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Pc3-Pc4 pulsations at Terra Nova Bay (Antarctica): seasonal dependence of the power and its relationship with solar wind parameters

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Abstract. We conducted a statistical analysis of the pulsation activity detected during 1998 at the Antarctic Italian geomagnetic observatory at Terra Nova Bay (corrected geomagnetic latitude: −80°). In particular, the availability of high resolution (1 Hz) data for an entire year allowed us to extend also to the local winter, for the first time, the analysis of the daily variation of the Pc3-Pc4 pulsation power and of its relationship with the solar wind parameters and to investigate possible seasonal dependences. Our results suggest that the location of the station with respect to the polar cusp (which strongly depends on local time and season) plays an important role in determining the local Pc3-Pc4 power level and its dependence on the global magnetospheric activity and interplanetary parameters.

1. Introduction

The study of geomagnetic pulsations in Antarctica is important in that local field lines penetrate extreme magnetospheric regions, close to the magnetopause, where several generation mechanisms for ULF waves are active (Arnoldy et al., 1988). In this sense, the location of the Italian observatory at Terra Nova Bay (TNB, IGRF98 corrected geomagnetic latitude −80.0°; MLT=UT-8) is interesting in that, due to the Earth's rotation, it has a variable distance from the polar cusp projection: during the major part of the day it is in the polar cap, at the footprint of open field lines, while around local geomagnetic noon it approaches the cusp and, on particular magnetospheric conditions, could even reach closed field lines. From these considerations it emerges that, at such high latitudes, MLT is an important ordering parameter for geomagnetic phenomena.

As shown by previous studies (Fraser-Smith, 1982), Pc3 (10-45 s) and Pc4 (45-150 s) pulsations typically reach maximum amplitude in correspondence of the dayside cusp, at ∼ 70° geomagnetic latitude. In this sense, their power level at high latitudes tends to maximize around local magnetic noon, i.e. when the stations approach the cusp; however, a broad band

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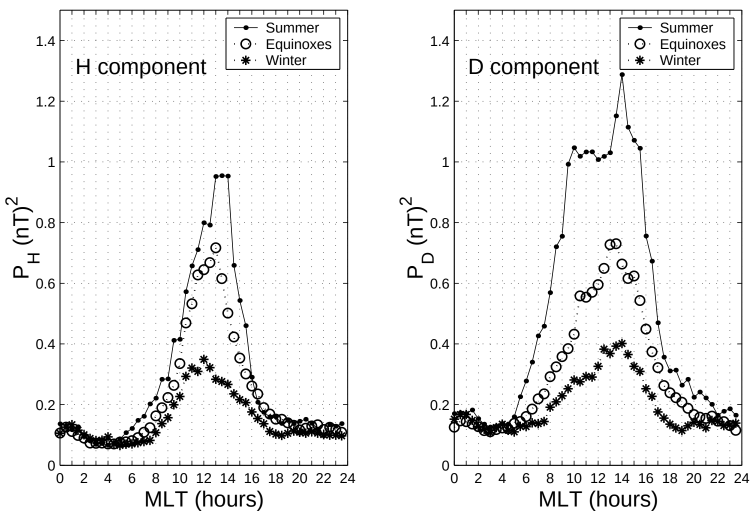

Fig. 1. Daily distribution of the H and D component power, separately for the three Lloyd seasons.

power increase is present also in the nightside hemisphere, in connection with substorm activity (Olson, 1986). Moreover, at high latitude, low-frequency pulsations are more frequent in the local summer (Fraser-Smith, 1982).

At high latitudes, the occurrence rate and the amplitude of Pc3-Pc4 pulsations have been found to be strongly influenced by the solar wind (SW) speed, and this suggests that the Kelvin-Helmholtz instability on the magnetopause plays an important role in the generation and/or amplification of high latitude ULF waves (Yumoto et al., 1987).

Previous studies of Pc3-Pc4 pulsations at TNB (Lepidi et al., 1996 ; Villante et al., 2000), based on 1-sec data measured during 93-94 and 94-95 austral summers, have shown a power enhancement around local magnetic noon and a clear correlation with the SW speed. During 1998, 1-sec measurements have been performed during the entire year, so we can extend the analysis also to the local equinoxes and winter.

2. Experimental observations and discussion

We analyzed 1-sec measurements of the geomagnetic field variations performed during 1998 at TNB by means of perpendicular search-coil magnetometers, oriented along the magnetic North-South (H component) and East-West (D component) directions; the declination is $\sim 136.5°$. The instrument transfer function is linear with frequency, with a slope of 10 Volt nT^{-1} Hz^{-1}. Period under investigation is from Jan. 6 to Nov. 18, 1998 (due to instrumental problems, the H component measurements are reliable only till Nov. 2). We conducted a spectral analysis of the H and D components by means of the DFT technique and integrated the power in the Pc3-Pc4 frequency range (the results obtained separately for the Pc3 and Pc4 bands are very similar). The hourly interplanetary data and the Kp index have been provided by NSSDC database.

The daily distribution of the average H and D power, separately for the three Lloyd seasons (Fig.1), shows a maximum around local geomagnetic noon, whose amplitude progressively increases from winter

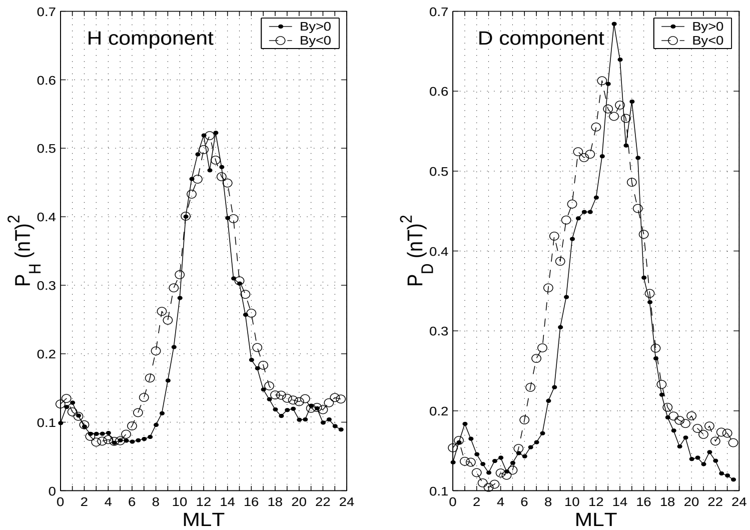

Fig. 2. Daily distribution of the H and D component power, for positive and negative IMF By conditions.

to summer; this result could be interpreted considering that the polar cusp in summer moves to higher latitudes (Newell and Meng, 1989), and then approaches TNB. Conversely, the nighttime power level does not show any seasonal dependence, suggesting that, deep in the polar cap, the ionospheric ionization level due to the solar radiation does not influence the pulsation power.

We also found that the daily variation of the yearly average pulsation power is dependent on the interplanetary magnetic field (IMF) orientation, in that for both components the morning power level is higher for negative By conditions (Fig.2). This feature can be explained in terms of an east-west displacement of the cusp: a positive By leads to a displacement to the postnoon side and vice versa (Newell et al., 1989).

Fig.3 shows the daily distribution of the correlation coefficient ρ between the logarithm of the H and D power and the (a) Kp index, (b) IMF Bz component and (c) SW speed, separately for the three Lloyd seasons. It is evident that the power level is well related to the Kp index, but the correlation coefficient shows a pronounced minimum around local geomagnetic noon, in particular during summer, suggesting that, close to the cusp, local phenomena become dominant. The power level is also generally anticorrelated with the IMF Bz component, as expected since the whole magnetosphere is more disturbed during negative Bz conditions; however, an evident diurnal variation emerges during summer, when in the late local morning r even becomes positive. This result could be explained taking into account that for positive Bz conditions the cusp moves poleward (Newell et al., 1989) reaching, during summer, TNB position; in this situation, the local power level increases due to local cusp phenomena. Fig.3c shows that the SW speed is clearly the external key element in determining the pulsation power.

In particular, the SW control of the pulsation power is higher during local morning and evening, as expected for a generation mechanism related to the Kelvin-Helmholtz instability on the magnetopause; this feature, already observed by Villante et al. (2000), is more evident during local summer.

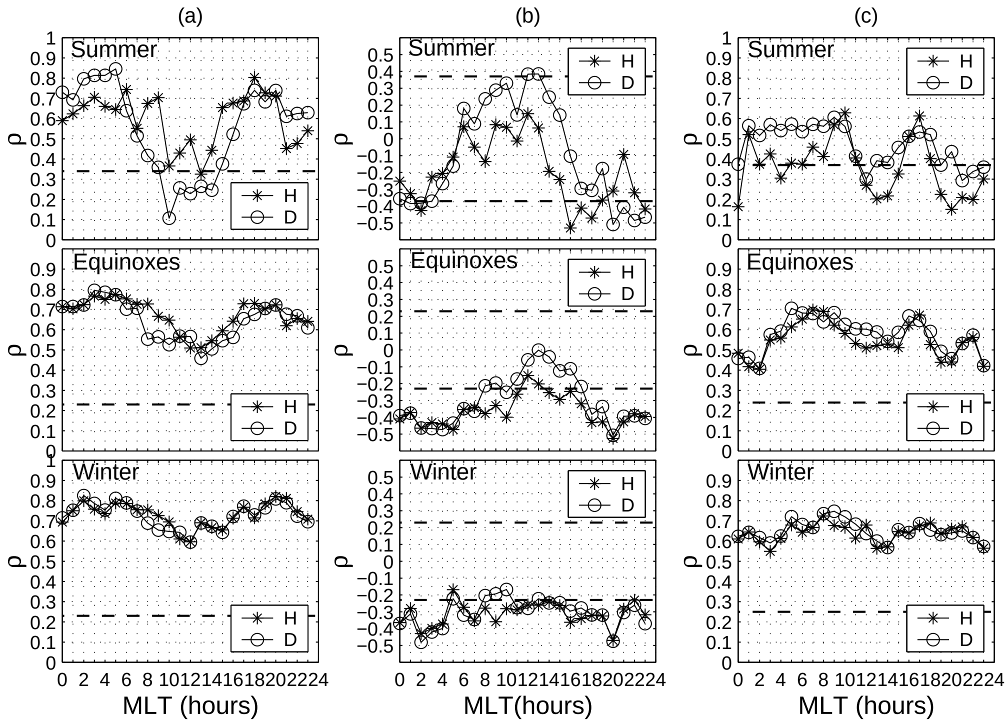

Fig. 3. Daily distribution of the correlation coefficient between the logarithm of the H and D power and the (a) Kp index, (b) IMF Bz component and (c) SW speed separately for the three Lloyd seasons. Dashed lines correspond to the 99% confidence level.

In summary, our results suggest that the power level and its relation with SW and magnetospheric parameters are strongly influenced by the distance of the station from the cusp, which minimizes around local geomagnetic noon and during local summer.

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