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Residual Disturbance Field *(JD)* in the Indian Equatorial Region*

B. N. BHARGAVA
Indian Institute of Geomagnetism, Colaba, Bombay 400005

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The residual disturbance field has been derived at one low latitude station and three stations in the equatorial electrojet belt in the same longitude zone for typically quiet to moderately disturbed conditions by successive elimination of non-cyclic variation, S_q, L and D_{st}. The main features of the field, so computed from samples of data from high, relatively low and declining phases of solar activity cycle have been discussed. The component of the residual field at Trivandrum, close to the dip equator, which can be associated with the modulation of the electrojet by disturbance, has also been computed and found to consist primarily of a southward directed field around 10-11 hrs LT and, in two of the three samples, this is followed by a northward field in the afternoon hours. The relative magnitudes of these fields at the stations in the electrojet belt suggest an equatorial enhancement. A striking feature of the residual field, a progressive increase of its mean level with magnetic activity, is discussed in relation to return currents of the eastward and westward polar electrojets.

1. Introduction

AKASOFU AND MENG[1] have shown that the eastward current in the afternoon and evening sectors, associated with positive bays in the auroral region, spreads to the equator and that the return current is strong enough to be observed at 10° dipole latitude. Recently, Onwumechilli *et al.*[2] have suggested that on moderately disturbed days, when substorm activity occurs, electric field associated with enhanced S_q^D may partially suppress the development of the equatorial electrojet but the electric field associated with substorm, responsible for eastward current in the auroral and sub-auroral zone in the afternoon sector, enhances the equatorial electrojet. It would, therefore, appear that the disturbance modifies the equatorial electrojet differently in the morning and the afternoon-evening sectors.

The field at a low latitude station, outside the electrojet can be represented by

$$H(t) = M + m + Sq(t) + L(t) + DR(t) + SD(t)$$

where M is the main field and m its secular variation, $Sq(t)$ and $L(t)$ are the solar and lunar daily magnetic variations respectively and $DR(t)$ and $SD(t)$ are the symmetric and asymmetric parts respectively of the disturbance field. Similar variation at a station under the influence of equatorial electrojet can be denoted by

$$H(t) = M + m + Sq(t) + L(t) + DR(t) + SD(t) + J(t) + JD(t)$$

where additional terms $J(t)$ and $JD(t)$ are the time variations of the quiet time and additional disturbance fields associated with the equatorial electrojet. With increasing disturbance, the pattern of the low latitude daily variation is observed to undergo an appreciable change. In low latitudes this is believed to be due to the superposition of field of the symmetric and the asymmetric ring currents [designated by the terms $DR(t)$ and $SD(t)$ respectively]. In the equatorial electrojet region, an additional field $JD(t)$, can be ascribed to the modification of the field of the equatorial electrojet. The JD term includes the modification of SD in the electrojet region. The aim of the present analysis is to study the time variation of the residual disturbance field JD in the electrojet region and its relation to the degree of magnetic activity.

2. Analysis

Hourly horizontal intensity, H, during selected parts of 1967, 1963 and 1962 representing high, relatively low and declining phases of solar activity has been utilized in this study. For each of these three years, 20 consecutive days were selected such that the daily index of magnetic activity, Ap, for the days was uniform and around 5. These intervals were designated as quite interval groups. Similar selection of 20 consecutive days was made for two additional samples when Ap was approximately 10 and 20. These have been termed as slightly and moderately disturbed groups respectively. The intervals which constituted the three groups of days in each year along with the mean Ap for 20 days are shown in Table 1.

The residual field at the low latitude station, Alibag (dip, 24·6°N) outside the electrojet and electrojet stations, Trivandrum, Kodaikanal and Annamalainagar (dip, 0·6°S, 3·3°N and 5·4°N respectively)

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for each *Ap* group, was computed from the samples of Table 1 using the following procedure. Non-cyclic variation was removed from the mean hourly values following the usual procedure. From the equation,

$$L = \sum_{n=1}^{4} c_n \sin(nt - 2\nu + \lambda_n)$$

L was computed for each hour of the 20-day intervals using c_n and λ_n computed earlier for the four stations[3]. From the hourly values, corrected

Table 1—Intervals Selected for Computing Residual field

Year	Quiet $Ap \sim 5$ Interval	Quiet Average *Ap*	Slightly disturbed $Ap \sim 10$ Interval	Slightly disturbed Average *Ap*	Moderately disturbed $Ap \sim 20$ Interval	Moderately disturbed Average *Ap*
1967	26·2·1967 to 17·3·1967	5.6	27·10·1967 to 15·11·1967	12·7	13·9·1967 to 2·10·1967	19·9
1963	14·3·1963 to 2·4·1963	4·3	28·6·1963 to 17·7·1963	9·6	1·9·1963 to 20·9·1963	19·5
1962	7·5·1962 to 26·5·1962	6·0	21·6·1962 to 10·7·1962	11·2	16·10·1962 to 4·11·1962	18·7

for non-cyclic change, the corresponding *L* was subtracted. For eliminating *Sq*, mean hourly intensities *H* on five international quiet days of the respective month were utilized. When the intervals extended over two calendar months, international quiet days were selected from two months in proportion to the number of days included in the sample from each month. For the electrojet stations, the quiet day field computed in this manner, included the electrojet field, $J(t)$. Subtraction of this field from the hourly values, corrected for non-cyclic and lunar variation, yielded $[DR(t) + SD(t)]$ for Alibag and $[DR(t) + SD(t) + JD(t)]$ at the three electrojet stations. The residual disturbance fields $SD(t)$ and $[SD(t) + JD(t)]$ for non-electrojet and electrojet stations respectively were computed by subtracting the hourly equatorial D_{st} (derived by Sugiura and Poros[4]) reduced to geomagnetic latitude of the respective stations. Residual field averaged over 20 days for three levels of magnetic activity ($Ap \sim 5, 10, 20$) at each of the four stations for the years 1967, 1963 and 1962 is shown in Figs. 1, 2 and 3 respectively.

3. Results

(i) Non-electrojet Station

The residual field at Alibag (dipole lat., 9·5°) for quite interval group for 1967 and 1963 (Figs. 1 and 2) is small and random about its mean value

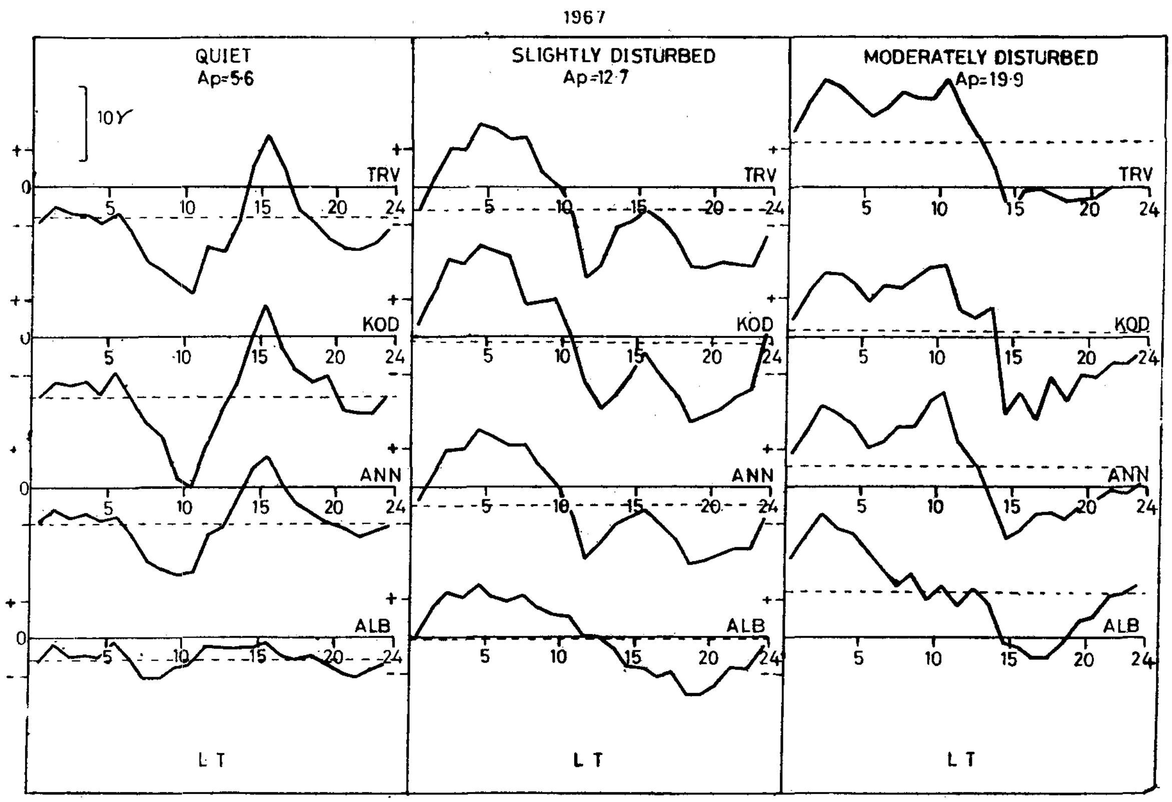

Fig. 1—Daily variation of residual disturbance for three levels of magnetic activity for 1967 (The broken lines represent the mean level)

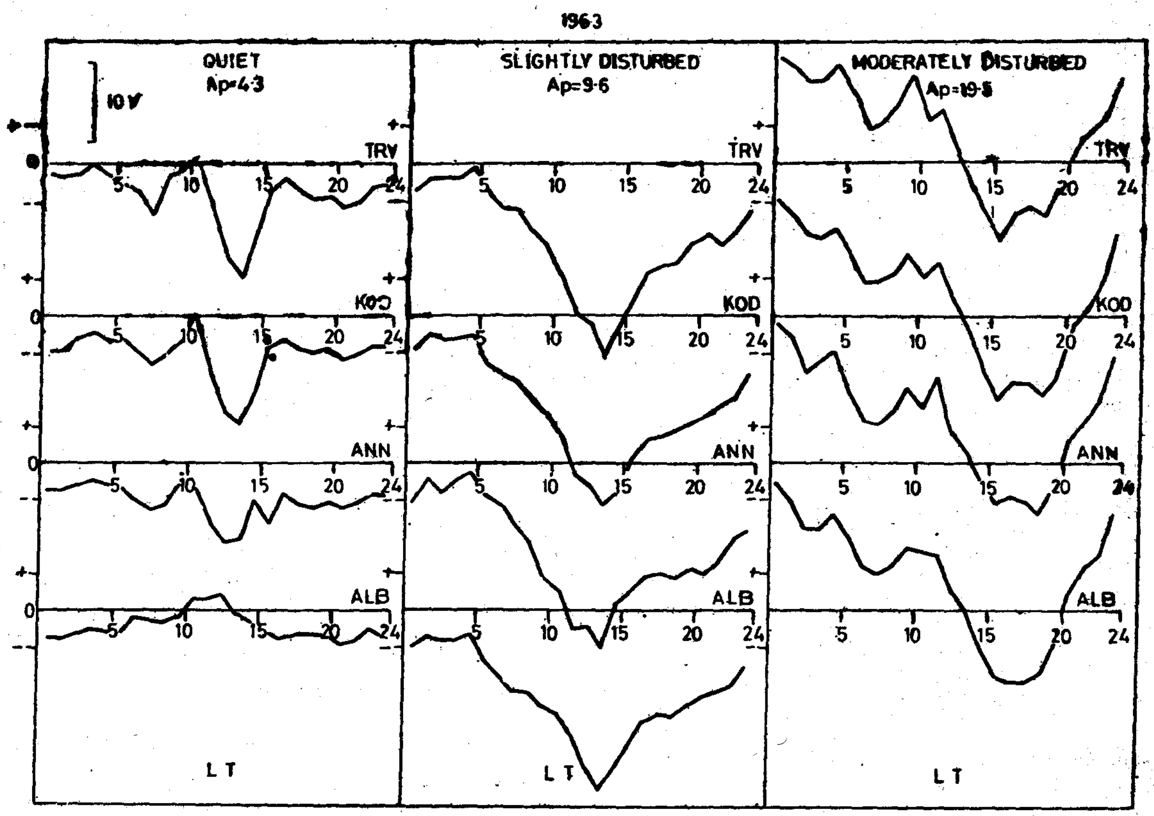

Fig. 2—Daily variation of residual disturbance for three levels of magnetic activity for 1963

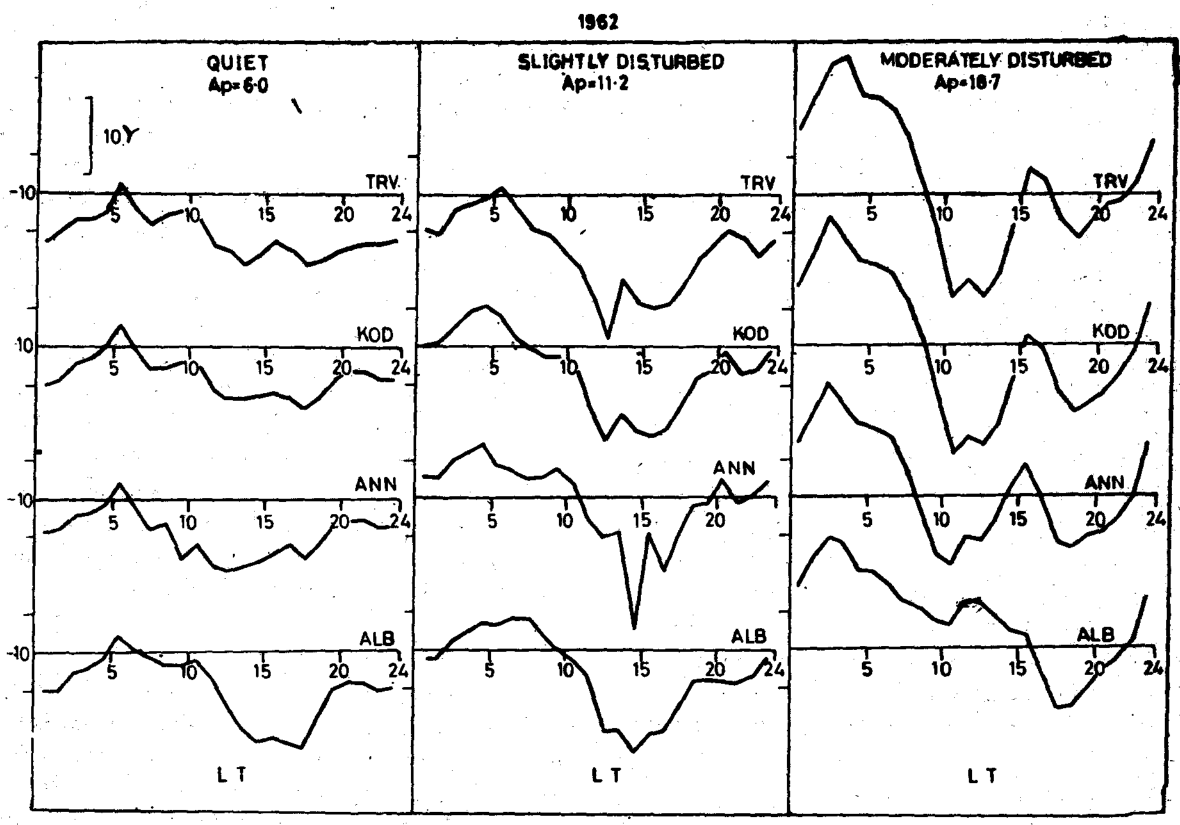

Fig. 3—Daily variation of residual disturbance for three levels of magnetic activity for 1962

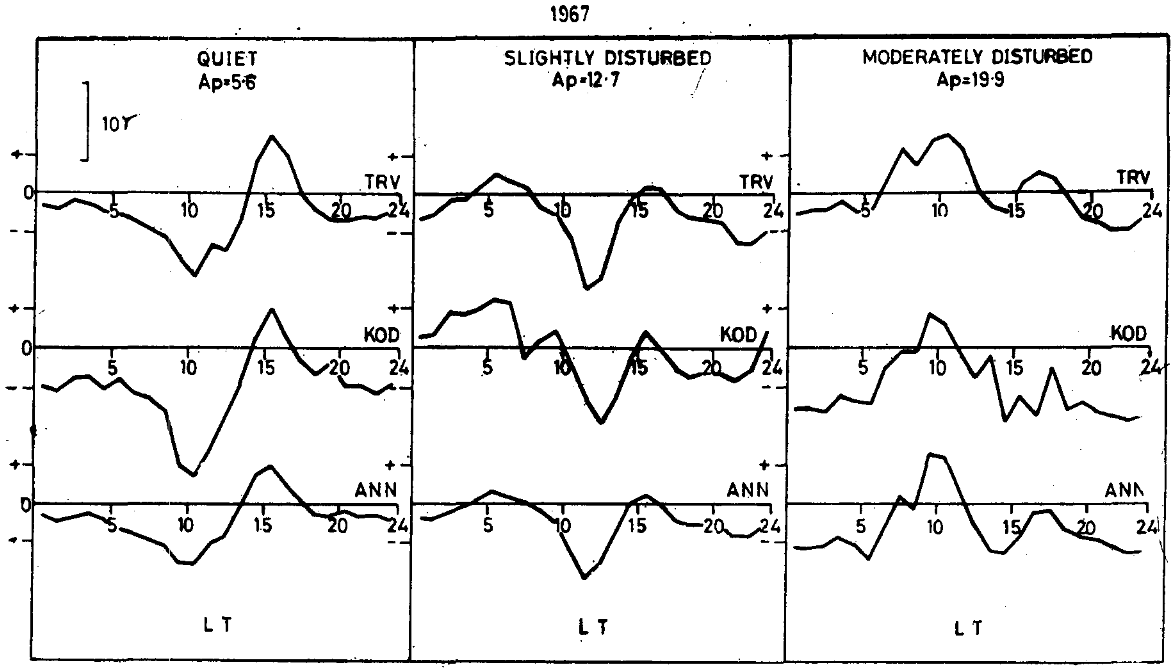

Fig. 4—Daily variation of *JD* (*t*) component of disturbance field for the electrojet stations for 1967

Table 2—Average Levels of the Residual Field for the Three Groups

Year	Station	Quiet $Ap\sim5$	Slightly disturbed $Ap\sim10$	Moderately disturbed $Ap\sim20$
	TRV	− 4·0	− 3·0	+6·0
	KOD	− 8·1	− 0·7	+0·9
1967	ANN	− 4·9	− 2·5	+2·8
	ALB	− 2·9	− 0·3	+6·0
	TRV	− 4·1	−10·5*	+3·7
	KOD	− 5·3	−12·6	+2·4
1963	ANN	− 5·3	−12·4	+5·9
	ALB	− 2·3	−12·0	+4·2
	TRV	−15·4	−17·5	+11·7
	KOD	−14·2	−13·1	+10·1
1962	ANN	−14·7	−10·2	+11·2
	ALB	−15·0	−12·9	+13·9

* In 1963 sample for $Ap\sim10$ group, the residual field at Alibag itself shows an abnormal depression around 12-13 hrs LT.

(less than twice the standard deviation). However, for 1962 sample (Fig. 3), the residual field is diurnal with largest negative value in local evening hours. This suggests that, in this sample, the field associated with the asymmetric ring current, had developed even at a relatively low level of magnetic activity. For higher magnetic activity groups the residual field appears as an appreciable depression in the evening sector with its magnitude increasing with magnetic activity.

(ii) Electrojet Stations

Assuming that the residual field, associated with asymmetric current, is similar at the four stations, we subtract the residual at Alibag successively from residuals at each of the three electrojet stations. The remainder then represents the modified electrojet field *JD* (*t*). This component for 1967 for quiet and slightly disturbed magnetic conditions, shown in Fig. 4, undergoes a significant depression centred around 10-11 hrs LT which, normally, is the time of maximum northward electrojet field. The depression is followed by a sharp increase in the northward field around 15-16 hrs LT. At Trivandrum and Kodaikanal, close to the dip equator, both the effects are appreciably enhanced relative to Annamalainagar, farthest from the jet axis. With increasing activity, the minimum observed between 10 and 11 hrs LT shifts to a later part of the day by an hour or more. The maximum observed between 15 and 16 hrs LT for lower magnetic activity, however, continues to occur at the same time but in this sample the afternoon increase of northward field is considerably smaller compared to lower activity interval. For 1963 the main features are similar to those of 1967. In 1962 sample, while the nature of *JD* (*t*) remains more or less identical to the 1967 sample, the forenoon depression is smaller during the quite interval.

(iii) Mean Level of Residual Field

The average level of the residual field for the three groups are shown in Fig. 1 (broken line) for the 1967 sample. A progressive increase of the northward field occurs with increasing magnetic activity. Mean levels of the field for the four stations are shown in Table 2. For deducing the change in the residual field with

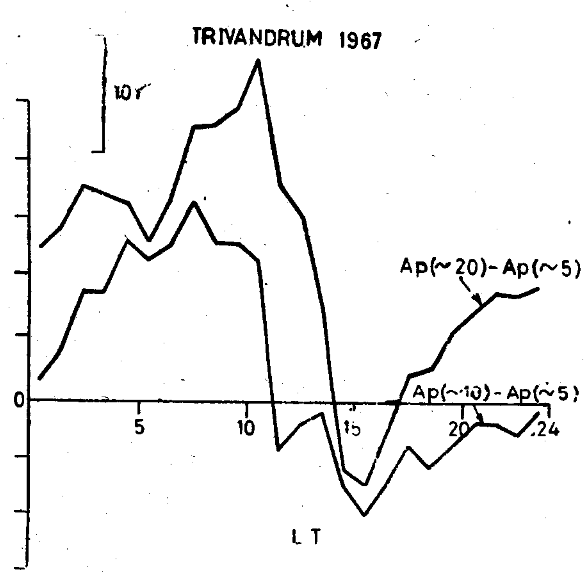

Fig. 5—Change in *JD* (*t*) at Trivandrum with increasing magnetic activity

increasing disturbance, the average residual field corresponding to the low level of magnetic activity (*Ap* ~ 5) was subtracted from those corresponding slightly to ((*Ap* ~ 10) and moderately disturbed (*Ap* ~ 20) intervals. For 1967 sample from Trivandrum, these are shown in Fig. 5. This result leads to the suggestion that the field of the westward currents in the low latitudes, which, presumably, is caused by a part of the return currents of the afternoon sector in the polar region, is more than offset by the field of the eastward currents in the low latitudes for which return currents of the westward polar electrojet in the morning and midnight sector are responsible. In other words, the eastward currents in low latitudes (caused by return currents of westward polar electrojet) predominate progressively as the level of disturbance increases.

Acknowledgement

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