A COMPARISON BETWEEN APRIL 1999 AND FEBRUARY 2000 SOLAR-TERRESTRIAL CONNECTION EVENTS: INTERPLANETARY ASPECTS

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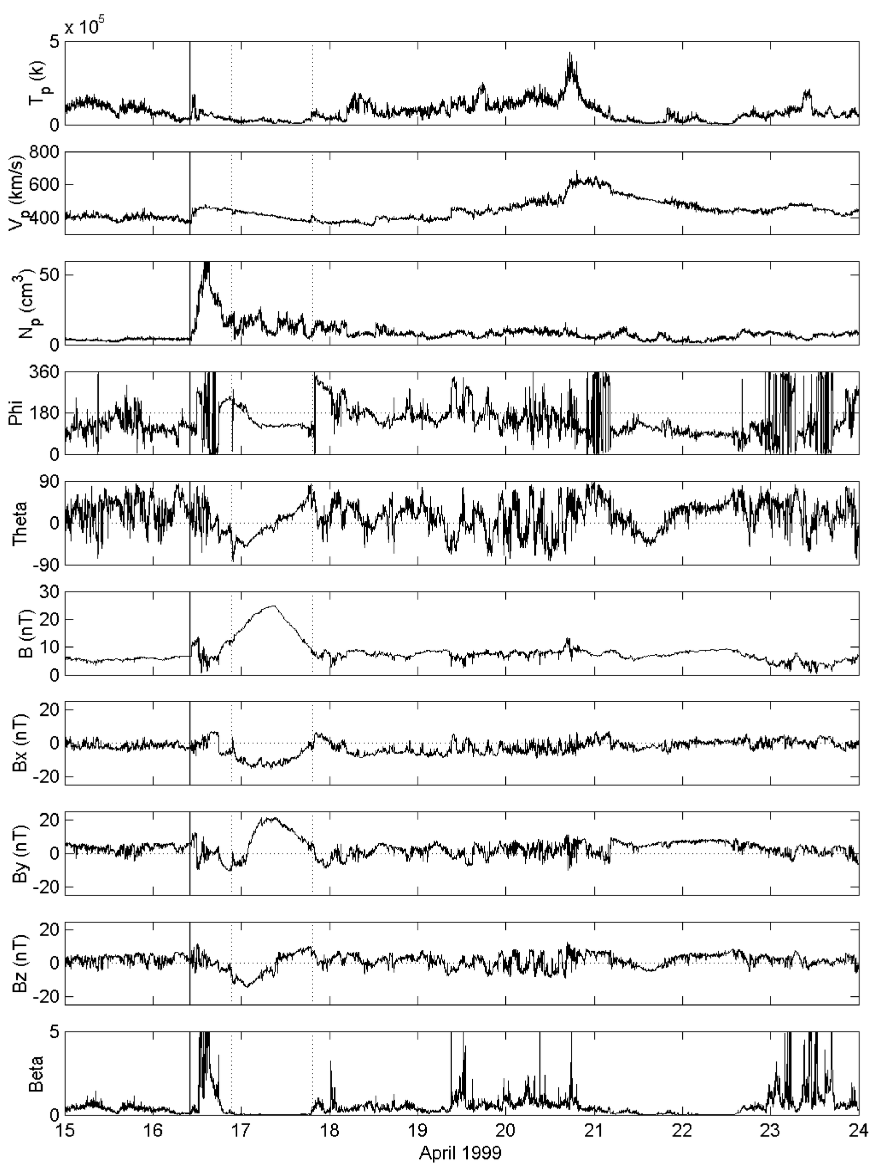
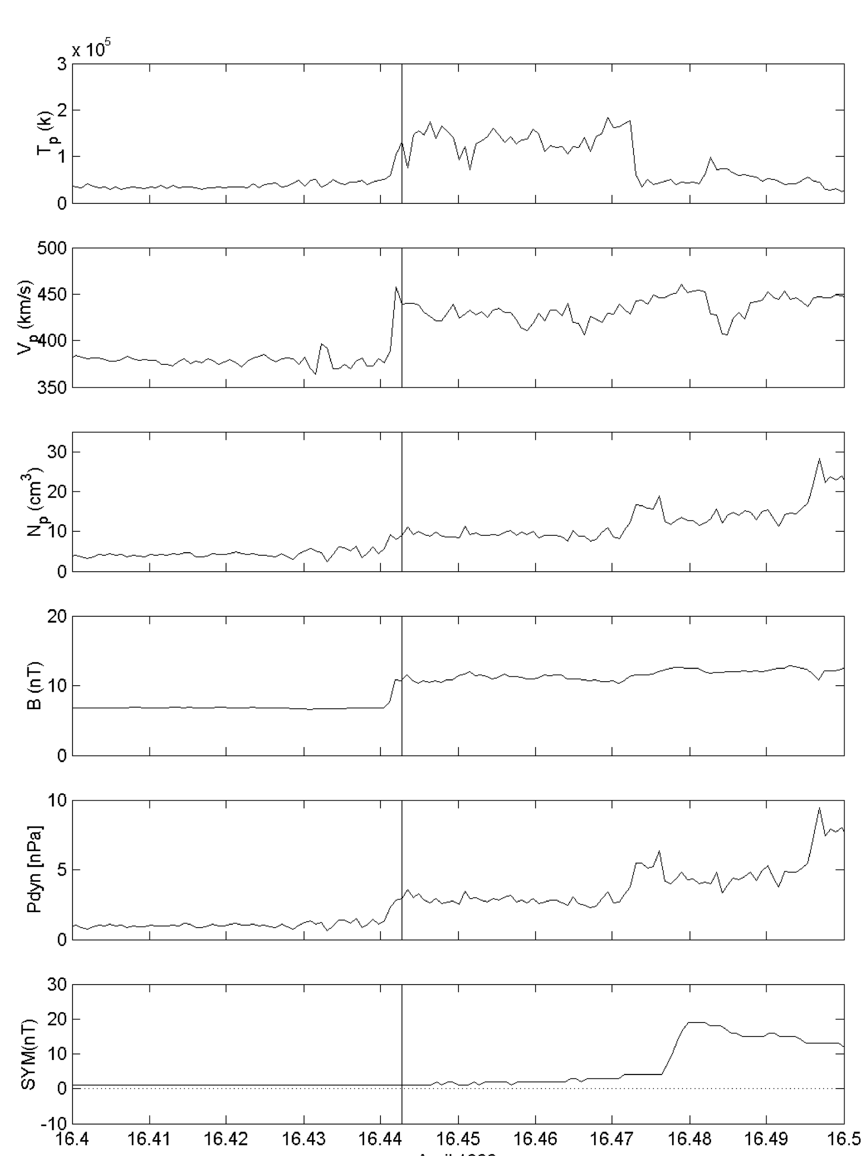
The strong geomagnetic storms on April 17th 1999 (Dst peak = -91 nT) and on February 12th 2000 (Dst peak = -131 nT) were caused by different interplanetary structures. The April 1999 event was caused by a south-north fast magnetic cloud, which drove an interplanetary shock detected at 1 astronomical unit (UA) at 10:30 UT on April 16th 1999. This interplanetary shock had Alfvenic Mach number of about 2.5. The magnetic cloud arrived at UA around 23:00 UT on April 16th and ended around 19:00 UT on April 17th. The southward component of the interplanetary magnetic field remained above -10 nT for 5 hours, with peak value of -14 nT. The February 2000 event was caused by the interaction of two interplanetary remnants of coronal mass ejections. Two interplanetary shocks were detected on February 11th 2000 at 02:00 and at 23:00 UT. These shocks had Alfvenic Mach numbers of about 2.0 and 2.8, respectively, and were driven by interplanetary ejecta. The first interplanetary ejecta arrived at 1 UA around 16:00 UT on February 11th. However, it was engulfed by the second one around 20:00 UT on the same day, creating an intense and highly turbulent southward magnetic field, which remained above -10 nT for 3 hours, with peak value of -16 nT. In this paper the interplanetary aspects of these two solar-terrestrial connection events are analyzed and compared. Plasma and magnetic field data obtained from sensors on board ACE spacecraft orbiting L1 point are used.

Interplanetary parameters – Magnetic Cloud April 1999



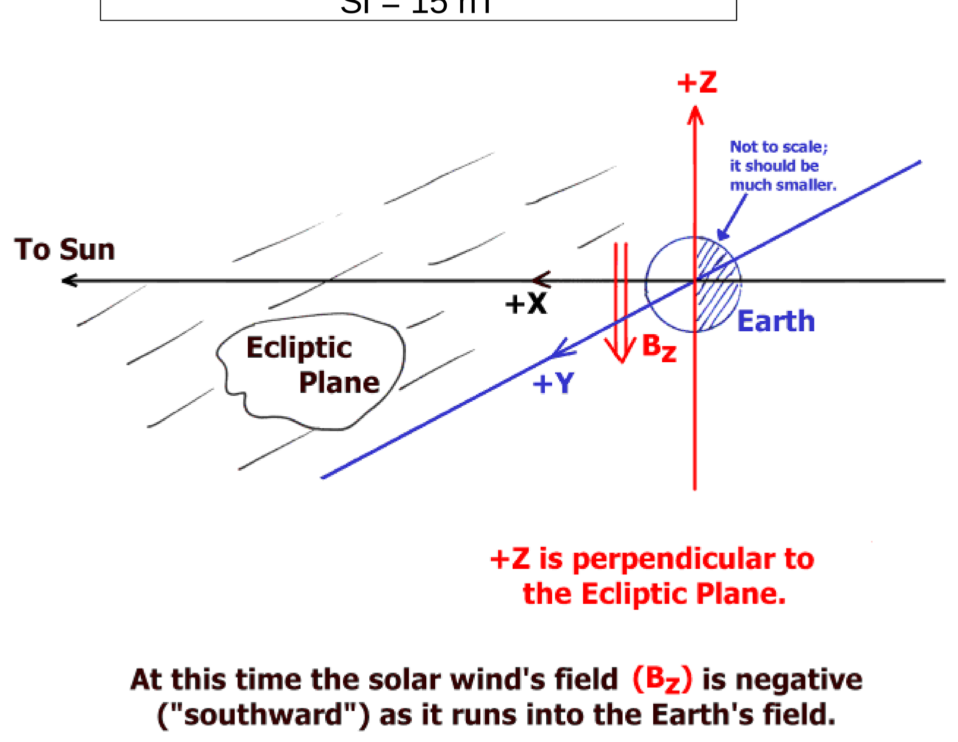
From top to bottom: T_p, proton temperature, V_p, proton velocity, N_p proton density, azimutal angle ϕ, latitudinal angle θ, IMF intensity B, IMF components B_x B_y, and B_z, and β.

Magnetic Cloud - April 1999



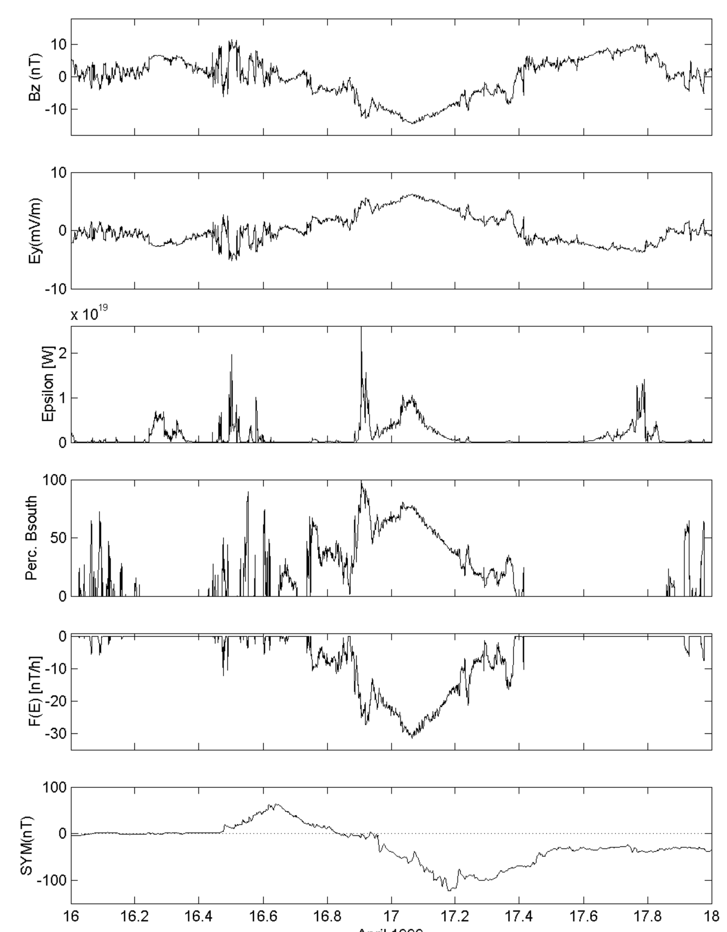
Plasma parameters, T_p, V_p, N_p, B, dynamical pressure P_{dym}, and SYM (in fraction of day, April 16, 1999)

Interplanetary shock : 10:30 UT April 16th
Parameters:
M_A = 1.3;
U_s = 470 km/s;
n_{GSE}=(0.96; -0.11; -0.26)
θ_{Bn} = 56° (oblique shock)
r_n = 2; r_B = 1.7
SI = 15 nT

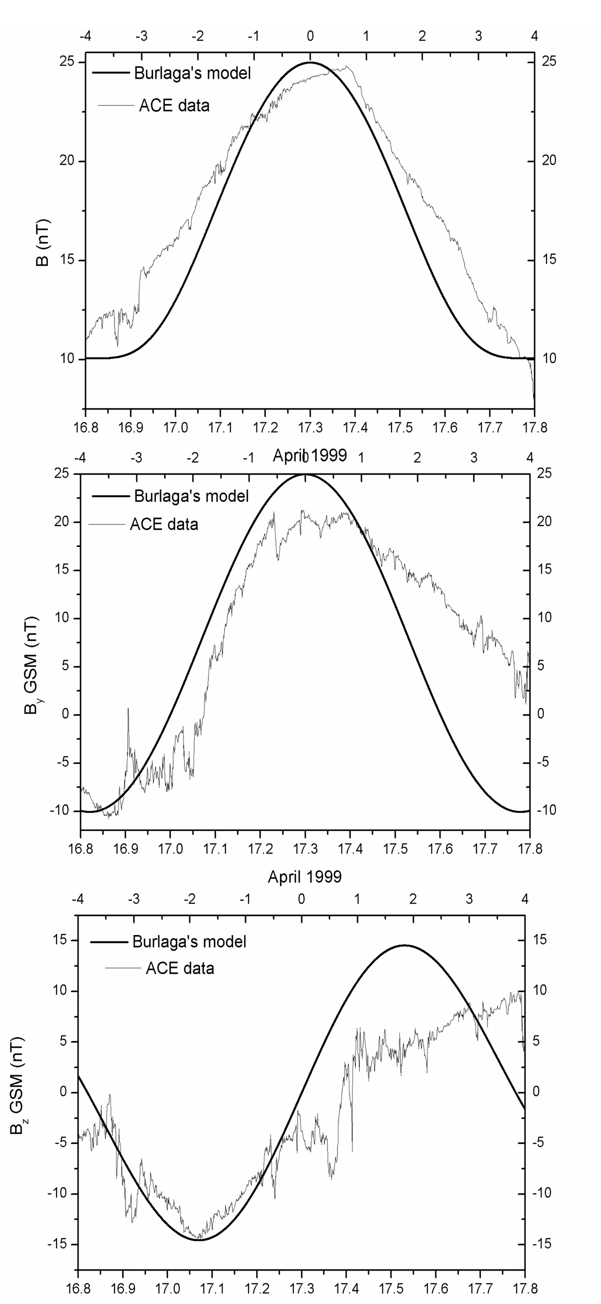


GSE coordinate system: Earth at its center; the x-axis points to the Sun, the z-axis is perpendicular to the ecliptic plane, and the y-axis is perpendicular to both the x and z axes with a positive direction opposite to the Earth's motion around the Sun.

Geoeffectiveness of April 1999 event



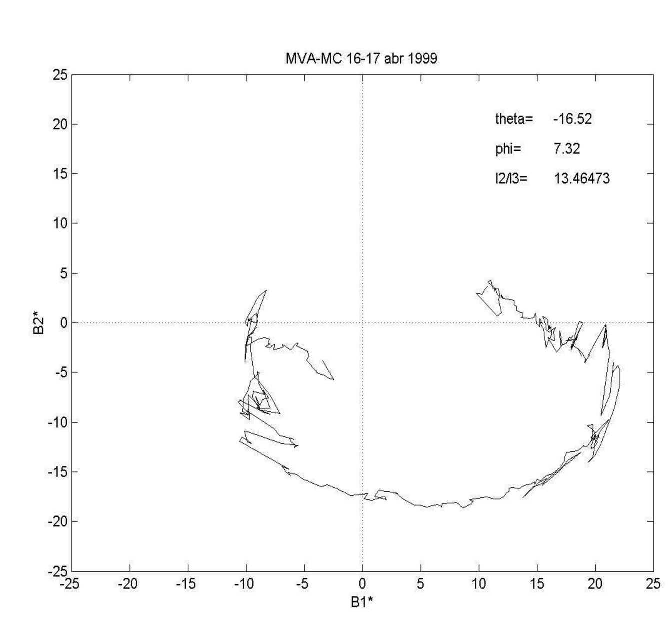
Geoeffectiveness parameters – April 1999
South magnetic field componente B_z
electric field E_y = $-VB_z$
$\varepsilon = l_o^2 V B^2 \sin^4(\theta)$; $l_o = 7R_E$, $\theta = \mathrm{asin}(B_z/B)$
F(E) =0 if E_y < 0.5 mV/m
F(E) = -1.5*1E-3*(E_y(ii)-0.5) if E_y > 0.5 mV/m



Comparison between data (soft line) and Burlaga´s model for MC (full line)

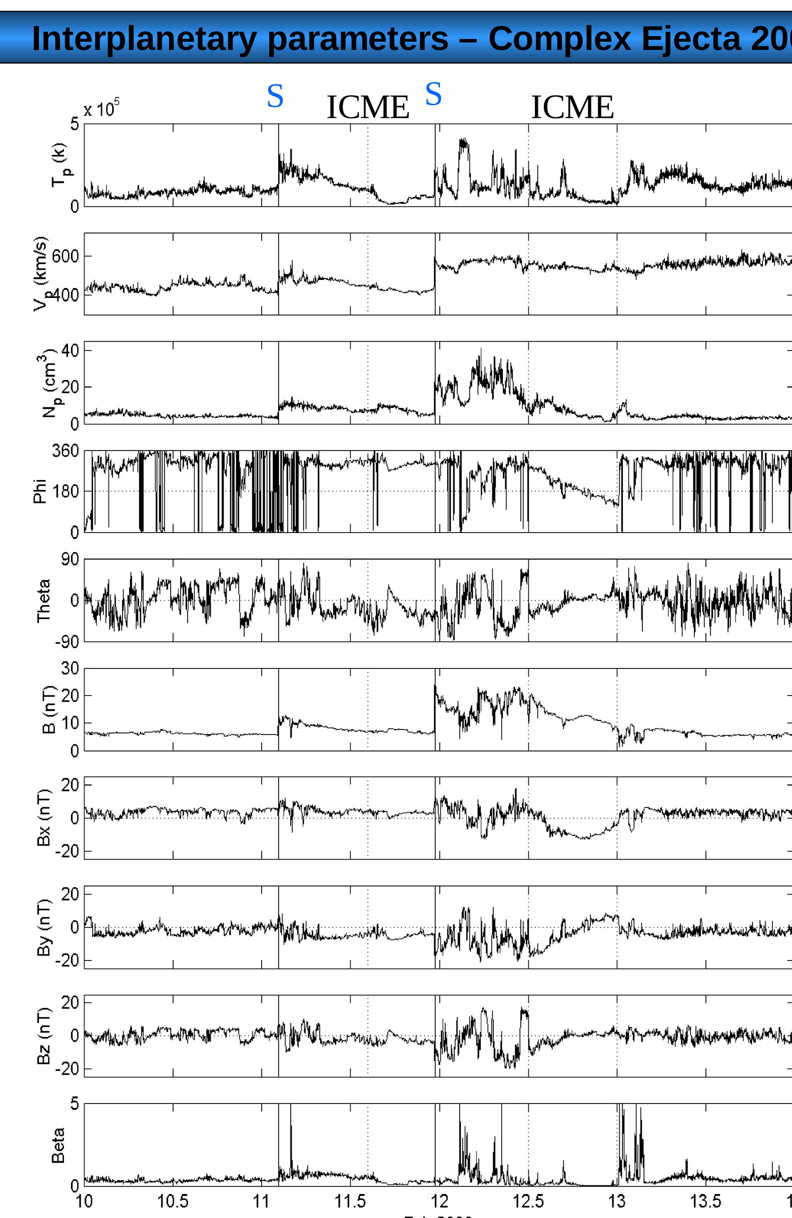
Burlaga' s model for Magnetic Clouds (Lundquist' s solution) Force-free flux rope

$$J \times B = 0; \quad J = \alpha B$$
$$B_R = 0$$
$$B_\phi = \pm B_0 J_1(\alpha R)$$
$$B_z = B_0 J_0(\alpha R)$$



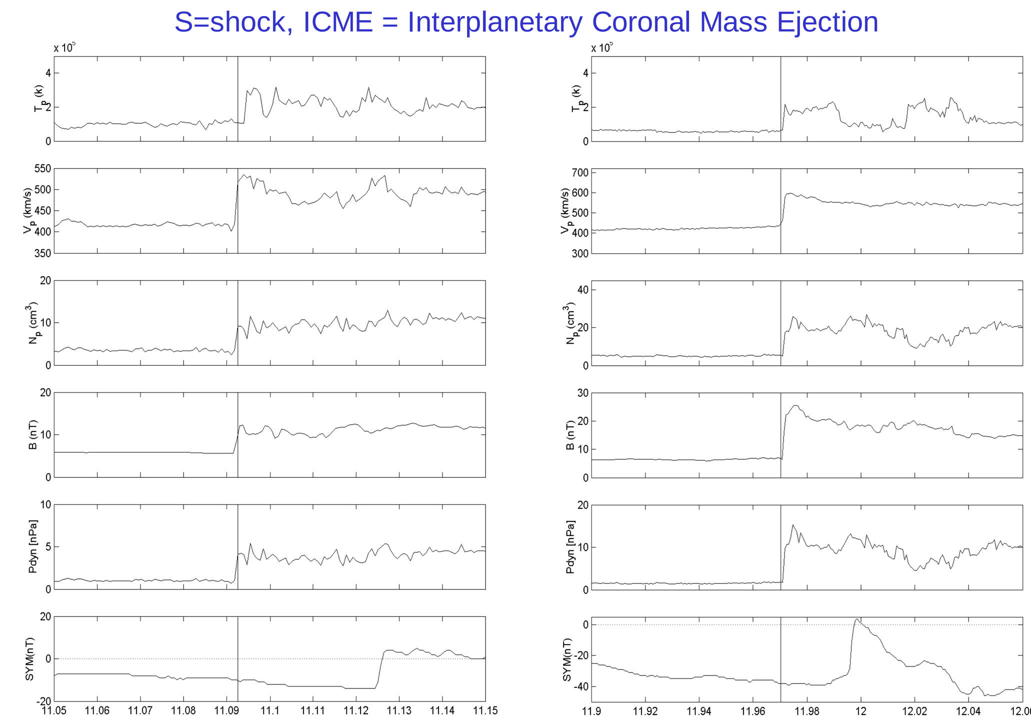
Minimum Variance Analysis
SN Cloud:
23:00 UT Apr 16 – 19:00 UT Apr 17
Axis inclination: -16.5°
Axis azimuth: 7.3°

Interplanetary parameters – Complex Ejecta 2000

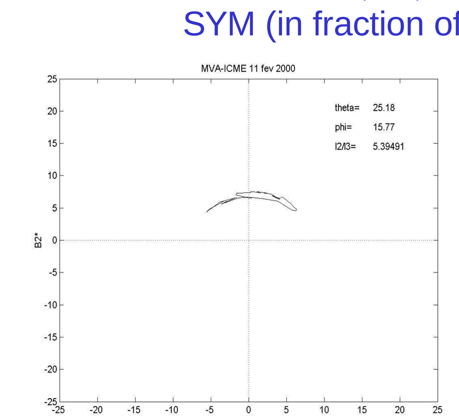


From top to bottom: proton temperature T_p, proton speed V_p, proton density N_p, azimutal angle ϕ, latitudinal angle θ, IMF intensity B, IMF components B_x B_y, and B_z, and β.

S=shock, ICME = Interplanetary Coronal Mass Ejection

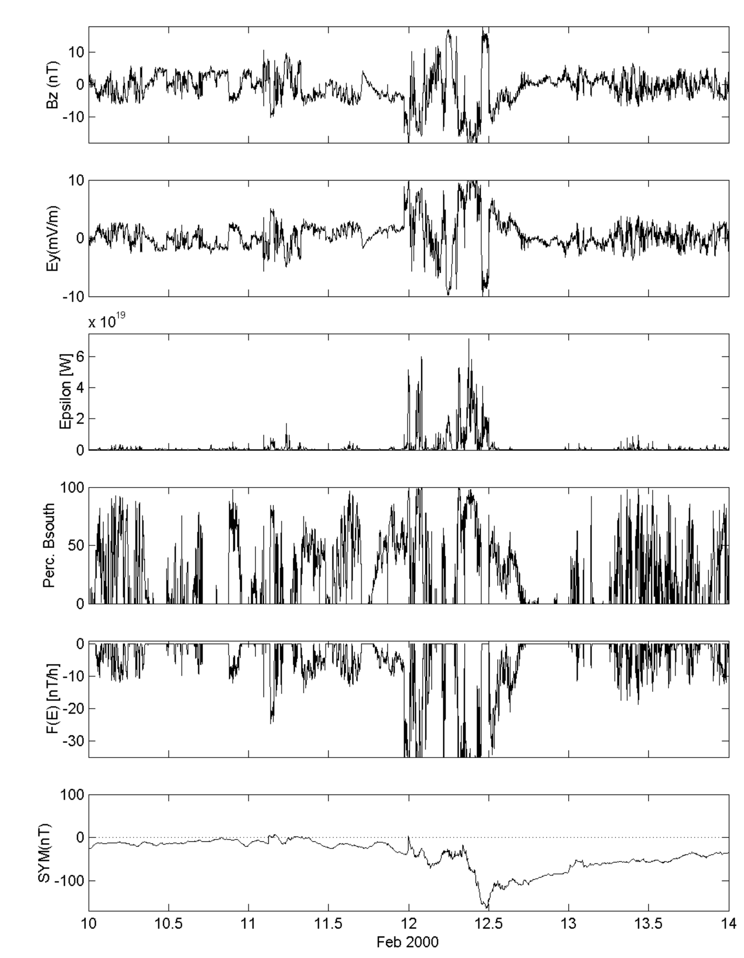


Plasma parameters, T_p, V_p, N_p, B, dynamical pressure P_{dym}, and SYM (in fraction of day, near the shocks)



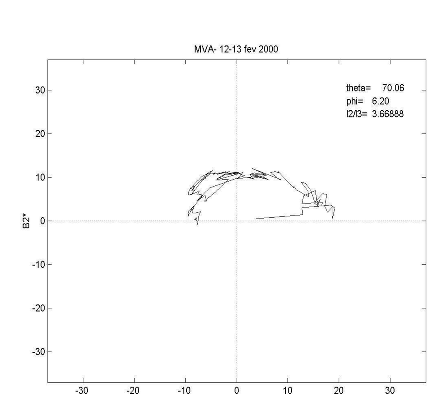
Minimum Variance Analysis
ICME
1600 UT 11 Feb
2000 UT 11 Feb
Inclination: 25°
Azimuth: 16°

Geoeffectiveness – February 2000



Pameters related with geoeffectiveness: South magnetic field component B_z, electric field E_y, ε parameter, percentage of B_z over B, energy injection function F(E), and SYM.

PARAMETERS	
02:00 FEBRUARY 11	23:00 February 11
M_A=2.0	M_A=2.8
U_s=560 km/s	U_s=560 km/s
n_{GSE}=(0.83, -0.51,-0.21)	n_{GSE}=(0.83, -0.51,-0.21)
θ_{Bn}=25° (quasi-//)	θ_{Bn}=88° (quasi-⊥)
r_n=2.6; r_B=1.8	r_n=4.0; r_B=2.7
SI=18 nT	SI = 45nT



Minimum Variance Analysis
ICME
1200 UT 12 Feb
0000 UT 13 Feb
Inclination: 70°
Azimuth: 6°

COMPARISON BETWEEN GEOEFFECTIVENESS PARAMETERS

PARAMETERS	APRIL 1999 (MC)	FEBRUARY 2000 (CE)
B_s peak	- 14 nT	- 16.4 nT
E_y peak	6 mV/m	9.5 mV/m
interval for B_s < -10 nT	5 hours	3 hours
(during B_s < -10 nT)	130 (mV/m) h	73 (mV/m) h
% of B_s peak	74 %	82 %
F(E) peak	-30 nT/h	-49 nT/h
$\varepsilon_{Akasofu}$	2.6×10^{19} W	7.2×10^{19} W
Dst peak	-91 nT	-133 nT

CONCLUSIONS AND ACKNOWLEDGEMENTS

Although the duration of an intense southward (less than -10 nT) magnetic field was smaller in the complex ejecta event (3 hours) than for the magnetic cloud (5 hours) the complex ejecta storm was more intense, because higher values of magnetic field and electric field (9.5 mV/m) were followed. The electric field integrated value was lower (73 mV/m h), confirming that lower values of this are needed in sheath fields than in magnetic clouds in order to cause intense storms, because the injection rate is higher (in this case, -49 nT/h for complex event against -30 nT/h for magnetic cloud). Also the total power dissipated in the magnetosphere was higher, 7.2×10^{19} W, a value 2.7 times higher for the complex ejecta than for the magnetic cloud event.

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