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A NOTE ON THE EQUATORIAL ELECTROJET

The width of the equatorial electrojet has been estimated from observed daily variations in H and Z from stations situated approximately along a longitude upto distances of 500 or 600 km on both sides of the dip equator. Onwumechilli (1959) obtained ratios of the jet contribution in the vertical force to the jet contribution in the horizontal force from observations at stations upto a distance of 3° latitude on both sides of the magnetic equator in Nigeria and estimated the width to be about 440 km during the period November 1956 to January 1957. Forbush and Casaverde (1961) found that during a period of high solar activity, the width of the electrojet in the region of 75° W longitude, was of the order of 660 km. From daily variation in Z, observed at 10 stations in Nigeria during May to July 1962, Ogbuehi and Onwumechilli (1963) obtained a value of approximately 203 km for the semi-width of the electrojet. The existence of longitudinal inequalities in the width as well as in the strength of the electrojet have been found by Rastogi (1962). From horizontal force data, collected in the Indian equatorial region during 1950 to 1953, the width of a uniform current band has been determined by Pisharoty and Srinivasan (1962). They compared the observed ratios of H range due to electrojet at different latitudes to H range under the jet axis with similar ratios computed from

$$H = 0 \cdot 2\, C \tan^{-1} \frac{2v}{1+u^2-v^2}$$

where $u = x/h$, $v = w/h$, H being the field at distance x km due to a uniform current band of semi-width w km and density C amp/km flowing at a height of h km. For obtaining the observed ratios, however, they adopted a value of 0·75 for the ratio of H range outside the electrojet region to the range under the axis of the electrojet.

These values of width and height, deduced by methods which differ from one another, cannot be utilized for comparing the electrojet characteristics in different longitudes. It is the purpose of this note to indicate a method essentially the same as used by Pisharoty and Srinivasan (1962), but with slight modification which can be uniformly adopted for computing the width as well as the probable height and the strength of the electrojet. No assumptions are made about the value of H range outside the electrojet region. A model of the electrojet, with the parameters so obtained, would produce the observed variation of the horizontal force in any longitude. Horizontal force and its range being large in the equatorial region, the H ranges, utilized for computing the electrojet characteristics, can be conveniently obtained from a magnetic survey. Besides, use of vertical force data may lead to an error because a close relation exists between the earth current amplitude and the daily range of Z in the equatorial region (Hutton and Wright 1961).

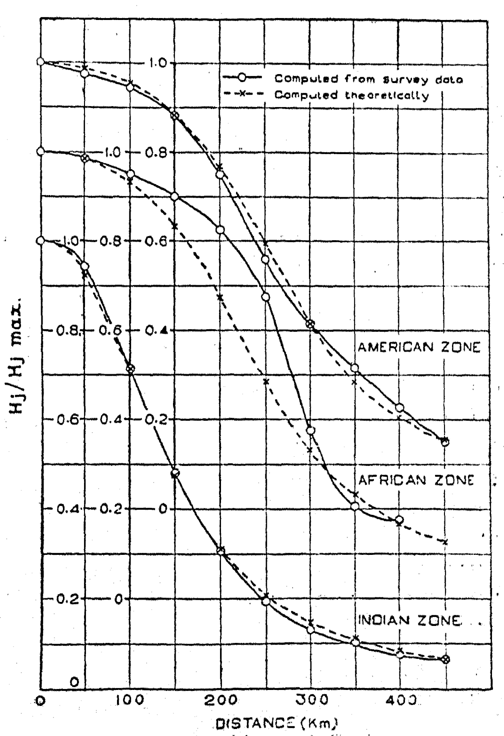

Fig. 1

If a fraction f of the range in H is contributed by the electrojet at a point under the axis of the electrojet, the fraction contributed by the normal S_q current will be $1-f$. If, therefore, HS_q and H_{max} indicate the contribution to the H range by S_q and total range in H respectively under the electrojet axis,

$$HS_q = H_{max}\,(1-f) \quad (1)$$

The survey data, usually in the form of ratios of the range at a station to the range at the base station, can be normalized in terms of the range under the electrojet axis, *i.e.*, $H_{station}/H_{max}$. Assuming that the jet effect at a station H_j is the difference between total range ($H_{station}$) and the normal S_q range (HS_q) and that HS_q does not vary in the equatorial region we get

$$\frac{H_{j\ station}}{H_{j\ max}} = \frac{H_{station} - HS_q}{H_{max} - HS_q} \quad (2)$$

From (1) and (2)

$$\frac{H_{j\ station}}{H_{j\ max}} = \frac{(H_{station}/H_{max})-1}{f} + 1 \quad (3)$$

Using several probable values of the fraction f, a series of values of $(H_{j\ station}/H_{j\ max})$ can be computed from observed $(H_{station}/H_{max})$ values. Again assuming several probable values of w/h and h, another series of values of the same ratio can be computed from the expression

$$\frac{H_{j\ station}}{H_{j\ max}} = \frac{\tan^{-1}[2v/(1+u^2-v^2)]}{2\tan^{-1} v} \quad (4)$$

The two sets of values can then be compared. The values of f, w/h, and h, utilized in the two sets of values of $H_j / H_{j\ max}$ which agree with each other, will yield the fraction f contributed by the electrojet to the H range, the semi-width of the idealized band of line currents which will produce observed $(H_{station}/H_{max})$ ratios and the probable height of the current.

The method has been applied to data collected by Giesecke in 1949 and by Forbush *et al.* in 1957 in the American zone and to the data from Nigeria obtained by Onwumechilli (1959) during November 1956 to January 1957. To obtain the fraction f and height h in the Indian zone the data obtained during surveys of 1950, 1951 and 1953 have

TABLE 1

	w/h	h (km)	w (km)	f
American Zone 1949 and 1957	2·3	110	253	0·5
African Zone (Nov 1956—Jan 1957)	2·0	110	220	0·4
Indian Zone (1950, 1951 and 1953)	0.95	105	100	0·375

been utilized. The best fitting sets of values of $H_j / H_{j\ max}$ for the three zones are shown in Fig. 1. For the American and Indian zones one set of values obtained from observed data using a particular value of f agrees very well with a set computed from (4) using given values of w/h and h. For the African zone, however, no two sets of values could be found to agree entirely satisfactorily. The width to height ratios, heights, widths and the fractions f of range in H due to electrojet, which yielded most satisfactory agreement between the two sets of values in the three zones are shown in Table 1.

The semi-width in the Indian region is essentially the same as determined by Pisharoty and Srinivasan (1962). A height of 105 km rather than 110 km, adopted by these authors, yielded better agreement between the two sets of values $H_j / H_{j\ max}$. The semi-width in the African Zone agrees with the value derived by Onwumechilli (1959).

In the American zone the semi-width is almost two and a half times the value in the Indian region. In this region a small width is partly due to the fact that the available survey data were collected during a period of very low solar activity; those for the American and African zones were obtained during the peak of solar activity.

For comparison purposes, the electrojet characteristics can be computed from survey of the horizontal force of the earth's magnetic field in different longitudes and during low as well as high solar activity by the method outlined here.

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