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Low-frequency (1-4 mHz) geomagnetic field fluctuation power at different latitudes for a diagnosis of the auroral oval position

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Abstract. We conducted a statistical analysis of the low frequency (1-4 mHz) geomagnetic field fluctuations recorded at 30 geomagnetic observatories in the northern hemisphere from low to very high latitude during two consecutive years (1998-99). The results show that low frequency fluctuation power exhibits a clear latitudinal dependence: it increases with increasing latitude up to about 70°, then decreases; the results obtained for different magnetic local times, magnetospheric conditions and seasons suggest that the latitude of the maximum power can be considered an indication for the auroral oval position.

Key words. Magnetosphere – MHD waves – Auroral oval

1. Introduction

Low frequency geomagnetic field fluctuations (with frequency of few mHz) are mainly interpreted in terms of an exogenic source; in particular, they could be triggered by MHD instabilities along the flanks of the magnetopause driven by the solar wind or by solar wind discontinuities impacting the magnetopause. In this sense, the amplitude of the geomagnetic field fluctuations is expected to maximize in correspondence of the auroral oval, in that local field lines reach the most external magnetospheric regions, where the generation mechanisms are active. Indeed, Matthews et al. (1996) studied a pulsation event at 3.3 mHz driven by changes in the solar wind, whose amplitude showed a strong, broad maximum close to the latitude of the cusp (at about 76° geomagnetic latitude) as inferred from an independent radar-satellite analysis; moreover, recent results by Kokubun et al. (2000) have shown a close coupling between surface waves on the magnetopause and ground Pc5 magnetic field oscillations near the polar cap boundary, at 70°-75° geomagnetic latitudes. Moreover, in the auroral nightside ionosphere field-aligned currents drive an intense ionosheric current,

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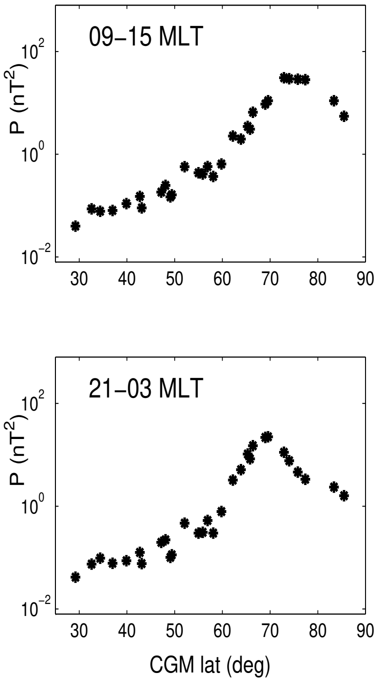

Fig. 1. The latitudinal dependence of the fluctuation power averaged over the 6-hr intervals centered around local geomagnetic noon (upper panel) and midnight (lower panel).

which can give rise to geomagnetic field variations (Campbell 1997). In this paper, we address the question of the latitudinal dependence of the low frequency fluctuation power and suggest that this kind of investigation may be used for a diagnosis of the auroral oval position. In this sense, several recent studies have investigated the magnetospheric boundaries by means of low frequency magnetic field fluctuations; for example, the study of field line resonances on the ground at cusp latitudes has been used to establish the boundary between open and closed field line regions, leading to the identification of the polar cusp around local magnetic noon Ables et al. (1998).

2. Experimental observations and discussion

We analyzed the low frequency geomagnetic field fluctuations measured during the entire years 1998-1999 at 30 geomagnetic observatories in the northern hemisphere from low to very high latitudes (about 30°-86° corrected geomagnetic latitude). We used as original data the 1 min average values of the horizontal north-south geomagnetic field component provided by the 1998-1999 INTERMAGNET CD-ROMs. In order to study the latitudinal dependence of the low frequency fluctuation power we calculated, for each station, the hourly values of the 1-4 mHz power and then logarithmically averaged the values corresponding to the 6-hr time intervals centered around local geomagnetic noon and midnight (Fig. 1). As can be seen, the low frequency power shows a clear, smooth latitudinal dependence: it increases with increasing latitude up to about 70°, then it decreases. It is also evident that the latitude of the maximum power shifts from 75° around local noon to about 70° around local midnight. Moreover, the latitudinal growth of the power is more steep beyond about 60°, possibly in correspondence of the footprint of the plasmapause.

We also analyzed separately the time intervals corresponding to very quiet and disturbed magnetospheric conditions ($Kp < 1$ and $Kp >= 4$, respectively; Fig. 2); although at all latitudes the power level is definitely lower for quiet magnetospheric conditions, the latitudinal dependence of the power in the two cases is substantially similar. However, the latitude where the power around local geomagnetic noon is maximum shifts from almost 80° for $Kp < 1$ to 73° for $Kp >= 4$; moreover, for $Kp >= 4$ the maximum around local midnight extends over a wider latitudinal range between 60° and 70°. Lastly, we considered separately the Lloyd seasons and found that the latitudinal behaviour of the power around local geomagnetic noon shows also a seasonal dependence: indeed,

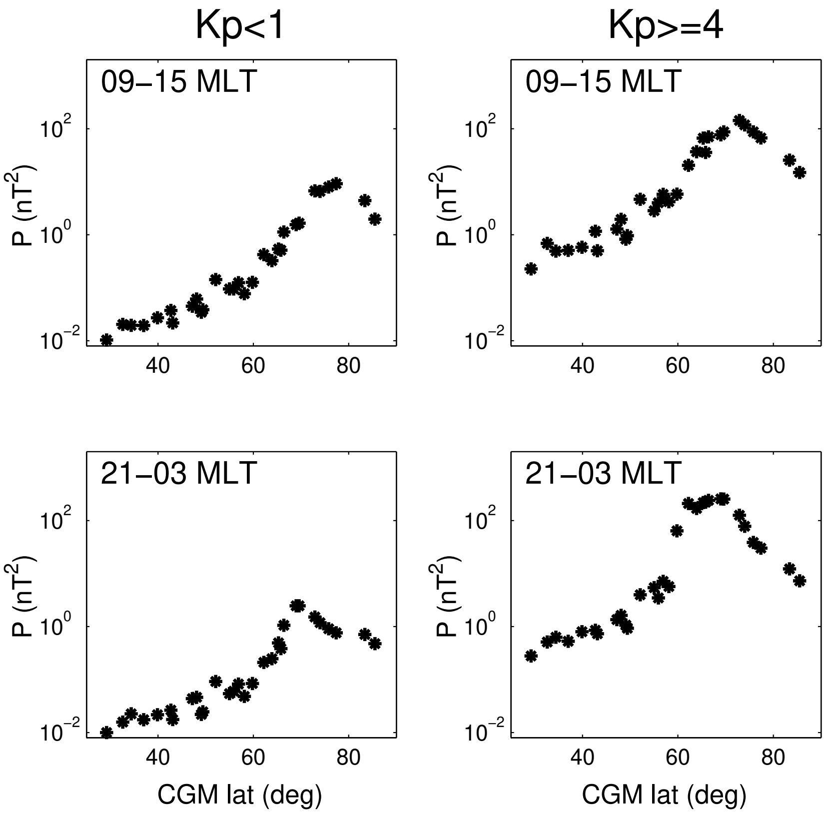

Fig. 2. The same as Fig. 1, for very quiet ($Kp < 1$, left panels) and for disturbed ($Kp >= 4$, right panels) magnetospheric conditions.

as can be seen in Fig. 3, the position of the maximum power level shifts toward slightly higher latitudes during summer with respect to winter (about 80° and 70°, respectively).

In summary, we found that the latitude of the maximum fluctuation power depends on magnetic local time, magnetospheric conditions and season; if we assume that the power level maximizes in correspondence to the auroral oval, all these findings could be well interpreted in terms of its geometry and dynamics; it is well known indeed Kamide (1988) that the auroral oval is asymmetric with respect to the geomagnetic pole and that, with increasing magnetospheric activity, its dayside portion, and in particular the polar cusp, advances equatorward and the latitudinal extension of the nighttime portion increases (for disturbed magnetospheric conditions it covers the whole region from 60° to 70°); moreover, the polar cusp position has also a seasonal dependence (it occurs at lower latitudes in the winter hemisphere), related to the change of the dipole tilt angle during the year (Newell & Meng 1989), (Zhou et al. 1999), (Russell 2000). We suggest that the possibility of statistically identify the position of the auroral oval from the analysis of the latitudinal profile of low frequency geomagnetic fluctuation power could provide a further investigation

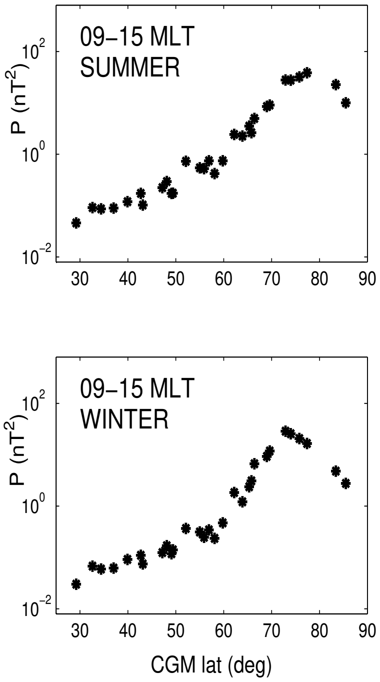

Fig. 3. The latitudinal dependence of the fluctuation power around local geomagnetic noon during summer (upper panel) and winter (lower panel).

tool in the framework of magnetospheric dynamic studies.

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