PARAMETERS OF INDIAN EQUATORIAL ELECTROJET

BY

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Abstract :

Using a comprehensive three dimensional model of equatorial electrojet, parameters of the Indian equatorial electrojet for winter of 1972 are computed and are compared with those obtained using uniform band model. The electrojet estimated using three dimensional model is found to be wider but weaker in intensity than that obtained using uniform band model. A comparison of these (three dimensional model) parameters with those obtained elsewhere for the Indian region for September 1958 shows that the intensity of the electrojet in 1958 was about thrice of that in 1972. The width of the electrojet is found to reduce appreciably with increase in solar activity and supports the suggestion of Onwumechilli (1967) that the electrojet is narrower when ever it is strong. In the three dimensional model the return currents of the electrojet for winter 1972 are found to be maximum around 11.3° dip latitude in the Indian equatorial region.

Introduction :

Onwumechilli (1967a) developed a comprehensive model which allowed for the decrease of current density away from the axis of the electrojet and using the magnitude of world-wide Sq at electrojet stations calculated with the parameters of model Sq current system derived quantitatively from the Sq ranges of low and mid-latitude stations. Using this model and 21 days data of September 1958 from Indian region, Onwumechilli and Ogbuehi (1967b) determined the parameters of the equatorial electrojet but their estimate of world-wide Sq, for lack of observations above 18° latitude in this zone, was based on the constancy of the ratio of Sq field at any two points within 15° of the position of the maximum field (equator). The average of Sq range at Alibag (dip lat.12.92°N) and Kuyper (dip lat.17.55°S) were used to estimate Sq at electrojet stations. Since the northern Sq current system is known to be stronger than southern Sq current system even in equinox (Matsushita,1967), the average of Sq range from northern and southern stations may amount to under-estimating the Sq for stations in northern hemisphere. With the start of Sabhawala and Hyderabad observatories in the 75°E longitude, it is now feasible to compute the parameters of overhead current system responsible for Sq variation. With this in view, Sq and electrojet parameters for the winter months of 1972 in the Indian region are determined following the procedure outlined by Onwumechilli

(1967a) and these are compared with the results obtained by earlier workers.

Data and Analysis :

The data used are the hourly values of H for the international quiet days during the northern winter months of 1972. Geographic and geomagnetic coordinates along with the dip angle of the stations whose magnetic data are used in the present analysis are given in Table 1. The quiet day hourly values are corrected for non-cyclic variation and averaged to give seasonal mean hourly values. The seasonal mean quiet-day range, R_H, at a station is obtained by substracting the average field of the four hours around local mid-night from the average field of four hours around local noon. The mean seasonal range for each station is also given in Table 1.

Estimation of World Wide Sq Field :

The horizontal field of the model for ionospheric currents causing geomagnetic quiet day variation is given by (Onwumechilli, 1967a):

$$R_H = 1/2\ K\ a\ \frac{\left[(V+\ V+2\alpha a)U^2+(V+\alpha V+2a)(V+a)^2 \right]}{\left[U^2+(V+a)^2 \right]^2} \quad \ldots(1)$$

where K, α and a are constants, u is the geographic latitude of the station and V is the height of ionospheric currents. V is taken to be 110 km, equivalent to 1° latitude. Equation (1) can be put in the form :

$$K_p + \alpha Kq - 2\ R_H = 0 \quad \ldots(2)$$

where p and q are functions of u and a only. The quiet-day ranges of winter 1972 are plotted against the geographic latitude of respective station and a smooth curve is drawn. The R_H values for u (latitude) = 10°, 15° and 20° are read off from the smooth curve and substituting these in equation (2), the solution for k, a and α is obtained graphically. The graphs of 'a' against α and K, (given) in Fig.1, yielded a = 65.0, α = -2.07 and K = 40.0

Estimation of Electrojet Parameters :

Sq(H) values for the electrojet stations, calculated using these Sq parameters, are given in the last column of Table 1. The field of the electrojet is thus obtained by subtracting the calculated value of Sq(H) from the observed value, R_H, for all Indian electrojet stations. The electrojet field strength, J_H, so computed is still made up of the fields of the external (overhead) and internal induced currents. The induced field component can be estimated by replacing V in eqn.(1) by V', the depth of image current. The depth of the underground image is difficult to estimate and since it depends on the geological structure of the locality, it may vary from station to station. Yacob (private communication) using POGO observations and ground based data of Indian stations has estimated the mean depth of image current to be 550 km (5°). Adopting this value of the depth of image current and adding the component of field associated with internal induced current in equation (1) and simplifying the equation in the manner described in equation (2), the major parameters (K, α and a) of the Indian electrojet are graphically computed. Since electrojet is best approximated with reference to the dip equator, dip latitudes of the three electrojet stations Annamalainagar, Kodaikanal and Trivandrum are used for the purpose of computing electrojet parameters. The intersections of the K(a) and α(a) arising from the solution of the three equations are shown in Fig.2a. The value of a, α and K are respectively 9.4°, -4.23 and 37,00 . The width, total forward current, peak intensity and the distance of maximum return current, computed from the relations given by Onwumechilli (1967), are listed in Table 2. Also given are the peak intensity and total eastward current of Sq system. To facilitate the study of variability of the electrojet with longitude and solar activity, the major parameters of electrojet obtained by earlier workers using this model are also included in Table 2.

In order to bring out the differences resulting from the use of uniform band model and three dimensional model, the half width and peak current intensity of the electrojet for winter 1972 are also computed using uniform band model. (The width and peak current intensity are found to be 4.8° and 174 Amp/km respectively. The corresponding values with three dimensional model are 9.1° and 59 Amp/km. It is obvious from the above figures that electrojet current estimated using band model appears to be narrower but stronger than that obtained using three dimensional model).

Discussions :

The examination of the parameters of Indian electrojet for September 1958 and for winter 1972 (Table 2) shows that the peak current intensity has increased by a factor of 2.7. Onwumechilli and Ogbuehi (1967a) has observed a two fold increase in the intensity of electrojet from December 1962, a period comparable to winter, 1972 to August 1958. Comparing the results for 1958 and 1972, it is noticed that the jet was wider during the period of low solar activity. This is contrary to the earlier conclusions reached by Yacob (1967) and Rao (1972) who, considering a uniform band model, showed that the jet was wider during IGY than IQSY. The direct dependence of the jet intensity and inverse dependence of the width on solar activity obtained by the model of the electrojet in the Indian zone and similar results in Nigeria, supports the suggestion of Onwumechilli (1967a) that the electrojet is narrower whenever it is strong.

The peak Sq and jet intensities are comparable in magnitude for winter 1972, suggesting that the normal Sq currents are augmented in electrojet belt by a factor of about 2. The return currents of the electrojet are found to be maximum at 11.30 dip latitude, i.e. around the dip latitude of Hyderabad.

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