WESTWARD IONOSPHERIC CURRENTS OVER THE DIP EQUATOR DURING GEOMAGNETIC DISTURBANCES

R.G.Rastogi

Physical Research Laboratory, Ahmedabad 380009, India
and
Indian Institute of Astrophysics, Kodaikanal 624103, India

Abstract. During geomagnetic disturbed periods, the q type of sporadic E layer near the dip equator is shown to disappear with maximum error of five minutes during the period when the difference of the geomagnetic H field between the equatorial and non-equatorial station decreases below the night level. These periods are identified with the reversal to westward direction of the electrojet currents at the base of the E region around 100 km level irrespective of the changes in the S_q current system which might be produced by the disturbance.

Inroduction

Although the equatorial sporadic E layer had been known to be associated with the equatorial electrojet currents, Cohen et al.(1962) were first to show a disappearance of Es-q at Huancayo during a decrease of the geomagnetic H field. This phenomenon of sudden disappearance of Es-q during the depression of the H field was shown to be associated with the reversal of ionospheric drifts measured by space receiver technique (Rastogi et al., 1971) and later with the reversal of the electron drift measured by VHF doppler shifts (Rastogi, 1973). Fambitakoye et al.(1973) showed that the disappearance of Es-q is not coincident with the time of ΔH becoming negative (relative to the nighttime level) but with the reversal of the latitude profile of H and Z fields. Chandra and Rastogi (1974) have shown that the simple criterion for the disappearance of the Es-q is that the difference of the H field between the equatorial and non-equatorial station should decrease below the corresponding nighttime level.

During geomagnetic disturbances, the ground level measurement of the H field completely fails to give any idea of the overhead currents in the ionospheric E-region. In the present study, the author examined the ionograms of Kodaikanal taken at short intervals of every five minutes during geomagnetic disturbed period.

Disappearance of Es-q and the H field

In Fig.1 are shown the variations on 21 December 1957 of the geomagnetic fields and the foEs-q in the 75°E longitude zone. The geomagnetic indices for this day were Ap = 14 and Cp = 0.8 and thus the day may be considered as a rather undisturbed day. However, the magnetogram at Kodaikanal, an equatorial station, showed large fluctuations and a significant decrease of the H field between 1000 and 1300 LT. The H field at station close to the Sq focus - Tashkent, showed very much decreased fluctuations suggesting that these fluctuations of the H field at Kodaikanal are due to the variations in the equatorial electrojet currents and not due to the current effects common to both stations. The Es-q at Kodaikanal had disappeared between 1020 and 1110 LT and again between 1140 and 1215 LT; the foEs during the rest of the period being around 10 - 12 MHz. It is remarkable to find that the difference of the H field between Alibag and Kodaikanal had decreased below its value at 0000 LT precisely during the periods identical to that of the disappearance of Es-q.

The second example (Fig.2) is presented for 27 November 1957. A sudden commencement type of geomagnetic storm had occurred on 26 November at 0152 UT (0652 LT) and ended on 27 November at 2300 LT. The geomagnetic indices for 27 November 1957 were Ap = 47 and Cp = 1.5. The five international disturbed days for the month of November 1957 included all the days from 25 to 28 November 1957. Thus the period under study was within a greatly disturbed period. The magnetograms at Kodaikanal and Tashkent showed large fluctuations of the H field of almost the same magnitude and phase during the nighttime hours suggesting the origin of these fluctuations to be in the magnetospheric currents. During the daytime, very large fluctuations in the H field were seen at Kodaikanal without any corresponding changes at Tashkent suggesting these to be due to variations in the equatorial electrojet currents. The ionograms at Kodaikanal indicated disappearance of Es between 0755-1050 LT, 1110-1115 LT and 1320-1400 LT. The value of H (Kodaikanal)

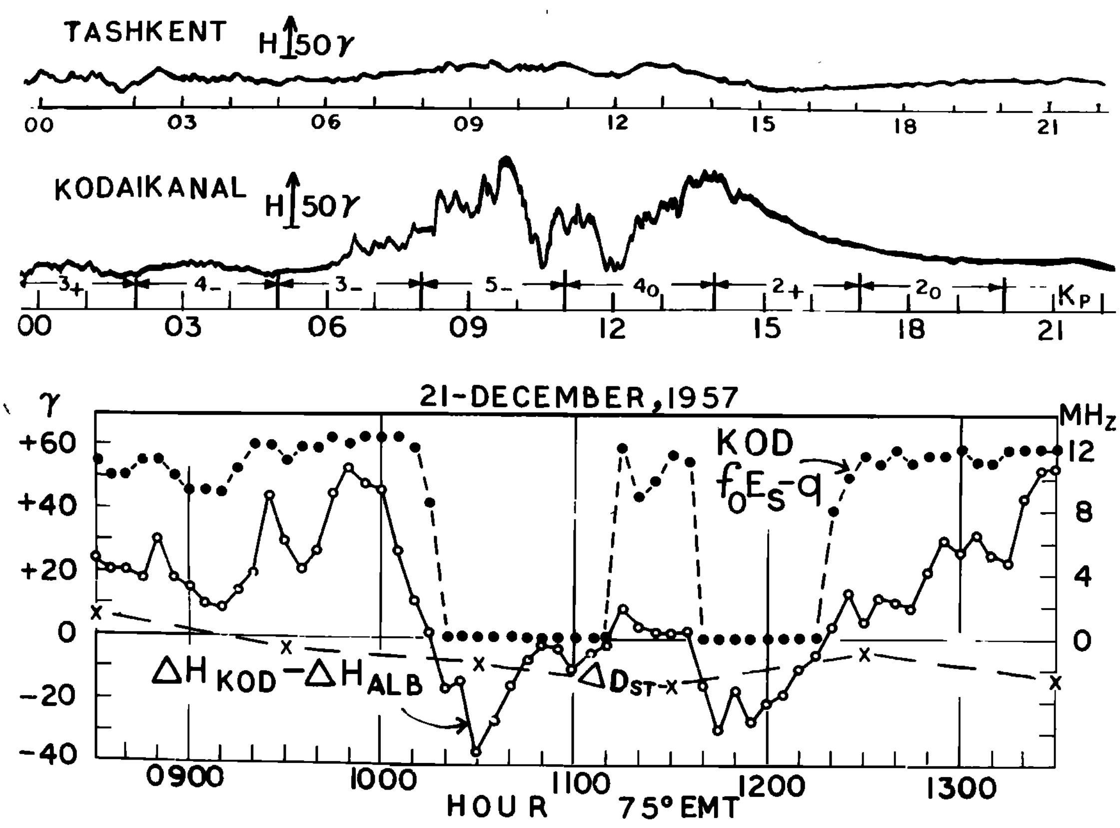

Fig.1 : The variations of the geomagnetic H field at equatorial station - Kodaikanal, a station near the Sq focus - Tashkent, and the difference of the H field between Kodaikanal and Alibag compared with the foEs-q at Kodaikanal on 21 December 1957.

minus H (Alibag) relative to its value at 0000 LT became negative precisely within the period of no Es-q condition. Even a value of ΔH (KOD) - ΔH (ALB) of the order of +10γ had turned on the Es-q of foEs above 10 MHz. Thus, the appearance or disappearance of Es-q at Kodaikanal occurs almost in synchronous with the changes in value of ΔH Kodaikanal minus ΔH Alibag, even during highly disturbed periods.

Discussion

Studying the temporal correlation between the intensity of VHF radio waves scattered from the irregularities associated with the electrojet and the horizontal intensity of the earths magnetic field, a measure of the electrojet current, Cohen and Bowles (1963) found that the echo strength builds up along with the current as midday is approached but as the current decays in the afternoon, a phase lag is noted in the decay of the echo strength. They suggested that the geomagnetic field strength measured at the ground is being affected by currents other than those flowing within the electrojet. The hysteresis feature was eliminated when the difference between the geomagnetic H fields at Huancayo and Bogota was used to represent the strength of the electrojet current. Farley and Balsley (1973) have shown that the scattering cross section of the V.H.F. radio waves by the type II irregularities is linearly related to ΔH (Huancayo) - ΔH Bogota. Nair et al. (1970) suggested that the difference of ΔH at Trivandrum and Alibag is related to purely ionospheric currents. Rastogi (1974) has shown that even when the ΔH at an equatorial station is significantly positive, i.e. above the night level, there may exist counter-electrojet currents as evidenced by the reversal of the latitudinal profiles of ΔH and ΔZ fields. During such partial counter-electrojet events, the Es-q is shown to disappear and the ionospheric drift reverses to eastward direction. This has been interpreted by Rastogi (1975) as due to simultaneous flow of Sq currents around 107 km and of the counter-electrojet currents at a lower level around 100 km.

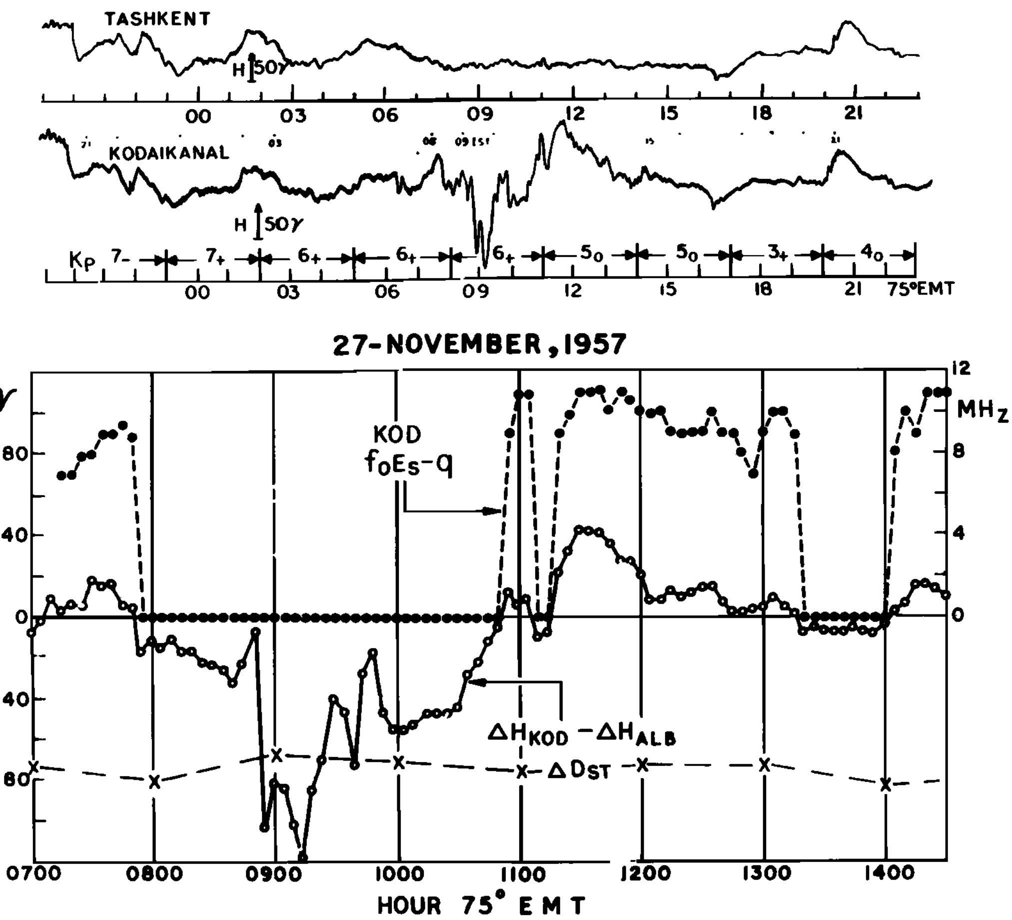

Fig.2 : The variations of the geomagnetic H field at equatorial station- Kodaikanal, a station near the Sq focus - Tashkent and the difference of the H field between Kodaikanal and Alibag compared with the foEs-q at Kodaikanal on 27 November 1957.

The present results indicate that during moderately or severly disturbed conditions there are brief periods during the daytime hours when the currents over the equator are definitely reversed to westward direction. These currents are precisely coincident with the time of Es-q disappearance and hence flow at the level of Es-q i.e. at the base of E layer around 100 km. Unlike during quiet conditions, it is not possible to estimate the changes in the Sq current system during geomagnetic disturbed periods. In the absence of an ionospheric station near the dip equator in any particular longitude zone, two geomagnetic observatories one within and other outside the electrojet current region can delineate these periods of equatorial substorms. An examination of ionospheric storms in association with the changes in Es-q or with the variation of the difference of the H field between the equatorial and a non-equatorial station would help to isolate the effect of the changes of electrostatic field on the F2 region of the ionosphere during geomagnetic storms.

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