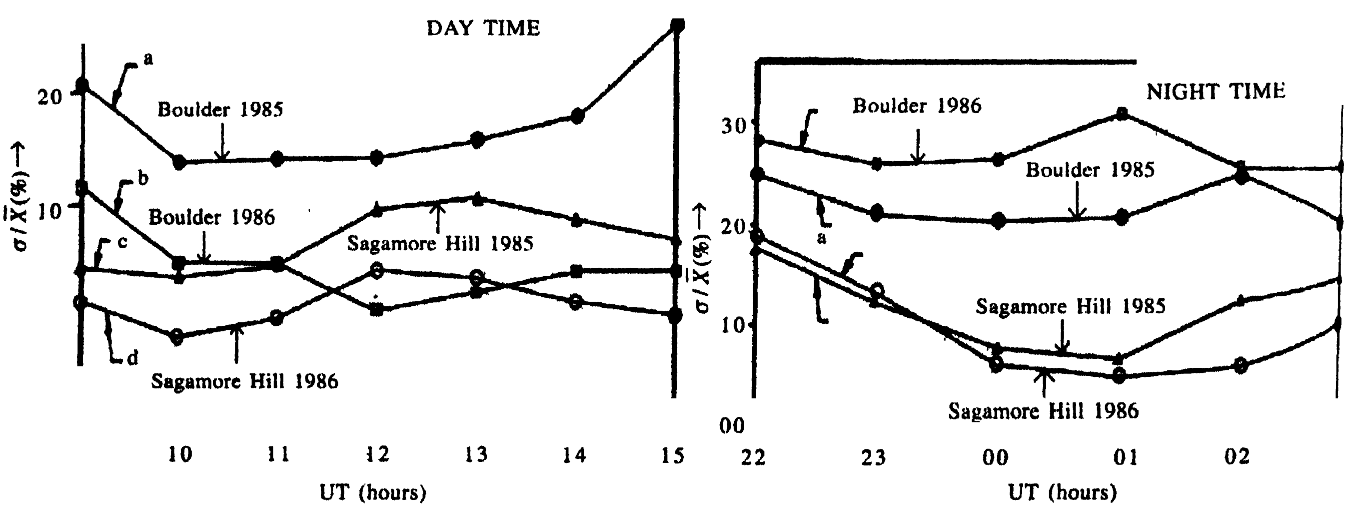


**Figure 2.** Day-to-day variability of IEC during day time hours and night time hours for (a) Boulder (1985) (b) Boulder (1986) (c) Sagamore Hill (1985) and (d) Sagamre Hill (1986).

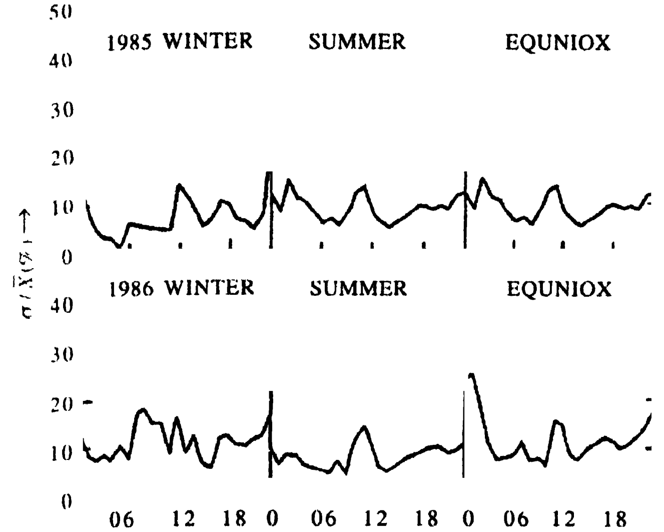


Figure 4. Seasonal variation of the variability parameter for Sagamore Hill

1986. During 1985 it is higher for winter month while lower for summer months and during 1986 it is higher for equinoxial months while lower for summer months. Figure 5 represents the seasonal variation of the variability for Boulder. During 1985 the variability is higher for equinoxial months while lower for summer months and during 1986 it is higher for summer while lower for winter months.

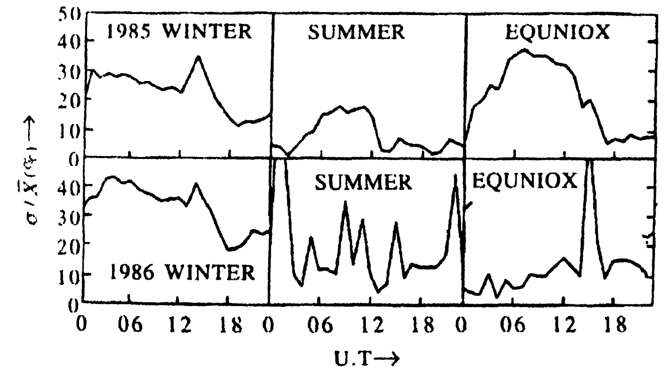


Figure 5. Seasonal variation of the variability parameter for Boulder.

*Effect of magnetic activity :*

We have reported that the sunspot numbers has appreciable association with the variability of IEC at Boulder while it is uncorrelated for Sagamore Hill as shown in Figure 3. Annual mean diurnal variation of variability parameter separately for almost all quiet days (*Q*-days) and almost all disturbed days (*D*-days) during 1985-1986 have shown in Figure 6. It is seen that almost for all the time, both stations show that the variability on *D*-days is higher than that for *Q*-days, except at Boulder during 1985.

Variability from average IEC behavior can be large and may be important to some radio wave systems, which must

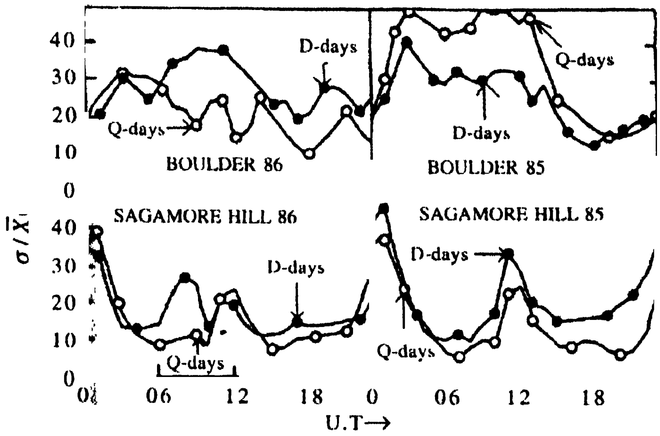


Figure 6. Variations of the average variability parameter for 60 International quiet days (Blank circle) and 60 International disturbed days (Dark circle).

propagate through the ionosphere. Many workers [6–9] have reported large day-to-day variations in IEC and tried to correlate this with solar and geomagnetic disturbances. Kane [10] concluded that the high day-to-day variability is observed at mid latitudes on quiet as well as on disturbed days and it is very difficult to distinguish between TEC on quiet and disturbed periods. He also found that the fluctuations at different locations were well correlated only when the separation distance of stations is less than 3000 km. Rise in day-to-day variability is due to erratic neutral winds produced in polar regions, causing large scale ionospheric irregularities.

The variation in IEC is well correlated with solar activity and can be represented as a linear function of ionospheric index [11]. Davies [9] also reported similar results for Boulder. We suggested that the ionosphere over Boulder may be responded much more closely to sunspot numbers. Similar results were obtained by earlier workers [12] for solar flux at Hawaii and Stanford. It has also been summarized that the correlation of ionospheric electron content with solar flux is higher than that for the sunspot number. For the same period, the variability at Boulder is significantly higher than for Sagamore Hill. Low day-to-day variability at Sagamore Hill may be due to loss rate of ionization *via* ion exchange and dissociative recombination processes [13]. Soicher and Gorman [14] concluded that the variation of TEC appears be a function of seasons at mid latitudes. In the present study we did not find any such type of relation, which may be due to the difference of ionosphere over the Boulder and Sagamore Hill.

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