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# The effect of solar flare index on the seasonal variation of 5577 Å line intensity at Calcutta

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**Abstract** Twilight and night airglow observation of 5577 Å line was observed by Dunn-Manring type photometer for the period 1983-1987 This paper presents the seasonal variation of 5577 Å line intensity ($A_{t}$) and its variation with solar flare index ($I_f$) which is calculated considering all the flares which occurred during a particular month for which airglow intensity is considered It is concluded that the variation of the intensity of airglow line (5577 Å) with solar flare index ($I_f$) shows a periodic trend. Average period of 5577 Å line intensity with monthly mean of flare index are compared for lower and higher values of solar flare index ($I_f$). A possible explanation of such type of variation is invoked by considering the formation and destruction of $O_3$ by ultraviolet rays during flare time.

**Keywords** . Airglow, solar flare index

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Several studies on the effect of various kinds of solar activity, such as, solar flares, relative sunspot numbers *etc.* upon 5577 Å line emission were made from time to time by different investigators throughout the world. From the observations made during the period 1956-1963, Rosenberg and Zimmerman [1] found out a correlation between mean monthly and annual intensity with sunspot number and 10.7 cm solar flux. Bates [2] and Chamberlain [3] showed that the mean yearly intensities of different components of airglow have a tendency to increase with the increasing spot area. Correlation with 5577 Å line intensity was established by them.

Roach [4] did not observe any correlation of it with the sunspot number. Dandekar and Silverman [5] summarised the effect of solar flares on 5577 Å line emission in the night airglow from 71 centres. They found that out of 132 observations associated with solar flares, only 85 showed intensity enhancements. They found an average enhancement of 10% over the preceding and following nights of solar flares. Kundu and Ghosh [6] observed a time lag of 18-58 hours between the occurrence of solar flares and enhancement of intensity. Singh and Chatterjee [7] observed that 11 out of 13 flares produced enhancement. They found this enhancement occurs between one or two days after the occurrence of solar flares. They reported that the enhancement of intensity was between 1.8 to 16%. Kazakov [8] observed strong oscillations of intensity with increase of solar and geomagnetic activity. Fukuyama [9] concluded that solar semidiurnal tide may be the main cause for the diurnal variation of the 5577 Å emission at middle latitude.

Thus we see that different investigators obtained different results to find the correlation between different solar parameters and airglow intensity. In all these studies, the airglow intensity has been correlated with the relative sunspot numbers, solar flare numbers *etc.* which do not take into consideration of the quantitative measure of the energy output of the respective solar event. But the solar flare index ($I_f$) which is being widely used now, gives the actual energy estimate of a flare. In our previous paper [10], we have shown that the enhancement of 5577 Å line during twilight periods can be correlated with solar flare index ($I_f$). The flare index was calculated considering all the flares which occurred 24 hr before the time of occurrence of enhancement. Hence, we have manoeuvred in this paper to find out the effect of the seasonal intensity variation of solar flare index on 5577 Å night airglow emission which was observed by the authors during 1983-1987 at Calcutta.

In the experimental set-up, Dunn-Manring type photometer was used to observe 5577Å line intensity. The detailed experimental arrangements were given in our previous papers [11 and 12]. The flux of light was incident on the cathode of the photo-electric detector. Integrated over a fraction of second, the flux yields measurable photocurrent. The telescope was pointed towards west with an angle of elevation 45°W. The observations were taken at Ramakrishna Mission Residential College (lat. 22°35'N, long. 88°21' E) about 18 km South of Calcutta.

From the microphotometer tracing of night airglow, one can see that the contributions of OH (7.2) and OH (8.3) bands are very small compared to 5577 Å line. Enhancement of OH bands occur only in the infrared region, Barthier [13]. From the above consideration it may be concluded that the radiation recorded by the photometer is mainly of 5577 Å line.

The seasonal variation of 5577 Å line (Figure 1) during the period 1984-1985 at Calcutta was presented by Ghosh and Midya [14]. Half-hourly intensities for the dark hours of night are averaged. The monthly mean is obtained from the average intensities having more than 8 hours observations in a night. The missing monthly values for two/three months during rainy season (Mid. June to Mid. August) are obtained by linear interpolation. Smith and Owen [15] and Ciner and Smith [16] presented curves showing seasonal variations of 5577 Å line at Cactus peak, Haleakala, Haute Provence, Tamanrasset and El-Leoneito. Rao and Kulkarni [17] also presented seasonal variation of 5577 Å and 5893 Å lines at Mt. Abu during 1964-1968. It appears that for all stations, there is a seasonal maximum in November and April, while minimum around June and January.

The mean monthly values of solar flare index ($I_f$) is calculated using the following formula as given by Sawyer [18],

$$I_f = \frac{0.76}{T^*} \Sigma A_d^2$$

where $A_d$ is the flare area in millionths of solar disk and $T^*$ is the effective observing time in minutes. For finding out the monthly values of $I_f$ all the flares which occurred in the respective month were considered and the averaging was performed only over the days in which airglow data had been collected after observations. Solar data for our required period are taken from Solar Geophysical Data published by NOAA, Department of Commerce, USA.

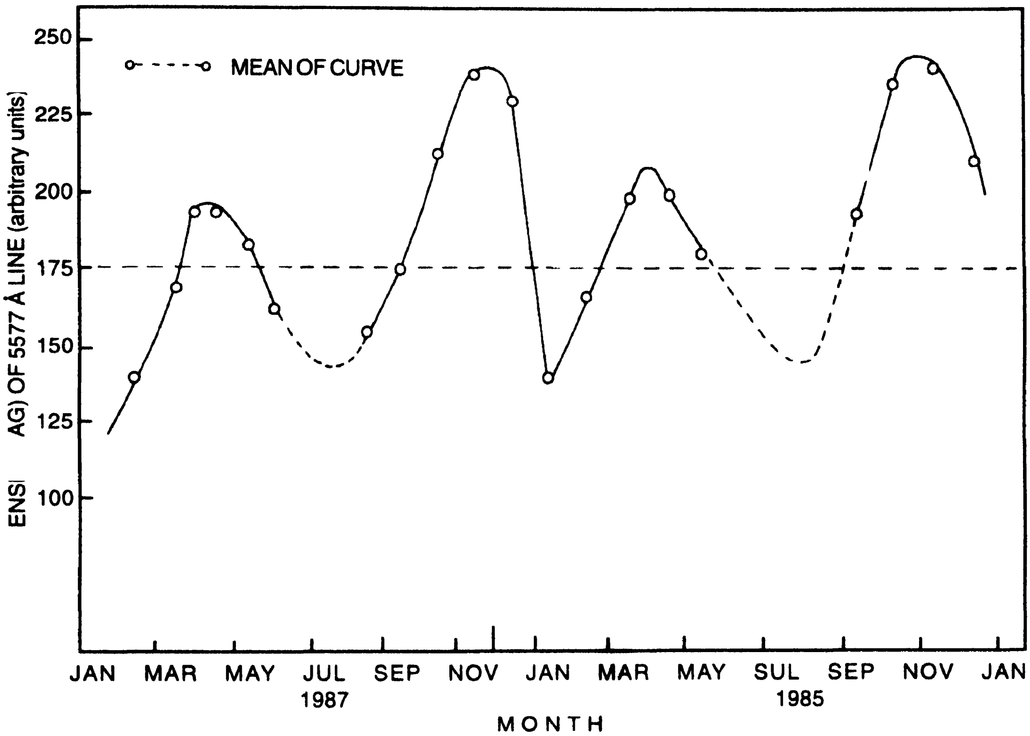


**Figure 1.** Seasonal variation of 5577 Å line emission at Calcutta is a result of linear interpolation during rainy season.

According to Takakura *et al* [19] most intensive centimetric and metric burst tend to occur in the descending or ascending phase of solar cycle avoiding the peak phase. In this connection it may be mentioned that our period of airglow observation is not the peak phase. It is the descending part of the secondary peak of 21st Solar cycle. The values of 5577 Å night airglow intensity is plotted against flare index $I_f$ (Figure 2). It is clear that the values of $A_G$ fluctuates with $I_f$ in a periodic manner. Minute observation shows that the variation is nearly periodic in nature with varying periodicity – lower periodicity for lower value of $I_f$ and higher periodicity for higher value of $I_f$. Analysis of data is given in Table 1. We may compare the data of Table 1 with the values associated with the corresponding sunspot cycle. Thus, while the average length between sunspot maximum is 11.1 years, in our paper the average length between intensity maxima is 6.167 (in $I_f$ units) and while in the sunspot cycle, the length between successive maxima varies between 8 and 15 years, in our case this length varies between 1.7 and 10.4 (in $I_f$ units). In the sunspot cycle, the rise from minimum to maximum (average 4.8 years) is appreciably shorter than the fall from maximum to minimum (Average 6.2 years) while in our case, the rise (average 3.375) takes a greater length than the fall (average 2.875).

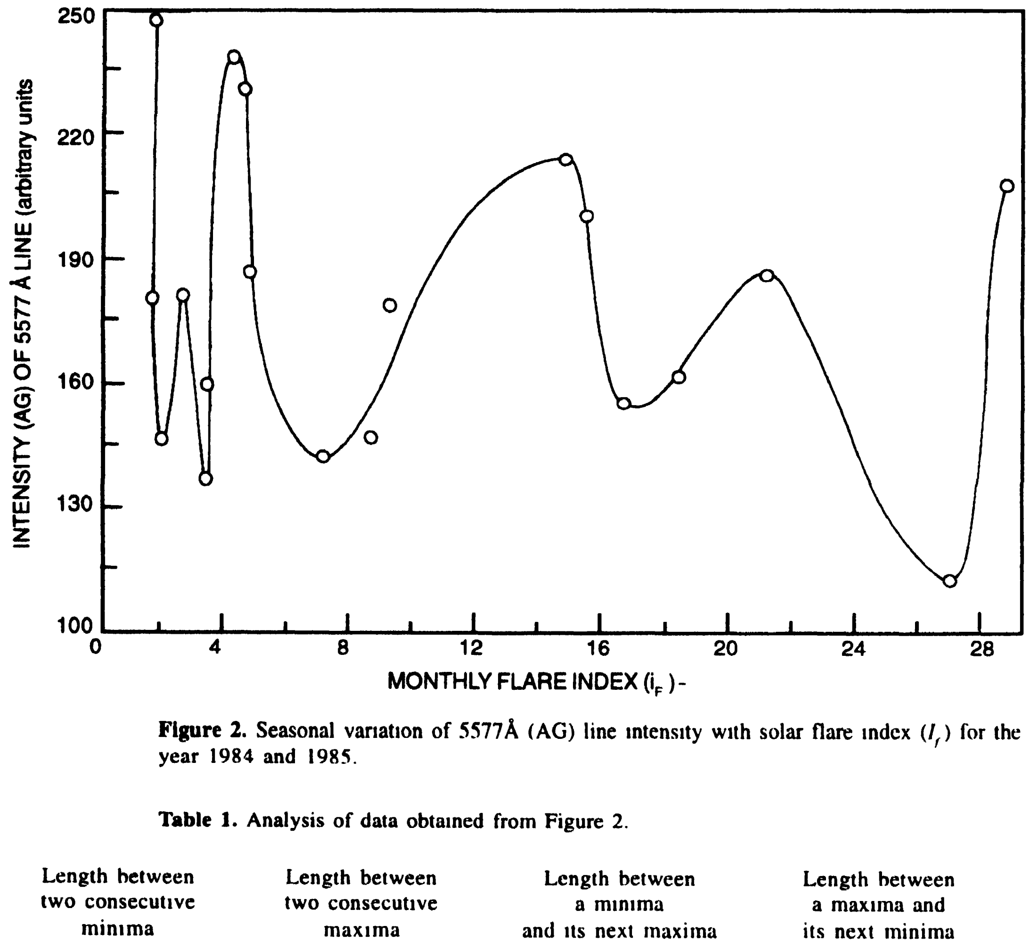


**Figure 2.** Seasonal variation of 5577Å (AG) line intensity with solar flare index ($I_f$) for the year 1984 and 1985.

**Table 1.** Analysis of data obtained from Figure 2.

| Length between two consecutive minima (in $I_f$ Units) | Average | Length between two consecutive maxima (In $I_f$ Units) | Average | Length between a minima and its next maxima (in $I_f$ Units) | Average | Length between a maxima and its next minima (in $I_f$ Units) | Average |
|---|---|---|---|---|---|---|---|
| 3.5 - 2.0 = 1.5 | | 4.3 - 2.6 = 1 7 | | 2.6 - 2.0 = 0.6 | | 3.5 - 2 6 = 0.90 | |
| 7.1 - 3.5 = 3.6 | 8.750 | 14 7 - 4.3 = 10.4 | 6.167 | 4.3 - 3.5 = 0 8 | 3 375 | 7.1 - 4.3 = 2.8 | 2.875 |
| 16.6 - 7.1 = 9.5 | | 21.1 - 14.7 = 6.4 | | 14.7 - 7.1 = 7.6 | | 16.6 - 14.7 = 1.9 | |
| 27.0 - 16.6 = 20.4 | | | | 21.1 - 16.6 = 4.5 | | 27.0 - 21.1 = 5.9 | |

Chapman [20] and Barth [21] mechanisms are the two important mechanisms for the emission of 5577Å line. Bates [22] showed that the latter is much more important source of 5577 Å line during both day and night. Ghosh and Midya [23] also showed from chemical kinetics that Barth mechanism is more appropriate for oxygen 5577 Å line during night time. It is clear from this mechanism that atomic oxygen is responsible for emission of the line. Again, production rate of $O_3$ is dependent on atomic oxygen concentration. Thus, it may be concluded that $O_3$ plays an important role for the emission of 5577 Å line. There are different formation and loss processes of $O_3$. It is expected that the formation and destruction rates of $O_3$ are comparable. Thus, concentration of $O_3$ fluctuates in periodic manner and it creates variations in the intensity curve. For higher values of $I_f$, the production rate of $O_3$ predominates and the intensity of the line increases gradually. Thus, we have obtained different periods in higher solar activity. Midya *et al* [24] obtained almost same type of result for the seasonal variation of 5893 Å line emission with solar flare index.

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