

STORM-ASSOCIATED EQUATORIAL Pc3 GEOMAGNETIC PULSATIONS BASED ON THE ONE-SECOND INTERMAGNET MULTI-STATION MEASUREMENTS

N.G. Kleimenova¹, O.V. Kozyreva¹, L.M. Malysheva¹, A. A. Soloviev²,
S. P. Bogoutdinov², N. R. Zelinsky²

¹Institute of the Earth Physics RAS, Moscow, 123995, Russia, e-mail: kleimen@ifz.ru;
²Geophysical Center RAS, Moscow, Russia

Abstract. New 1-s sampled magnetic data have been obtained from 6 near-equatorial longitude spaced INTERMAGNET observatories. That provides a possibility to study the multi-station behavior of the equatorial geomagnetic pulsations, ranged in 20-50 mHz (Pc3 type). Here we presented the first preliminary results of the Pc3-4 analysis during the initial phase of the moderate magnetic storm on April 5, 2010. It was found, that Pc3-4 geomagnetic pulsation bursts occur simultaneously at all considered equatorial stations with significant amplitude enhancement near local magnetic noon. The pulsation amplitude spectra demonstrated the clear similarity at all equatorial stations. Some of Pc3-4 events were compared with the simultaneous pulsation data obtained at INTERMAGNET subauroral Kerguelen (PAF) station and mid-latitude Chambon-la-Forêt (CLF) station. The Pc3 wave packets were good correlated in time and spectral maximum with the simultaneous Pc3 pulsations at the mid-latitude station (CLF). We suppose that the equatorial Pc3 pulsations are a result of the propagation of the field line resonant mid-latitude waves. The possible effects of the solar wind and Interplanetary Magnetic field (IMF) disturbances on the behavior of Pc3-4 geomagnetic pulsations have been studied.

Introduction

The array of 6 near-equator ground INTERMAGNET observatories (marked by green in Fig.1), located at globally distributed longitudes with 1 second sampling records, has been established since the beginning of 2010. For the first time, a study of Pc3 (20-50 mHz) geomagnetic pulsations could be carried on at the equatorial latitudes in the global scale.



Fig.1. The map of the near-equatorial INTERMAGNET stations.

The geomagnetic coordinates of these stations are the following: PPT (-16.13°, 284.37°, magnetic noon at 21 UT), IPM (-20.26°, 327.10°, magnetic noon at 18.30 UT), MBO (04.05°, 58.50°, magnetic noon at 13

UT), AAE (09.03°, 38.77°, magnetic noon at 09 UT), PHU (13.72°, 177.53°, magnetic noon at 05 UT) and LZH (23.65°, 175.71°, magnetic noon at 06 UT).

Observations

Here we present the first preliminary results of the investigation of the storm-time equatorial Pc3 pulsations behavior. The example of one day (24 hours) of the typical raw 1-s sampled data at the equatorial latitude is shown in Fig.2 (bottom panel). Any pulsations could be seen in such data presentation. In order to extract the Pc3 pulsations (marked by the red color in Fig.2), the raw data were band-pass filtered on a 20–50 mHz and some analysis procedures as a general dispersion parameter calculation were applied. The general dispersion parameter was calculated using covariance matrix, and then was smoothed in a time window of 6 visible periods.

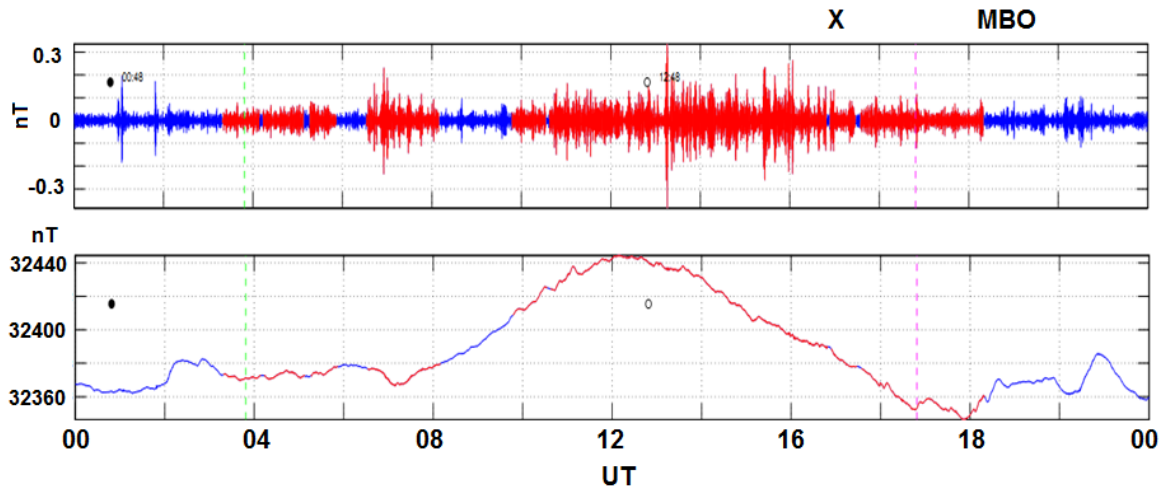


Fig.2. An example of typical 24-hour geomagnetic data at the equatorial latitudes (MBO station), the raw data are shown in the bottom panel and the 20-50 mHz filtered – in the upper one. The Pc3 pulsations are marked by red color. The open circle shows the local magnetic noon, the black one – midnight.

We found that equatorial Pc3 pulsations, like the mid- and low- latitude ones, demonstrate the typical day-time amplitude enhancement, as it was found by the previous studies at the low latitudes [Ansari and Fraser, 1986; Sutcliffe et al., 1987; Pathan et al., 1999; Cardinal and Yumoto, 2009; Ndiitwani and Sutcliffe, 2009]. The amplitudes of the storm-time pulsations were much higher than quiet time ones. The magnetic storm on April 5, 2010 started with SC at 08.26 UT (Fig. 3).

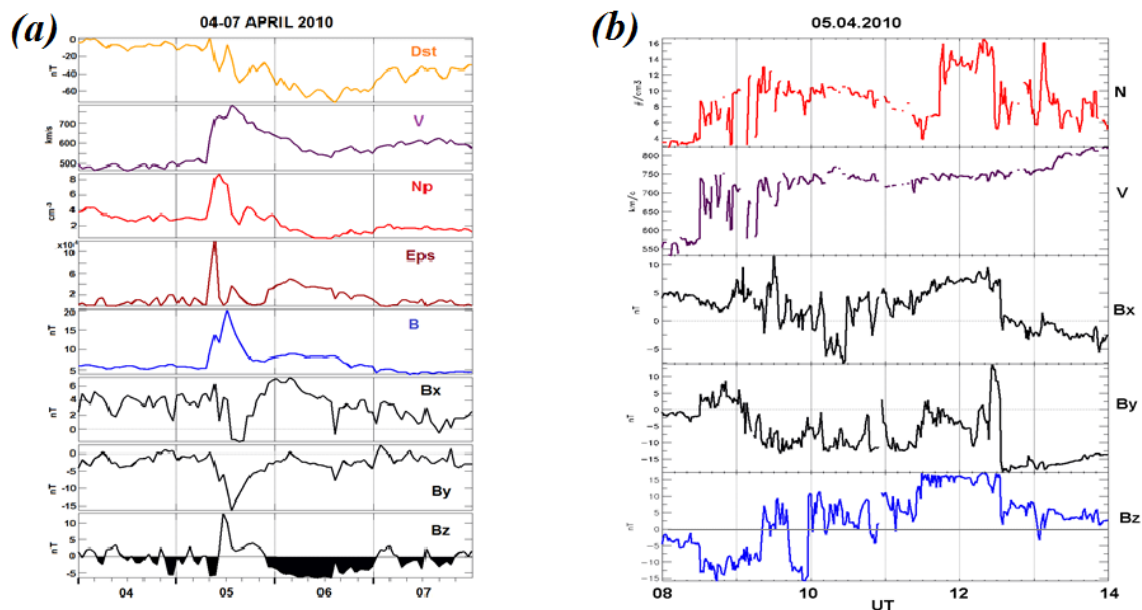


Fig.3. IMF and solar wind data for 04-07 April 2010 (a) and at 08-14 UT on 05 April (b)

The magnetic storm onset (SC) was accompanied by a strong daytime Pc3 impulse (Fig.4). The spectra of pulsations during SC (Fig.5a) were very similar at all dayside stations with the main maximum at ~ 35 mHz. However, a much stronger burst of Pc3 pulsations was recorded a little later, near 09 UT. It is seen that on the night (PPT station) and pre noon (MBO station) sides, the amplitude of these pulsations was twice higher than in the afternoon (PHU station). Near 09 UT, the pulsation spectra significantly changed (Fig.5b), the main spectral maximum shifted to the lower frequencies (~ 25 mHz). At least 4 different peaks are seen in the pulsation spectra, the amplitudes of all these peaks and pulsations were similar at the night-side (PPT, IPM) and day side (MBO, AAE) stations.

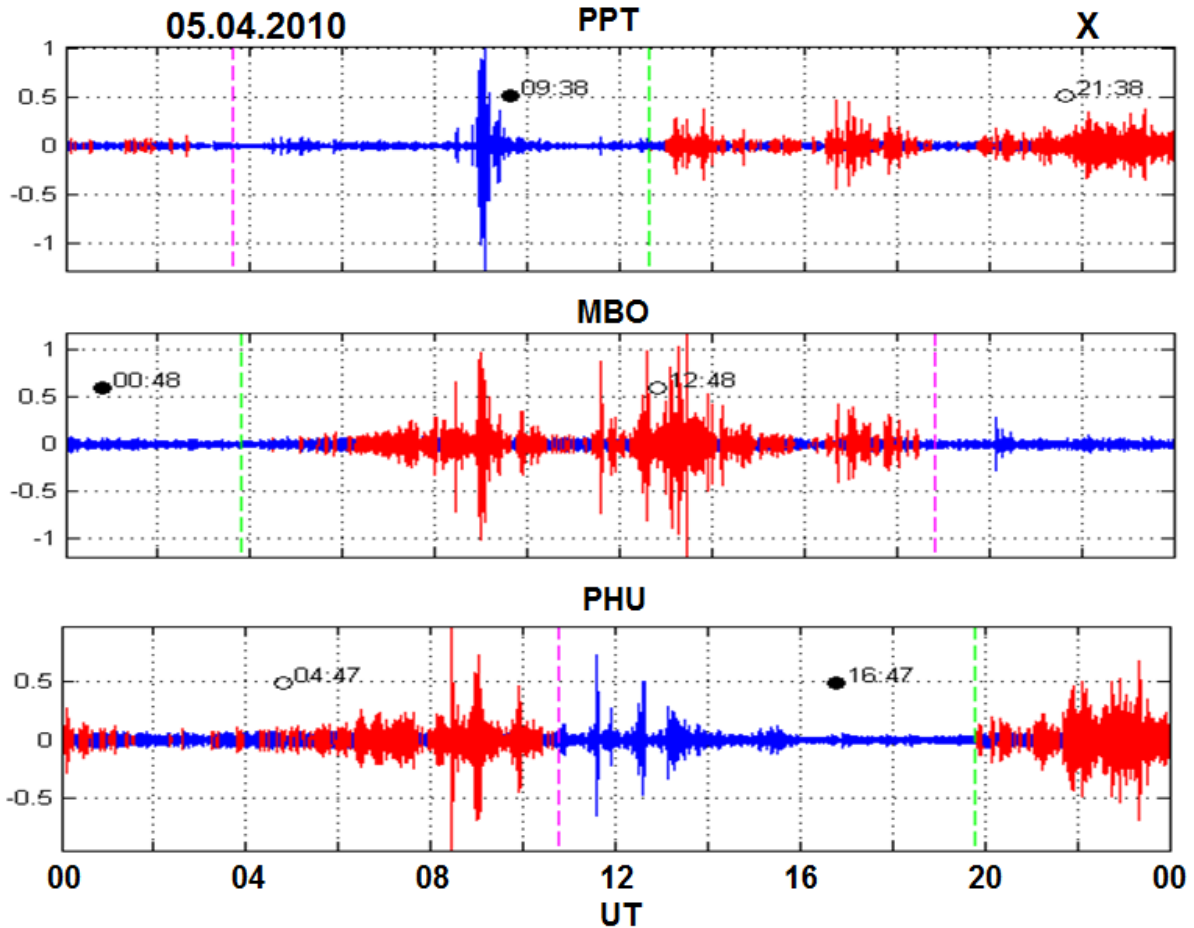


Fig.4. Pc3 pulsations at 3 near-equatorial stations

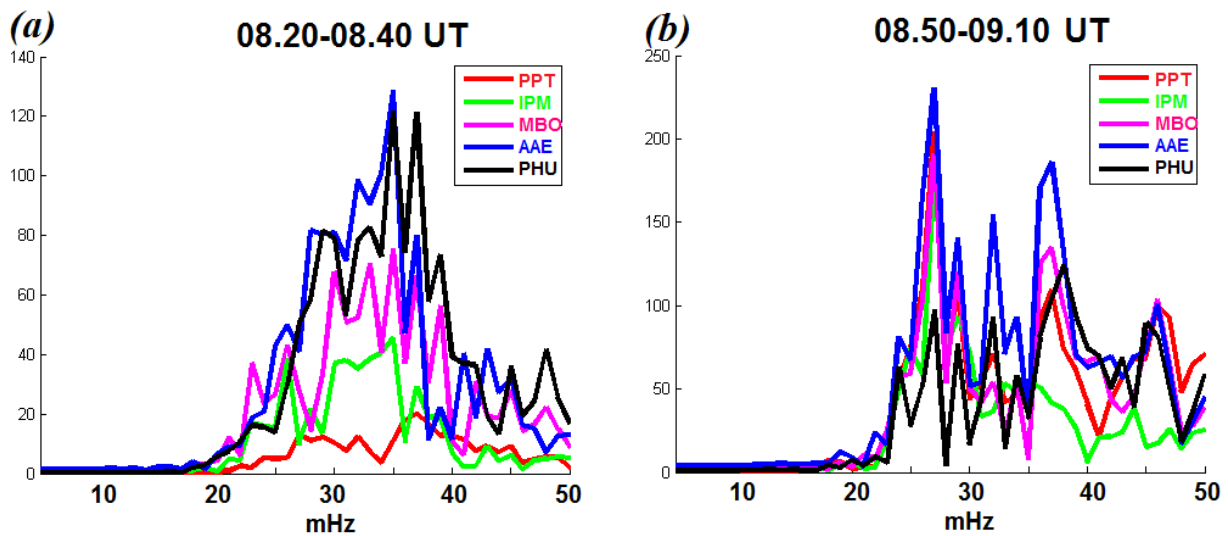


Fig.5. Amplitude pulsation spectra at the near-equatorial stations: during the SC at 08.20-08.40 UT (a), and after SC, at 08.50-09.10 UT (b)

Two strong bursts of Pc3 pulsations were observed at 11.30-11.40 UT and 12.30-12.40 UT on 5 April 2010 (Fig.4 and 6) in association with positive and negative jumps in the solar wind density (N) and IMF Bz (Fig.3b). In both events, the Pc3 bursts started at first near noon simultaneously at mid-latitude (CLF) and near-equator (MBO) and about 1 minute later these pulsations were recorded at the afternoon stations (AAE, LZH). The Pc3 spectra at the equator (MBO, AAE) and mid-latitudes (CLF) were similar but differed from subauroral PAF station.

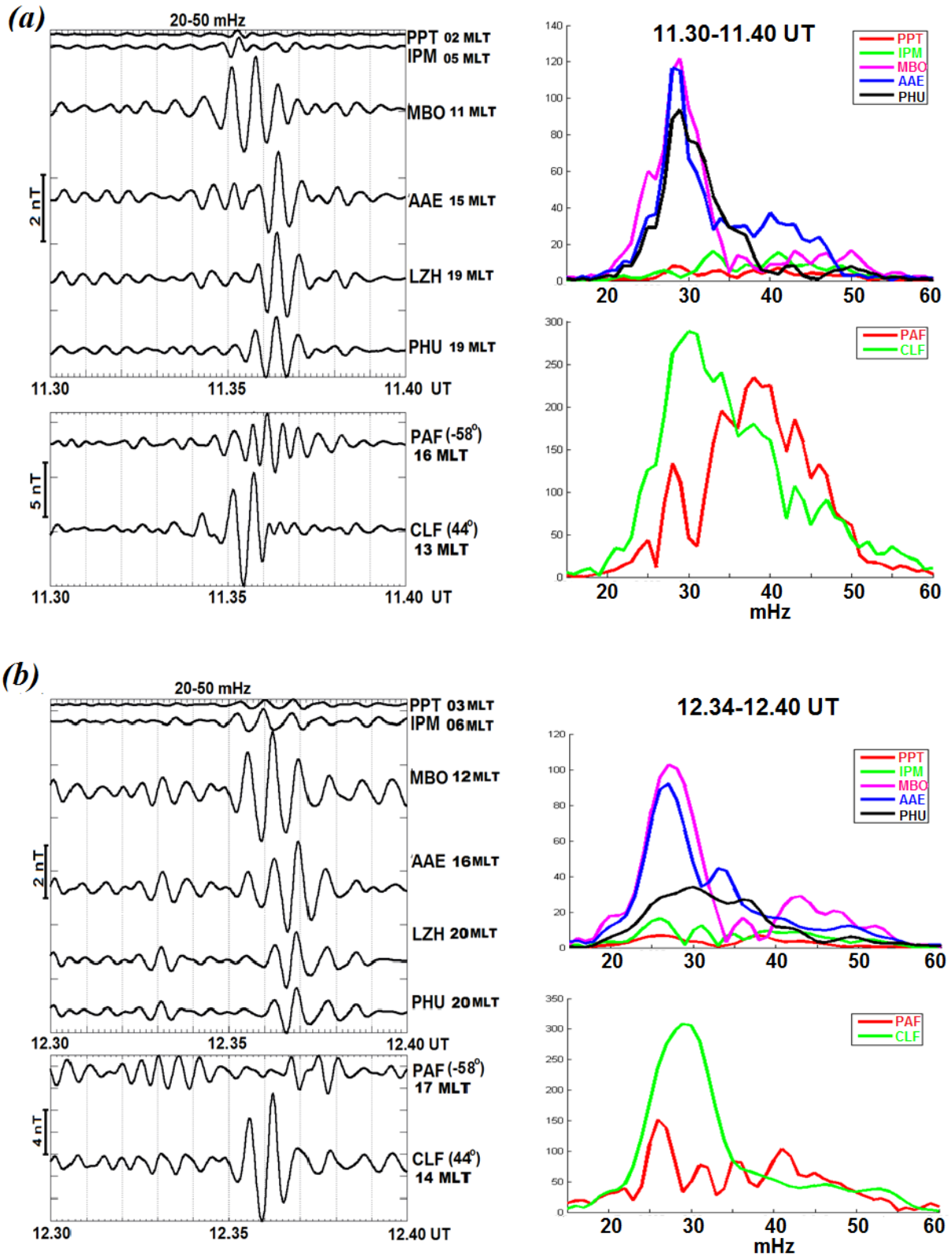


Fig.6. Two examples of Pc3 bursts at the near-equatorial, mid-latitude (CLE) and subauroral (PAF) stations and their spectra on 5 April 2010 (*a* - 11.30-11.40 UT, *b* - 12.30-12.40 UT)

Discussion

The low-latitude continuous pulsations, termed Pc3, are mainly associated with the transmission into the magnetosphere of interplanetary upstream waves generated through ion cyclotron instability by solar wind protons reflected off the bow shock [Russell et al., 1983]. Under the condition of small IMF cone angle, waves in the subsolar upstream region can be carried to the magnetopause boundary. The fast mode compressional waves or wave guide modes couple to the local field line resonance (FLR) where the frequencies match (Fig.7). Ndiitwani and Sutcliffe (2009) confirmed that studying a Pc3 geomagnetic pulsation event at a time when the CHAMP satellite passed over the South Africa ground station HER. Heiling et al. (2010) supported the interplanetary upstream waves as the dominant source of mid-latitude Pc3s. They showed that the solar wind density is one of the key parameters controlling ground Pc3 activity. Menk et al. (2000) studied the dynamics of field line resonances by using a ground magnetometer array in Australia spanning from $L=1.3$ to $L=2.0$. They found that the resonant frequency increases with decreasing latitude up to $L\sim 1.6$ and then decreases at lower latitudes as a result of mass loading on field line eigenfrequency due to the effect of ionospheric heavy ions at low altitudes. The same result was obtained by Pilipenko et al. (1998).

The day-time Pc3 amplitude enhancement, observed at the equatorial stations, can be influence of equatorial electrojet, as it was supported by Sarma and Sastry (1995) and Roy and Rao (1998). We found that the Pc3 pulsation spectra at the near-equatorial stations and at the dayside middle latitude station (CLF) were similar but differed from the Pc3 spectra at subauroral station (PAF). We supposed that the equatorial Pc3 pulsations were results of magnetospheric propagation of the resonant Pc3 range waves generating in the middle latitudes inside the plasmapause. The source of the energy can be upstream waves.

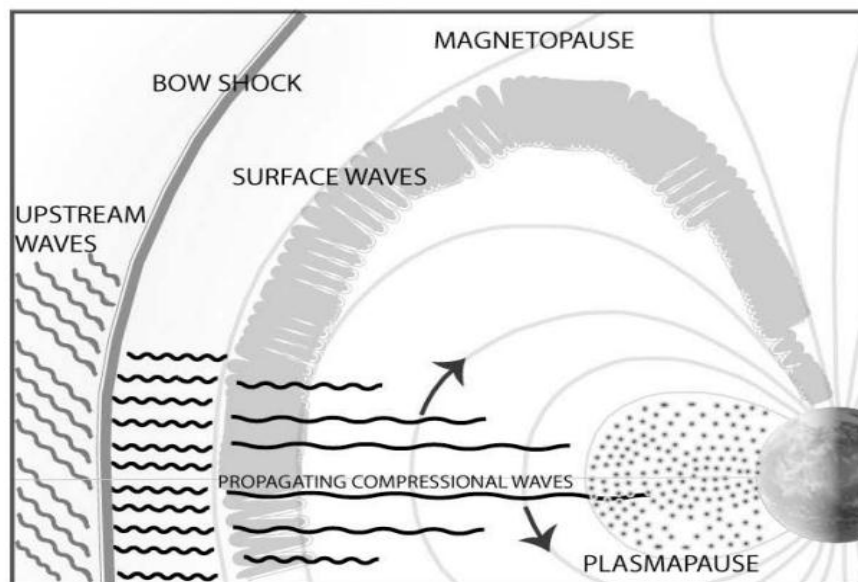


Fig.7. Propagation mechanisms of daytime Pc3-4 pulsations according to Menk et al, 2000

Conclusions

1. New 1-s sampled magnetic data have been obtained from 6 near-equatorial longitude spaced INTERMAGNET stations. The behavior of the equatorial Pc3 geomagnetic pulsations (20-50 mHz) have been analyzed during the initial phase of April 5, 2010 magnetic storm.

2. It was found, that Pc3 geomagnetic pulsation bursts occur simultaneously at all considered equatorial stations from the early morning to the late evening with the similar spectra and significant amplitude enhancement around the local magnetic noon, where the wave polarization was near linear.

3. The Pc3 wave packets were good correlated with the simultaneous Pc3 pulsations at the mid-latitude station (CLF) in time and spectral maximum. We suppose that the equatorial Pc3 pulsations are a result of the propagation of the field line resonant mid-latitude waves.

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