J. Ind. Geophys. Union (July 2010)
Vol.14, No.3, pp.177-182

Ionospheric drifts over Udaipur during counter electrojet events

R.K.Rai, M.Mittal[1] and H.Chandra[2]
M.S.University Udaipur - 313 001
[1]Govt. Holkar Science College, Indore - 452 017
[2]Physical Research Laboratory, Ahmdabad - 380 009
E-mail:hchandra@prl.res.in

ABSTRACT
Ionospheric drift measurements made at Tiruchirapalli, situated close to the magnetic equator and Udaipur a tropical latitude station during the years 1973-74 are examined on few counter-electrojet days covering both winter and summer seasons. The examples presented here show that on counter electrojet days the drift velocity tends to shift eastward not only at equatorial stations but also at Udaipur. This suggests that there is change in the global scale wind pattern during counter electrojet events.

INTRODUCTION

Electrodynamics plays an important role in the equatorial and low latitude ionosphere [Rastogi et al. 1972, Abdu 1997, Rastogi & Chandra 1999 and references therein]. The configuration of the northward magnetic field and zonal electric fields of dynamo origin give rise to special features of the ionosphere at low latitudes. Intense daytime eastward current that flows in the E-region in a narrow band of latitudes centered over the dip equator was named 'Equatorial Electrojet' by Chapman [1951]. This is caused by the enhanced conductivity resulting from the vertical Polarization field close to the dip equator. Associated with the equatorial electrojet is the regular daytime transparent type of sporadic-E (Es_{-q}) observed in ionograms. The Es_{-q} arises due to the scattering of radio waves from plasma density fluctuations caused by the plasma instabilities that operate near the magnetic equator (two-stream instability and the cross-field instability). There are occasions when the westward current flows during the daytime due to the electric field reversals. Such events are known as counter electrojet and observed as depression in H during daytime in the electrojet region [Gouin 1962]. During periods of daytime counter electrojet when electric field reverses the equatorial type of sporadic-E also disappears as demonstrated from the ionosonde and ionospheric drift measurements made at Thumba (dip 0.6°N) near the magnetic equator [Rastogi, Chandra & Chakravarthy 1971]. Later the drift measurements were also made at Tiruchirapalli (dip 4.8° N) and the features were found to be similar to those at Thumba but with a slight decrease in the magnitude of drift velocity [Vyas, Chandra & Rastogi 1978]. Thus the drift measurements at Tiruchirapalli could also be used to monitor the electric field in the electrojet region. The occurrence features of counter electrojet have been described in detail [Rastogi 1974] based on examination of geomagnetic H variations in the electrojet region. Occurrence features of counter electrojet were also reported from ionospheric drift measurements at Thumba by Chandra [1973] and at Tiruchirapalli (dip 4.8 N) by Vyas, Chandra & Rastogi [1979].

In the electrojet region ionospheric drifts are westward during daytime and eastward during night during each of the seasons with reversals around 07h and 20h local time [Chandra & Rastogi 1970, Vyas, Chandra & Rastogi 1978]. The magnitude of drift is maximum during equinoxes and the steady drift, as determined by harmonic analysis, is reduced during summer by about 20 m/s. At tropical latitude stations Ahmedabad (23° N, 72.6° E, dip 33.8° N) and Udaipur (24.6° N, 73.7° E, dip 35.3° N), daytime drifts are westward during winter and eastward during summer with change over during equinoxes [Chandra, Patel & Rastogi 1977, Rastogi et al. 1978]. Chandra, Patel & Vyas [1981] examined the E-region drifts at Ahmedabad on two counter electrojet events during winter of 1974 and showed that drifts shifted to eastward on such days. Kane and Patel [1980] studied geomagnetic field variations at a chain of stations in the Indian longitude sector for a low sunspot year of 1964 for normal days and strong afternoon counter electrojet days. Though nothing abnormal was seen during summer season but during winter and equinoxes larger geomagnetic H variations were seen at low and middle latitudes during strong afternoon counter electrojet days.

In the present study ionospheric drift measurements at Udaipur are examined on four counter elecrojet events for low solar activity period of 1973-74, two each for winter and summer. Ionospheric drifts at Tiruchirapalli are also used whenever data is available.

DATA AND RESULTS

The experimental set up used at Tiruchirapalli and Udaipur have been described earlier [Rastogi et al. 1978; Kumar, Janve & Rao [1973]. The hourly drift records were analyzed using Mitra's similar fade method [1949] that gives the apparent drift velocity. The difference in the deviations in H at Trivandrum and Alibag, $\Delta H_{TRI-ALB}$ is used as indicator of counter electrojet. For comparison the monthly mean values of the E-region drift is used. Fig. 1a shows the results on 15 May 1974. The variation of $\Delta H_{TRI-ALB}$ shows fairly strong electrojet strength with its maximum value of almost 80 nT around 10-11 h. There is sudden decrease in electrojet strength from 11 h to 14 h with value dropping below nighttime base level around 13h and falling to about -35 nT at 15h before recovering to nighttime level at 17h. Ionospheric E-region drift during this month decreases steadily from more than 100 m/s westward at 07-08 h to about 20 m/s westward at 17 h. However on 15 May 1974 westward drift at Tiruchirapalli reversed to eastward sharply between 14 and 15h. The monthly mean drift at Udaipur is eastward varying between 5 to 45 m/s. On 15 May 1974 the drift was eastward up to 09 h,

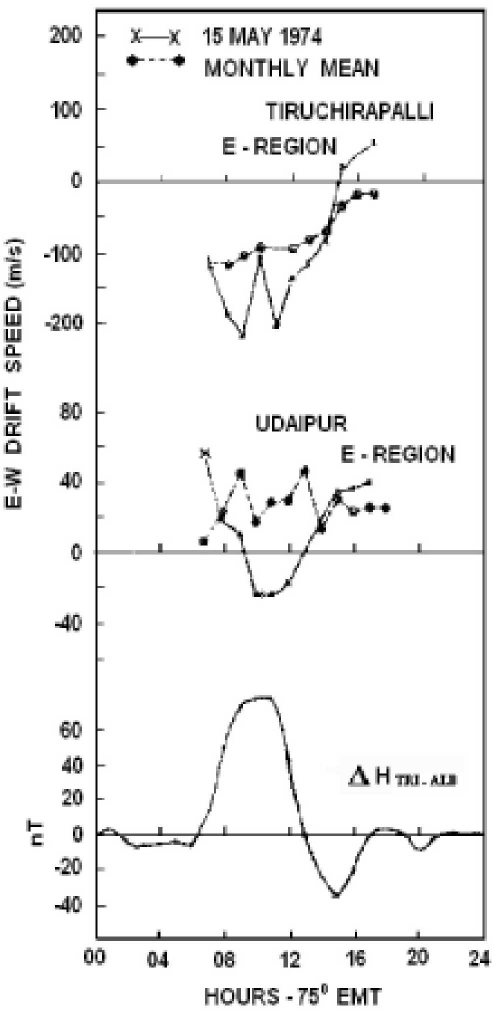

Figure 1a. Daily variations of the E-W drift speed at Tiruchirapalli and Udaipur on 15 May 1974 (along with the monthly mean E-W drift speed) and the difference of the range in H at Trivandrum and Alibag, $\Delta H_{TRI-ALB}$ on 15 May 1974.

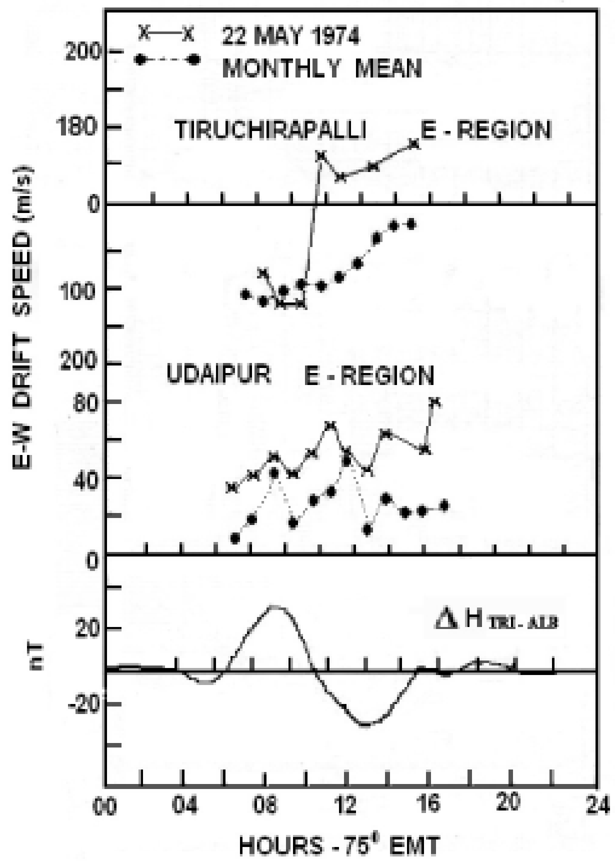

Figure 1b. Daily variations of the E-W drift speed at Tiruchirapalli and Udaipur on 22 May 1974 (along with the monthly mean E-W drift speed) and the difference of the range in H at Trivandrum and Alibag, $\Delta H_{TRI-ALB}$ on 22 May 1974.

westward from 10 h to 12 h and then again reversed to eastward during 15-17 h. The magnitude of the eastward drift in the evening hours was more than the monthly mean values. Thus one can conclude that following the counter electrojet on 15 May 1974, drift velocities changed towards eastward both at Tiruchirapalli and Udaipur.

The second example of the counter electrojet and drift measurements both at Tiruchirapalli and Udaipur is shown in Fig. 1b. The electrojet was comparatively weaker on this day with $\Delta H_{TRI-ALB}$ about 30 nT at 09 h. $\Delta H_{TRI-ALB}$ decreased from 10 h to 14 h and the value was below the night level from 11 h to 17 h. The counter electrojet peaked at 14 h with $\Delta H_{TRI-ALB}$ value of about – 30 nT. The ionospheric E-region drifts at Tiruchirapalli showed westward drift of about 100 m/s between 08 and 10 h but there was sudden change in drift velocity from 10 to 11 h with value reversing to about 60 m/s eastward. The drift remained eastward between 11 and 16 h. Compared with the monthly mean, the magnitude of E-region drift is shifted by 100-150 m/s to eastward on 22 May 1974. The E-region drift at Udaipur on 22 May 1974 are eastward but greater in magnitude than the monthly mean values by about100 m/s during the period of counter electrojet. The third example of counter electrojet shown in Fig. 1c is for 3 February 1973. The electrojet strength, as described by $\Delta H_{TRI-ALB}$, remained below the night level from 12h to 15h with peak depression of about -25 nT. There were no observations of drift at Tiruchirapalli on this day. On this day also the drifts on 3 February 1973 were shifted towards east, the shift ranging between 20 to 60 m/s compared to the monthly mean values.

The counter electrojet event of 20 February 1973 is shown in Fig. 1d. $\Delta H_{TRI-ALB}$ decreased to below night time level between 1230 to 15h with minimum value of -20 nT at 14h. Though the drift did not reverse to eastward at Tiruchirapalli on this day but it was very much reduced in magnitude after 13h. The magnitude of drift at Udaipur did show change to eastward from 1230h to 1630h.

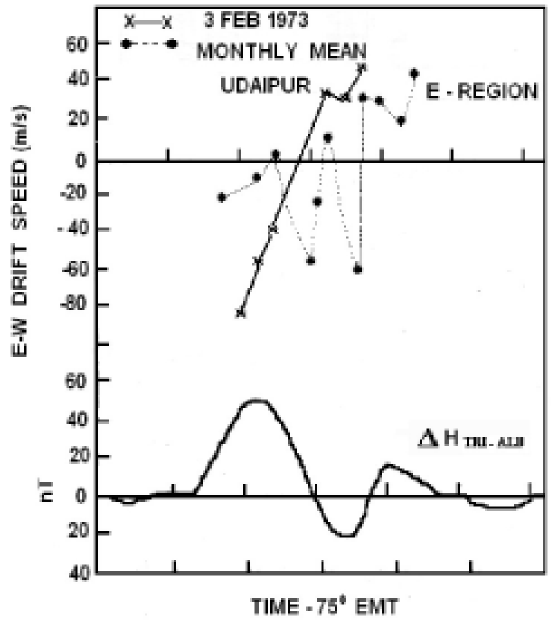

Figure 1c. Daily variations of the E-W drift speed at Udaipur on 3 February 1973 (along with the monthly mean E-W drift speed) and the difference of the range in H at Trivandrum and Alibag, $\Delta H_{TRI-ALB}$ on 3 February 1973.

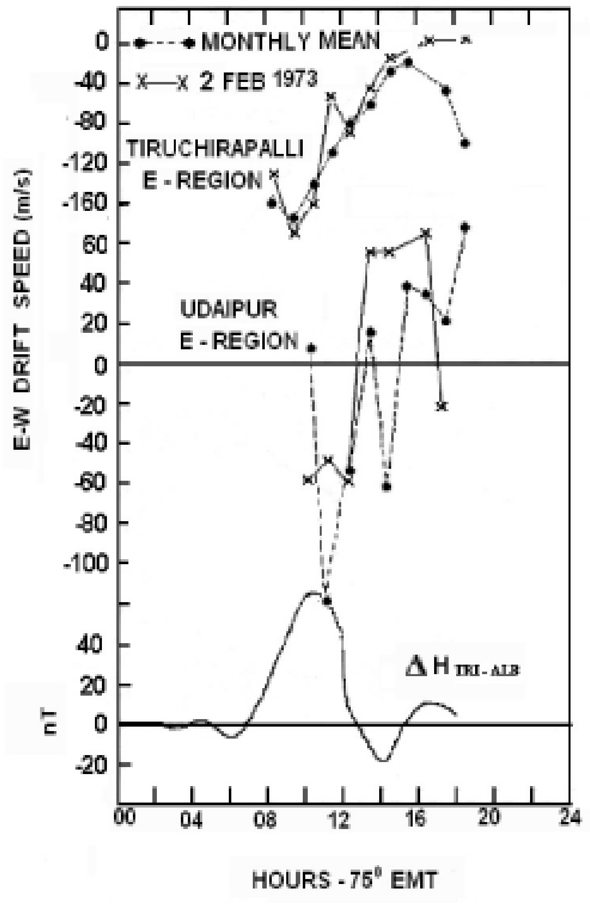

Figure 1d. Daily variations of the E-W drift speed at Tiruchirapalli and Udaipur on 2 February 1973 (along with the monthly mean E-W drift speed) and the difference of the range in H at Trivandrum and Alibag, $\Delta H_{TRI-ALB}$ on 2 February1973.

SUMMARY AND DISCUSSION

Chandra, Patel & Vyas [1981] presented two events of counter electrojet during the winter months. The example of 22 November 1974 showed a change of more than 100 m/s from normal westward drift to about 20 m/s of eastward drift at the peak of counter electrojet at Tiruchirapalli and from 20 m/s westward to 50 m/s eastward at Ahmedabad. The monthly mean drift was westward at Ahmedabad but on counter electrojet day it was eastward. The example of 20 December 1974 showed a higher westward drift throughout day hours at Tiruchirapall as compared to monthly mean values by about 30 m/s and by about 100 m/s at the peak of counter electrojet. The monthly mean drift at Ahmedabad was westward during most of the daytime hours and on the counter electrojet day remained eastward throughout day hours. The difference was 20-60 m/s. The examples shown here cover both winter and summer. Thus even for the counter electrojet events of summer season there is an evidence of the change in the global wind system.

Kane & Patel [1980] studied the geomagnetic H and X variations at a number of stations in the Indian longitude sector, covering from dip equator to the Sq focus and beyond, on strong afternoon counter electrojet days of winter and equinox of 1964. They reported differences compared to mean variations indicating that there were changes in the global wind pattern. The geomagnetic H variations at stations in the equatorial electrojet region also showed higher values in the pre-noon hours on counter electrojet days. This indicates strong semi-diurnal component. Explanation of the counter electrojet is given in terms of the global scale tidal winds. The diurnal tide is mainly responsible for the generation of electric field necessary to drive the normal Sq current system and the normal equatorial electrojet in the daytime. But the dynamo action of semi-diurnal tides is considered to contribute to dynamo region electric fields particularly in December solstices [Forbes & Lindzen 1976, Marriott, Richmond & Venkateswaran 1979, Reddy 1989]. Somayajulu [1988] showed that the amplitudes and phases of the diurnal and semi-diurnal components of the geomagnetic H variations on counter electrojet days differ substantially from those on normal electrojet days. Alex & Mukherjee [2001] investigated the counter electrojet events of different local time groups and highlighted the importance of the semi-diurnal tides of varying magnitude to influence the local time behaviour of counter electrojet events.

The examples presented here show that on counter electrojet days, both during winter and summer, the drift velocity tends to shift eastward not only at equatorial station but also at stations away from equator like Udaipur. This suggests that there is change in the global scale wind pattern during counter electrojet events and support the earlier work (Chandra, Patel & Vyas 1981) based on two winter events of counter electrojet and drift observations at Ahmedabad and Tiruchirapalli

REFERENCES

Abdu, M. A., 1997. Major phenomena of the equatorial ionosphere-thermosphere system under disturbed conditions, J Atmos. Sol-Terr. Phys., 59, 1505-1519.

Alex, S. & Mukherjee, S., 2001. Local time dependence of the equatorial electrojet effect in a narrow longitudinal belt, Earth Planets Space, 53, 1151-1161.

Chandra, H., 1973. On the disappearance of Es at Kodaikanal-Thumba, J Inst. Telecom. Engrs., 19, 539-544.

Chandra, H. & Rastogi, R. G., 1970. Daily variation of F-region drifts at Thumba, J Atmos. Terr. Phys., 32, 1309-1311.

Chandra, H., Patel, V. P. & Rastogi, R. G., 1977. Ionospheric E-region drift pattern at low-latitudes, Curr. Sci., 46, 835-836.

Chandra, H., Patel, V. P. & Vyas, G. D., 1981. Change in the low latitude E-region drifts associated with counter electrojet, Ind. J Radio Space Phys., 10, 164-66.

Chapman, S., 1951. The equatorial electrojet as detected from the abnormal electric current distribution above Huancayo and elsewhere, Arch. Meteorol. Geophyik. Bioklimatol., A4, 368-392.

Forbes, J. M. & Lindzen, R. S., 1976. Atmospheric solar tides and their electrodynamic effects, II The equatorial electrojet, J Atmos. Terr. Phys., 38, 911-920.

Gouin, P., 1962. Reversal of the magnetic daily variations at Addis-Ababa, Nature 193, 1145-1146.

Kane, R. P. & Patel, V. P., 1980. Association of equatorial counter-electrojets with geomagnetic changes in low and middle latitudes in the Indian region, J. Geomagn. Geoelectr., 32, 137-144.

Kumar, V., Janve, A. V. & Rai, R. K., 1973. Effect of size and orientation of the receiving triangle in ionospheric drift measurements, Ind. J Radio Space Phys., 2, 283-286.

Marriott, R., Richmond, A. D. & Venkateswaran, S. V., 1979. The quiet time equatorial electrojet and counter electrojet, J Geomagn. Geoelectr., 31, 311-340.

Rastogi, R. G., 1974. Westward equatorial electrojet during daytime hours, J Geophys. Res., 79, 1503-1512.

Rastogi, R. G. & Chandra, H., 1999. Geomagnetic and Ionospheric Research, In Space Research in India: Accomplishments and Prospects, ed. By M S Narayanan, Hari Om Vats, B Manikiam, H Chandra & S P Gupta, PRL Alumni Association, P 99-135.

Rastogi, R. G., Chandra, H. & Chakravarty, S. C., 1971. The disappearance of equatorial Es and the reversal of electrojet current, Proc. Ind. Acad. Sci., 74, 62-67.

Rastogi, R. G., Chandra, H., Sharma, R.P. & Rajaram, G., 1972. Ground based measurements of ionospheric phenomena associated with equatorial electrojet, Ind. J Radio Space Phys., 1, 119-135.

Rastogi, R. G., Rai, R.K., Chandra H., Janve, A.V., Kumar, V. & Singhal, K.P., 1978. Simultaneous investigation of ionospheric E-region irregularities at two low-latitude stations by spaced receiver technique, Ind. J. Radio Space Phys., 7, 6-8.

Reddy, C. A., 1989. The equatorial electrojet, PAGEOPH, 131, 485-508.

Somayajulu, V. V., 1988. Behaviour of harmonic components of the geomagnetic field during counter electrojet events, J Geomagn. Geoelectr., 40, 110-130.

Vyas, G. D., Chandra, H. & Rastogi, R. G., 1978. Daily variations of E and F region drifts over Tiruchirapalli, Proc. Ind. Acad. Sci., 87, 215-224.

Vyas, G. D., Chandra, H. & Rastogi, R. G., 1979. Counter electrojet in the Indian zone Ind. J Radio Space Phys, 8, 33-35.

(Revised accepted 2010 April 12; Received 2009 December 31)

Prof. R K Rai obtained Ph. D. in ionospheric physics from BHU, Varanasi. He set up the ionospheric research group at the Mohan Lal Sukhadia University, Udaipur in late sixties. The group was actively involved in the studies of ionospheric absorption, ionospheric drifts, total electron content and scintillations at low latitudes. He held the positions of the Head of Physics Department, Chairman Faculty of Science and Vice Chancellor (1992-98) of the MLS University Udaipur.

Dr. Mithilesh Mittal obtained Ph. D. in ionospheric Physics from Mohan Lal Sukhadia University, Udaipur in 1984. Her research work was on the E-region and F-region drift measurements at a low latitude station Udaipur. She has been teaching Physics, Electronics and Computer Science since then and currently is Professor in Physics at Holkar Science College at Indore.

Prof. H Chandra obtained M. Sc. (Physics) in 1964 from Agra University and started research in equatorial ionosphere at Thumba as research student of the Physical Research Laboratory, Ahmedabad. He obtained Ph. D. in 1970 from Gujarat University. His research interests cover ionospheric drifts, equatorial ionosphere, spread-F, scintillations, radar probing of mesosphere, lidar, in-situ measurements of equatorial ionosphere and mesosphere. He has published 200 research papers in national and international journals.