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GROUND GEOMAGNETIC Pi3 PULSATIONS DURING THE BASTILLE MAGNETIC STORM (JULY 15, 2000)

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Abstract. Geomagnetic pulsations in the frequency range of 0.5-10 mHz during the strong magnetic storm on July 15, 2000 have been analysed by using 1-min sampled digital geomagnetic measurements on 78 globally distributed INTERMAGNET stations. This storm was caused by an interplanetary magnetic cloud impact. The dynamic spectral and wavelet analysis of ground geomagnetic pulsations and IMF and solar wind data from GEOTAIL spacecraft (X ~20 Re, Y ~ -6 Re, Z ~ 2 Re) has been carried out. The analysis showed that the strong IMF and solar wind density variations were observed in the turbulent region, located before the leading edge of the cloud. The spectral structure of the different IMF components was different. The IMF irregularities triggered the magnetic substorm and Pi3 range geomagnetic pulsations in the polar cap with the strongest amplitudes near the footprint of the border between the close and open field lines. We suppose that the polar Pi3 pulsations could be attributed to the wave generation at ionosphere altitudes by the oscillations of the electron precipitation of field aligned currents. The IMF fluctuations behind the leading edge were very small. After the leading edge of magnetic cloud passage, the Pi3 pulsation activity suddenly shifted into day- and night- time inner magnetosphere. The daytime geomagnetic pulsations were associated with the field line resonance and the nighttime pulsations – with substorm activity.

Introduction

The large magnetic storm on July 15, 2000 with Dst about 300 nT (Fig.1) was caused by passage of interplanetary magnetic cloud (Fig.2), originated from the powerful coronal mass ejection (CME), occurred one day before (July 14) and was called because of this date "Bastille Day Event". The front edge of this magnetic cloud (~15-19.30 UT) was characterised by the large and variable values both of IMF (up to 70 nT) and solar wind speed (up to 1000 km/s). The leading edge of the cloud passage (near 19.30 UT) led to the main phase of magnetic storm development (Fig.1).

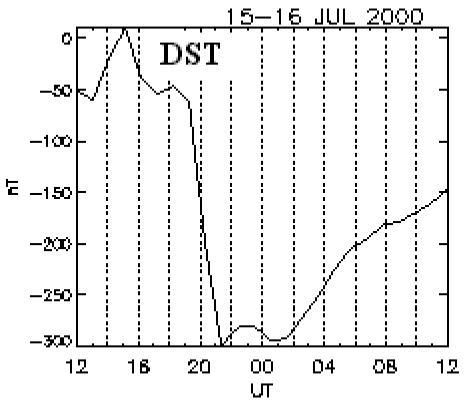

Fig.1. Dst variation during the magnetic storm on July 15, 2000.

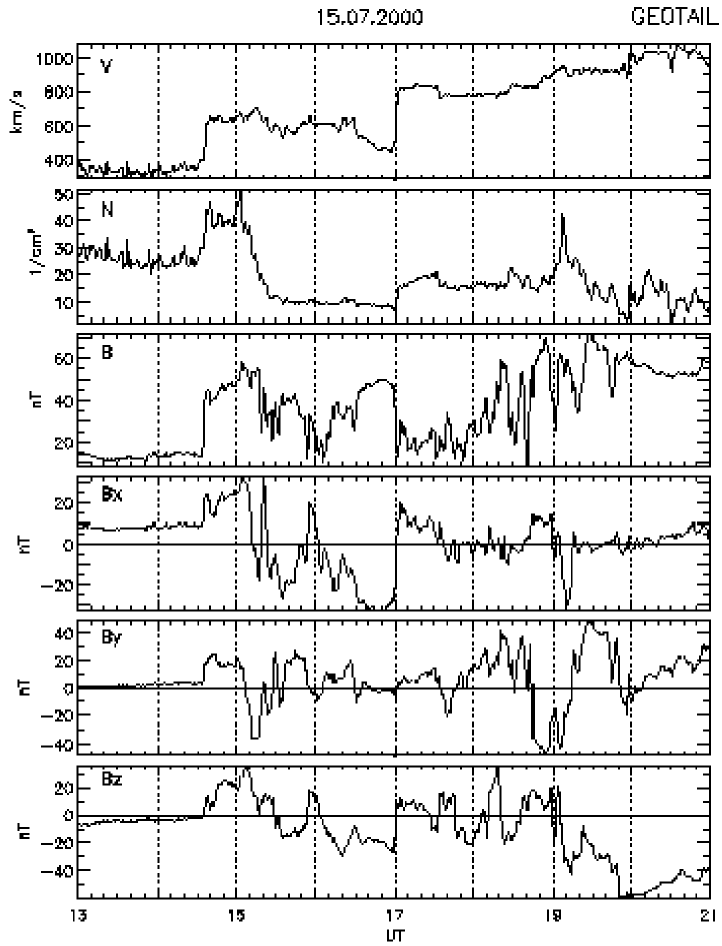

Fig.2. IMF and solar wind data from Geotail (X~20 Re, Y~-6 Re, Z ~2 Re).

The aim of this paper is to study the wave geomagnetic response to the magnetic cloud impact. Our analysis was based on 1-min sampled digital geomagnetic measurements on 78 globally distributed stations of INTERMAGNET, including 7 French observatories as well as the Scandinavian magnetometer chain (IMAGE) and Russian observatory Irkutsk.

Results

The results of the spectral analysis of the pulsations in the IMF and at several ground stations are presented in Fig.3 (before the leading edge of magnetic cloud passage and after that). During the intervals under consideration BRW and DRV were located at the morning side, IQA and MEA– near noon, NUR and CZT -at the night side. The geomagnetic latitudes of these stations are marked in the Figures. The IMF fluctuation intensity before the leading edge of the cloud (Fig.3, left panel) was about 3 times as strong as behind it (Fig.3, right panel). The strongest geomagnetic pulsations were observed near cusp (IQA) latitudes with the amplitude spectrum similar to that of By IMF.

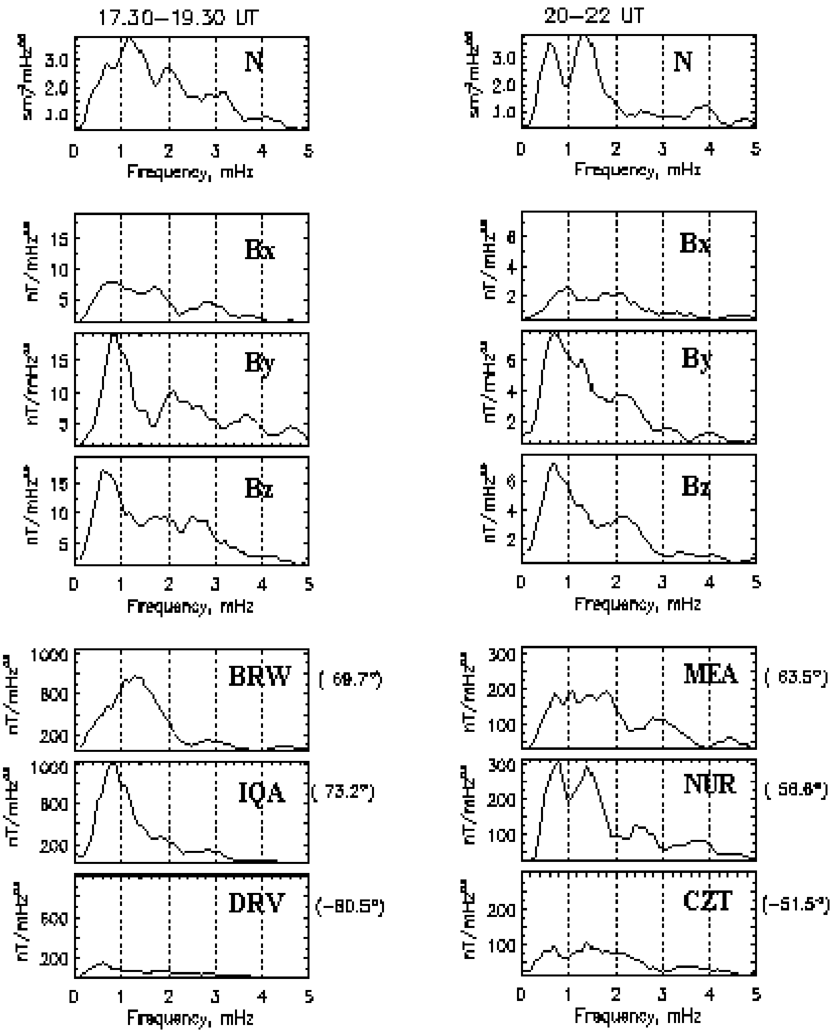

Fig.3 The spectra of IMF and ground geomagnetic pulsations: left panel -before the leading edge of the cloud: right panel-behind its passage.

After the leading edge passage, i.e. in the main body of the magnetic cloud, By and Bz IMF spectra became similar to each other. However, at that time, the day (MEA) and night (NUR) ground pulsation spectra were different and not coincident with the spectra of IMF fluctuations.

The results of the wavelet analysis (T<15 min) of the solar wind and ground based pulsation data are presented in Fig.4. It can be seen that the wavelet structure of different IMF components is different. The burst in the By IMF caused the Pi3 burst at IQA (dayside cusp). The burst in the Bx IMF and in the solar wind density (N) caused the Pi3 burst on the morning side of the polar cap (BRW). We suppose that these compression IMF waves may modulate the intensity of precipitating electrons associated with the field-aligned currents. Such high latitude morning

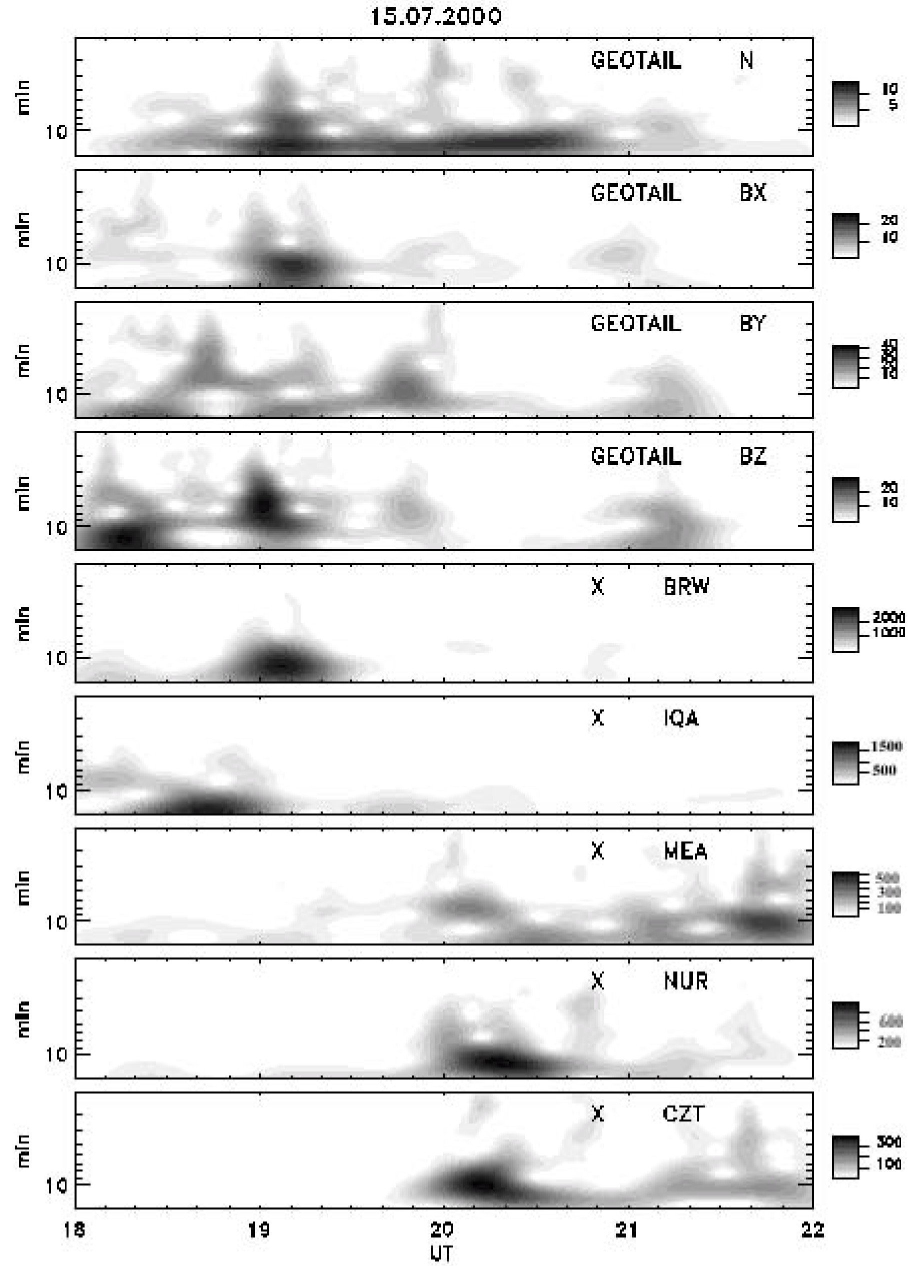

Fig.4. The results of the wavelet analysis.

pulsations were observed by Manninen et al., (2002) during the initial phase of the magnetic storm, caused by the turbulent front edge of the magnetic cloud on January 10, 1997.

Fig.5 demonstrates the MLT-UT amplitude distribution of 1-3 mHz geomagnetic pulsations at polar cap latitudes and in the inner magetosphere. It is seen, that the passage of the magnetic cloud turbulent front edge caused the geomagnetic pulsation activity mostly at the high latitudes with the strongest amplitudes at polar cusp and near morning side of the polar cap equatorial border. According to Prikryl et al., 1998, we can suggest that the ULF waves in the solar wind modulate the magnetic reconnection at the dayside magnetopause into pulses, which are seen as Pi3 geomagnetic pulsations near dayside cusp.

The cloud leading edge passage displaced the Pi3 pulsation activity into the inner magnetosphere. Fig.5, bottom panel, shows that after 19.30 UT strong 1-3 mHz pulsations were observed on the ground before noon (08-11 MLT) and after noon (14-18 MLT) as well as at night (23-02 MLT). The properties of daytime pulsations fit the field line resonance. The night side Pi3 range pulsations represent the fine structure of the simultaneously observed magnetosphere substorm and can be associated with modulated particle precipitation. Both day and night geomagnetic pulsations are seen to be the result of the processes in the inner magnetosphere, which were caused by the magnetic cloud leading edge impact.

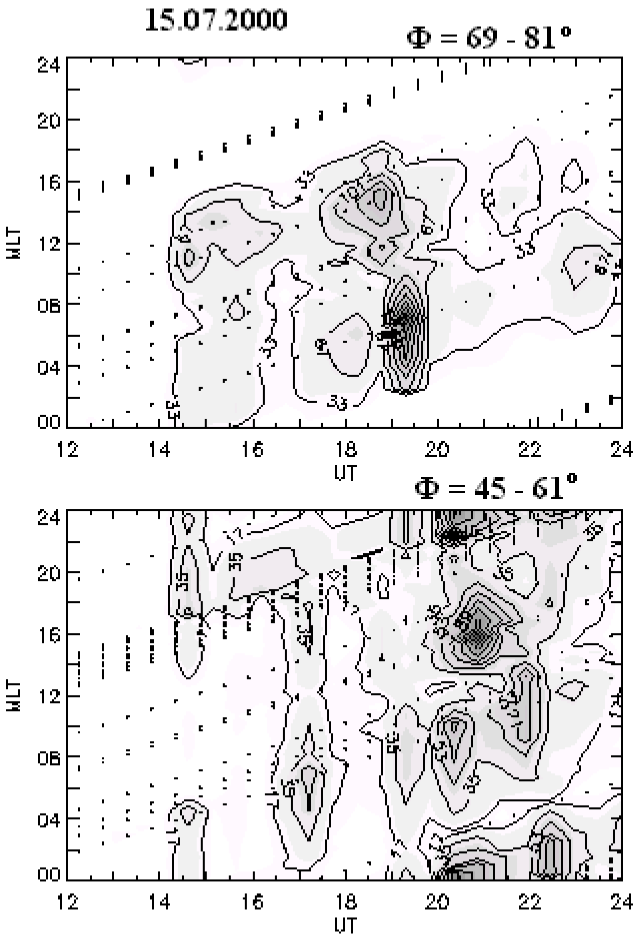

Fig.5. The space-time Pi3 range (1-3 mHz) geomagnetic pulsation distributions, top panel -at the high (Φ=69-81°) latitudes; bottom panel - in the inner magnetosphere (Φ=45-61°).

Conclusion

1. In the event considered the spectra of different IMF components were different. There was a strong compression wave at the front edge of the magnetic cloud.
2. The passage of the turbulent front edge of magnetic cloud initiated Pi3 range geomagnetic pulsation activity in the polar cap, with the strongest intensity near its dayside equator border.
3. After the passage of the leading edge of the magnetic cloud the pulsation activity suddenly shifted into the inner magnetosphere. The daytime geomagnetic pulsations were associated with the field line resonance, and night time pulsations – with substorm activity.

References

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