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Global Pc5 event during 29–31 October 2003 magnetic storm

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Abstract

On 30–31 October 2003 magnetic observatories over the whole Earth surface observed a very strong and enduring long-period ULF activity during the recovery phase of the magnetic storm, which had begun a day before, at 0611 UT on October 29th, 2003. Amplitude of oscillations in the Pc5 frequency range was as high as 150 nT at mid-latitude stations. We use magnetic data from INTERMAGNET database, IMAGE magnetometer network, and GOES-10,-12 satellites to study this event. According to IMAGE data, Pc5 polarization pattern along a meridian does not correspond to that expected for field line resonance model. Latitude profile of the horizontal components has its maximum at auroral latitudes. At medium latitudes, Pc5 were observed at all local time sectors simultaneously with larger amplitude at prenoon or noon hours. Boundary layer instability is suggested as a probable source of the global magnetospheric wave activity. Possible consequences of large amplitude oscillations for charged particle acceleration owing to various wave-particle interaction mechanisms are discussed.

Keywords: Magnetic storm; Global ULF oscillations

1. Introduction

Pc5 ULF pulsations represent the longest hydromagnetic waves, which can exist in the Earth's magnetosphere. Their wavelength is comparable with the magnetosphere dimensions. These waves play an important role in the processes of the solar wind interaction with the geomagnetic field. On the other hand, they provide a probing instrument to explore the magnetosphere structure. In their characteristics, Pc5 pulsations are very inhomogeneous. Most frequently they present local auroral oscillations that cannot be observed at medium latitudes (Mathie et al., 1999). But sometimes Pc5 oscillations are observed from the polar cap boundaries to the geomagnetic equator (Trivedi et al., 1997; Motoba et al., 2002). Solar-geophysical extreme events in October–November 2003 included a period of unusually strong and prolonged Pc5 oscillations on 30–31 October 2003. Their uniqueness was connected not only with large amplitude and long persistence, but also with a global character of the pulsation observation. Here, we are giving the results of study of this Pc5 event using data from three satellite missions and on-ground chains of magnetometers.

2. Data and analysis

Kp and Dst indices along with the solar wind conditions near the Earth's orbit in terms of available data from ACE satellite were employed to show the general geophysical conditions for the time interval under consideration.

To study in detail amplitude characteristics of the pulsations in high-latitude region where the main resonance particularities are usually seen the 10-s data from eight stations of the IMAGE network of magnetometers were exploited. Spectral density plots and polarograms (plots showing time

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Table 1
List of the on-ground stations used in the study

Name of station	Code	Geographic		Corrected Geomagnetic[a]		L
		Latitude	Longitude	Latitude	Longitude	
Ny Alesund	NAL	78.92	11.95	76.25	111.14	17.70
Longyearbyen	LYR	78.20	15.82	75.30	112.01	15.53
Bear Island	BJN	74.50	19.20	71.49	108.02	9.92
Sørøya	SOR	70.54	22.22	67.39	106.17	6.77
Sodankylä	SOD	67.37	26.63	63.96	107.29	5.19
Hankasalmi	HAN	62.30	26.65	58.76	104.65	3.72
Nurmijarvi	NUR	60.50	24.65	56.93	102.21	3.36
Tartu	TAR	58.26	26.46	54.52	102.93	2.97
Novosibirsk	NVS	55.03	82.90	50.72	155.73	2.49
Irkutsk	IRT	52.17	104.45	47.31	177.38	2.18
Hartland	HAD	51.00	355.52	47.61	74.66	2.20
Victoria	VIC	48.52	236.58	53.76	296.44	2.86
Tihany	THY	46.90	17.89	41.91	92.31	1.81
Surlari	SUA	45.32	26.25	40.30	99.58	1.72
Memambetsu	MMB	43.91	144.19	37.11	215.50	1.57
Beijing	BMT	40.30	116.20	34.57	188.86	1.47
Lanzhou	LZH	36.10	103.84	30.45	176.21	1.35
Qsaybeh	QSB	33.90	35.60	27.86	107.45	1.28
Phuthuy	PHU	21.03	105.95	14.08	177.79	1.06
Alibag	ABG	18.62	72.87	10.20	146.10	1.03
Addis Ababa	AAE	9.03	38.77	5.30	112.12	1.01

[a] The corrected geomagnetic coordinates (CGM) were calculated for 2003 at an altitude of 100 km using IGRF converter at http://nssdc.gsfc.nasa.gov/space/cgm/cgm.html.

variation of degree and sense of polarisation depending on oscillation period) along the IMAGE chain were plotted for two time intervals of the most intense Pc5 oscillations.

Besides, one-minute H-component values from a selection of the worldwide network of INTERMAGNET observatories have been used to study distribution of Pc5 wave activity in the magnetosphere by comparing on-ground magnetograms with GOES-10 and -12 data plots.

Table 1 lists all on-ground stations used in the study. It shows station names, codes, geographic and corrected geomagnetic co-ordinates, and L values. Data from all the sources have been processed with the fast Fourier transform routine to estimate position of spectral peaks in the Pc5 frequency range and filtered using a Gauss filter centred at the revealed peak frequency with $\alpha = 5$.

3. Results

Fig. 1 shows the general geophysical situation for three days from 29 to 31 October 2003. SSC occurred on the first day at 0611 UT. It raised Kp index level up to 9_0 immediately after SSC, and afterwards Kp kept its very high level until the afternoon of the third day, with one exception, from 0600 to 1500 UT of the second day. Dst index reached its lowest value of Dst = −401 in the evening of the second day. Global Pc5 oscillations started with the beginning of the second day and lasted until the third day dusk. Maximum Pc5 intensity was observed in the third day morning. The solar wind data are only available from ACE magnetic and plasma instruments for the third day. One can see that pulsation activity on this day occurred against the background of extremely high values

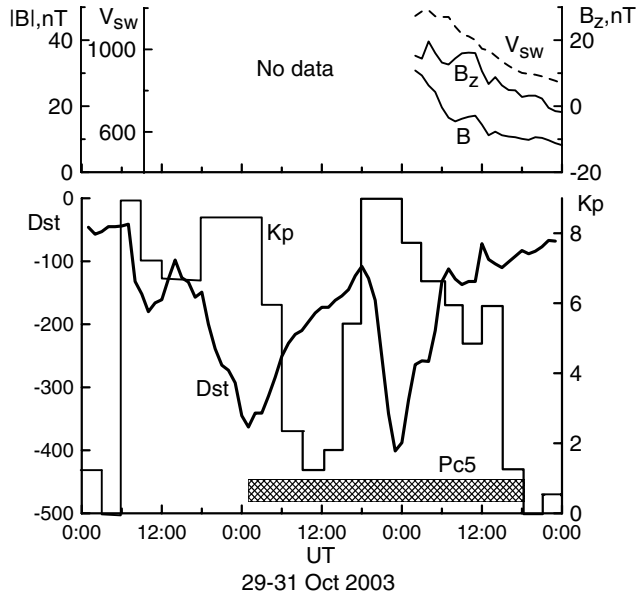

Fig. 1. The general geophysical conditions on October 29–31, 2003. Top panel shows available data on the solar wind velocity, the interplanetary magnetic field intensity, and z-component of the IMF. Variations of Kp and Dst geomagnetic indices are shown in bottom panel.

of the solar wind velocity (up to 1200 km/s) and enhanced level of the IMF intensity B. Pc5 oscillations ceased when the solar wind velocity dropped below 800 km/s. It is worth to note that there were no intervals with negative values of the IMF B_z-component during the Pc5 activity period.

Fig. 2 shows magnetogram stackplot from four low to mid-latitude INTERMAGNET observatories, more or less evenly distributed over the longitude (see Table 1), along