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Day-to-day Variability in Ionospheric Drifts at Tiruchirapalli in relation to Electrojet Strength

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East-west drift motion of ionospheric E and F-region irregularities over Tiruchirapalli (dip 4·8°N) during the period 1973-74 has been compared with various definitions of the electrojet strength as determined from ground magnetograms. These include the range in H at an equatorial station like Trivandrum (ΔH_T) or Kodaikanal (ΔH_K), the difference between the ranges at an equatorial station and at a station away from equator such as Alibag ($\Delta H_T - \Delta H_A$ or $\Delta H_K - \Delta H_A$) and Sd_I which is defined as $\Delta Sd_I = \Delta H_T - \Delta H_A + \overline{\Delta H_A}$ ($\overline{\Delta H_A}$ being the average quiet day Sq-range). High correlations are obtained between the E-W component of drift and various electrojet parameters, the correlation being higher for $\Delta H_T - \Delta H_A$ or $\Delta H_K - \Delta H_A$ and ΔSd_I. Linear relationship is noted except in the morning hours (0800-1000 hrs LT) for E-region, with drift speed being constant (about 150 m/sec) at higher ranges of the electrojet strength. Another interesting feature noted is that the electrojet strength is positive when drift speed is zero, indicating simultaneous opposite drift velocities at different altitudes in the dynamo region.

1. Introduction

Drift measurements of the ionization irregularities in the electrojet region are proportional to the electric field. The E-W electron drift speed (V_e) over E-region at Jicamarca (dip 2°N) measured by vhf doppler radars[1] is related to the E-W electric field by the expression

$$E_y \approx -6 \times 10^{-6}\, V_e \qquad \text{(V/m)} \qquad \ldots(1)$$

The features of the diurnal variations of the velocity measurements at Jicamarca are similar to those of the diurnal variations of the drift of ionization irregularities measured by spaced receiver technique at Thumba[2] (except for the difference in the magnitude of the velocity). From about fiftyone observations by spaced receiver technique at Ibadan, Oyinloye and Akinrimisi[3] computed the following relation between the E-W electrojet field (E_y) and the E-W drift (v) in E-region.

$$E_y \approx -2{\cdot}88\, \text{v} \times 10^{-6} \qquad \text{(V/m)} \qquad \ldots(2)$$

The expression in Eq. (2) was derived assuming mean electric field in the E-region and mean velocity in the electrojet.

Midday drift measurements both in the E and F regions over the equatorial station Thumba (dip 0·6°S) were shown to be highly correlated with the electrojet strength.[4] An extensive series of drift measurements was conducted at Tiruchirapalli near the edge of the electrojet (dip 4·8°N) during the period 1973-75 (Ref. 5). The results were marked by a large day-to-day variability in the magnitude of the westward drift velocity. The purpose of this paper is to examine in detail whether this variability is seen in the electrojet strength as determined from ground magnetograms.

2. Electrojet Strengths

Three definitions of the electrojet strength are used in the present study. First the conventional definition where the H values minus the mean night level are used as a measure of the electrojet strength. For a particular day we have taken mean of the values for the periods 0000-0200 and of 2200-2300 hrs. This is subtracted from the day time H values at a particular hour to give electrojet strength at that hour and denoted by ΔH_T for Trivandrum values and by ΔH_K for Kodaikanal values. Another definition is that following Nair *et al.*[6] where H at a station outside the electrojet is subtracted from the value of ΔH at an equatorial station to remove the non-ionospheric contributions such as magnetospheric currents, and defined by $\Delta H_T - \Delta H_A$ or $\Delta H_K - \Delta H_A$, where A stands for Alibag. The third definition is that of Kane[7] known as ΔSd_I and given by the expression $\Delta Sd_I = \Delta H_T - \Delta H_A + \overline{\Delta H_A}$, where $\overline{\Delta H_A}$ is the average Sq-range at Alibag. The second and the third definitions would therefore measure

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FIG. 2

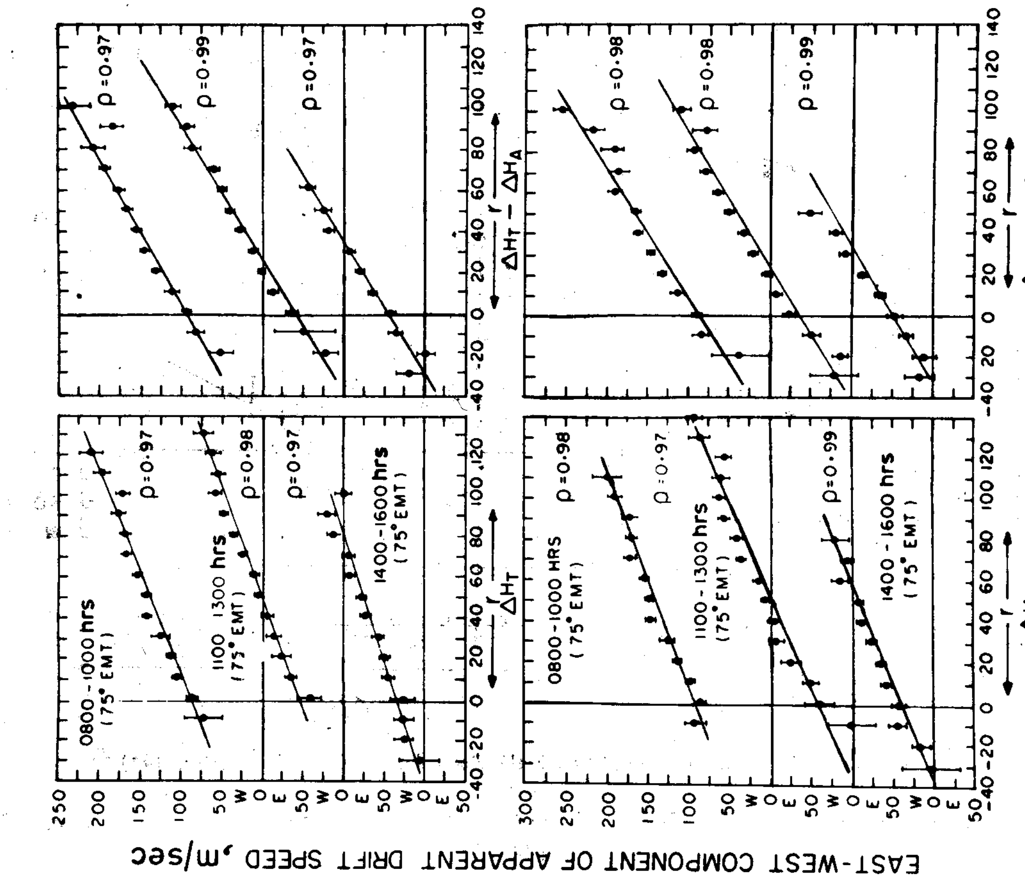

Fig. 2 — Same as Fig. 1 but for F-region drift speed

FIG. 1

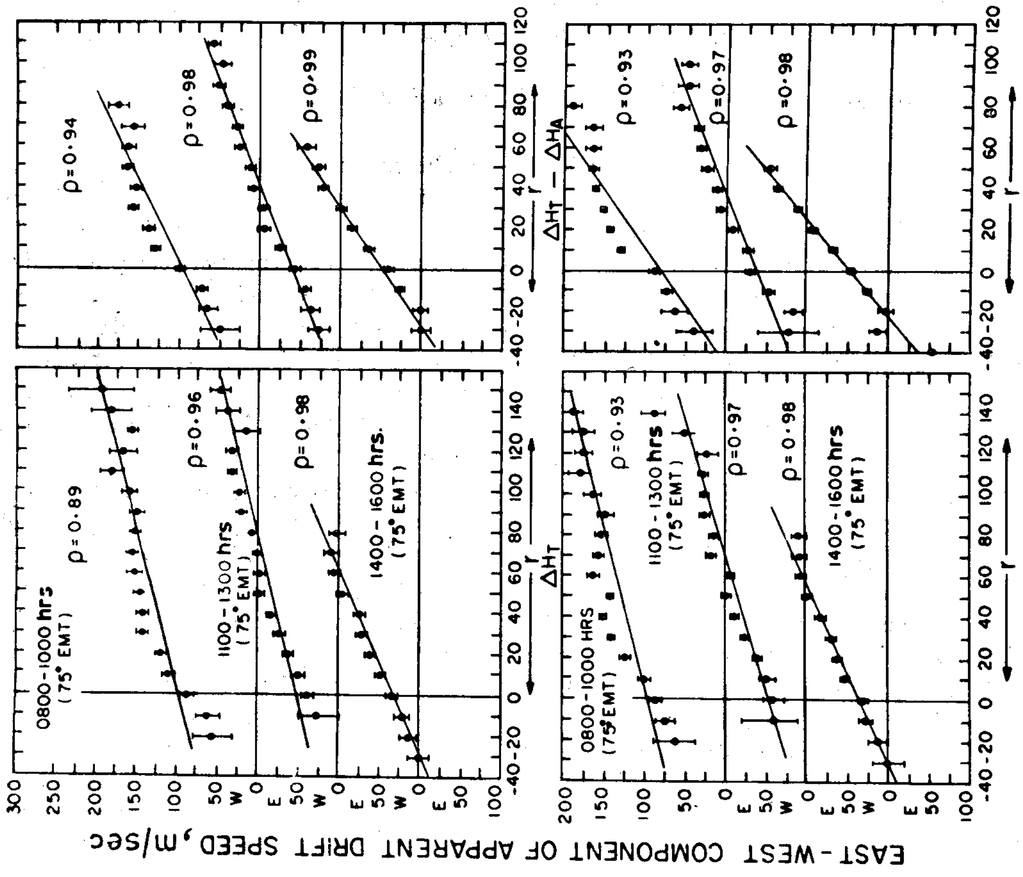

Fig. 1 — Variation of the E-region drift speed with electrojet strength parameters ΔH_T, ΔH_K, $\Delta H_T - \Delta H_A$ and $\Delta H_K - \Delta H_A$ for different hour groups during 1973-74

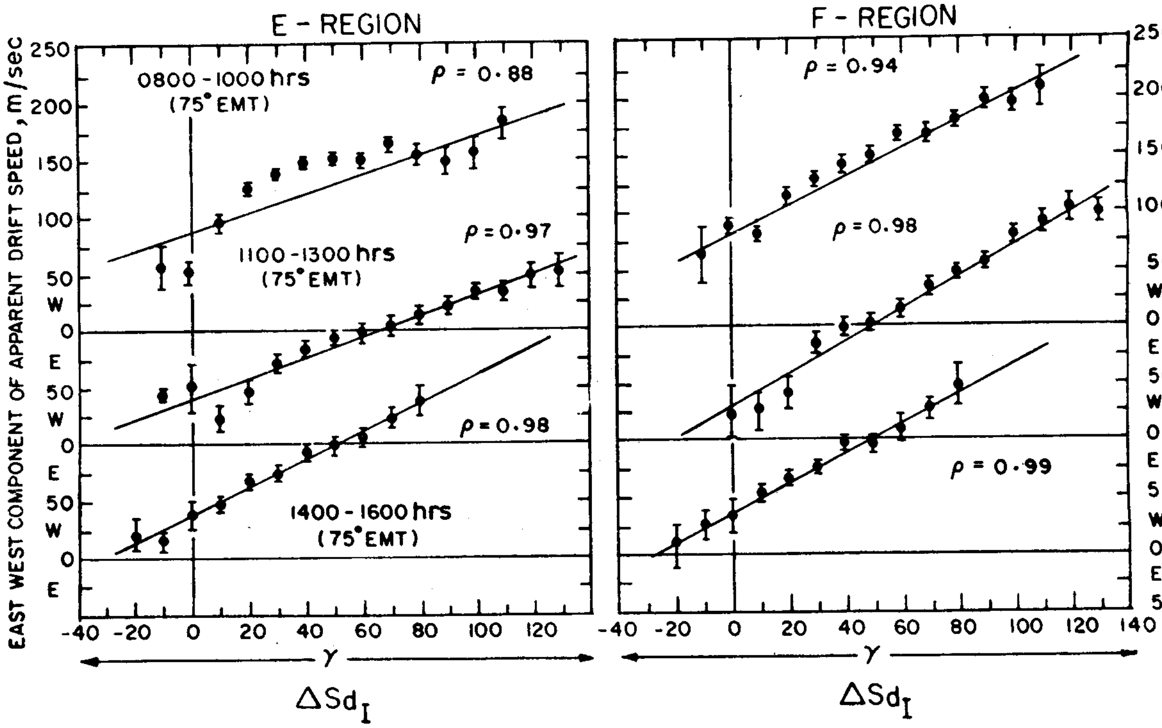

Fig. 3 — Variation of the E- and F-region drift speeds with the electrojet strength ΔSd_I during 1973-74

electrojet strength even on magnetically disturbed days.

3. Correlation between the E-W Drift and Electrojet Strengths

To investigate the relationship between the day-to-day changes in the electrojet strength and in the E-W drift speed entire data in the period 1973-74 has been grouped into three time periods. The morning period (0800-1000 hrs, 75° EMT), noon period (1100-1300 hrs) and afternoon period (1400-1600 hrs). Daily mean values of drift speeds in these three hour groups have been worked out both for E and F regions and compared with the mean electrojet strengths corresponding to these hour groups of each day. Electrojet strengths are divided into different steps of 10γ each and the mean drift speeds for each slab of electrojet strength computed. The variations of the mean drift speed with electrojet strength thus obtained are shown in Figs. 1 to 3. Variations of the E-region drift speed with the electrojet strength parameters ΔH_T, ΔH_K, $\Delta H_T - \Delta H_A$, and $\Delta H_K - \Delta H_A$ are shown in Fig. 1, while similar results for F-region are shown in Fig. 2. The variation of the drift speed with ΔSd_I both for E and F regions are shown in Fig. 3. Each curve shown in Figs. 1-3 is based on about three hundred measurements, i.e. on the average 15 to 20 measurements per point plotted. The error bars in mean are, therefore, very small. The straight lines fit by least square method are also drawn in Figs. 1-3 and the constants of the equation of the type

$$V' = V_0 + a\,(\Delta H)$$

where V_0 is the speed at range equal to zero are collected in Table 1. The salient features observed are as follows.

(i) High correlations varying between 0·88 and 0·99 are obtained between the various electrojet strength parameters and the drift speed. Correlations are a little smaller in case of ΔH_T or ΔH_K compared to other parameters. This is due to the fact that on magnetically disturbed days ΔH_T or ΔH_K will not be truly representative of electrojet strength.

(ii) For any of the electrojet strength parameters, the correlation with F-region drift speed are higher than the correlation for E-region drift speed.

(iii) For any electrojet strength parameter correlation values with E-region drifts are a little less in the morning hour group than in the noon or afternoon hour group. For the F-region drift the correlation values are nearly equal at all the hour groups.

(iv) For the E-region the drift speeds in the morning hour group do not show linear relationship. A saturation effect is noticed with the drift speed becoming constant at about 150 m/sec for higher values of the electrojet strength.

(v) The drift speeds are about 30 to 100 m/sec towards west at zero values of electrojet strength. The westward drift speed V_0 at zero electrojet strength is highest for the morning hour group and lowest for the afternoon hour group. If the drift velocity was in one direction in the entire dynamo region the straight lines should have passed through the origin. Counter-electrojets with values ranging from 30 γ to more than 60 γ are noted when drift reversals take place at about 100 km level. This indicates that there are simultaneously opposite drift at different altitudes around these events. Further the occurrence of counter-electrojet events would be in error if deduced from magnetograms.

Table 1 — Constants of the Equation $V' = V_0 + a\ (H)$ at Tiruchirapalli

Hour	Parameter	E-region		F-region	
		V_0	a	V_0	a
Morning	ΔH_T	95	0·65	82	1·08
	ΔH_K	93	0·64	95	0·98
	$\Delta H_T - \Delta H_A$	92	1·27	100	1·37
	$\Delta H_K - \Delta H_A$	83	1·64	90	1·60
	ΔSd_I	87	0·83	77	1·25
Noon	ΔH_T	52	0·60	55	0·93
	ΔH_K	45	0·75	40	1·15
	$\Delta H_T - \Delta H_A$	60	0·97	62	1·58
	$\Delta H_K - \Delta H_A$	60	1·03	68	1·52
	ΔSd_I	40	0·90	27	1·42
Afternoon	ΔH_T	30	1·10	35	0·80
	ΔH_K	35	1·10	37	1·08
	$\Delta H_T - \Delta H_A$	47	1·72	50	1·55
	$\Delta H_K - \Delta H_A$	45	2·12	52	1·36
	ΔSd_I	37	1·23	32	1·30

To look for the seasonal changes in the correlations between the drift speeds and electrojet strengths, we have further divided the dates into three seasonal groups of winter, equinoxes and summer. Since the correlations between different electrojet strength parameters are nearly identical we have chosen $\Delta H_K - \Delta H_A$ only for this study and the results are shown for the E-region and F-region in Figs. 4 and 5, respectively. The constants representing the straight line fit are collected in Table 2. There are no differences in the correlation values during different seasons. However, the westward drift at zero electrojet strength (V_0) is highest for winter and lowest for summer.

4. Discussion

The horizontal drift either in the E-region or in the F-region in the electrojet region are highly correlated with the electrojet strength deduced

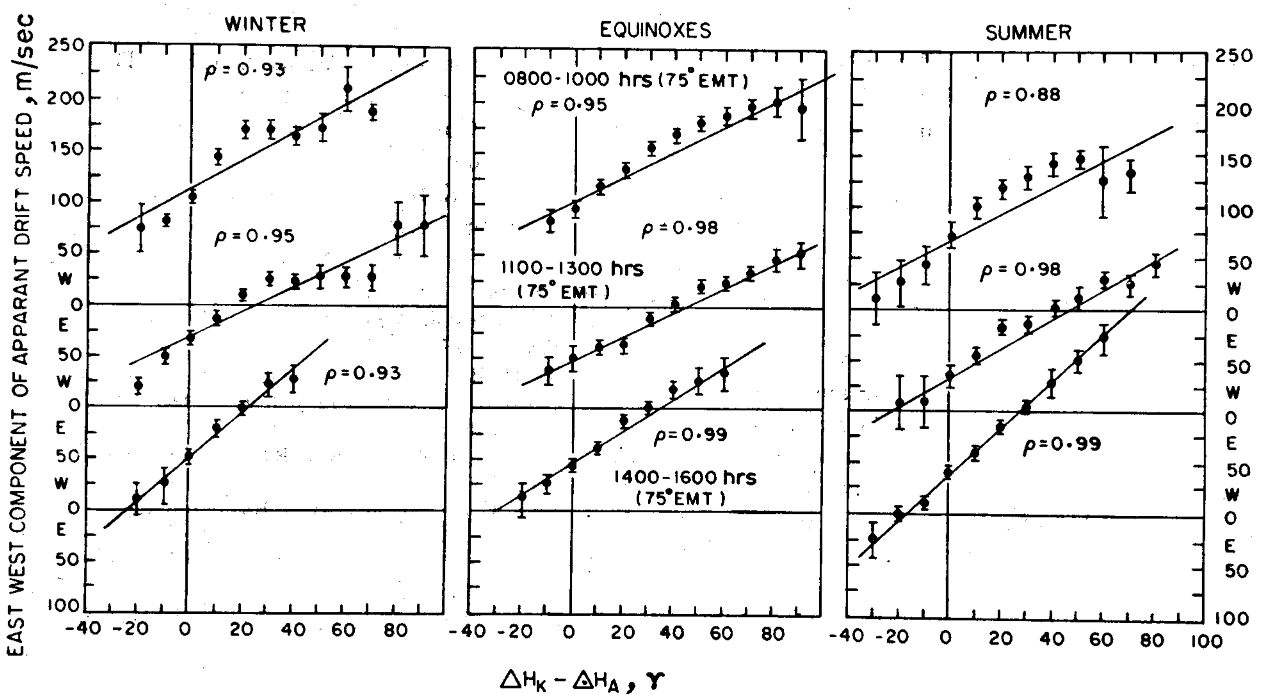

Fig. 4—Variation of the E-region drift speed with $\Delta H_K - \Delta H_A$ for different hour groups during different seasons of 1973-74

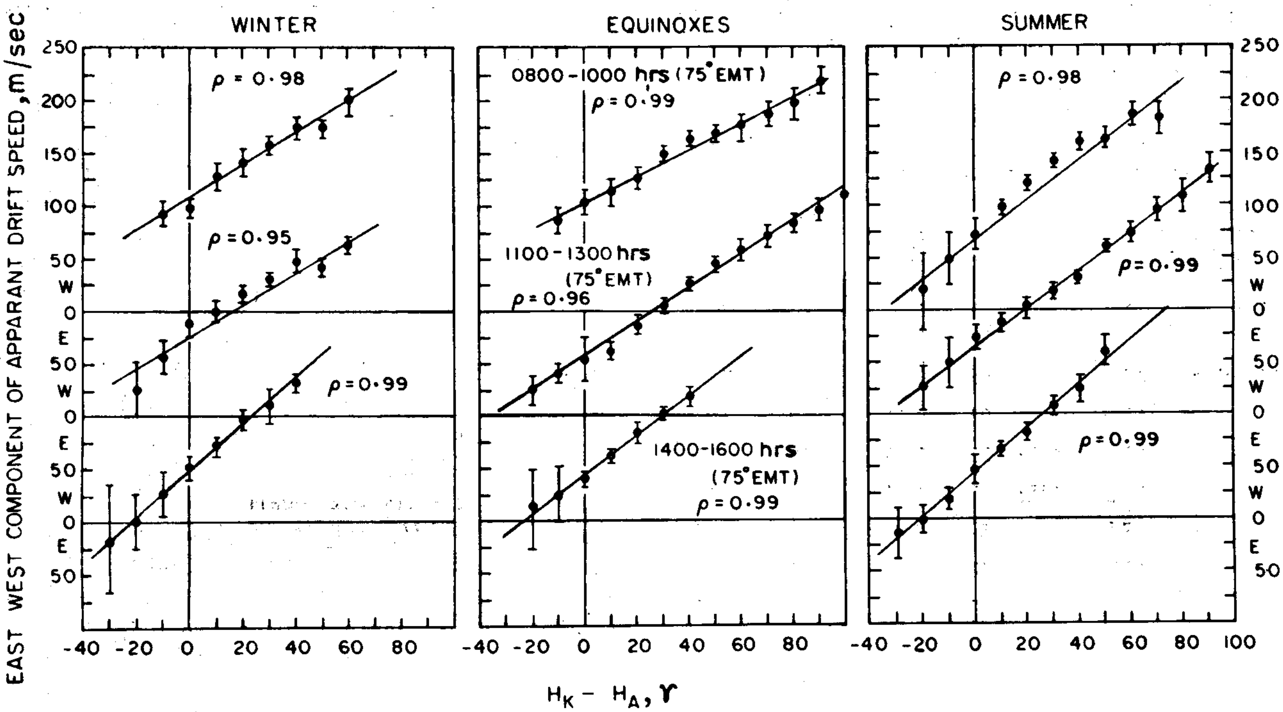

Fig. 5 — Same as Fig. 4 but for F-region

Table 2 — Constants of the Equation $V' = V_0 + a(\Delta H_K - \Delta H_A)$ for Tiruchirapalli

Season	Hour group	E-region V_0	E-region a	F-region V_0	F-region a
Winter	Morning	112	1·37	110	1·35
	Noon	70	1·17	75	1·50
	Afternoon	50	2·12	45	2·35
Equinoxes	Morning	105	1·20	105	1·25
	Noon	50	1·17	60	1·60
	Afternoon	47	1·55	40	1 95
Summer	Morning	70	1·30	70	1·90
	Noon	35	1·50	65	1·90
	Afternoon	40	2·30	45	2·25

from magnetograms, the sensitivity in the relation between the two differing with the time of day as well as with the season. This is because the magnetograms give an integrated effect in the entire dynamo region while the drift measurements relate to an altitude about 100 km. The winds are known to have altitude variation and could be opposite in direction at different altitudes. Further the wind profile may change from time to time and cause different sensitivity in the relation between the drift and electrojet. We have given here the relationship between the drift speeds and electrojet strength for different hours of the day and for different seasons and these could be used to estimate the velocities from magnetograms.

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