Letters to the Editor

SEASONAL CHANGE IN THE POSITION OF THE EQUATORIAL ELECTROJET IN INDIAN REGION

Price and Wilkins (1951) first reported about the equatorial electrojet movement with season. They found that the seasonal movement of the electrojet was opposite to that of the Sun. Forbush and Casaverde (1961) measured the jet field for one season at a number of stations across the dip equator and concluded that the jet did not move with the season. Osborne (1962) found that the seasonal changes in jet position in Peru and Ghana were within error limits. Ogbuehi and Onwumechilli (1964) recently studied the daily and seasonal changes in the equatorial electrojet in Nigeria. They used two methods to calculate the seasonal change. In the first method, they assumed the width of the electrojet constant and in the other, they calculated the width, intensity and position for each of the selected days. In both the methods they showed a marked seasonal change of position in the same direction with the Sun, even though the magnitudes given by the two methods were different. Ogbuehi and Onwumechilli (1965) studied the seasonal variation of the jet centre in low solar active period. They determined the position of the electrojet by using the mean values and reported that the analysis have not detected any seasonal movement. They have also remarked that a method of analysis using average range ratios is not sensitive enough to detect the small seasonal movements of the electrojet axis. Matsushita and Maeda (1965) have from the spherical harmonic analysis of the S_q field, corroborated the findings of Price and Wilkins regarding seasonal movement of jet centre. These are conflicting views on the seasonal change of the position of the jet centre.

In the present paper, the movement of the axis of the electrojet in Indian region has been studied assuming the width of the electrojet to be constant during the year. The method employed is the same as that of Ogbuehi and Onwumechilli (1964). The data used are diurnal ranges in H at Trivandrum, Kodaikanal and Annamalainagar for the year 1958. The distances of the observatories from the dip equator (measured positive to the south) considering the dip values of the observatories are: Annamalainagar —297 km, Kodaikanal —198 km and Trivandrum 35 km. The data for 10 International Quiet Days of a month for which records of all the three observatories are available, are used.

For each quiet day, the diurnal range $M(H)$ in H is obtained for each of the observatories by subtracting from the day time maximum hourly mean value, the mean values of the first two and last two hourly values for the same local day.

Some workers consider that the jet effect should be studied by splitting the observed range into jet and normal ranges, whereas others are of the view that it should not be split as the jet is nothing but a day time enhancement of the normal S_q current system.

Chapman (1951) worked out the mathematical equations for various models of the electrojet. For an electrojet consisting of a band of uniform current intensity C amp/km, width 2β km and height h km, its horizontal magnetic field H at a place distance x km from the current axis is,

$$M(H) = 0\cdot2\,C \tan^{-1} \frac{2\,\beta\,h}{h^2+x^2-\beta^2} \qquad (1)$$

Following Ogbuehi and Onwumechilli, the normal range is eliminated from the observed range as follows: Denoting by J and N the jet and normal ranges respectively, the total range $M(H)$ is the combination of J and N. Assuming N to be the same for all the three observatories, which is not unreasonable as the observatories are not widely separated, the term C and the normal range can be eliminated by taking the ratio of the difference of ranges as

$$R(H) = \frac{J_T(H)-J_A(H)}{J_K(H)-J_A(H)} = \frac{M_T(H)-M_A(H)}{M_K(H)-M_A(H)} \qquad (2)$$

Subscripts T, A, K refer to the observatories Trivandrum, Annamalainagar and Kodaikanal respectively.

The observed ratio $R(H)$, can also be calculated by using Eq. (2). Appropriate value of β for the period under study (for the year 1958) is used. The centre of the electrojet is first assumed to coincide with the dip equator, $X=0$. X is varied from $+80$ to -80 km in steps of 20 km and for each X value the theoretical $M(H)$ values are calculated for each of the three observatories by Eq. (1). Substituting the value of $M(H)$ for the observatory in the r.h.s. of Eq. (2), the $R(H)$ value is calculated for each X value.

In Indian region, the half-width of the electrojet has been determined by a number of investigators, Pisharoty and Srinivasan (1962) and Bhargava
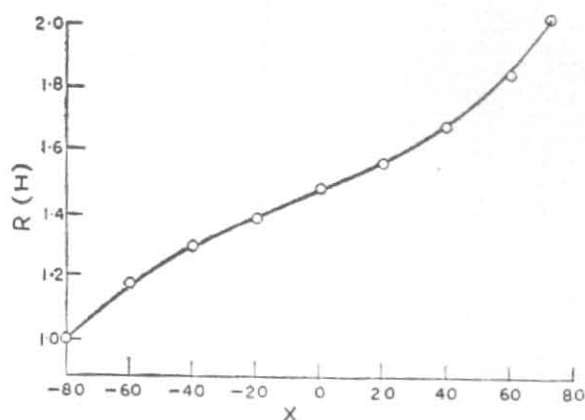
Fig. 1. Plot of $R(H)$ against X

(1964). They determined the half-width by considering the ranges of H at various places on different days during the period 1950—1953 and comparing the ranges with that of Kodaikanal. They inferred the half-width to be 110 km. Yacob and Khanna (1963) inferred the half-width of the electrojet to be 300 km, by considering the H ranges of Annamalainagar and Trivandrum for 1958-59. They also indicated that the half-width does not show any appreciable change from season to season.

Rao *et al.* (1966) determined the value of β by considering vertical and horizontal component ranges at Kodaikanal and Annamalainagar for each of the years 1951—1958 in case of Kodaikanal and 1958—1963 in case of Annamalainagar. They reported the value of β to be 300 km in the Indian region and also concluded that there was no significant seasonal change in the width. By considering the values obtained so far it is felt that the half-width in this region is 300 km and the same value is selected for calculations here.

Taking β=300 km and h=110 km (Cahill 1959), $R(H)$ values for different values of X from —80 to +80 km are calculated and shown in Fig. 1. For each International Quiet Day in the month the observed $R(H)$ is obtained and the corresponding values of X are read off from the graph. The three seasonal mean values are calculated by considering all the available days in each of the seasons, j, e and d. Monthly mean position of the axis and the seasonal mean values are given in Table 1.

The seasonal mean value is computed with 37, 32, 34 days in j, d and e seasons respectively. There is considerable amount of variation in the value of X during season. Ogbuehi and Onwumechilli computed the width and position daily in Nigeria. In Fig. 4 of their paper, they have given the position and width and current intensity for each selected day in the month of May. There is remarkable daily change in the position of the electrojet

TABLE 1
Monthly and seasonal mean positions of centre of the jet

January	+29·0 km	July	—16·1 km
February	+55·0	August	+21·6
March	+37·3	September	+10·9
April	—30·0	October	+37·1
May	— 9·4	November	+16·9
June	+ 8·9	December	+ 7·2
Seasons			
j (May, Jun, Jul, Aug)			+ 1·4±6·5 km
e (Mar, Apr, Sep, Oct)			+14·4±7·1 km
d (Jan, Feb, Nov, Dec)			+24·8±6·8 km

(+ 50 to —50 km nearly). This shows that the scatter that is obtained by this method is not entirely due to the assumption of constant β but there is considerable daily change in the position. Even though the standard error of the mean is much more, the seasonal change of position from d to e is 10·4 km and from e to j is 13·0 km which is more than the error limits. The December solstice to June solstice movement in Indian region is 23·4 km and its direction is northwards.

To examine the relationship between the movement of the jet centre and the Sun, (the Sun's declination), the correlation coefficient between X and α, the apparent solar declination of the month, is calculated. As the International Quiet Days may not be evenly distributed in a month, the α value is calculated by taking the mean for the individual days in a month for the International Quiet Days, reckoning positive southwards. The coefficient of correlation is + 0·54 and it is significant at 5 per cent level.

The monthly means and seasonal mean values are statistically insignificant because of large scatter,

It can, therefore, be concluded that there is no clear evidence of any seasonal movement and that there is a large scatter in the position of the axis of the jet.

A detailed investigation by considering more number of quiet days in the season and calculating the daily changes of width, position and intensity is under progress.

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