Daily variations of *E* and *F* region drifts over Tiruchirapalli

G D VYAS, H CHANDRA and R G RASTOGI

Physical Research Laboratory, Ahmedabad 380 009

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Abstract. Daily variations of the E-W and N-S components of ionospheric drifts, measured using closely spaced receiver method over Tiruchirapalli near magnetic equator, are described for the periods 1973-75 for *E* region and 1974-75 for *F* region. N-S component is not observed except for a few occasions during summer months for the *E* region. E-W component is generally eastward during night hours and westward during day hours. There is a large day-to-day variability in the magnitude as well as in the evening reversal time. Daily variations primarily consist of the diurnal component with average amplitude of about 90 m/sec for *F* region and of about 80 m/sec for *E* region. The drift speeds are found to decrease with magnetic activity. It is concluded that the abnormal electrojet region extends upto north of Tiruchirapalli in the Indian zone and drifts here can be used as a monitor of electric field.

Keywords. Equatorial ionospheric drift; magnetic activity dependence of drift.

1. Introduction

Ionospheric drift measurements at Tiruchirapalli (dip 4.8° N) using the method of closely spaced receivers (Mitra 1949) were started in October 1972 for *E* region and in May 1973 for *F* region. The objectives and preliminary results of the apparent drift speed and direction derived from about twelve thousand hourly observations during the period upto December 1975 have been described by Rastogi *et al* (1978) for *E* region and by Vyas *et al* (1978) for *F* region. In this paper the daily variations of the E-W and N-S components of the *E*- and *F*-region drifts are described in detail. Most of the *E*-region observations are confined to day time hours except for the occasions when night *E_s* reflections could be recorded. Nevertheless, there were sufficient observations for the night hours to obtain seasonal averaged diurnal picture. *F* region measurements cover round the clock observations and it was possible for the first time to fourier analyse the data for each month separately and study month-to-month variation of major fourier components present in the daily variations of *F* region drifts in the electrojet region.

2. Results and discussion

Mass plots of the *E* region E-W drift for selected months of January, April, July and October during the year 1973 are shown in figure 1. There is a large scatter showing large day-to-day variability. The maximum westward drift occurs in the morning

Figure 1. Mass plots of the E-W component of *E* region drift over Tiruchirapalli for the months of January, April, July and October 1973.

Figure 2. Mass plots of the E-W component of F region drift over Tiruchirapalli for the months as in figure 1.

Figure 3. Mass plots of the N-S component of *E* region drift over Tiruchirapalli for the months as in Figure 1.

around 0900 hr with magnitude between 75 and 200 m/sec. During day time hours there are a few observations particularly in the afternoon hours showing eastward drift which imply presence of counter electrojet. These are most prominent during the month of July and least during the months of April and October. Westward drift around midnight are also noticed. Similar mass plots for *F* region are shown in figure 2. In general, drift is eastward during nighttime and westward during daytime. The reversal is regular in the morning with changeover occurring between 0600 and 0700 hr. The evening reversal time is very much variable. Westward drift can be noticed even around midnight for a few nights. N-S component is normally not observed in the *F* region but in the *E* region there are a few occasions when N-S drift is significant. Mass plots showing N-S component for *E* region are shown in figure 3. There is a tendency of southward component in the morning and evening hours, particularly for the month of July.

For comparing mean daily variations of the E-W and N-S components of drift during different seasons, the entire data have been grouped into three seasons of winter (November, December, January and February), equinoxes (March, April, September and October) and summer (May, June, July and August). Fourier analysis of the mean daily variations thus obtained has been done upto the first four harmonics. Figure 4a shows the seasonal mean daily variations during different seasons as well as the annual mean daily variations of the E-W component of drift at Tiruchirapalli both for *E* and *F* regions. The amplitudes and the times of maximum of different fourier components as well as the times of morning and evening reversals are collected in table 1. The nature of daily variations is similar for *E* and *F* regions except for the earlier morning reversal by about one hour in the *E* region as compared to *F* region. The dominant component is the diurnal one with annual mean amplitude of about 90 m/sec for *F* region and about 80 m/sec for *E* region. The steady component is comparable in the *E* region while 12-hourly and 8-hourly components are also significant. The maximum time of the diurnal component is close to midnight while that of semidiurnal component varies between 0300 hr and 0500 hr. Similar mean daily variations of the N-S components are shown in figure 4b. The mean values are insignificant except during summer season for the *E* region where a clear trend is noticed with southward component during evening and night hours.

The large uniform data in the case of *F* region permitted study of daily variations for each month separately with good statistical reliability. Figure 5a shows the month-to-month variation of the amplitudes of steady, diurnal and semidiurnal components. An annual variation is noticed in the seasonal variation of the steady component with magnitude of about -30 m/sec during winter months and about -10 m/sec during summer. Both diurnal and semi-diurnal components show semi-annual variations with equinoctial maxima. The seasonal variations of the times of maximum of these components are shown in figure 5b. A clear semiannual variation is noticed for the diurnal component but the seasonal variation of the semidiurnal component is not very clear; however the maximum is definitely delayed during summer months. The morning reversal time is more or less uniform at 0600 hr but a large variation is noticed in the seasonal variation of the evening reversal time. The reversal occurs earliest during June at about 1700 hr and around 2000 hr during winter months.

Similar studies of the daily variations of E-W drifts for different seasons at

Figure 4a. Seasonal mean and annual mean daily variations of the E-W component of drift in the E and F regions over Tiruchirapalli. b. Seasonal mean and annual mean daily variations of the N-S component of E and F region drifts over Tiruchirapalli.

Figure 5a. Month to month variations of the amplitude of steady, diurnal and semidiurnal components present in the daily variations of the E-W *F* region drift over Tiruchirapalli. b. Month-to-month variations of the maximum time of the diurnal and semidiurnal components present in the daily variations of the E-W *F* region drift over Tiruchirapalli as well as of the morning and evening reversal times.

Thumba (dip 0.6°S) have been reported by Chandra and Rastogi (1970) and Misra and Rastogi (1971). The amplitude of the diurnal component at Thumba was shown to be about 150 m/sec for *F* region and about 100 m/sec for *E* region. The results at Thumba for the year 1967 and 1968-69 belong to a moderate or

Table 1. Fourier components of E-W drift at Tiruchirapalli.

Period	Season	Amplitude m/sec					Time of maximum LT				Reversal times LT	
		a_0	a_1	a_2	a_3	a_4	T_1	T_2	T_3	T_4	Morning	Evening
<i>E region</i>												
1973-75	Winter	-48	90	18	21	3	23.8	1.6	5.0	3.3	4.2	19.9
	Equinoxes	-48	82	23	27	13	23.2	3.0	5.3	5.2	5.3	20.5
	Summer	-34	63	18	19	13	22.3	5.1	4.9	4.6	5.0	18.2
	Annual	-44	76	15	25	7	23.0	3.8	5.0	5.1	5.2	19.4
<i>F region</i>												
1974-75	Winter	-37	85	19	18	6	23.9	3.5	5.2	0.1	5.6	19.9
	Equinoxes	-29	95	35	28	7	23.8	3.9	5.2	4.4	6.1	19.6
	Summer	-4	86	31	16	10	0.6	5.2	5.1	2.4	7.2	18.5
	Annual	-29	88	28	22	6	23.9	3.8	5.2	4.7	6.0	19.8

Figure 6. Daily variations of the mean drift speed on international quiet and disturbed days for E and F regions over Tiruchirapalli.

high sunspot epoch in comparison to the results at Tiruchirapalli which are for a low sunspot epoch. However, the solar cycle variations of apparent drift speed reported for the electrojet region either decrease by a small amount (Misra *et al* 1971) or independent (Oyinloye and Onolaja, 1977) of sunspot number. Thus the results at Tiruchirapalli are similar in nature to those obtained at Thumba except for the amplitudes being comparatively much smaller. The drifts at Tiruchirapalli, situated at the edge of the electrojet region, are well correlated with the electrojet currents and therefore provide a monitor of the electric field.

To study the effects of magnetic activity on drifts, mean daily variations of the E-W component have been derived separately for the international quiet and disturbed days during the three seasons and are shown in figure 6. The vertical bars denote the standard error in deriving the mean values. For the E-region (daytime only) there is a small reduction in the drift speed on disturbed days. The reduction is significant

Figure 7. Variation of the mean midday drift speed with K_p index for E and F regions over Tiruchirapalli.

during winter and summer but within the error limit during equinoxes. For the *F*-region, reduction on disturbed days is clear during daytime hours particularly near the time of maximum westward drift; however at other hours the change is of the order of error bar or less. During night time hours the drift values are smaller on disturbed days than on quiet days in general during winter and equinoxes while during summer the opposite is true. However, the error bars are quite large during night time and the conclusions have to be taken with a caution. To find the relation between daytime drift speed and magnetic activity index K_p on a statistical basis the drifts speeds at midday (1100–1300 hr LT) in each season have been grouped for different values of the midday K_p index and the variation of the mean drift speed with K_p index for different seasons has been obtained. These are shown in figure 7 along with the variation of the annual mean drift speed with K_p index. In order to show the significance of these variations, the error in mean and the number of observations in deriving the mean are also shown in the figure. A significant decrease in the mean drift speed with increasing K_p index is noticed in each season. Annual mean drift speeds decrease from about 125 m/sec for K_p index of zero to about 100 m/sec for K_p index of six in the case of *E* region, while in the case of *F* region decrease is from about 135 m/sec to about 100 m/sec. These results support the earlier observations at Thumba (Rastogi *et al* 1971). Skinner *et al* (1963) had also shown that the diurnal component of eastward drift at Ibadan (dip 6°S) is reduced by about 30 per cent on disturbed days. Thus, it is confirmed that drift speed decreases with magnetic activity at electrojet latitudes.

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