Confinement of Equatorial Counter Electrojets to Restricted Longitudes

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(Received June 8, 1979; Revised November 28, 1980)

The average patterns of the daily variation of the geomagnetic variation of the $H$ component at equator on quiet days is a steady level in the dark hours, an increase from about 6 AM to Noon and a decrease back to the night level by about 6 PM. However, on some days the level falls below the night level for a few hours, generally near about 7 AM or 4 PM. GOUIN and MAYAUD (1967) termed these events as counter-electrojets. It was shown by KANE (1973) and RASTOGI (1973, 1974) that these events were often restricted to very narrow longitude zones. However, in a recent review, MAYAUD (1977) has expressed the opinion that no clear examples have yet been presented of such a fact and that a given event is never restricted to a narrow longitude band (say 2 hr wide) and is commonly spread over 5–8 hr in longitude and sometimes occurs within a much wider band.

Geomagnetic observatories near the dip equator are very few. Amongst these, Addis-Ababa (39 E) and Trivandrum (77°E) are two locations closest to each other (about 2½ hr LT difference) and data from these locations were used earlier for demonstrating the occasional restricted longitudinal extent of the counter-electrojet. Recently, we came across a set of short-term magnetic observations carried out in the Brazilian region during the 4 months September–December, 1970. Details are given in GAMA (1972). Out of these, the period September 16–22, 1970 was devoted to a location called Ribeirão Água Branca on the dip equator and at a longitude of 48°.5W. Since there is a permanent magnetic observatory at Huancayo (Peru), on the dip equator at a longitude of 75°.3W, i.e., differing by less than 2 hr in LT, a comparison of $H$ variations at these two locations could be used fruitfully.

In Fig. 1, we show the actual plot of $H$ values read at 10 min intervals, for September 17, 18 at the top, September 19, 20 in the middle and September 21, 22 at the bottom. The upper curve is for Huancayo and the lower curve for Ribeirão. Amongst the geomagnetic daily variations, some occur at the same UT while others occur at the same LT. If a UT time scale is chosen, the daily variation peaks at Huancayo and Ribeirão would appear about 2 hr apart. If local time is chosen for each, all UT peaks would appear about 2 hr apart. As a compromise, as also to get the daily variation peaks

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379
reasonably near each other, the time scale for Ribeirão is so chosen that Huancayo daily variations peaks are only 1 hr ahead of Ribeirão (instead of 2 hr) and all UT effects at Huancayo are 1 hr behind those at Ribeirão. Thus, the UT scale shown matches with Huancayo LT but is 1 hr out for Ribeirão LT. Vertical scales are different for Huancayo and Ribeirão, as indicated by the vertical scale bars. The actual average daily variation ranges at Huancayo and Ribeirão are almost equal.

Some UT effects are immediately obvious and are indicated by inclined arrows. We will not discuss these. Local times 0, 6, 12, and 18 hr are marked on each plot. On almost every day, we find marked differences between the trends of H at the two locations as shown by the hatched portions. H values at Ribeirão are more depressed both in the morning (0600–0800 LT) and in the afternoon (1300–1800 LT), as compared to Huancayo H. The magnitudes of these differences may be somewhat subjective. But the qualitative difference is very obvious. In particular, the strong morning counter-electrojets at Ribeirão on September 19 and September 21 and their absence at Huancayo are very conspicuous indeed.

The origin of counter-electrojets is not yet fully understood. Strong effects due to abnormal neutral wind systems and shears in the dip equator region are suspected. In
earlier works, the effect of neutral wind at or near dip equator was considered to be negligible. However, Kato (1973) pointed out that such winds could produce a non-zero electric field. Richmond (1973) discussed the effect of tidal winds expected to be dominant at electrojet altitudes. Forbes and Lindzen (1976) have developed a three dimensional model of the equatorial electrojet incorporating the effects of horizontal winds of the diurnal (1, 1), (1, −2) and semi-diurnal (2, 2) and (2, 4) modes, and exhibited the possibility of counter electrojets at 0600 hr and 1800 hr LT. However, the afternoon counter-electrojets occur earlier than 1800 hr, requiring larger variations in the phases of the tidal winds than permissible by theory. Anandarao (1976) investigated the effects of horizontal wind shears and later (Anandarao, 1977) the effects of vertical winds too, indicating vertical velocities of about 20–25 m/s to explain the observed counter-electrojet magnitudes. Reddy and Devasia (1977) have calculated the effect of shearing neutral winds on the height structure of the equatorial electrojet. The very restricted longitudinal extent of the counter-electrojet demonstrated by us here imposes limitations on these hypotheses in the sense that it necessitates that the various peculiar neutral wind patterns should be confined to very narrow geographical longitude zones.

Ideally, the longitudinal restriction can be demonstrated conclusively only if there are data available from at least 3 nearby locations (within a 3–4 hr longitude difference) and the middle location exhibits a counter-electrojet event while the other two (one on each side) do not show any trace of it. In the present case, we have no such facility. Thus, one could claim that the counter-electrojets at Ribeirão extended in longitudes more to its East than to its West. However, the contrast between the effects at Huancayo and Ribeirão on September 19 is so large (a counter-electrojet of about 40 gamma at Ribeirão against almost zero at Huancayo), that it forces one to believe that the nature of the phenomena changes very rapidly with longitude at least on some occasions. The most baffling aspect is of course the fact that, on several successive days, the phenomenon of counter-electrojet may be observed at one longitude on the equator but not at others, as for the sequences of December 18–21, 1964 and February 7–9, 1958 illustrated in Kane (1973).

Thanks are due to Prof. Lelio I. Gama and the Director, Observatório Nacional, Rio de Janeiro and their colleagues for the magnetograms for Ribeirão; and to the Director, Huancayo Observatory and to WDC-A for Solar-Terrestrial Physics, Boulder for the magnetograms for Huancayo. We thank Dr. Nelson de Jesus Parada, Director of INPE, for the encouragement and support. This work was partially supported by FNDCT Brasil, under contract FINEP CT/271.

REFERENCES


