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THE AURORAL BREAK-UP AS RELATED TO THE INTERPLANETARY PARAMETERS AND THE GEOMAGNETIC ACTIVITY

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ABSTRACT

In the present study, we used as a significant indicator of the auroral break-up the "sudden equatorward shift" in arcs or displays. For the dark months of May and June of 1971, auroral observations at Base General Belgrano (78,0° S; 38,8° W) were used.
Four-hourly sequences centered at the break-up (t=0) were studied for the following quantities:
a) The magnitude of the interplanetary magnetic field (B), b) The southward component of the interplanetary magnetic field (Bz), c) The solar wind speed (V), d) The solar wind electric field (the westward component: E), e) The auroral electrojet magnetic activity indices (AE, AL, AU).
On the basis of the seven substorms studied, one may deduce that an appreciable increase of geomagnetic activity occured about 40 minutes after the energy arrival at the magnetosphere , but it is not enough strong to take place the break-up, it will happen after another period of 35 minutes.
This result confirms that a substorm only occurs after a build-up process.
The present paper also confirms the possibility of using the auroral zone geomagnetic activity for estimating the solar wind velocity

RESUMEN

En el presente trabajo usamos como indicador de la ruptura de aurora al "sudden equatorward shift" en arcos o displays. Para los meses oscuros de mayo y junio de 1971, se usaron observaciones aurorales en la Base General Belgrano (78,0° S; 38,8° W)
Se estudiaron las secuencias de cuatro horas centradas en la ruptura (t=0) para las siguientes variables:
a). La amplitud del campo magnético interplanetario (B), b) La componente sur del campo magnético interplanetario (Bz), c) La velocidad del viento solar (V), d) El campo eléctrico del viento solar (la componente oeste: E), e) Los índices de actividad magnética del electrochorro auroral (AE, AL, AU)
Sobre la base de las siete subtormentas estudiadas uno puede deducir que ocurrió un incremento apreciable de la actividad geomagnética aproximadamente 40 minutos después de la llegada de la energía a la magnetósfera, pero no han sido lo suficientemente fuertes para tener lugar durante la ruptura, eso sucederá después de otro período de 35 minutos.
Este resultado confirma que una sub-tormenta solo ocurre después de un proceso tipo "build-up".
El presente trabajo también confirma la posibilidad de usar la actividad geomagnética de la zona auroral para estimar la velocidad del viento solar

1. INTRODUCTION

Numerous papers have been published that relate Interplanetary magnetic field (B) (Perreault et al. 1978, Foster et al. 1971, Rostoker and Fälthammar 1967, McPherron 1991, Lopez and Lui 1990) wind, plasma parameters and geomagnetic activity. They suggested the importance of the southward component (B_Z) of the Interplanetary magnetic field to produce geomagnetic disturbances. There are many examples of geomagnetic substorms during which the characteristics of the solar wind plasma did not change significantly. In 1971,Arnoldy (1971) showed that there is a close relationship between the north-south component of B and substorm activity. Therefore, it is reasonable to infer that there is also a close relationship between B_Z and the development of the main phase. Burton et al. (1975) proposed that the time evolution of the magnetosphere could be studied through the linear rectifier model of B_Z. Perrealut and Akasofu (1978) estimated the rate of the total energy dissipation (U_t). During storms and substorms U_t is closely related to the Poynting flux (ExB/4__). A large increase of U_t is associated with substorm activity, their accumulated effects can be understood as a geomagnetic storm phenomenon.

We studied the relationship among B, Solar wind parameters, AE index and the sudden changes of auroral morphology, generally called auroral break-up. We analyzed 7 geomagnetic substorms as observed at the Base General Belgrano (78° S,38.8° W), a site close to the northern border of the southern auroral zone. We considered the sudden equatorward shift as the indicator of the auroral break-up.

2. SELECTION CRITERIAS

We studied the auroral observations from the southern winter months of 1971 at Antarctic Base General Belgrano, because the data obtained at this Station (during the above mentioned period), is complete. The interval suitable for recording of aurora was found for every day. The sky should be sufficiently dark for a number of stars to be identified on the all-sky image. Periods with bright moonlight were rejected. The sky should be clear, though intermediate periods with partly cloudcover were accepted, if existing auroral activity could clearly be identified. Periods with shortlived clearance during long intervals with completely covered sky were rejected. After the commencement of the frequent auroral substorms the violent movement of the auroral forms and their distortion from a regular appearance were considered. Large regions with diffuse auroral light were observed in connection with the auroral substorms and on the morning side of the auroral oval. However, even during such conditions it was possible to find extended auroral forms embedded in the diffuse light. The auroral displays, evaluated in this way, are considered to be representative for the auroral break-up, as observed at Base General Belgrano. We have studied a) all-sky camera recordings of 1 minute intervals and b) visual observations every 15 minutes, which have observed the whole sky above 10° as locally visible. The skyline of this place is completely free, but a great number of photos were not workable, because the camera was installed in a low place, and it was perturbed by the frequent blizzards. To analyze auroral displays we have chosen the auroral electrojet magnetic activity indices AE, AL and AU (World Data Center 1975), Interplanetary magnetic field (magnitude and north-south component), and Solar wind speed (World Data Center 1977).

Initially we selected 18 substorms observed from May to June 1971, each of them had AE index values greater than 250 nT at the instant of the appareance of a sudden equatorward shift, but only 7 events with continuos interplanetary data records were studied.

3. INTERPLANETARY MAGNETIC FIELD, SOLAR WIND AND GEOMAGNETIC SUBSTORMS

We studied the average temporal evolution (for the 7 substorms above mentioned)

a) Magnitude of Interplanetary magnetic field
b) North-south Interplanetary magnetic field component
c) Solar bulk wind speed
d) Westward solar wind electric field component
e) Auroral electrojet activity index AE, AL and AU

We confirmed also the smooth linear relation between the ratio AL/AU and the Solar wind speed.

These five parameters were intercompared by considering that all of them are independent. The time scale used was of 7.5 minutes. The superposed epoch method was applied to obtaining the average magnitude. We defined the time zero as the instant of a sudden equatorward shift was detected at Base General Belgrano.

In 6 of the substorms studied we found that B_Z was negative during the four hours around break-up time. The other case showed that B_Z changed from positive (before t=0h) to negative values (after t = 0h).

4. RESULTS

Figures 1 to 5 show the temporal evolution of the studied parameters during four-hourly intervals centered at the instant of auroral break-up.

The average values indicate the following aspects:
a) the quasi-constant level of the mean Interplanetary magnetic field magnitude during the last 220 minutes and its small decrease during the first 20 minutes of the studied interval.
b) the negative values of the B_Z component. It decreases from t= 120 minutes till t=15 minutes. It has a minimum value around 35 minutes before auroral break-up. c) the constant values of the mean solar wind speed during 4 hours around the break-up time. d) the solar wind electric field (E) (the westward component only) decreases during the first 20 minutes. Then it has a small maximum with some 20 minutes. It increases from t=-75 minutes to t=-26 minutes. Then it increases up to 86 minutes. e) the average development of AE index practically increases during the 240 minutes around t=0h. We can notice that it shows a steady rise starting some 90 minutes before the auroral event and culminating after it. Fig. 6 shows the slight linear relation between the ratio AL/AU and the solar wind speed. The square fit predicts that AL/AU=(1.3±0.2)*V with an uncertainty of one standard-deviation. This smooth relation agrees with Maezawa (1979) prediction.

To find the relationship among the different parameters studied in a)...e) and their linking with the indicator of the auroral break-up it is important to analyze the temporal variations before and after the appearance of the sudden equatorward shifts

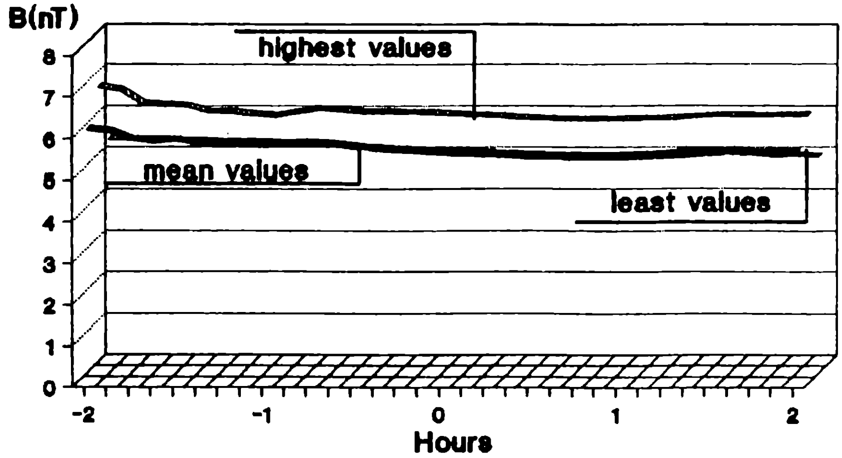

Figure 1. *Average temporal evolution of the Interplanetary Magnetic Field (Magnitude) around the instant that was observed a sudden equatorward shift at Base General Belgrano(t=0h). The number of isolated substorms included in this graph was equal to seven.*

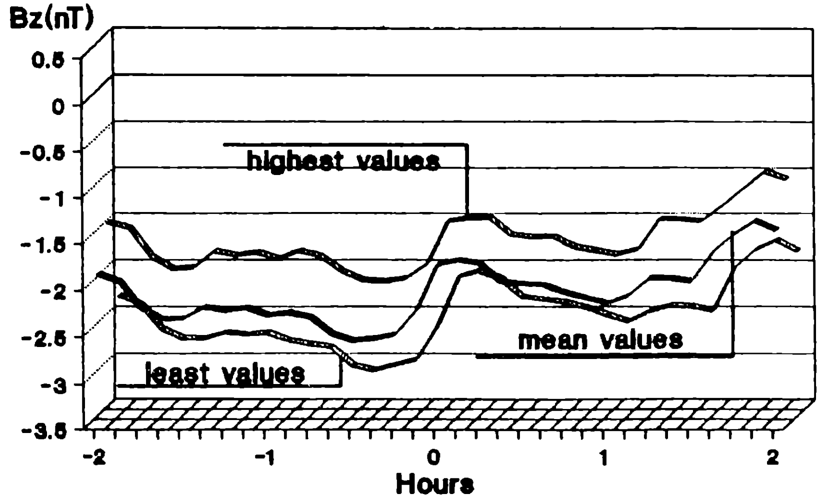

Figure 2. *Temporal evolution of the mean substorm (seven events) of B south component. The time t=0h corresponds at the observation of a sudden equatorward shift at Base General Belgrano. We studied seven events.*

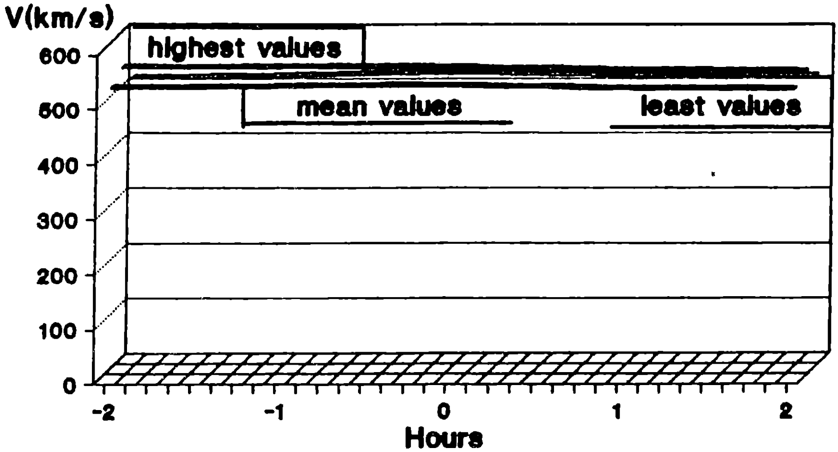

Figure 3. *Average temporal evolution of the Solar Wind Speed, during the 4 hours around break-up time, as observed at Base General Belgrano. This graph represents the average values for seven cases.*

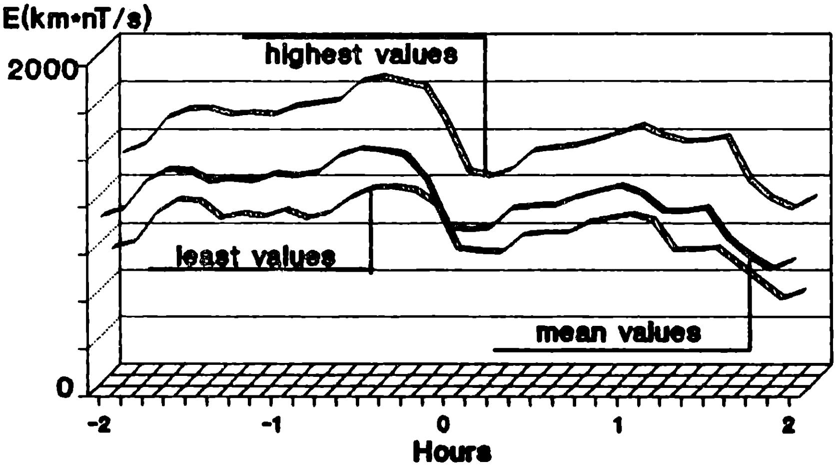

Figure 4. *Temporal evolution (of seven events) of the westward component of the solar wind electrical field from two hours prior till two hours after break-up, as detected at Base General Belgrano.*

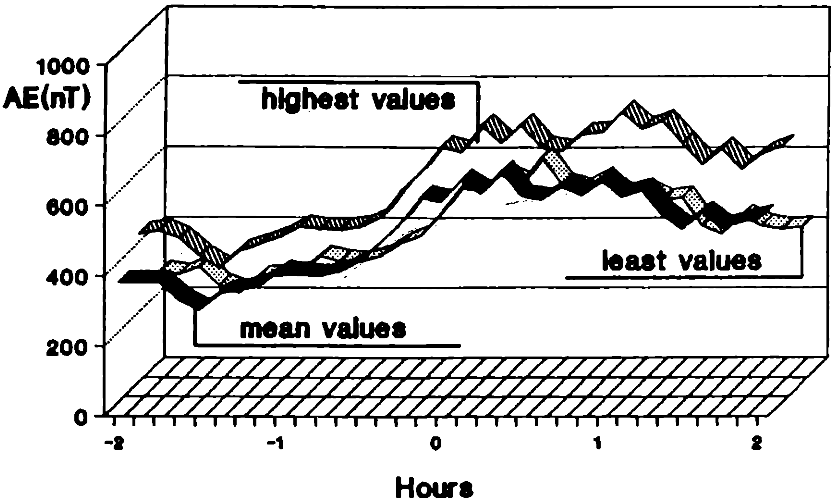

Figure 5. *Mean AE index values vs. break-up time, for the seven substorms studied in the present work. It represents the total current of the two ionospheric auroral electrojets.*

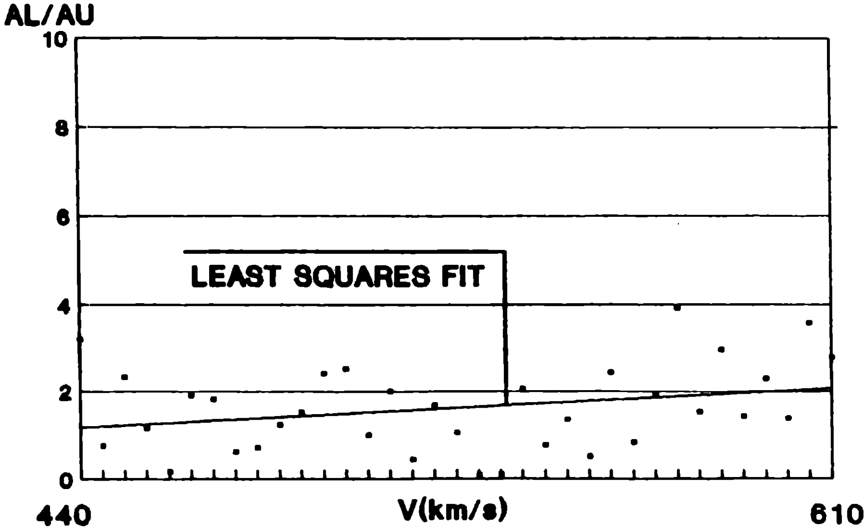

Figure 6. *Relation between the ratio AL/AU vs. V for all the values used in the present study. (Maezawa 1979). The slope is enlarged by the different characteristics of the seven substorms studied.*

5. CONCLUSIONS

According to previous studies (Silbergleit and Schneider 1992 a,b), the sudden equatorward shifts are good indicators of auroral break-up.They are related with high latitude increase of geomagnetic activity. In the present work, we studied the geomagnetic activity through the auroral electrojet activity indices AE. The graph can be used to identify three average substorm phases, according to Akasofu's model. We can observe the appearance of the pseudo break-up around some 60 minutes before break-up. The rise begins in advance of some 35 minutes to break-up time, and in the present work it is in coincidence with an important decrease of Bz values.Then, we can infer that the Base General Belgrano is spatially situated under the ionospheric auroral electrojet currents during the seven studied events.

The average development of the component of the electric field of the solar wind (E_y), has its maximum value about forty minutes (lead over) the maximum geomagnetic activity. So, we could deduce that it is necessary an ionospheric minimum energy threshold to produce geomagnetic substorms.

The mean temporal evolution of B_z component (and E) shows a secondary minimum (maximum), (for the present work), we can think that it is caused by other possible auroral break-up indicator (i.e. appearance of rayed structure, sudden increasing of brightness, variation of spectral composition...).

Also we concluded that some solar wind parameters do not change significantly during the four hours studied (i.e.: Solar wind speed, Interplanetary magnetic field magnitude).

To verify the possibility of using the auroral zone geomagnetic activity for estimating the Solar wind speed, we plotted the ratio AL/AU versus V. From the Fig. 6 we could think that AL and AU indices have an alike dependence on the Solar wind speed. Finally we proposed to research this relation using a high number of substorms.

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