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REPORT

STORM-TIME VARIATIONS OF ELECTRON CONCENTRATION IN THE EQUATORIAL TOPSIDE IONOSPHERE

By

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Abstract

Storm-time variations of the topside ionosphere in equatorial latitudes over the American zone are examined, by using Alouette I sounding data. Three typical types of variations of electron concentration during geomagnetic storms are recognized. First type is characterized by the development of the equatorial anomaly, and second one by the disappearance of the anomaly. The occurrence of electron concentration enhancement without the anomaly over wide range of latitudes is third type.

1. Introduction

Variations of electron concentration in the equatorial topside ionosphere during geomagnetic storms have been studied by several workers. Analysing Alouette I topside sounding data over the Asian zone, King et al. (1967) reported that during the geomagnetic storm on 15 September 1963 the depth of electron concentration trough and the latitudinal extent of equatorial anomaly crests decrease as compared with those observed during a magnetically quiet day. Sato (1968), using Alouette I data over the American zone, analysed the variations of electron concentration in the topside ionosphere and showed that during geomagnetic storms the formation of the equatorial anomaly in the daytime appears to be inhibited. On the other hand, Raghavarao and Sivaraman (1973) examined the latitudinal variations of the topside electron density during eight magnetic storm events and showed that for seven of the events the equatorial anomaly is enhanced during magnetically disturbed conditions. With respect to the latitudinal variations of total electron content in the noontime during geomagnetic storms, Basu and Das Gupta (1968) found that the peak of electron content anomaly in the equatorial region moves toward the magnetic equator on magnetically active days. On the contrary, Mendonca et al. (1969) showed that the position of the anomaly crest of total electron content moves away from the magnetic equator immediately after a magnetic sudden commencement.

As shown above, it seems that the morphology of the electron concentration variations in the equatorial latitudes has been far from being established until now.

In addition, it is not clear how the topside ionosphere behaves during various phases of geomagnetic storms. In this paper, we report storm-time variations of the topside ionosphere in equatorial latitudes during geomagnetic storms.

2. Data and results

We used Alouette I ionospheric data published by the Defence Research Board of Canada. Electron concentration profiles over the American zone were selected. Magnetically quiet days prior and close to the commencements of the geomagnetic storms were used as control days. Days used as control days were not ones immediately preceding the storm commencements when satellite ionospheric data on those days were not available. The data on quiet and disturbed days were for nearly the same local time and longitude. Twenty-one storm events were examined and typical types of events out of them are shown in Figs. 2 to 5.

Fig. 1 shows the geomagnetic variations at Huancayo, Peru. Geomagnetic storms occurred on 21 November 1962, 24 October 1963, 29 October 1963 and 7 November 1963, respectively. Arrows shown in this figure represent the time at which the ionospheric data were taken.

In Fig. 2 latitudinal electron concentration profiles at the height of 500 km at different phases of the geomagnetic storm on 24 October 1963 (dotted line) are compared with the corresponding profiles under undisturbed conditions on 23 October (solid line) and 24 October (chain line). As shown in this figure, the equatorial anomaly that have existed under undisturbed conditions disappears during

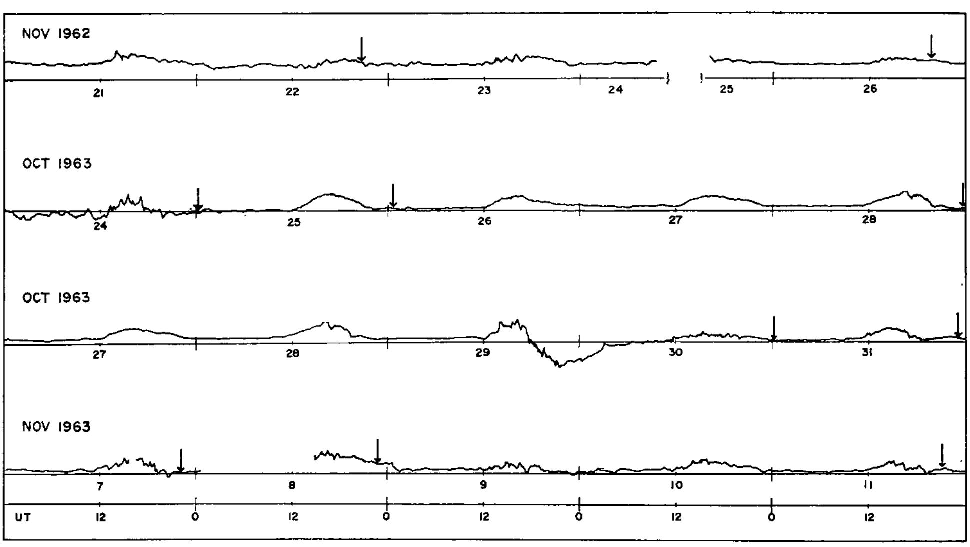

Fig. 1. Geomagnetic field data at Huancayo, Peru in November 1962, October and November 1963. The time at which the ionospheric data were acquired is shown by arrows.

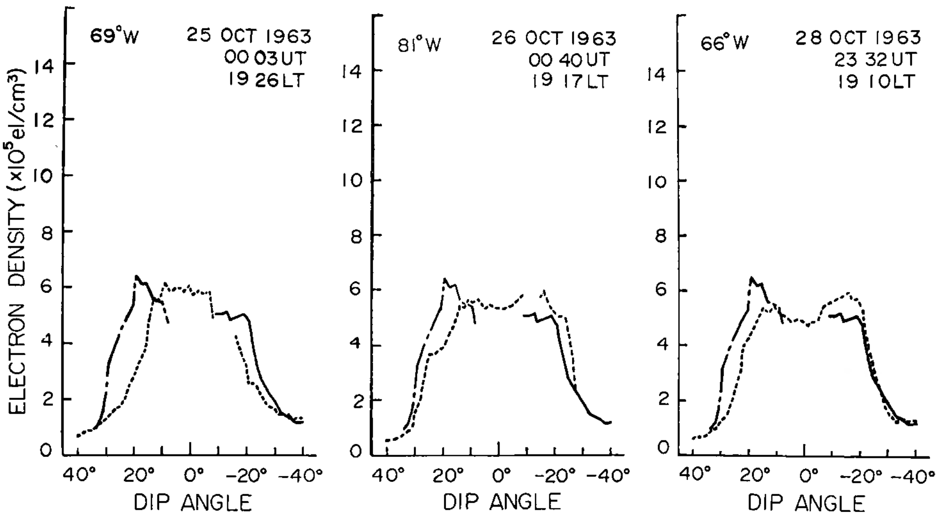

Fig. 2. Comparison of the latitudinal electron density profiles at the height of 500 km at different phases of the magnetic storm on 24 October (dotted line) with the corresponding profiles under undisturbed conditions at 2327 UT (1938 LT) on 23 October (solid line) and at 0110 UT (1932 LT) on 24 October (chain line). The dates, UT, LT and longitudes at which the satellite passed over the dip equator are also indicated.

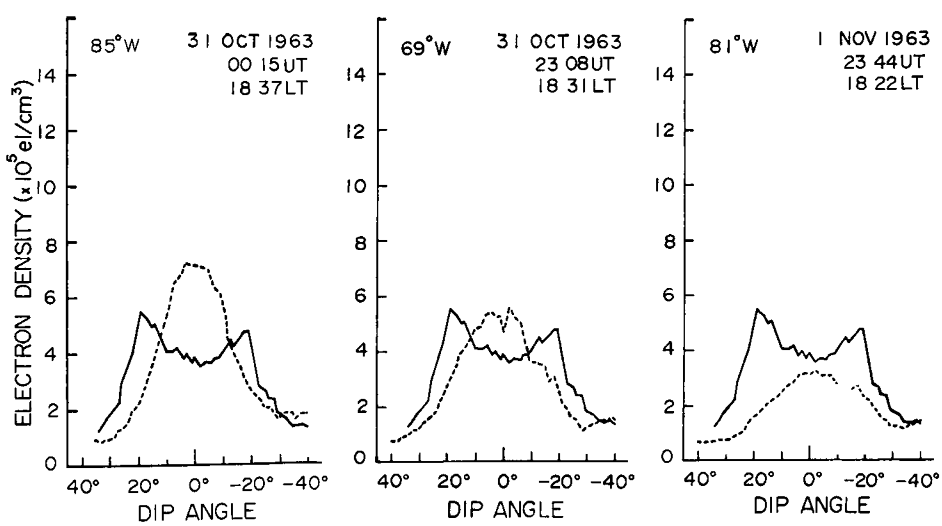

Fig. 3. The version is the same as Fig. 2. The storm occurred on 29 October 1963. The control day profile is taken at 2301 UT (1855 LT) on 28 October (solid line).

the recovery phase of the geomagnetic storm (0003 UT on 25 October). This type of variation is similar to Sato's D-type ones. Then, as geomagnetic conditions recover to quiet state the equatorial anomaly is formed again (2332 UT on 28 October). Fig. 3 also shows that the equatorial anomaly disappears on the disturbed days. During the recovery phase of the geomagnetic storm (0015 UT on 31 October) the anomaly disappears with the enhancement of electron density around the magnetic equator and with the depression at dip angles above 13° at the height of 500 km.

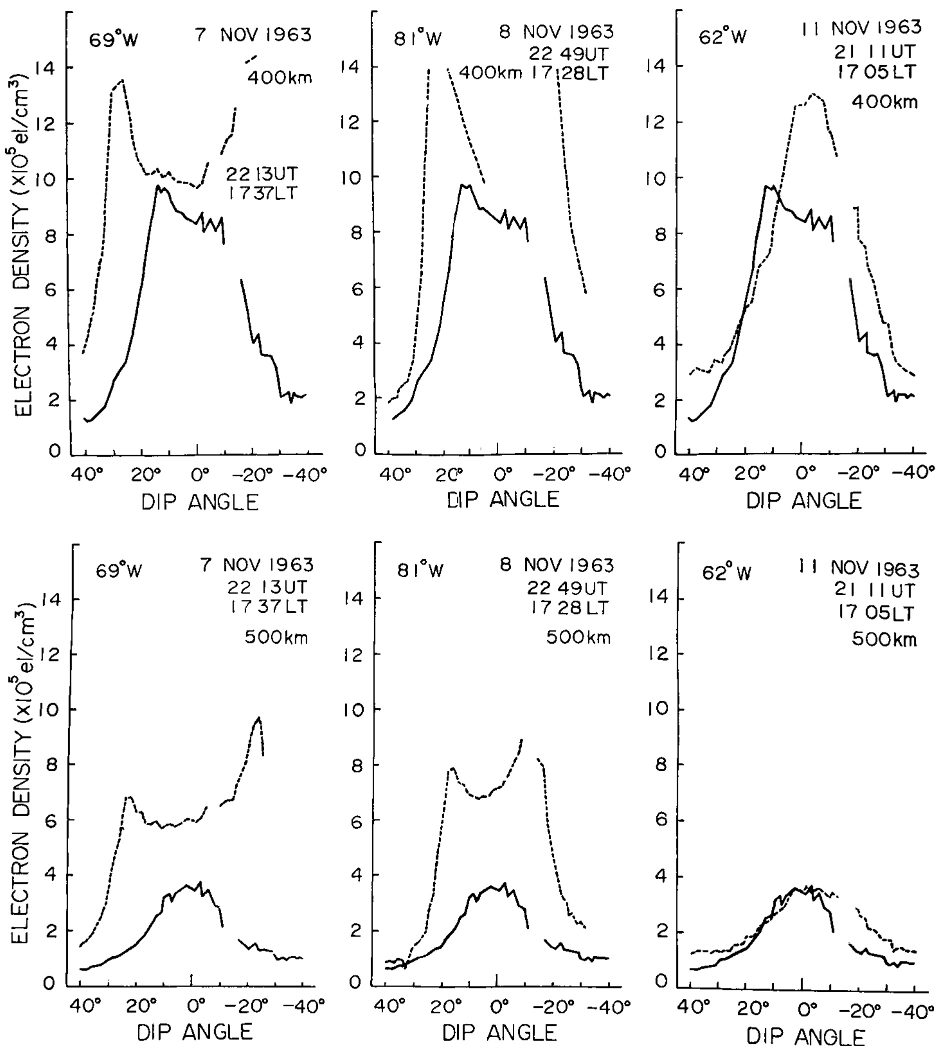

Fig. 4. The version is the same as Fig. 2. In this figure profiles at the height of 400 km and 500 km are shown. The storm occurred on 7 November 1963. The control day profile is taken at 2206 UT (1700 LT) on 4 November (solid line).

At the end of the recovery phase of the geomagnetic storm (2308 UT on 31 October) the disappearance of the anomaly is also seen, and the peak value of electron density at the equator decreases. However, under quiet conditions (2344 UT on 1 November) following the geomagnetic storm the electron concentration at the height of 500 km is depressed over all latitudes between dip angles of $\pm 40°$ as compared with that on the control day and the anomaly does not exist. Fig. 4 shows the variations at the height of 400 km and 500 km during the geomagnetic disturbance on 7 November 1963. On the control day (4 November) prior to the commencement of the disturbance the equatorial anomaly does not exist. Under the disturbed conditions on 7 November the asymmetrical anomaly is well developed both at 400 km and 500 km and the anomaly crests are located at dip angle of about 22°. The enhancement of electron concentration is also recognized over the wide range of latitudes at both these heights. On the next day (8 November) the anomaly crests move toward the magnetic equator and are situated at dip angle of about 15° at the height of 500 km, and the electron density at both heights is further enhanced around the magnetic equator. As the geomagnetic field recovers to quiet state the equatorial anomaly is inhibited again. Fig. 5 shows a different type of variation from ones shown above. The equatorial anomaly is not formed both on the control day and on the disturbed one, and electron density is enhanced under disturbed conditions.

3. Discussions

Three types of the variations shown in this report may be caused mainly by the

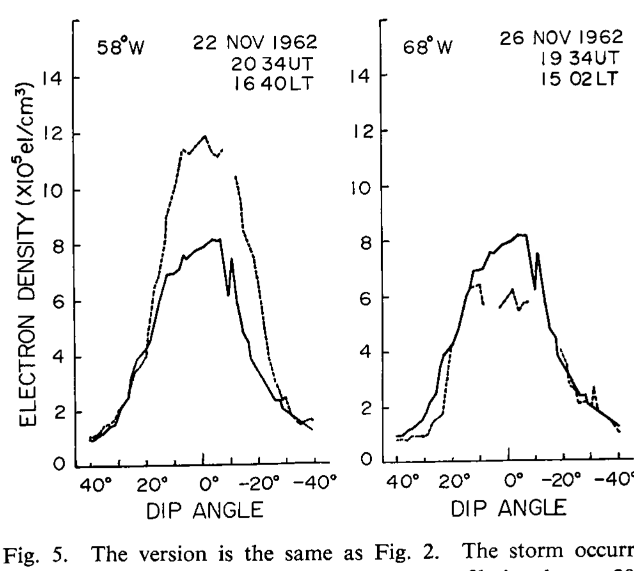

Fig. 5. The version is the same as Fig. 2. The storm occurred on 21 November 1962. The control day profile is taken at 2034 UT (1640 LT) on 19 November (solid line).

changes of electromagnetic drifts. The type shown in Fig. 2 that is characterized by the disappearance of the equatorial anomaly during geomagnetically disturbed days may be explained by the electromagnetic drift associated with an electric field for the DS magnetic variation as suggested by Sato (1968). Other types of the variations shown in Figs. 3 to 5 might also be related to changes in electric fields in the ionosphere during geomagnetic storms (Raghavarao and Sivaraman, 1973), while it appears that the depression of electron concentration on 1 November 1963 (Fig. 3) is partly due to changes of neutral composition as suggested by Rush et al. (1969).

In order to establish the morphology of the variations in the equatorial topside ionosphere, more data of the topside ionosphere will be needed, and to make clear the effects of geomagnetic storms on the electron concentration the observations of electric fields at the equatorial ionosphere will be required, too.

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