REPORT UAG-12
PART II

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Upper Atmosphere Geophysics

DATA ON SOLAR-GEOPHYSICAL ACTIVITY ASSOCIATED WITH THE MAJOR GEOMAGNETIC STORM OF MARCH 8, 1970

April 1971

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Prepared by Research Laboratories, NOAA, Boulder, Colorado
and published by

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ENVIRONMENTAL DATA SERVICE
Asheville, North Carolina, USA 28801

April 1971

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"Jicamarca Incoherent Scatter Observations during the March 1970 Storm"

by

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The purpose of this note is to report on ionospheric observations taken at Jicamarca (1° N Magnetic Latitude) during the March 8, 1970 magnetic storm. This report includes measurements of the electron density, electron temperature and vertical drift (or E-W electric field) for the 7, 8 and 9 of March 1970. These measurements are complemented by C-4 ionograms and magnetic field measurements taken at the Huancayo Observatory which is located at the same magnetic latitude 100 km east from the Jicamarca Observatory. We are including Huancayo ΔH magnetograms to illustrate our discussion.

The data reported here are still under study and it is being reported in response to the request of the World Data Center A, Upper Atmosphere Geophysics, in its effort to gather world-wide data taken during the magnetic storm in a single publication. Therefore, we shall present the experimental facts limiting our discussion and conclusions to those which can be derived from simple inspection of the records.

The techniques used to gather the data have been reported previously. The electron densities have been obtained using the Faraday rotation method and the electron temperatures using the cross correlation technique, both systems have been described by Farley [1969a,b]. The technique to obtain the vertical drift (E-W electric field) is described by Woodman and Hagfors [1969]. The three parameters were measured almost simultaneously.

We do not have quiet day measurements of density and temperature sufficiently close to the day of the storm to be taken as a control day. The reader will have to refer to the statistical behavior of these parameters as measured at Jicamarca and reported by J. P. McClure, D. T. Farley and R. Cohen [1970] and J. P. McClure [1970]. We have included here the statistical behavior of vertical drifts for the same season taken from Woodman [1970].

Results and Discussion

Figures 1a) and 1b) show the electron temperature, electron density and vertical drift (E-W electric field) for March 7, 1970. The conversion factor between velocity to electric field is 40 m/sec equal 1 millivolt/meter March 7 was already disturbed with three hour Kp's as high as 6-. The behavior of the electron density shows nothing very unusual, and the electron temperature agrees well with what one would expect from previous experience for the corresponding density profile. The vertical drifts did show some disturbance which can be better appreciated in Figure 4 (curve 7) in comparison with the typical behavior for the season. The fluctuations with low values at 1100 and 1500 hours LT* can be attributed to the storm.

There were two passes of OGO-6 close to the station which could be used to take a reference value for the electron temperature as measured by the satellite. The passes are shown by a satellite looking symbol in Figure 1a) (disregard the satellite height, it corresponds to the satellite range from the station).

On March 7 there was a solar eclipse but it was not seen at Jicamarca. The line of totality crossed our longitude at 1330 LT and 46° to the north of us. We did not see any effects which could be attributed to the eclipse, as could be expected being so far away from the affected zone.

Figures 2a) and b) show the electron temperature, electron density and vertical drift (E-W electric field) for March 8, 1970, the most disturbed day. Sudden commencement occurred at 0918 LT. We do not have any data from 0830 to 1130 LT; the transmitter was turned off to make some adjustments. We were not aware of the storm and were running a control day for the eclipse of the previous day.

The effects on the density contours are very dramatic. There was a very rapid uprising of the F layer starting at 1300 hours LT reaching a height for the maximum density, H_{max}, of 800 km at least! The sensitivity of the system at these heights went down as a new layer appeared at 1500 LT, increasing the Faraday dispersion effects [McClure, 1967] as a consequence of the increase in total electron content, and it is possible that the top peak went even higher at later times. The rapid uprising of the F layer was due to a very high upward vertical velocity as shown in the same Figure 2a) and in Figure 4, curve 8. The slope in the contour lines agrees well with the measured velocities. The appearance of a second peak can be attributed, in part, to new production in a re-

* All local times refer to 75° W.

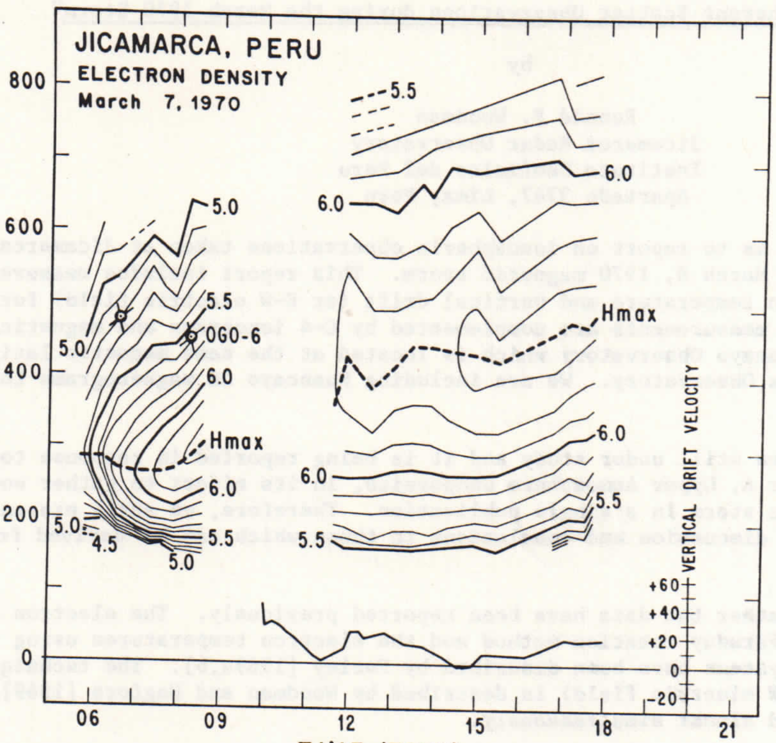

Fig. 1a. Contour line plot of the logarithm of electron density and F region vertical drift taken at the Jicamarca Radar Observatory on March 7, 1970.

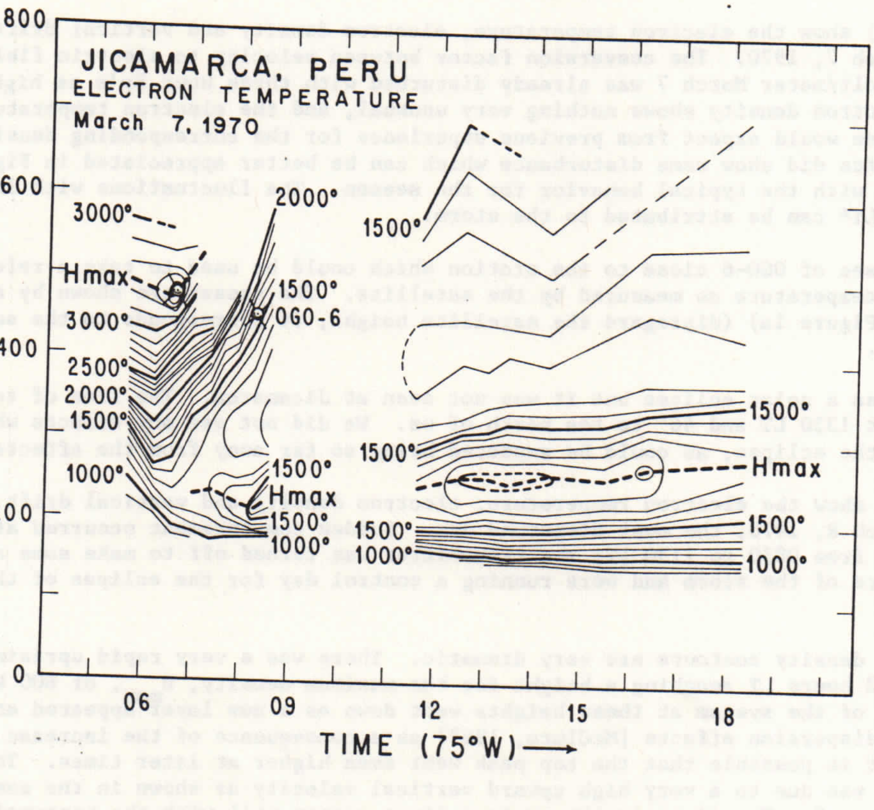

Fig. 1b. Electron temperature contour plot for March 7, 1970.

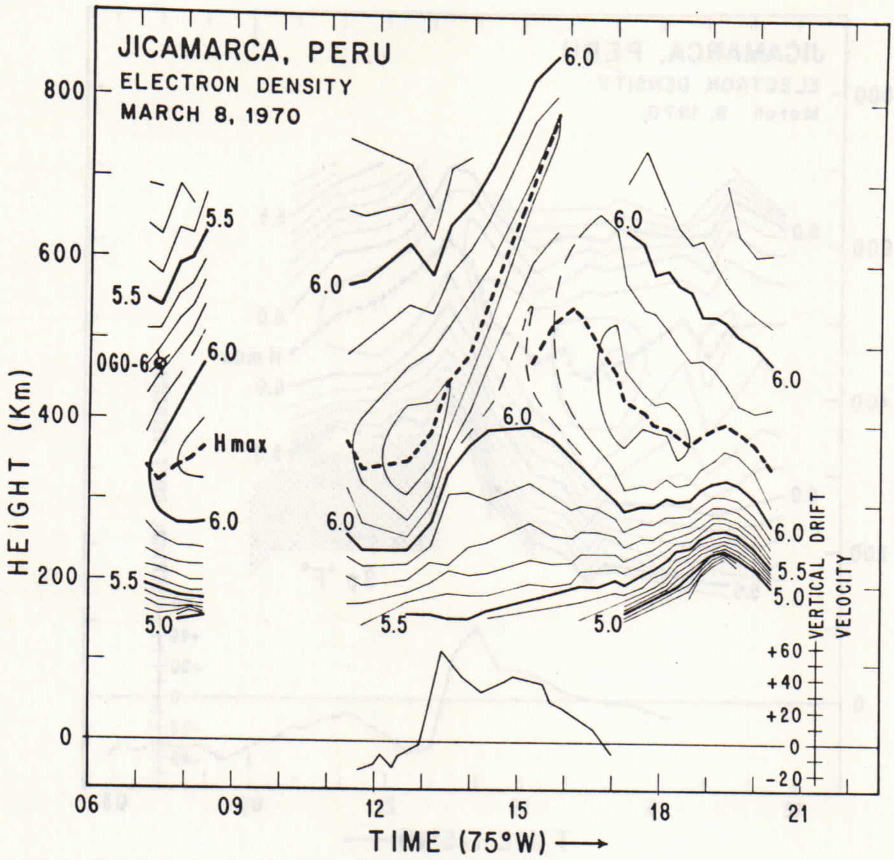

Fig. 2a. Contour line plot of the logarithm of electron density and F region vertical drift taken at the Jicamarca Radar Observatory on March 8, 1970.

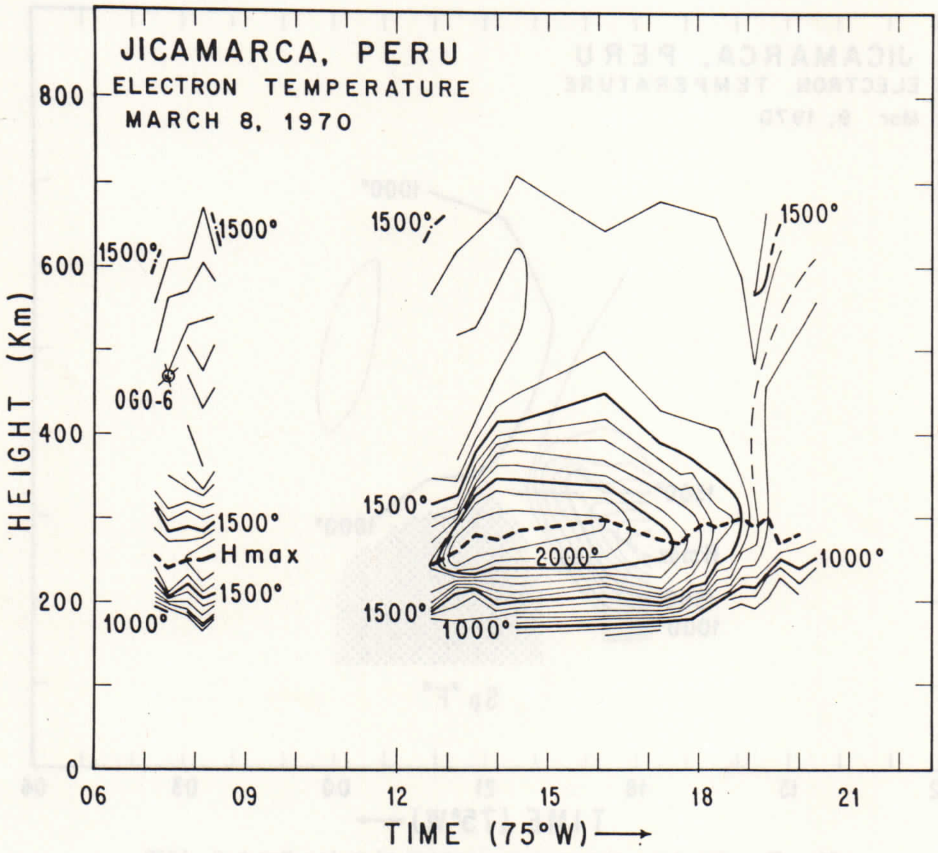

Fig. 2b. Electron temperature contour plot for March 8, 1970.

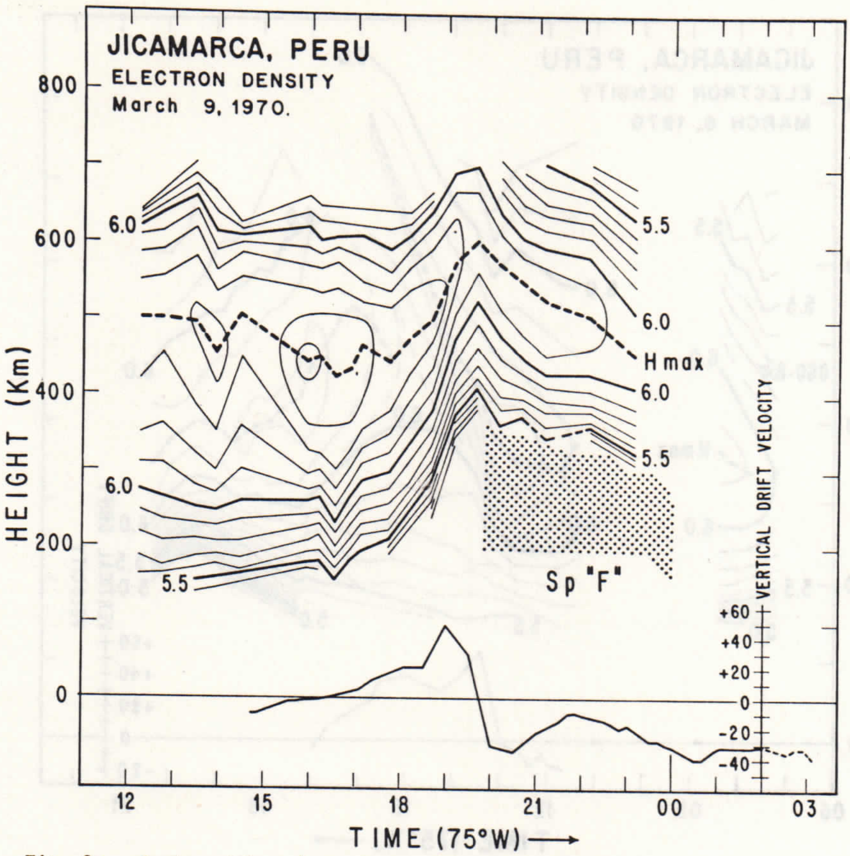

Fig. 3a. Contour line plot of the logarithm of electron density and F region vertical drift taken at the Jicamarca Radar Observatory on March 9, 1970.

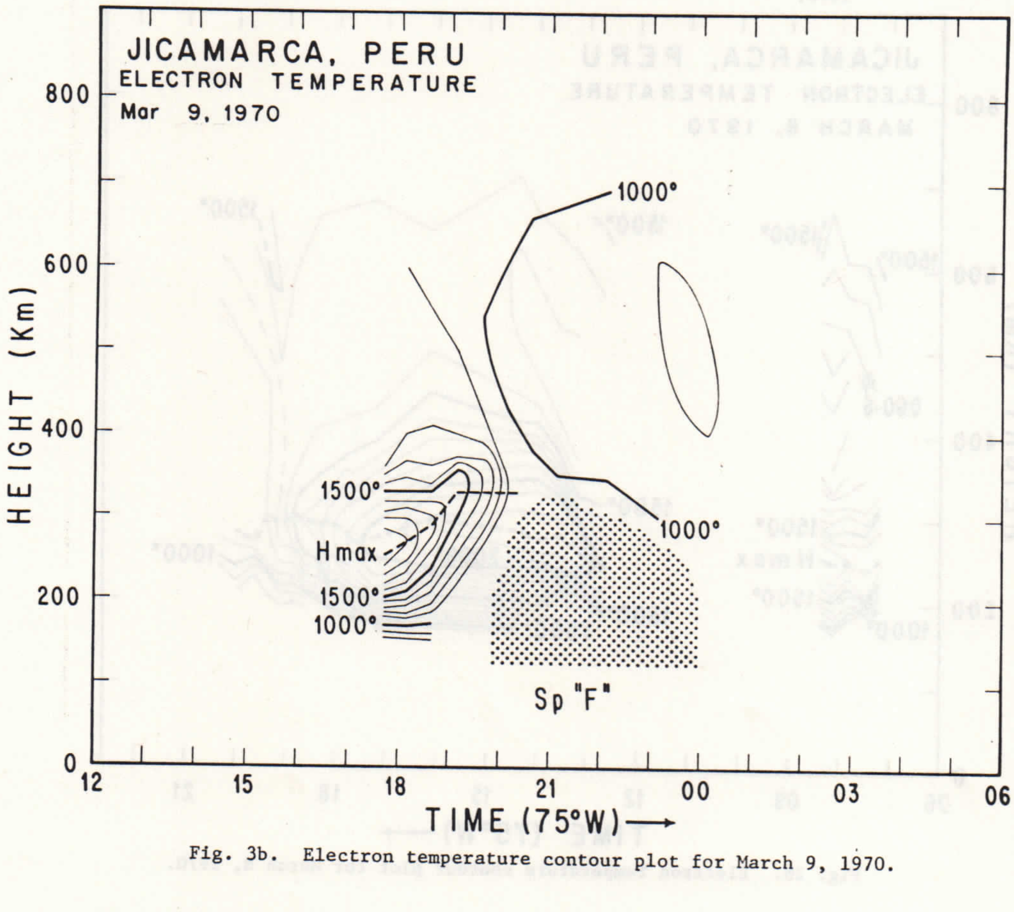

Fig. 3b. Electron temperature contour plot for March 9, 1970.

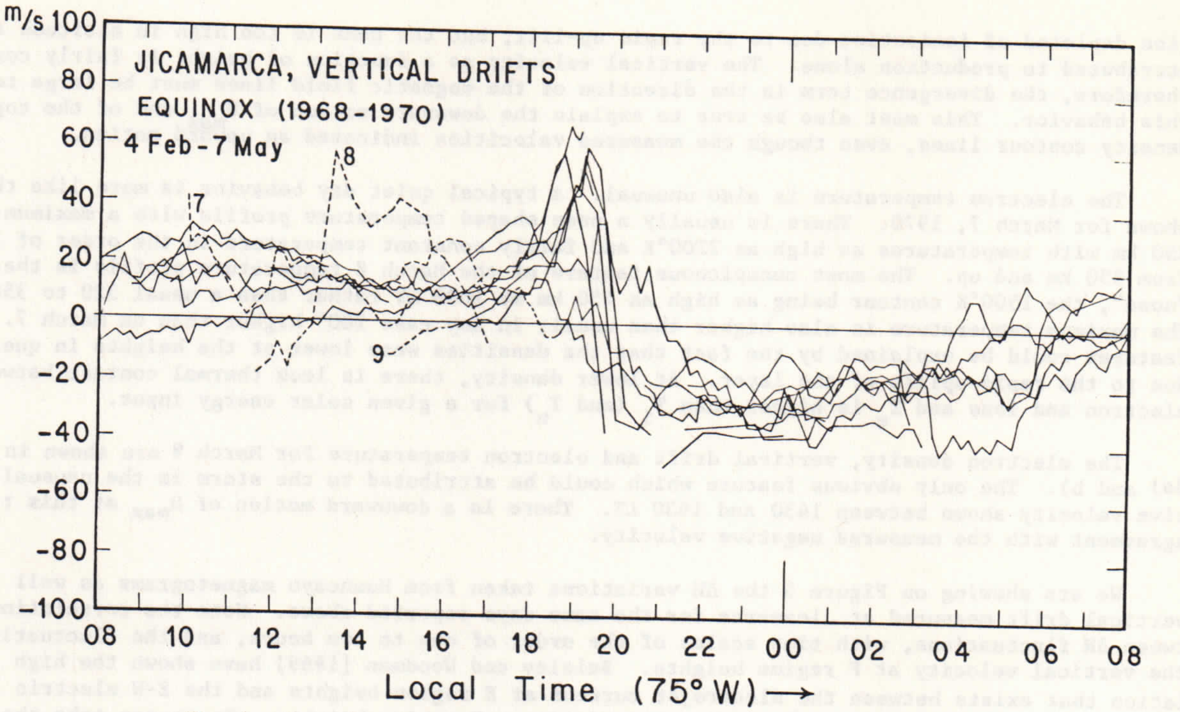

Fig. 4. Composite of vertical drifts taken at Jicamarca centered about March equinox. Curves 7, 8, 9 correspond to March 7, 8, 9, respectively. [After Woodman, 1970]

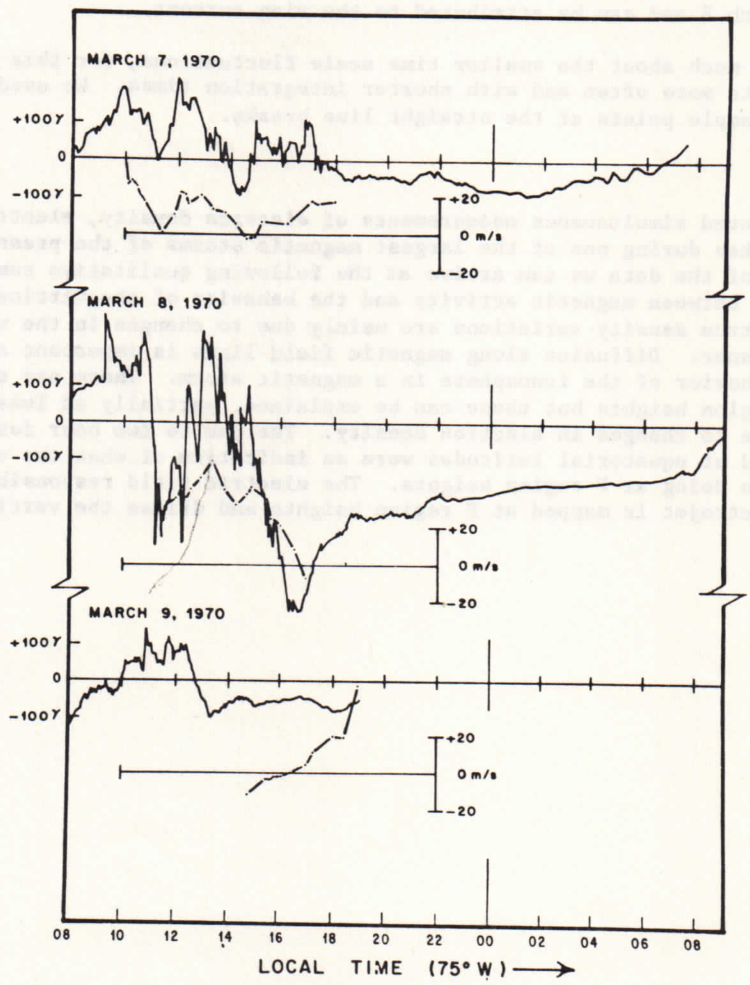

Fig. 5. Huancayo ΔH magnetograms and Jicamarca vertical drifts during the storm.

gion depleted of ionization due to the rapid up-lift, but the peak is too high in altitude to be attributed to production alone. The vertical velocity as a function of height is fairly constant, therefore, the divergence term in the direction of the magnetic field lines must be large to explain this behavior. This must also be true to explain the downward motion of H_{max} and of the top electron density contour lines, even though the measured velocities indicated an upward motion.

The electron temperature is also unusual. A typical quiet day behavior is more like the one shown for March 7, 1970. There is usually a nose shaped temperature profile with a maximum about 250 km with temperatures as high as 2100°K and fairly constant temperature in the order of 1200°K from 350 km and up. The most conspicuous feature of the March 8 temperature profile is the broad "nose", the 1500°K contour being as high as 450 km at 1600 LT rather than a usual 320 to 350 km. The maximum temperature is also higher than usual; in any case 200° higher than on March 7. Both features could be explained by the fact that the densities were lower at the heights in question, due to the rapid uplift of the layer. At lower density, there is less thermal contact between electron and ions and T_e is higher than T_i (and T_n) for a given solar energy input.

The electron density, vertical drift and electron temperature for March 9 are shown in Figures 3a) and b). The only obvious feature which could be attributed to the storm is the unusual negative velocity shown between 1430 and 1630 LT. There is a downward motion of H_{max} at this time in agreement with the measured negative velocity.

We are showing on Figure 5 the ΔH variations taken from Huancayo magnetograms as well as the vertical drift measured at Jicamarca for the same days reported above. Note the correlation between ΔH fluctuations, with time scales of the order of one to two hours, and the fluctuations on the vertical velocity at F region heights. Balsley and Woodman [1969] have shown the high correlation that exists between the electrojet current at E region heights and the E-W electric field associated with the vertical electromagnetic drift at F region heights. So we can take the vertical drifts as a measure of the electric field that drive the current at E region heights which in turn is responsible for the ΔH variations shown in the magnetograms; at least those fluctuations that correlate. There is a bias with a larger time constant which does not correlate. This is more conspicuous on March 8 and can be attributed to the ring current.

We cannot say much about the smaller time scale fluctuations, for this we would have had to take vertical drifts more often and with shorter integration times. We used a 5 to 10 minute integration with sample points at the straight line breaks.

Conclusions

We have presented simultaneous measurements of electron density, electron temperature and vertical drifts taken during one of the largest magnetic storms of the present solar cycle. From simple inspection of the data we can arrive at the following qualitative conclusions: There is a close relationship between magnetic activity and the behavior of the vertical drift at ionospheric heights. The electron density variations are mainly due to changes in the vertical drift although not in a simple manner. Diffusion along magnetic field lines is important and has to be considered in modeling the behavior of the ionosphere in a magnetic storm. There are electron temperature variations at F region heights but these can be explained, partially at least, by the changes in thermal contact due to changes in electron density. The one to two hour features of ΔH variations in a magnetic field at equatorial latitudes were an indication of what the vertical drift, or E-W electric field, was doing at F region heights. The electric field responsible for the changes in current in the electrojet is mapped at F region heights and drives the vertical motion of the ionosphere.

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