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On the correspondence between interplanetary, magnetospheric and geomagnetic fluctuations at selected frequencies.

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Abstract. The occurrence of ULF fluctuations at discrete frequencies (Pc5 range) in the power spectra of the geomagnetic field components has been currently interpreted in terms of ground signatures of magnetospheric cavity/waveguide compressional modes driven by solar wind pressure pulses. However, in a recent paper, Kepko et al. (2002) presented two events in which the wave power spectra in both the interplanetary medium and magnetosphere contain peaks at the same discrete frequencies, suggesting that discrete oscillations of the magnetospheric field can be directly driven by simultaneous fluctuations of the external solar wind pressure. For one of these events we conducted an analysis of ground observations at a low latitude station and found some correspondence for the lower frequency fluctuations also in the geomagnetic field observations.

Key words. Magnetospheric fluctuations – Selected frequencies

1. Introduction

An interesting aspect of the geomagnetic field observations at low latitudes is represented by the occurrence in the daytime power spectra of low frequency peaks at discrete frequencies in the approximate Pc5 range ($\sim$ 1.2 − 1.4, 1.8 − 2.0, 2.4 − 2.6, 3.2 − 3.4 mHz, Ziesolleck and Chamalaun, 1993; Francia and Villante, 1997; Villante et al., 2001). These low latitude discrete frequencies are approximately the same identified at auroral latitudes in the F-region drift velocities and in the local geomagnetic field components (Ruohoniemi et al., 1991; Samson et al., 1991, 1992; Walker et al., 1992; Ziesolleck and McDiarmid, 1994). In some cases, the same oscillation modes have also been simultaneously detected at low and Antarctic latitudes as well as in the magnetosphere (Villante et al., 2001). According to theoretical models (Radoski, 1974; Kivelson and Southwood, 1985, 1986; Samson et al., 1992) these fluctuations may be interpreted in terms of ground signatures of magnetospheric cavity/waveguide compressional modes driven by solar wind (SW) pressure pulses. In this sense, the much clearer statistical evidence in the afternoon sector and during higher pressure SW conditions suggests to relate the onset

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of these fluctuations with the Earth's arrival of corotating high pressure SW structures impinging the postnoon bow shock and magnetopause (Villante et al., 2001).

On the other hand, in a recent paper Kepko et al. (2002) presented two events in which the power spectra in both the SW pressure (Wind) and the magnetospheric field magnitude (Goes 10) contain peaks at the same discrete frequencies in the Pc5 range; then, they suggested (see also Takahashi, 1998) that, at least in some cases, discrete oscillations of the magnetospheric field can be directly driven by simultaneous fluctuations of the external SW parameters. For one of those events geomagnetic field observations are available at our low latitude ground station. We found then interesting to conduct a simple analysis of the simultaneous ground measurements in order to ascertain whether the simultaneous occurrence of SW and magnetospheric fluctuations finds some correspondence also in the geomagnetic field observations.

2. Experimental observations

Figure 1 shows a comparison between interplanetary (Wind), magnetospheric (Goes 8 and Goes 10) and geomagnetic observations (L'Aquila, AQ, Central Italy, corrected geomagnetic latitude $36,2°$; magnetic local time $LT = UT + 1.37$) for February 5, 2000, 15-19 UT; in this figure Wind observations have been delayed by 17 min to take into account the effects of the propagation time. Between ∼1528-1800 UT Wind observed a composite high pressure region that finds correspondence in the magnetospheric field both in the morning (Goes 10, 0640-0912 LT) and, more explicitly, in the noon sector (Goes 8, 1040-1312 LT), as well as in the ground field (H component, 1722-1954 LT). For this time interval the H component shows a much better correlation with magnetospheric observations in the noon sector than in the early morning ($\rho = 0.75$ for Goes 8, $\rho = 0.43$ for Goes 10).

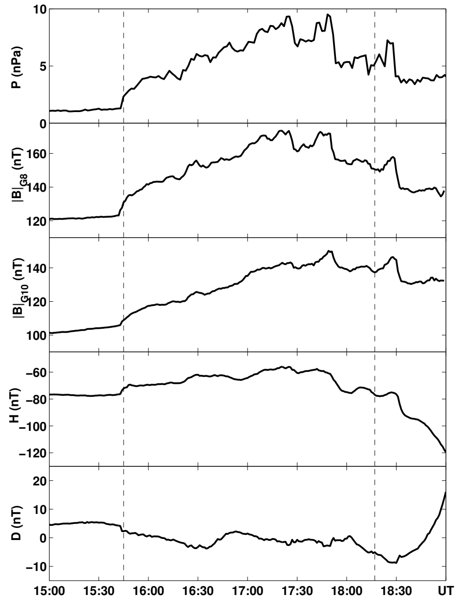

Fig. 1. A comparison between the solar wind pressure observed by Wind, the magnetospheric field magnitude from Goes 8 and Goes 10, and ground magnetic field observations. Wind observations have been delayed by 17 minutes.

As discussed by Kepko et al. (2002), the spectral analysis conducted between 1545-1817 UT (dotted lines in Figure 1) revealed power enhancements at discrete frequencies ($\sim$ 0.7, 1.4, 2.1, and 2.7 mHz, Figure 2a) in the interplanetary medium and at geostationary orbit (Goes 10). We conducted the same analysis for the same time interval for Goes 8 and ground observations with interesting results (Figure 2b): indeed, the experimental observations seem to suggest that the spectral enhancements which appear at $\sim$ 0.7, 1.4 and 2.1 mHz in the interplanetary and magnetospheric observations find correspondence also in the geomagnetic field observations (actually the lowest frequency peak corresponds to a broader band enhancement in the H component). It is however important to underline that these ground enhancements, at least in the afternoon sector, have much smaller ampli-

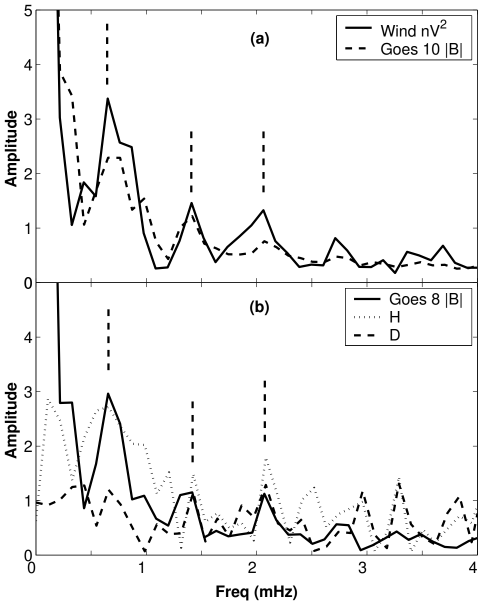

Fig. 2. a) Spectral analysis relative to the time interval 1545-1817 UT for Goes 10 (1528-1800 UT for Wind). b) Same analysis for Goes 8 and for ground magnetic field observations. Ground amplitudes in the bottom plot have been multiplied by a factor 10.

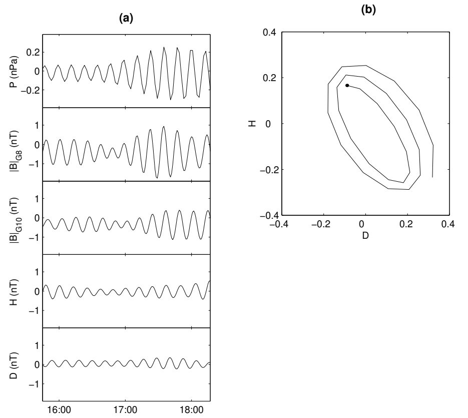

Fig. 3. a) Filtered data for 1.4 mHz frequency peak for the time interval 1545-1817 UT. From top to bottom, the solar wind pressure from Wind, the magnetospheric total field from Goes 8 and Goes 10, and the ground magnetic field components. b) The polarization pattern of ground pulsations filtered at 1.4 mHz.

tude than in the interplanetary and magnetospheric region. In addition, a different choice of the time interval makes less clear their identification: so, they do not appear as robust as in the SW and magnetospheric observations. Nevertheless, these enhancements appear on both H and D component, as usually observed for selected frequencies at low latitude stations (Villante et al., 2001). A comparison of the experimental observations for higher frequencies shows a poor correspondence between observations performed in different regions: indeed, the power enhancement detected at ~ 2.7 mHz in the SW and magnetospheric measurements does not emerge in geomagnetic measurements, while other prominent geomagnetic features (for example at ~ 2.9, 3.3 and 3.8 mHz, figure 2) are not associated with explicit power enhancements neither in the SW nor in the magnetospheric observations.

Figure 3a shows an example of the filtered data (1.4 mHz): as can be seen, the experimental results (here we only considered the time interval 1545-1817 UT in order to avoid the effects of the major variations, Figure 1) confirm the greater amplitude of magnetospheric fluctuations in the noon quadrant as well as the general correspondence between SW, magnetospheric and geomagnetic field fluctuations. Nevertheless, they also confirm that caution should be adopted before interpreting ground fluctuations as a simple consequence of the interplanetary pressure fluctuations: indeed, the onset, growing, and total duration of individual wave trains might not be same in different regions. Lastly, we evaluated the polarization aspects of ground pulsations (Figure 3b) and found a clear clockwise polarization which is consistent with the expected antisunward propagation and previous findings at the same station for late afternoon observations (Lepidi et al., 1999; Francia et al., 2001).

3. Conclusions

The occurrence of Pc5 geomagnetic pulsations at selected frequencies has been currently interpreted in terms of ground signatures of magnetospheric cavity/waveguide compressional modes driven by SW pressure pulses. Nevertheless, in a recent paper Kepko et al. (2002) presented cases in which the power spectra of the SW pressure and magnetospheric field magnitude contain peaks at the same discrete frequencies. This is an interesting feature in that it suggests that, at least in some cases, discrete oscillations of the magnetospheric (and geomagnetic, eventually) field might be directly driven by simultaneous fluctuations of the external SW parameters. In order to ascertain this aspect we compared these observations with the simultaneous geomagnetic field measurements performed at a low latitude station. As a matter of fact we found that in this case the lower frequency spectral peaks commonly appear in the interplanetary, magnetospheric and geomagnetic field observations. However, ground fluctuations have much smaller amplitude than in the magnetosphere and are also less explicit than in other cases (Francia and Villante, 1997; Villante et al., 2001). Other external and magnetospheric peaks occurring at higher frequencies do not find clear correspondence in ground measurements; similarly, other prominent geomagnetic features are not associated with explicit power enhancement neither in the SW nor in the magnetospheric observations. Future investigations, for selected events, will be then important to ascertain the correspondence between external, magnetospheric and geomagnetic wave modes at different frequencies and local times, as well as for a better understanding of the penetration or triggering mechanisms.

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