Geofísica Internacional (2000), Vol., 39, Num. 1, pp. 139-142

Magnetic field and plasma parameters for magnetic clouds in the interplanetary medium

A. Dal Lago[1], W. D. Gonzalez[1], A. L. C. de Gonzalez[1], and B. T. Tsurutani[2]
[1]*Instituto Nacional de Pesquisas Espaciais, São José dos Campos, SP, Brazil.*
[2]*Space Plasma Physics, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA.*

Received: November 9, 1998; accepted: May 15, 1999.

RESUMEN

Para un grupo de 16 nubes magnéticas observadas a 1 UA se realizó un estudio del campo magnético y de los parámetros del plasma con objeto de caracterizar la diferencia de presiones entre las nubes del medio circundante. La asimetría del perfil de la intensidad del campo magnético de la nube parece estar relacionada con la diferencia de presiones magnéticas entre las partes frontal y posterior del medio ambiente, debido probablemente a un proceso de compresión. Se describen brevemente algunas consecuencias geofísicas.

PALABRAS CLAVE: Medio interplanetario, nubes magnéticas.

ABSTRACT

For a set of 16 magnetic cloud events measured at 1 AU we investigated the magnetic field and plasma parameters in order to characterize the pressure differences between the structure and the environment. The asymmetry profile of the magnetic cloud field strength seems to be related to the magnetic pressure difference between the front and the rear medium, possibly by a compression process.

KEY WORDS: Interplanetary medium, magnetic clouds.

INTRODUCTION

Magnetic clouds are structures of the interplanetary medium, thought to be giant flux ropes (Farruggia *et al.*, 1997), whose essential features are strong magnetic fields, a smooth rotation of the magnetic field direction through a large angle and low plasma beta (Burlaga *et al.*, 1981). Gonzalez *et al.* (1998) have proposed a relationship between the peak magnetic field strength and the peak velocity value for a set of 13 magnetic clouds. Clouds which move at higher speeds also possess a higher core magnetic field strength (Figure 1). This relationship may be due to an intrinsic property of magnetic clouds, or to a compression exerted by the ambient solar wind (or stream interaction). To investigate the possibility of compression interaction we analyzed the magnetic field strength profile, localizing its peak value inside the cloud, and we computed the kinetic, magnetic and total pressure as well as the beta parameter for a set of 16 magnetic cloud events including the 13 events studied by Gonzalez *et al.*, (1998), from 1967 to 1996 (Figure 2). Compression can increase the magnetic field value. Since the total field of magnetic clouds has a substantial southward Bz component (see Figure 3), the interplanetary dawn-dusk electric field $v \times Bs$ responsible for the magnetospheric energization (Dungey, 1961) is enhanced, causing magnetic storms (see Table 1).

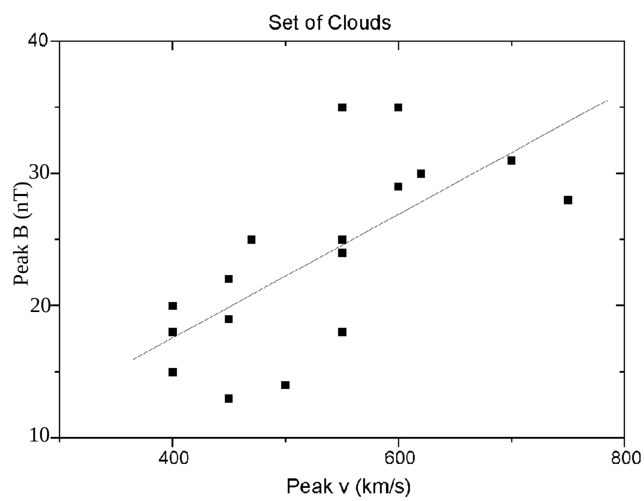

Fig. 1. Scatter plot for peak B versus peak v for a set of 13 magnetic clouds. The correlation coefficient is 0.73. (González *et al.*, 1998)

DATA ANALYSIS

We used OMNI data of 1 hour resolution to compute the magnetic, kinetic, total pressure and beta parameter, as shown in Figure 2. The magnetic field strength and the rotation of the Bz component (first and second panels) are also

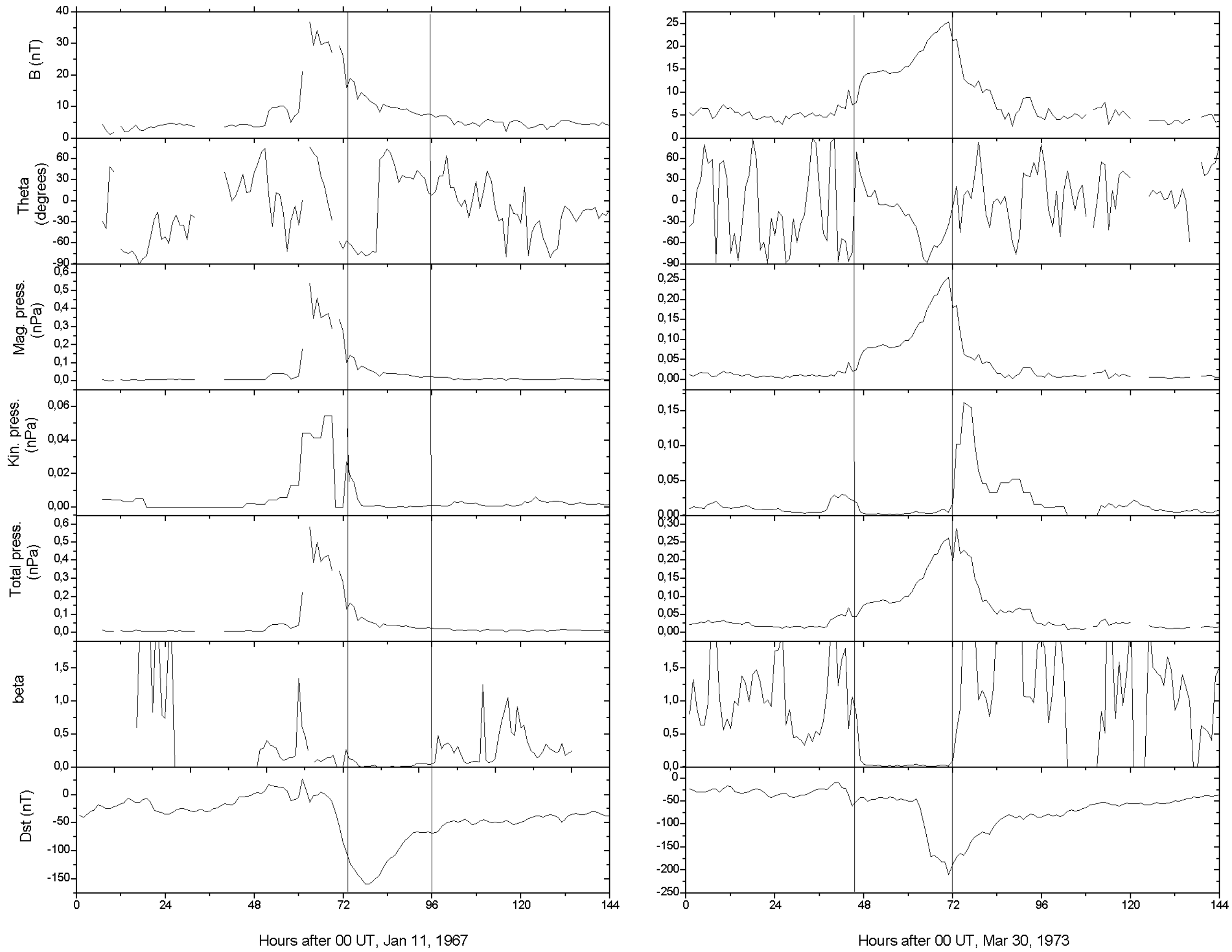

Fig. 2. From top to bottom, the magnetic field strength, the rotation of the Bz component, the magnetic pressure, kinetic pressure, total pressure, the beta parameter and the Dst index for the magnetic cloud events of Jan 14, 1967 and Apr 01, 1973.

Table 1

Intensity of magnetic storms caused by the magnetic cloud events of Figure 3.

Intensity of the Magnetic Storm	Number of Events
Weak (Dst > -50 nT)	2
Moderate (-100 nT < Dst < -50 nT)	1
Intense (Dst < -100 nT)	10

shown to better identify the magnetic cloud event, and the Dst index (bottom panel) is shown to identify the geomagnetic activity. We select regions of about the size of the magnetic cloud, in front of and behind it and we calculated the peak magnetic pressure difference between the front and the rear medium. Figure 4 shows the results as plotted against the peak position of the magnetic field strength inside the magnetic cloud. To find the peak B position we normalized all the magnetic cloud events in 20 normalized hours.

We also selected a subset of 13 events with south-north Bz rotation, to compute the mean B, Bz rotation angle and the percentage of the total field in the z and y directions.

RESULTS AND DISCUSSION

From Figure 2 it is found that the magnetic pressure is much higher than the kinetic pressure, and the total pressure is nearly equal to the magnetic pressure. The beta parameter is low (around 0.1), which is consistent with the magnetic cloud definition. In most cases the magnetic pressure is twice the ambient pressure, but in one case it is an order of magnitude higher. In two cases the pressure in the region between the shock and the magnetic cloud is higher than inside the

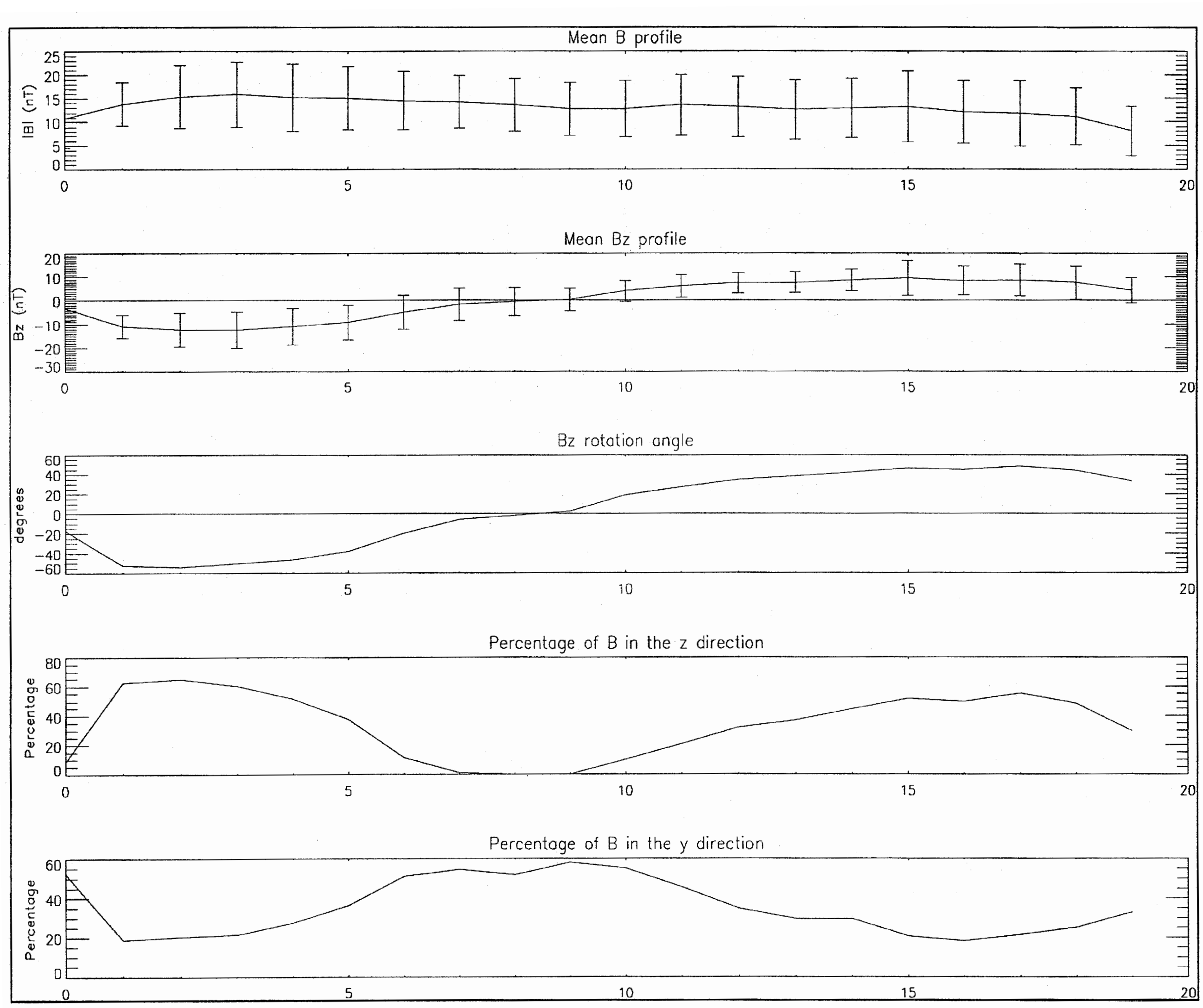

Fig. 3. Mean magnetic field strength profile, mean Bz component, mean rotation angle of the Bz component and the percentages of total field in the Z and Y directions of 13 magnetic cloud events (S-N)

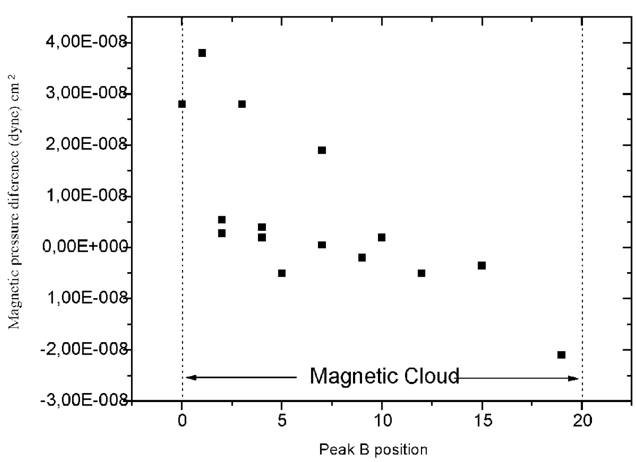

Fig. 4. Magnetic pressure difference between the front and the rear regions surrounding the cloud versus the position of the peak value of the magnetic field strength inside the magnetic cloud.

magnetic cloud, leading to asymmetry in the B profile. In one case the total pressure in the rear region was nearly as high as the value inside the magnetic cloud, due to a stream interface in the sector boundary. The resulting asymmetry is very atypical, as shown in the right-side example in Figure 2.

The fourth panel of Figure 3 shows that more than 60% of the magnetic field is in the z direction; thus magnetic clouds are important sources of –Bz (southward) fields. Any increase of magnetic field strength (by compression, for example) means an increase in the Bz magnitude leading to a geophysical consequence. Table 1 shows the intensity of the magnetic storms caused by these events, measured by the Dst index, where 10 of these 13 events caused intense magnetic storms (5 of them with Dst < -150 nT).

Figure 4 indicates a correlation between the position of the peak value of the magnetic field strength and the pressure difference between the front and the rear medium. Thus for magnetic clouds that encounter higher pressures in front of the cloud the peak magnetic cloud field is also in front and vice-versa. This suggests that some compression of the magnetic cloud structure might be occurring, displacing the magnetic field profile in the direction of the higher external magnetic pressure. This compression may cause an increase in the magnetic field strength.

BIBLIOGRAPHY

FARRUGIA, C.J., L.F. BURLAGA and R.P. LEPPING, 1997. Magnetic Clouds and quiet-storm effect at Earth. *In:* Magnetic storms, edited by B.T. Tsurutani, W.D. Gonzalez, Y. Kamide and J.K. Arballo. Amer. Geophys. Union Press, Washington D.C., Geophys. Mon. Ser., 98, 91-106.

BURLAGA, L.F., E. SITTLER, F. MARIANI and R. SCHUWENN, 1981. Magnetic loop behind a interplanetary shock: Voyager, Helios and IMP-8 observations. *J. Gephys. Res., 86*, 6673-6684.

GONZALEZ, W.D., A.L. CLUA DE GONZALEZ, A. DAL LAGO, B.T. TSURUTANI, J.K. ARBALLO, G.K. LAKHINA, B. BUTI, C.M. HO and S.-T. WU, 1998. Magnetic cloud field intensities and solar wind velocities. *Geophys. Res. Lett., 25*, 963-966.

DUNGEY, J.W., 1961. Interplanetary magnetic field and auroral zones. *Phys. Rev. Lett., 6*, 47.

GONZALEZ, W.D. and B.T. TSURUTANI, 1987. Criteria of interplanetary parameters causing intense magnetic storms (Dst<-100 nT). *Planetary Space Science, 35*, 1101-1109.

A. Dal Lago[1], W. D. Gonzalez[1], A. L. C. de Gonzalez[1], and B. T. Tsurutani[2]

[1]*Instituto Nacional de Pesquisas Espaciais, São José dos Campos, SP, Brazil*

[2]*Space Plasma Physics, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, USA.*