

Can we explain the low geo-effectiveness of the fast halo CMEs in 2002 with EUHFORIA?

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In 2002 (Cycle 23), Six halo CMEs related to six X-class flares, with velocities higher than 1000 km/s , and weak impact on the magnetosphere of the Earth has been reported.

(The registered Dst minima are all between -17 nT and -50 nT.) [Bocchialini et al 2018, Sol. Phys.](#)

A study of the Sun-Earth chain of phenomena related to these fast 6 halo CMEs reveals that two halo CMEs among them have, even a source close to the solar disk center.[Schmieder* et al.2020](#)

Why ? low Bz-component of the magnetic field? Geometry of the ICME, Solar Wind properties
TESTs with **EUHFORIA**

[\(Schmieder, Kim, Grison, Bocchialini, Kwon, Poedts, Démoulin 2020, JGR\)](#)

The 12 X-class flares and Halo CME

Here we work on two CMEs

No.	Flare			CME		
	Date/Time (UT)	X-ray class	Loc. ^a	AR NOAA	AW (°)	V _{CME} (km/s)
1	Apr-21 01:13	X1.5	S14W84	09906	360	2393
2	May-20 15:25	X2.1	S23E65	09961	140	553
3	Jul-03 02:10	X1.5	S20W51	10017	73	260
4	Jul-15 20:30	X3.0	N19W01	10030	360	1151
5	Jul-18 07:49	X1.8	N19W30	10030	360	1099
6	Jul-20 21:30	X3.3	S13E95	10039	360	1942
7	Jul-23 00:42	X4.8	S13E72	10039	360	2285
8	Aug-03 18:59	X1.0	S16W76	10039	138	1150
9	Aug-21 05:28	X1.0	S12W51	10069	66	268
10	Aug-24 00:49	X3.1	S02W81	10069	360	1913
11	Aug-30 12:47	X1.5	N15E74	10095	57	254
12	Oct-31 16:47	X1.2	–	–	26	160

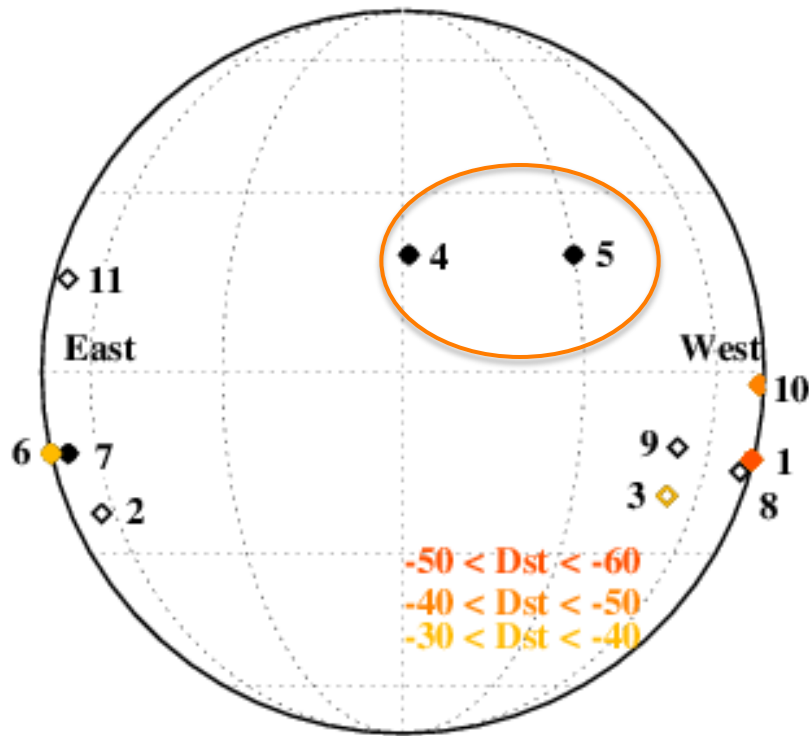
2 CMEs
with source
at the disk
center

[†] – : Backside event

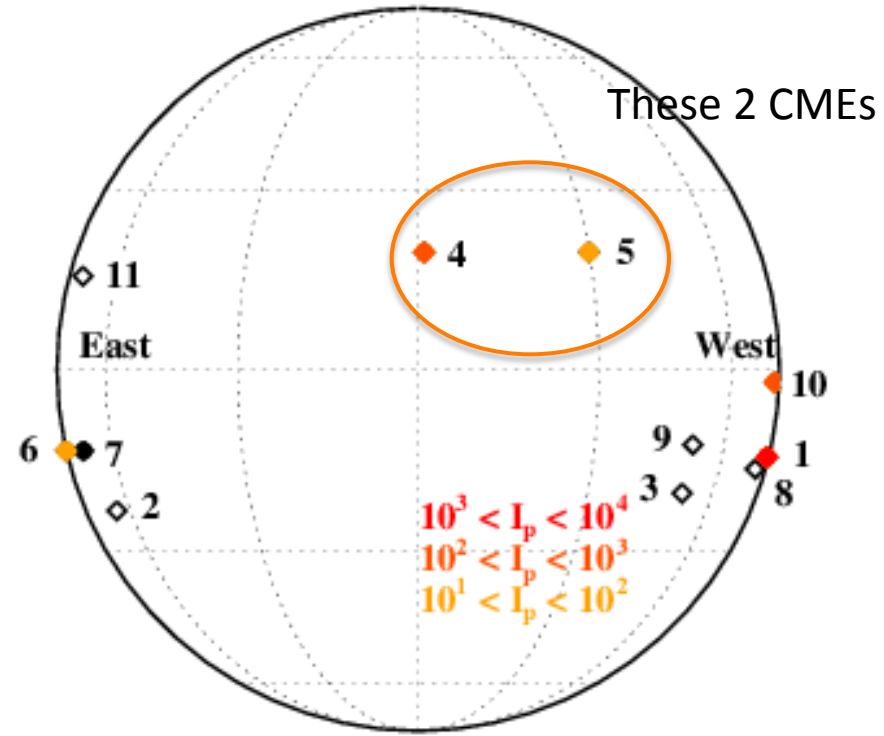
The 2 X flares with halo CME are related a weak Dst minimum : Why?

Relationship with the longitude

Preferential longitudes (Webb 2002, Lee et al 2014, Vasanth 2015) due the Parker spiral on the West. But SEP can go through the magnetic field lines (Podgorny 2018).



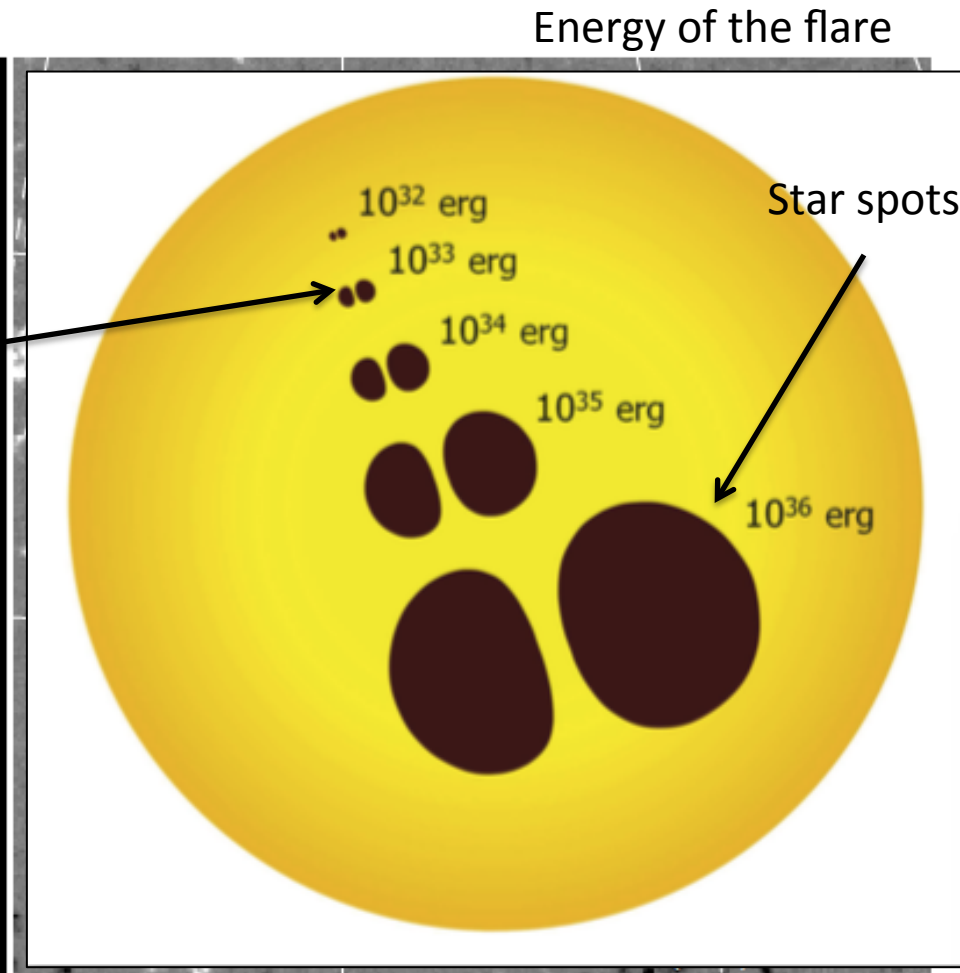
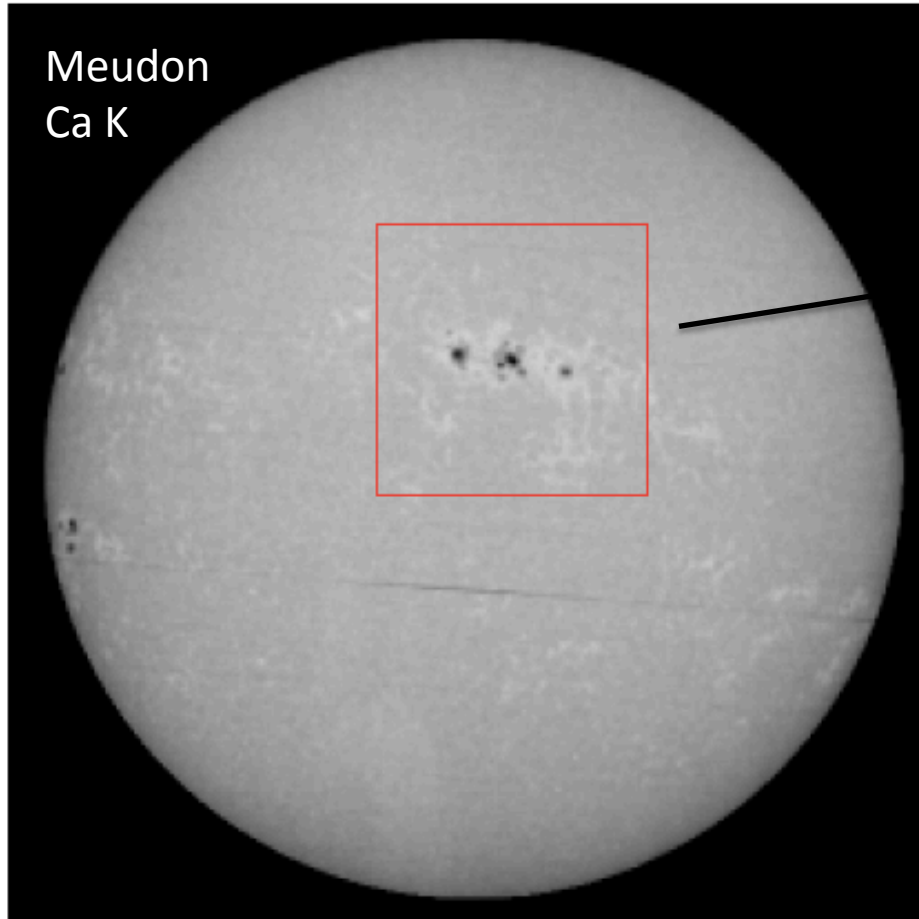
Dst moderate and weak



$I_p < 10^4$

There is NO relationship with the longitude, X class flares come from the limb in 2002 !

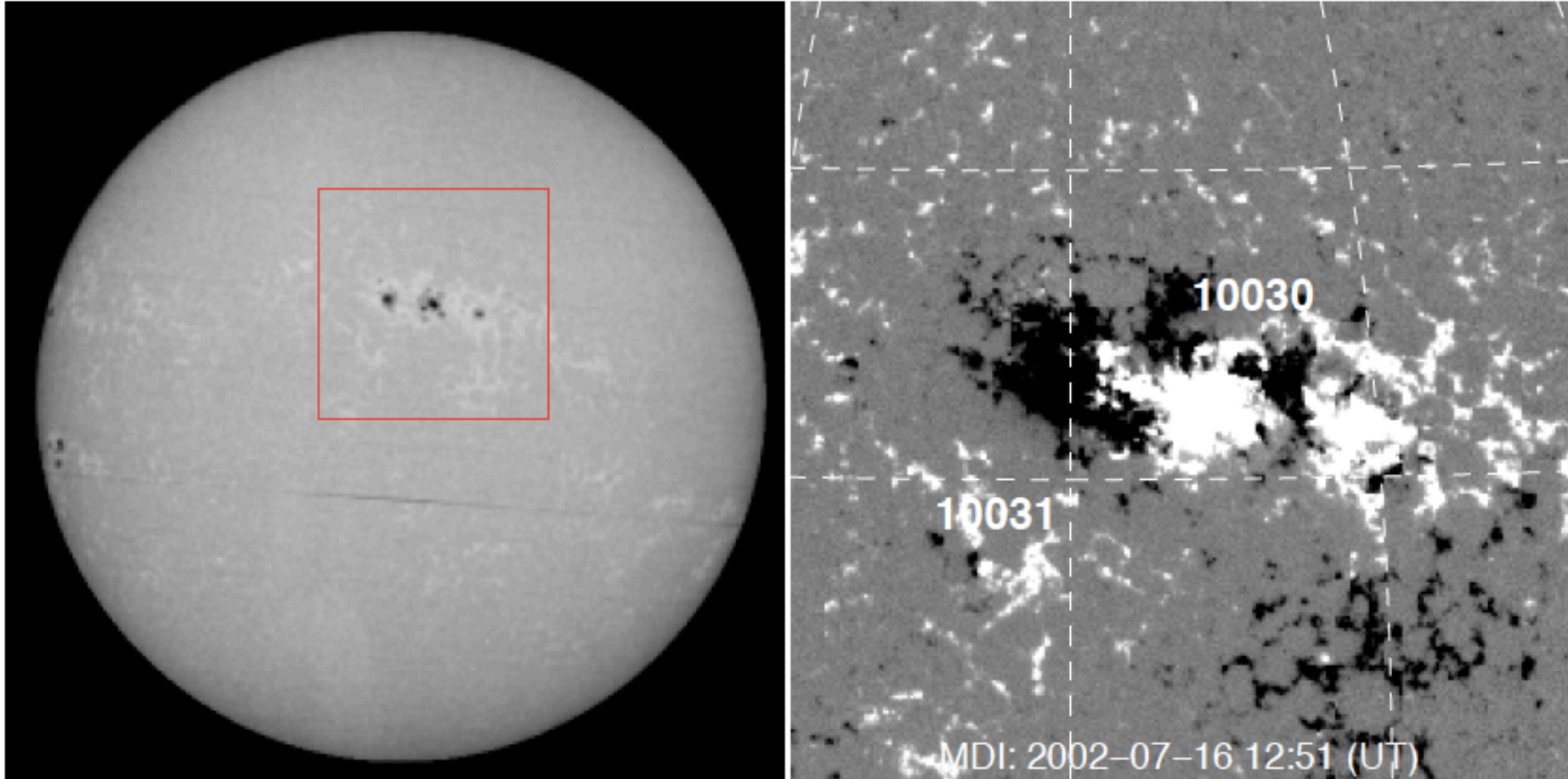
AR 10030 source of CMEs



Aulanier, Janvier, Schmieder 2003

« Syndrom of the big flare big CMEs but you need big stress »

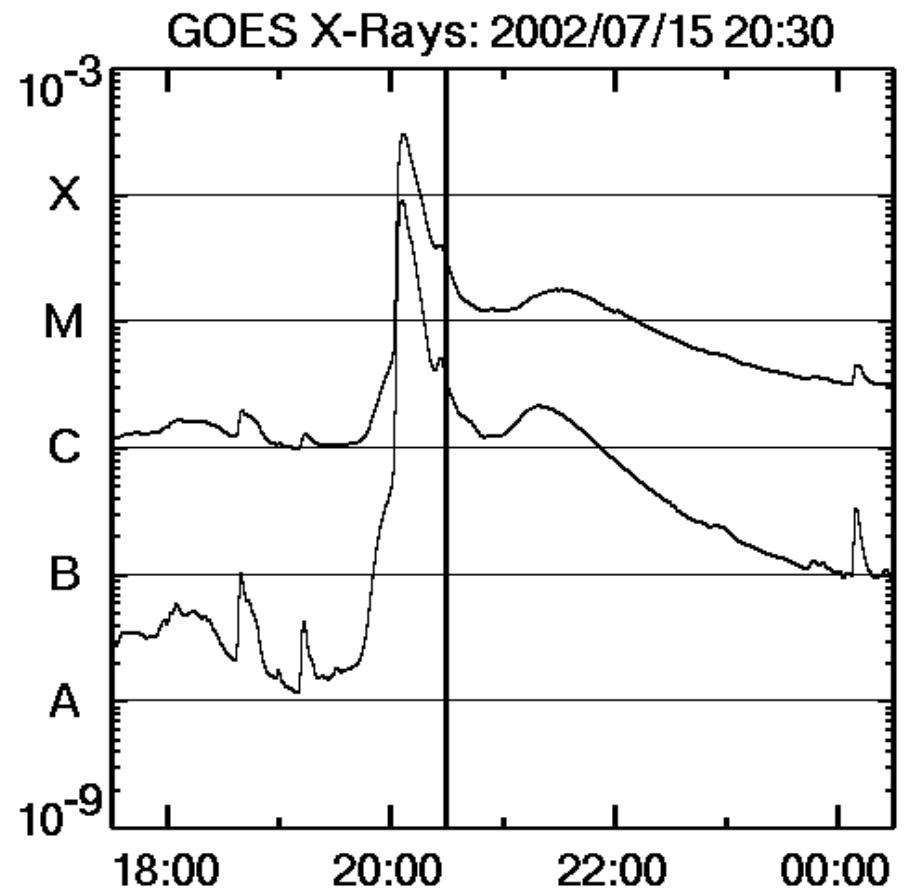
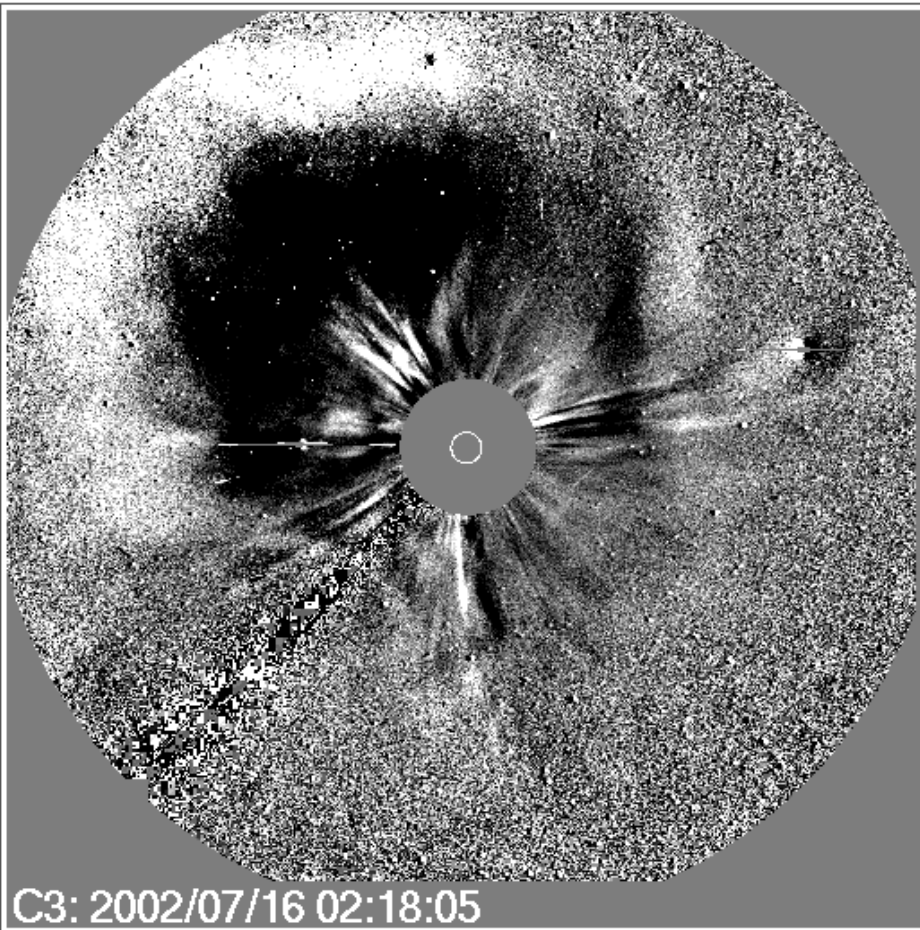
AR 10030 source of CMEs



Complex active region .. Big Stress

AR 10030

Source of the halo CME -15 July

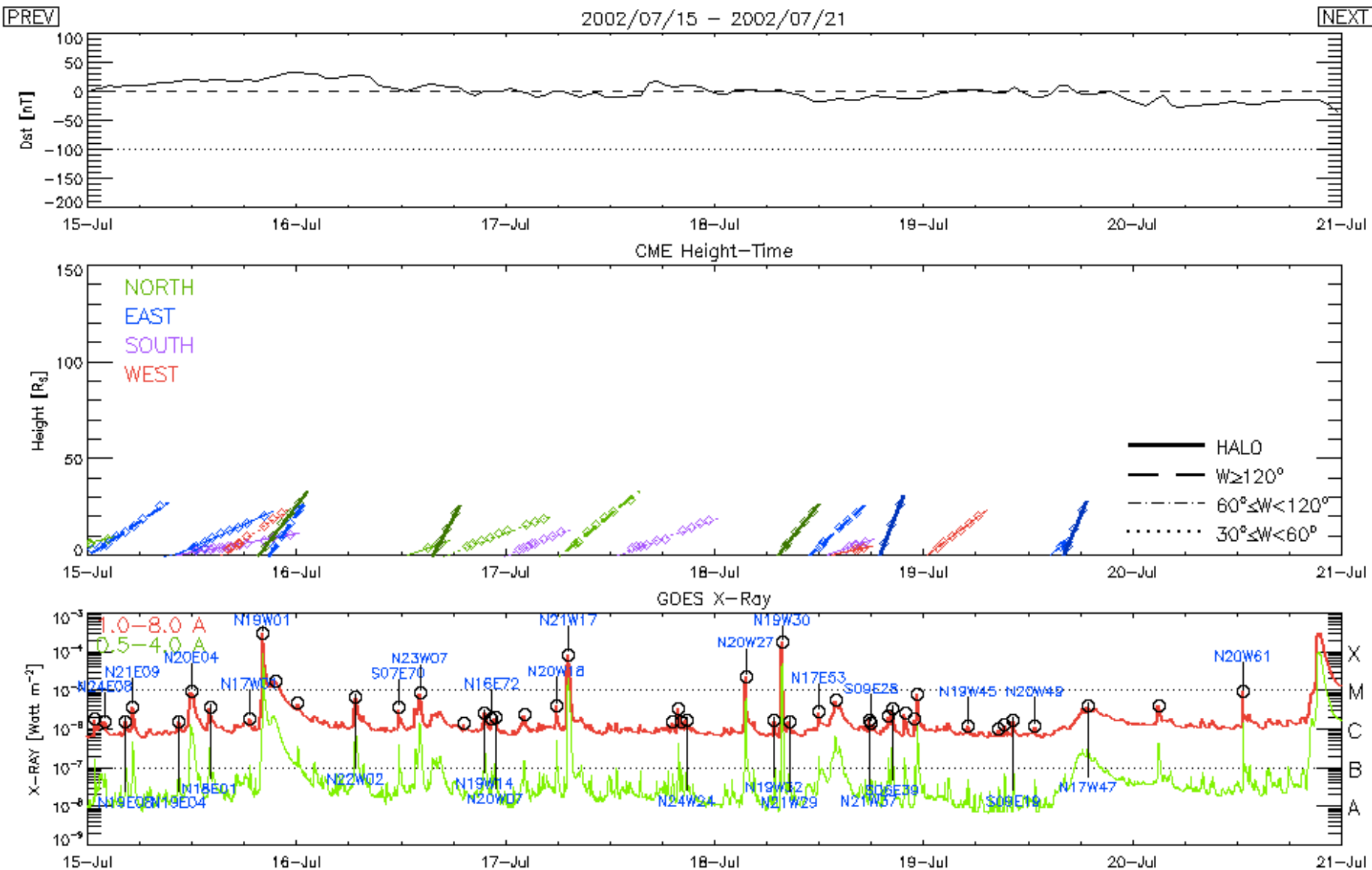


The geoeffectivity related to the 12 X-Class flares - ICME at L1

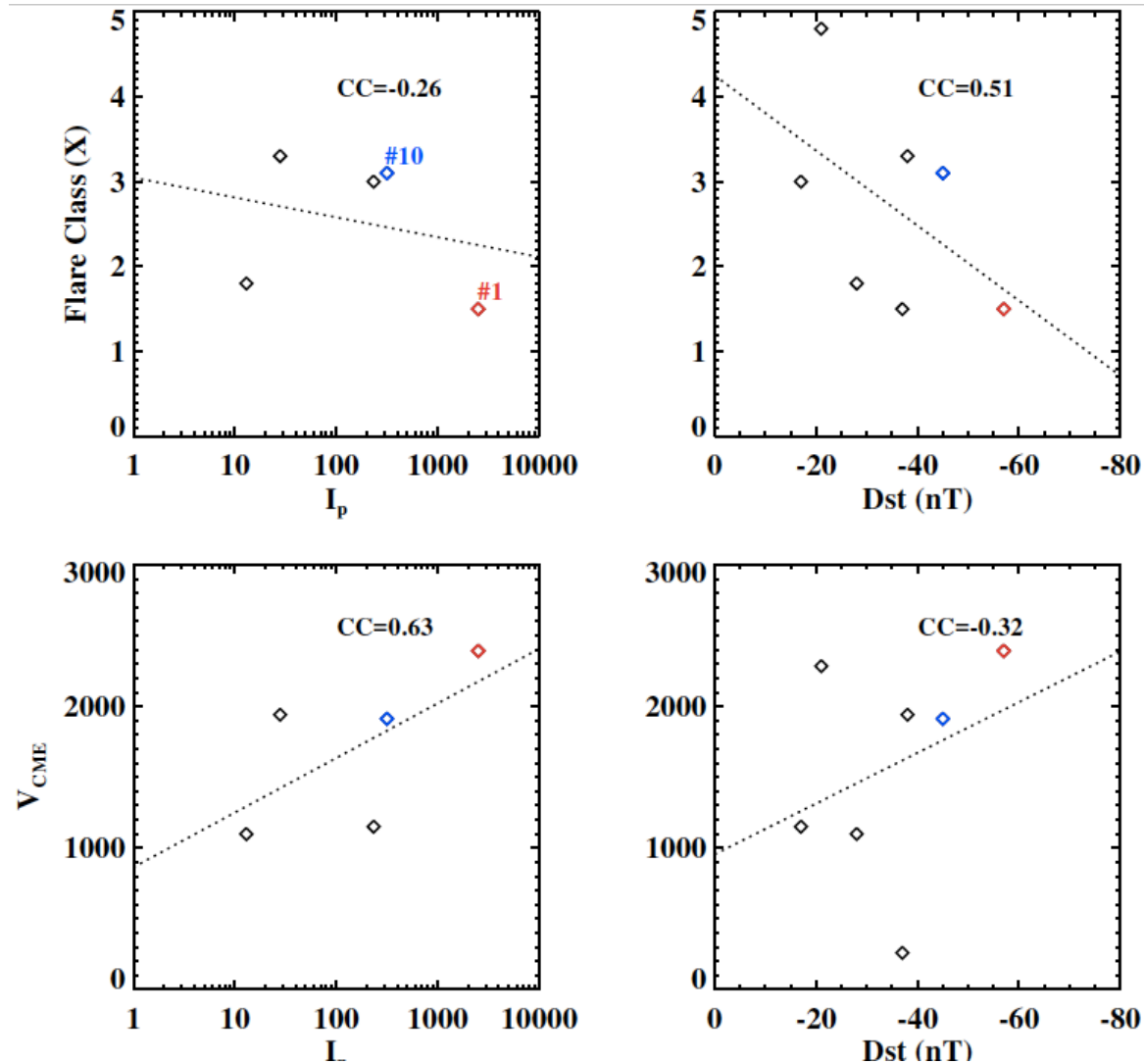
No.	SPE ^b			ICME at L1	Earth's Disturbances			
	Date/Time (UT)	I_p (pfu)	ΔT^c (min.)		SSC	PCP (kV)	Dst_{min} (nT)	Δt (day)
1	Apr-21 02:25	2520	1255	not clear	SSC11	85	-57	2.5
2	-	-	-	not clear	-	-	(-109)	-
3	-	-	-	not clear	-	-	-37	3.2
4	Jul-16 17:50	234	1330	ICME	SSC20	75	-17	2.75
5	Jul-19 10:50	13	265	ICME	SSC21	110	-28	2.90
6	Jul-22 06:55	28	1650	not clear	-	-	-38	1.5
7	-	-	-	not clear	-	-	-21	1.8
8	-	-	-	-	-	-	(-58)	1.5
9	-	-	-	-	-	-	(-20)	3.4
10	Aug-24 01:40	317	415	not clear	SSC26	90	-45	3.25
11	-	-	-	no	-	-	(-30)	2.75
12	-	-	-	no	-	-	(-73)	-

^b - :

July 15 2002 20:00 UT flare X3.0

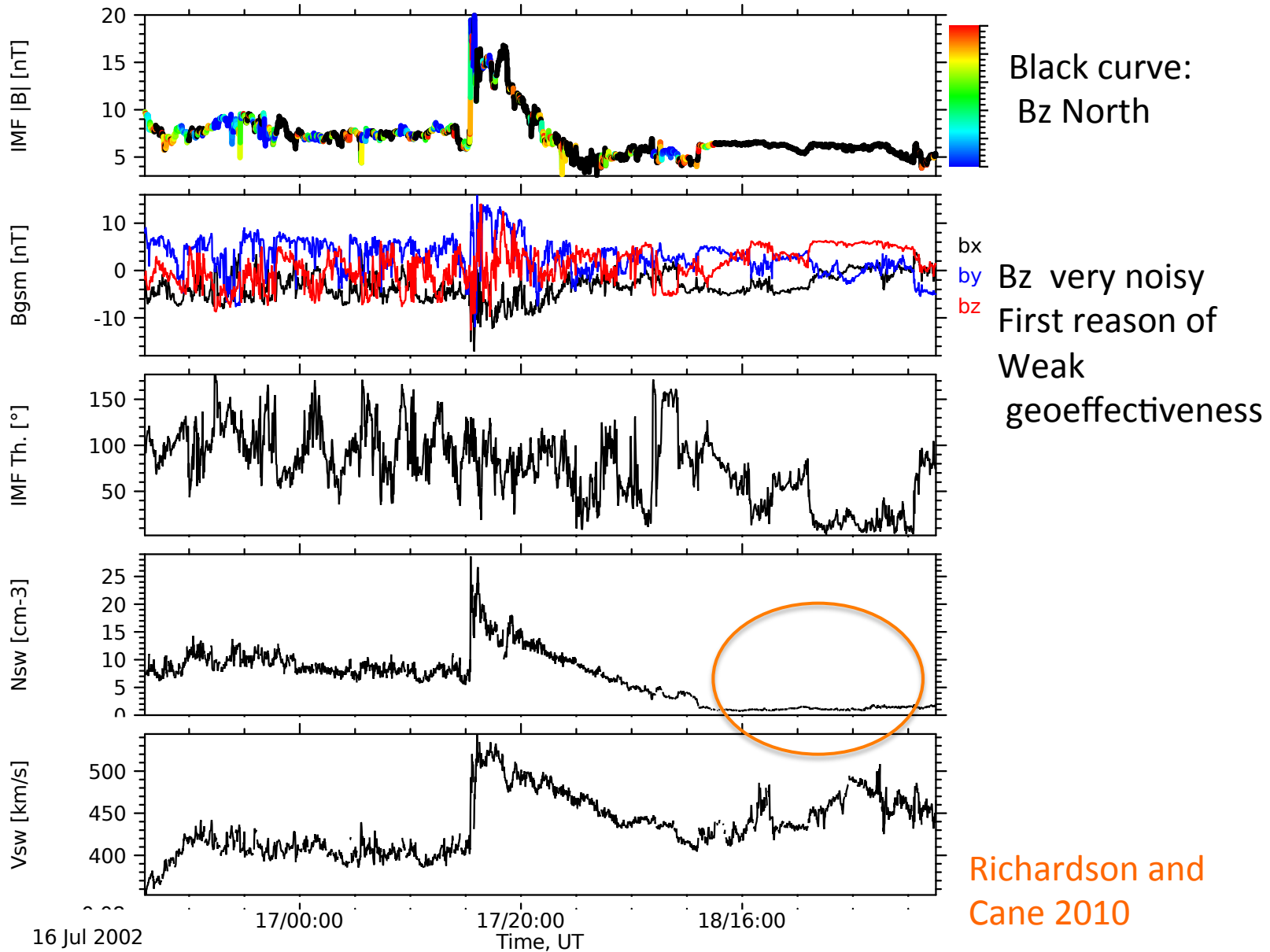


NO Relationship between flare CME and Dst and IP

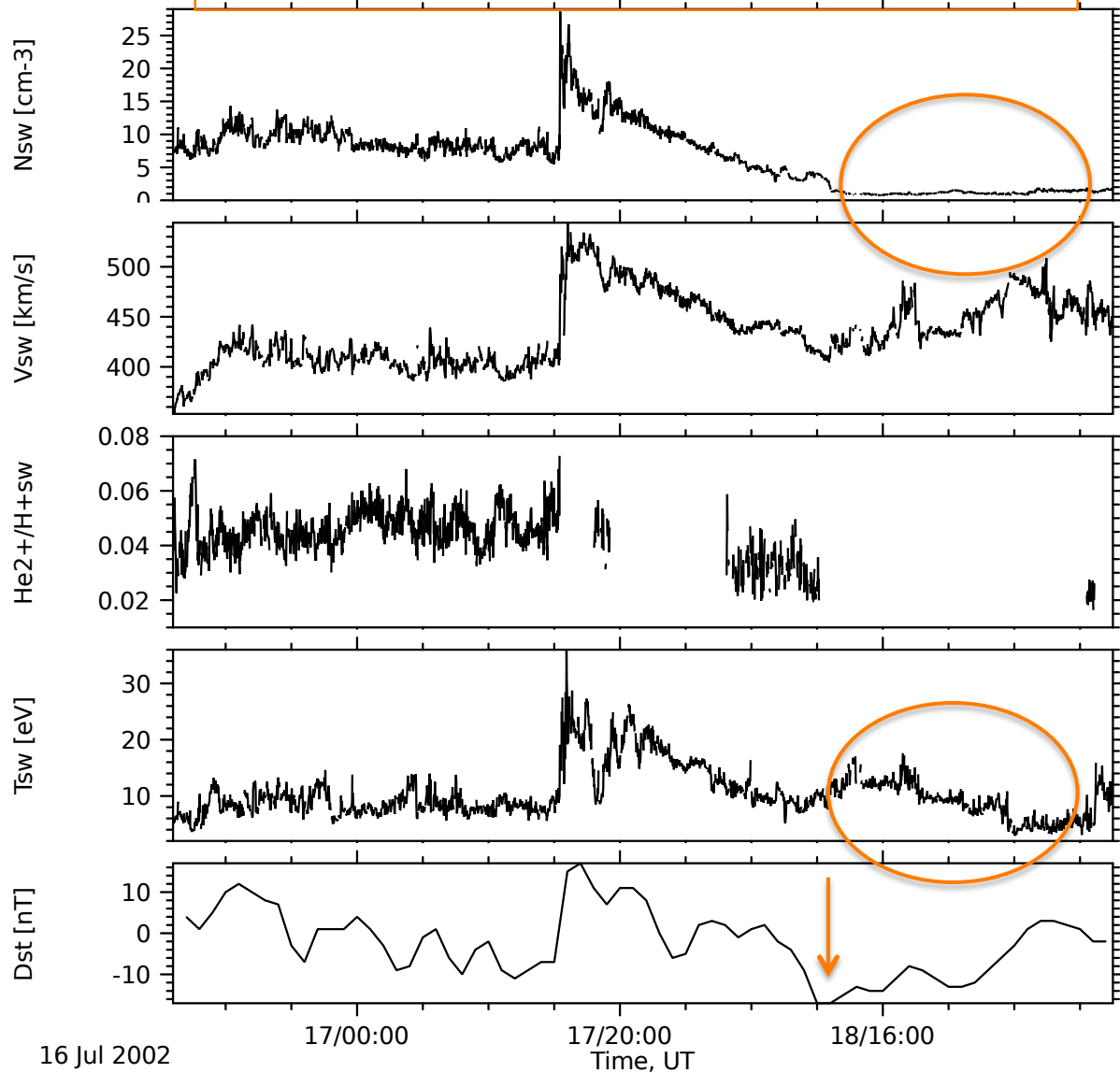


Too low number ?

Solar Wind and ICME of 17 July (CME 1: 15 July)



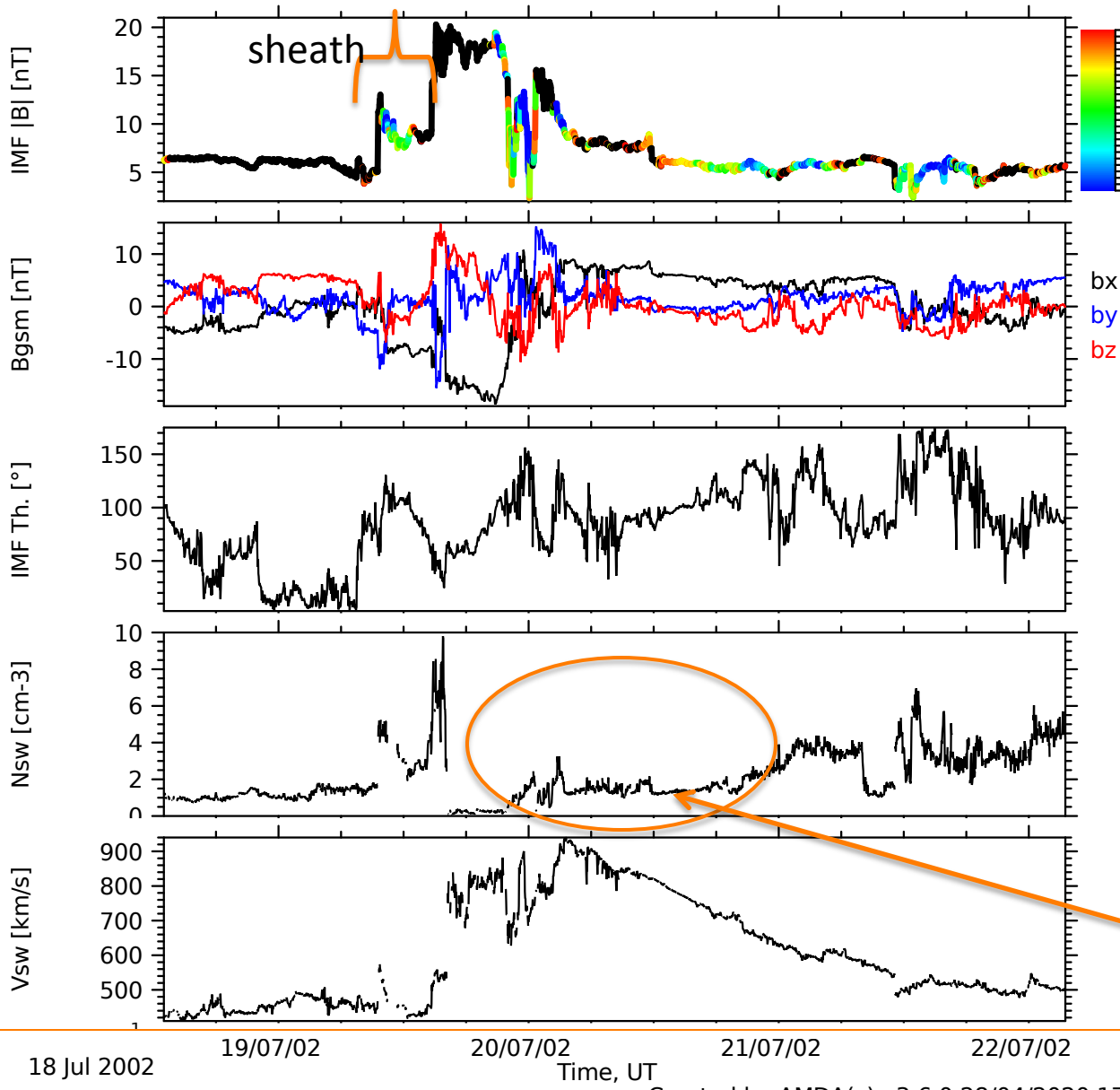
Solar Wind and ICME of 17 July (CME 15 July)



Why a so low Solar Wind?

The temperature Is increasing why? May be the flux rope is hot?

DST = -13 nT



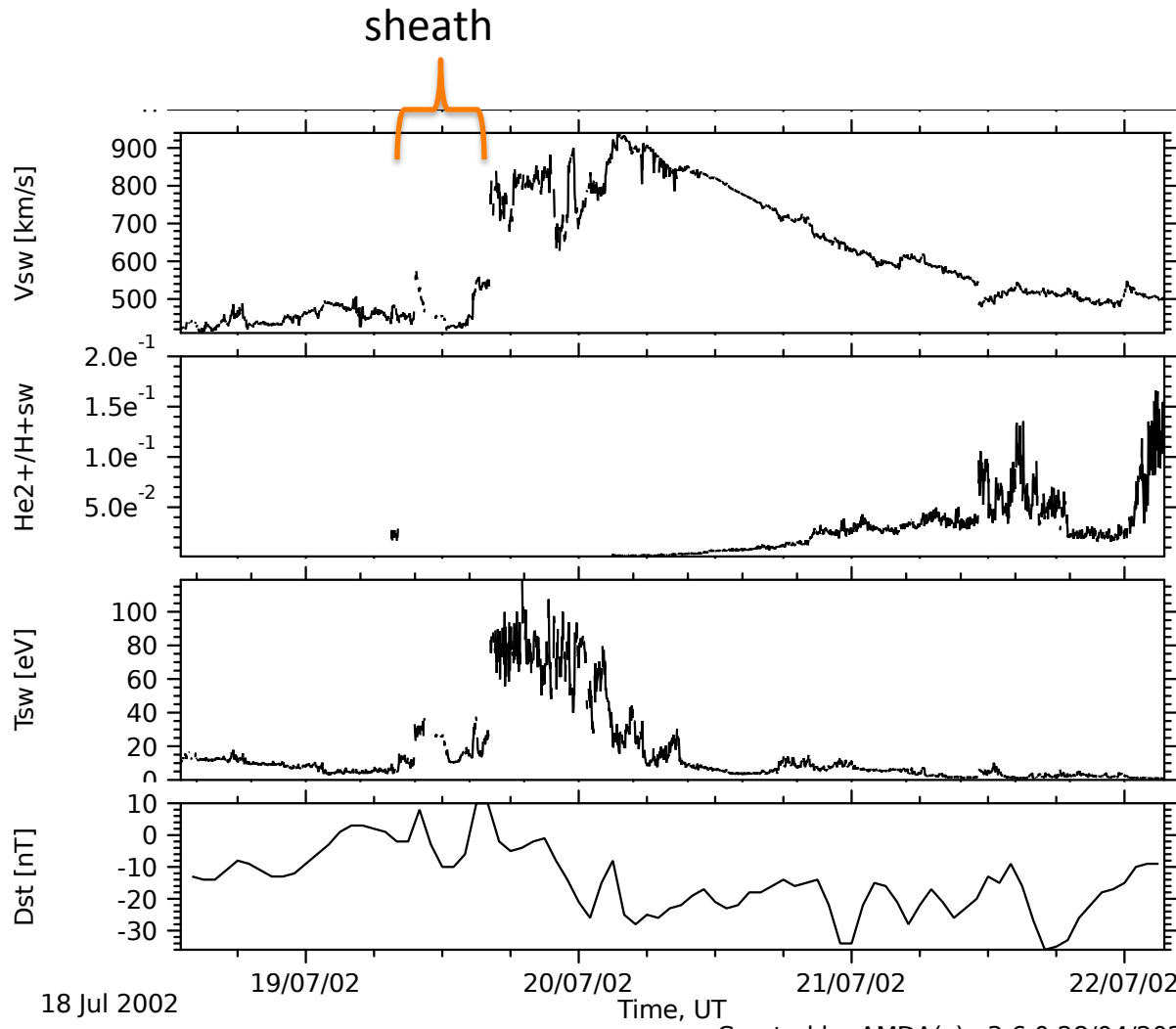
Second CME

CME 18 July

ICME 20 July

Dst = -28 nT

Low density ?



CME 18 July

ICME 20 July

Dst = -28 nT

Temperature
High because
Hot flux rope?
Like in
Dasso et al. JGR,
108, NO. A10, 1362

EUHFORIA

‘European heliospheric forecasting information asset’

Solar wind at @ 0.1 AU

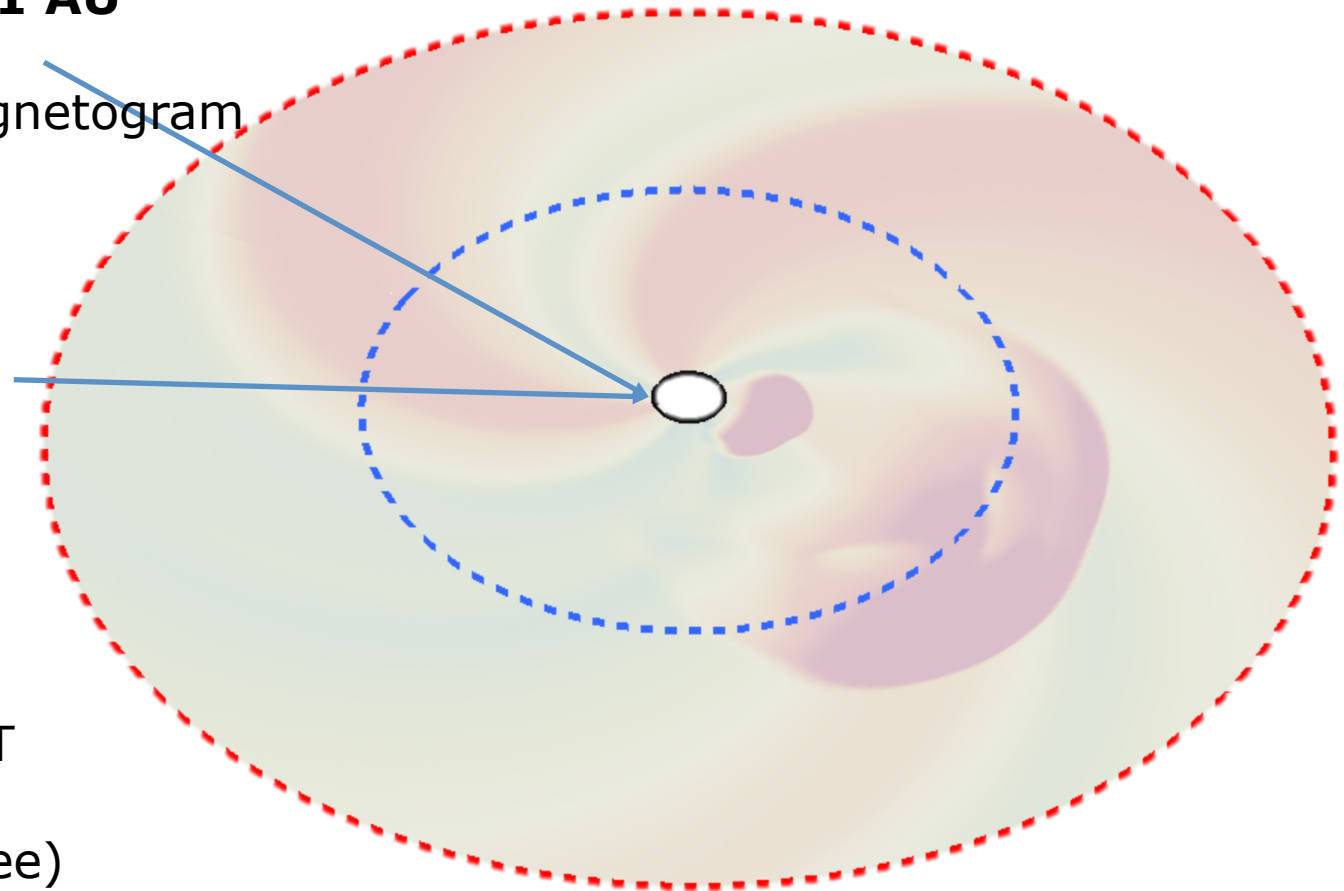
- Semi-empirical:
 - Gong/ADAPT magnetogram
 - PFSS
 - WSA/DCHB+CSC

CMEs at @ 0.1 AU

- Cone model
- Spheromak

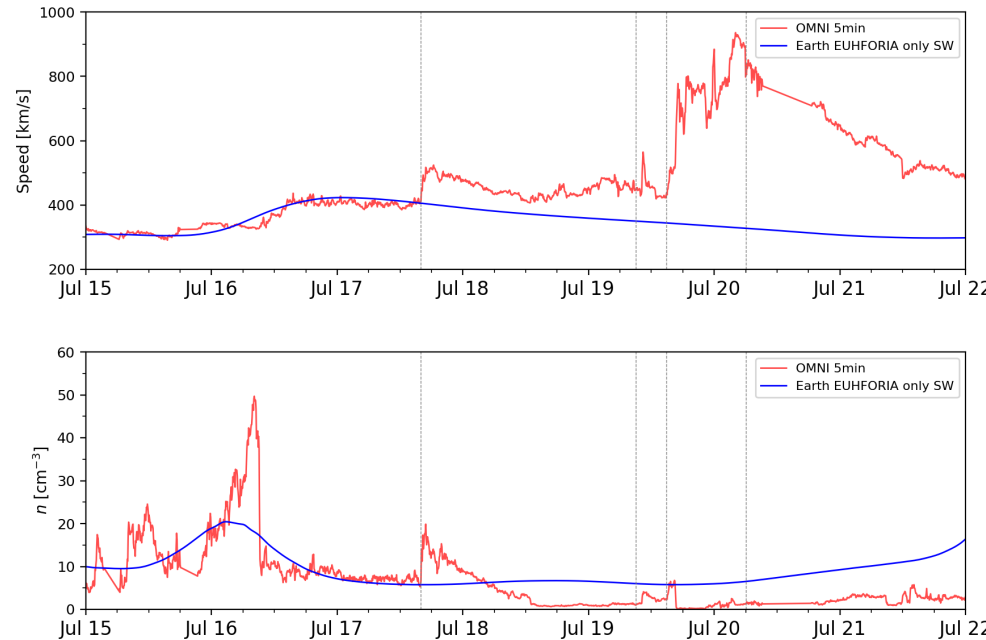
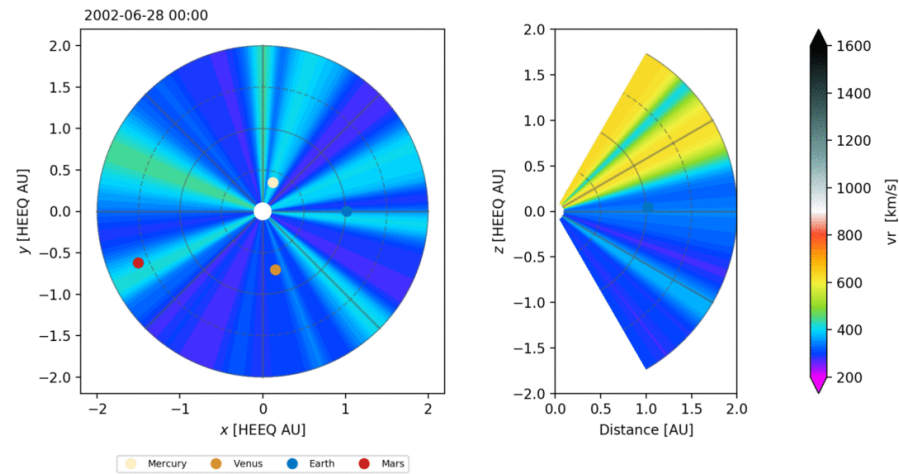
Inner Heliosphere

- 0.1 AU → 2.1 AU
- Time-dependent 3D MHD (FVM + CT approach for advancing **B** div-free)

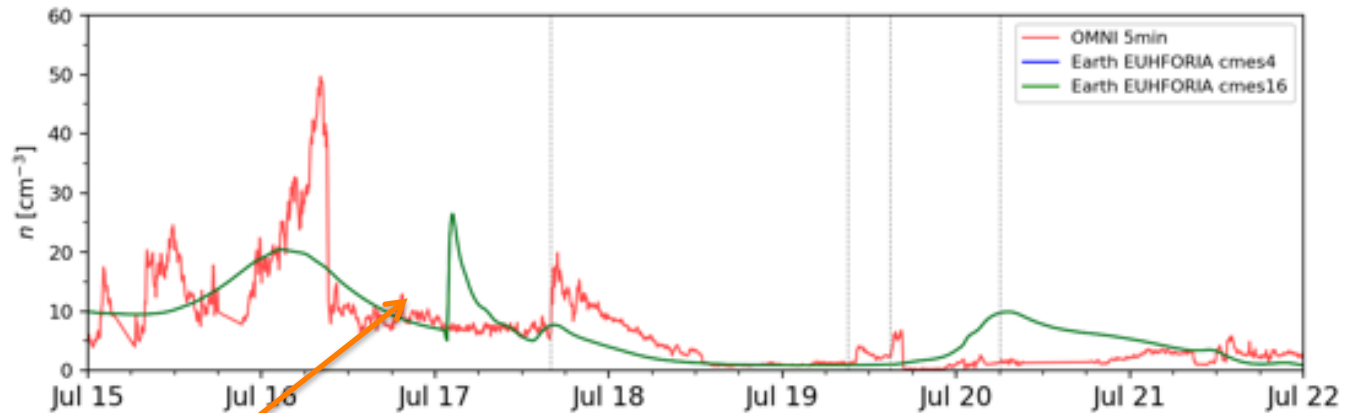


EUHFORIA modeling

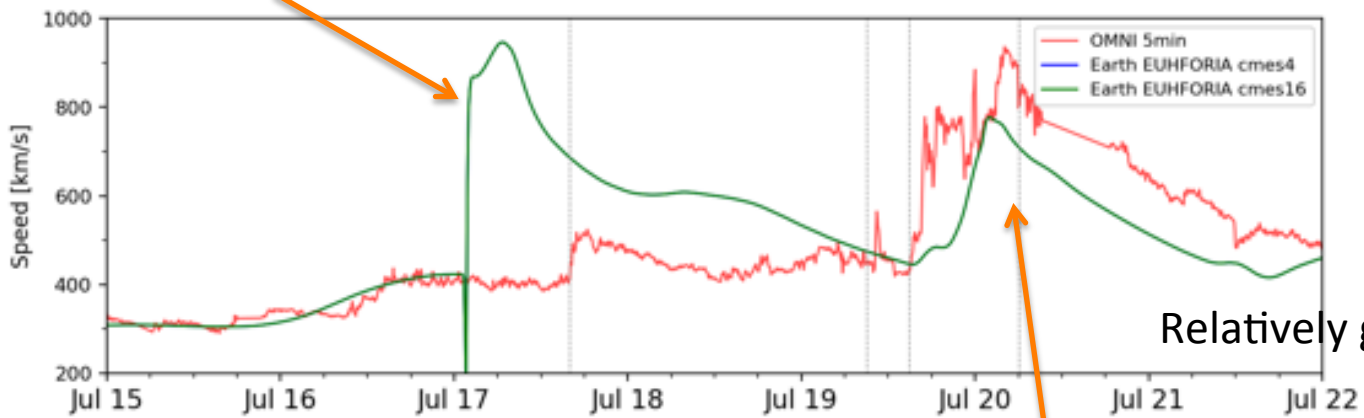
- Background solar wind: MWO CR1991 synoptic map
- CMEs launched on 15th and 18th of July
- ICMEs at 17th and 20th of July
- Results for the solar wind



First Run of Euhforia for the 2 CMEs



To high and too early



Relatively good

Project with EUHFORIA

- -
 - We performed a set of EUHFORIA simulations in an attempt to explain the low observed Dst and the observed magnetic fields.
 - We will study the degree of deviation of these halo CMEs from the Sun-Earth axis ~~and~~ as well as their deformation and erosion due to their interaction with the ambient solar wind (resulting in magnetic reconnections) according to the input of parameters and their chance to hit other planets.
 - The inhomogeneous nature of the solar wind and encounters are also important parameters influencing the impact of CMEs on planetary magnetospheres.

Conclusion

1 We analysed the causes of weak geo-effectiveness (Dst, SEP) of the 12 X-class flares. by analysis of the chain of events: (flare, CME, L1, SEP, and ground-based indices in a previous paper ([Schmieder et al 2020*](#)))

2 All the good proxies to forecast an intense geo-effective storm do not work in 2002. The X-class flares with fast halo CMEs are related only to weak geomagnetic disturbances

3 We need to understand why halo CMEs with high velocities > 1000 km/s are related to only weak geo-effectiveness.

4 Tests with EUHFORIA

--Role of interaction with other ICMEs

--- Deflection of the ICME

---Asymmetry N/S

--- $B^*z < 0$ during a too short time