Specific role of sheaths in generation of magnetic storms

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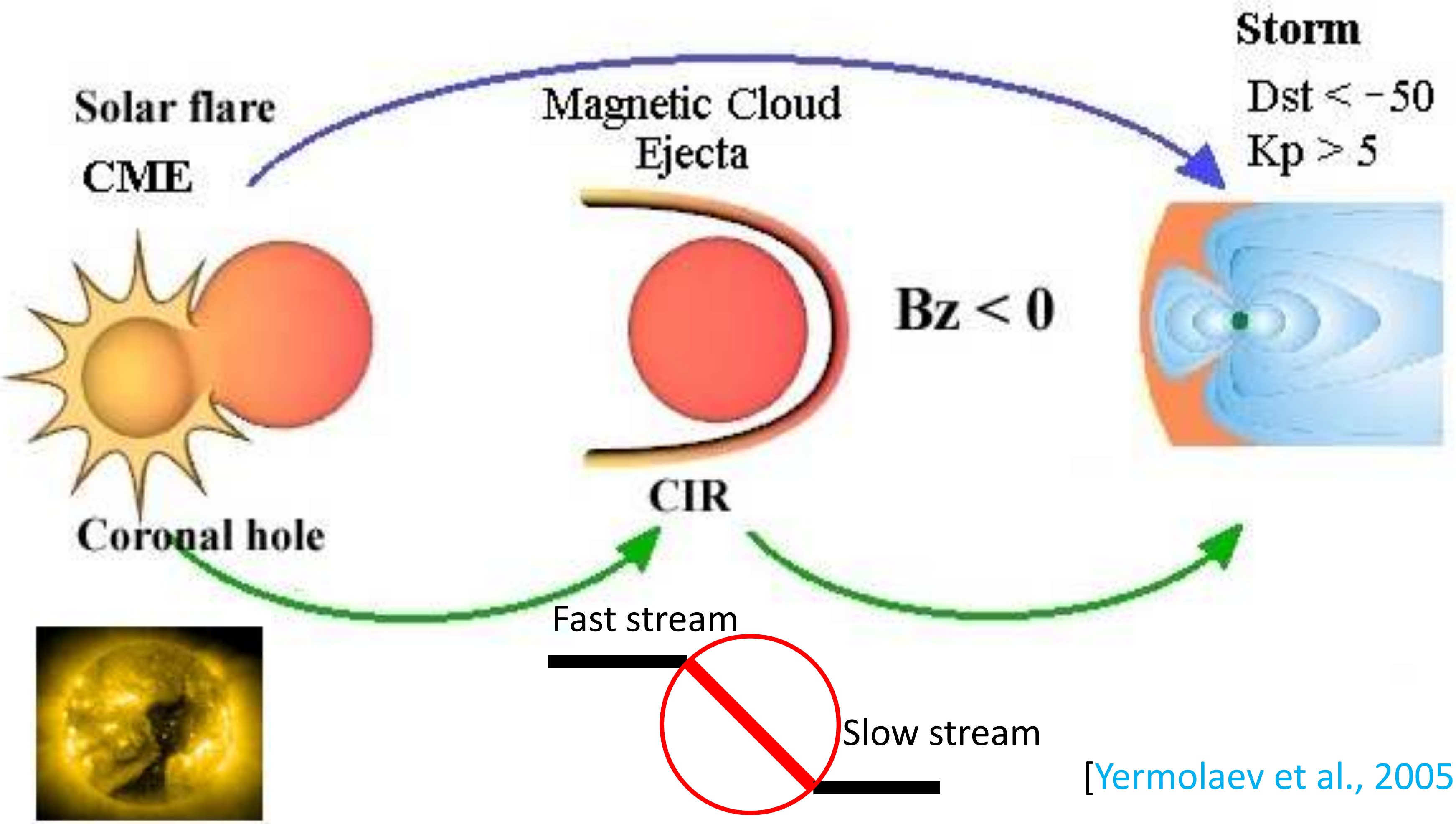
Introduction

- Interplanetary source of magnetic storms is southward IMF ($B_z < 0$) component (*Russell et al., 1974, Burton et al., 1975; Akasofu, 1981*)
- Non-disturbed solar wind contains IMF which lies in ecliptic plane => $B_z = 0$!
- Only disturbed types of solar wind may be geoeffective.
- 2 scenarios of generation of $B_z < 0$ component:

1) CME => MC/Ejecta + Sheath => $B_z < 0$ => Storm

2) Coronal hole => CIR => $B_z < 0$ => Storm

General concept of storm effectiveness of solar and interplanetary events



[Yermolaev et al., 2005]

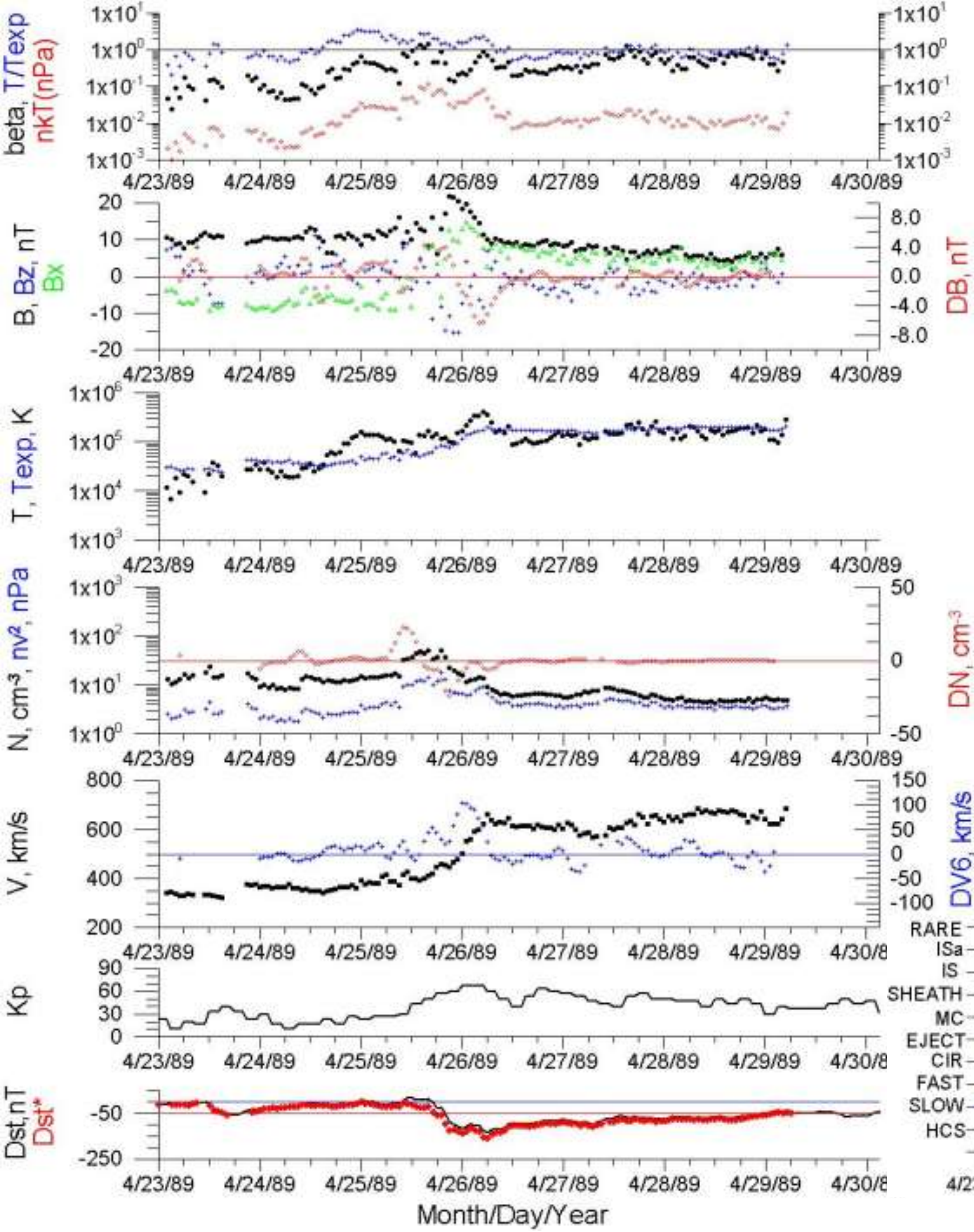
Motivation of the study

In the literature there are works indicating the dependence of magnetosphere reaction on the types of the SW streams [Borovsky and Denton, 2006; Pulkkinen at al., 2007; Yermolaev et al., 2007; Plotnikov and Barkova, 2007; Longden et al., 2008; Turner et al., 2009; Guo et al., 2011; Nikolaeva et al., 2013, 2014, 2015; Yermolaev et al., 2010, 2014, 2015, 2018; Dremukhina et al. 2018]

Coefficients CE (and CE*) of linear relation between Dst (and Dst*) and integral of interplanetary electric field Ey = Vx Bz
(Nikolaeva et al., 2013, 2015)

Efficiency of compression regions Sheath in generation of magnetic storms is ~ 50% higher than ICME.

SW type	MC	Sheath	CIR	Ejecta
CE (for Dst)	–2.55 ± 0.75	–3.2 ± 1.6	–2.8 ± 1.1	–2.3 ± 1.0
CE* (for Dst*)	–2.0 ± 1.1	–3.4 ± 1.9	–3.0 ± 1.5	–2.1 ± 1.1

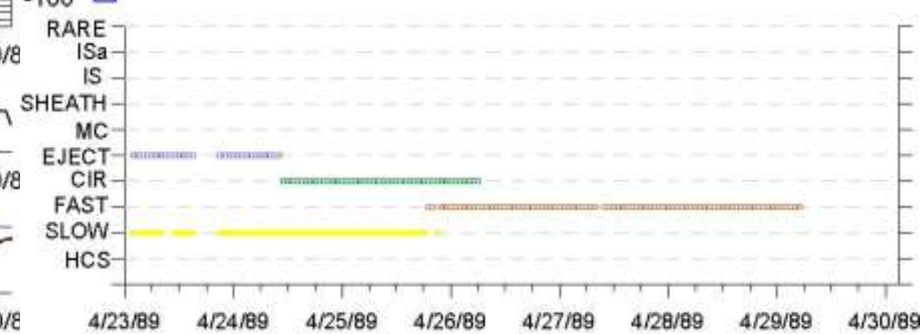


Catalog of solar wind phenomena

(Yermolaev et al., 2009)

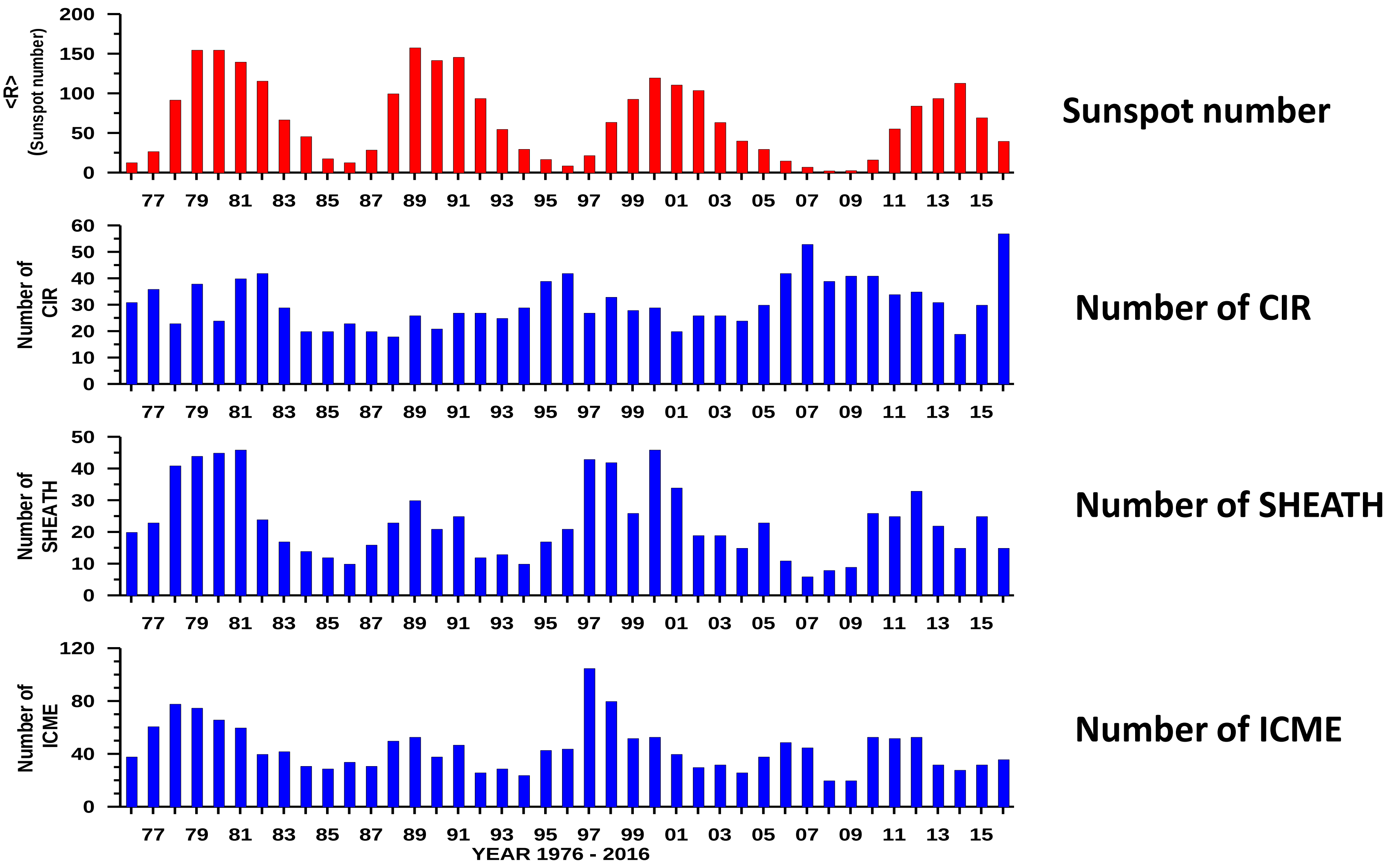
Example of OMNI
data and calculated parameters
in our database
ftp://ftp.iki.rssi.ru/pub/omni
(← left)

and identification of solar wind
types for **1976-2017**
ftp://ftp.iki.rssi.ru/pub/omni/catalog/
(↓ bottom)



Yearly number of different types of solar wind phenomena (1976-2016)

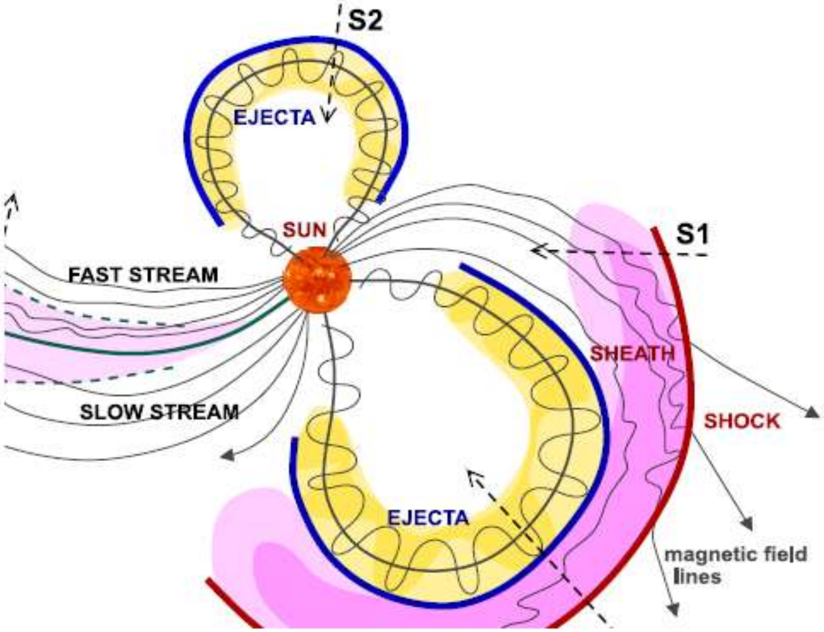
ftp://ftp.iki.rssi.ru/pub/omni



SW types and interaction between them

We separately analyze the following sequences of the phenomena (Yermolaev et al., 2015):

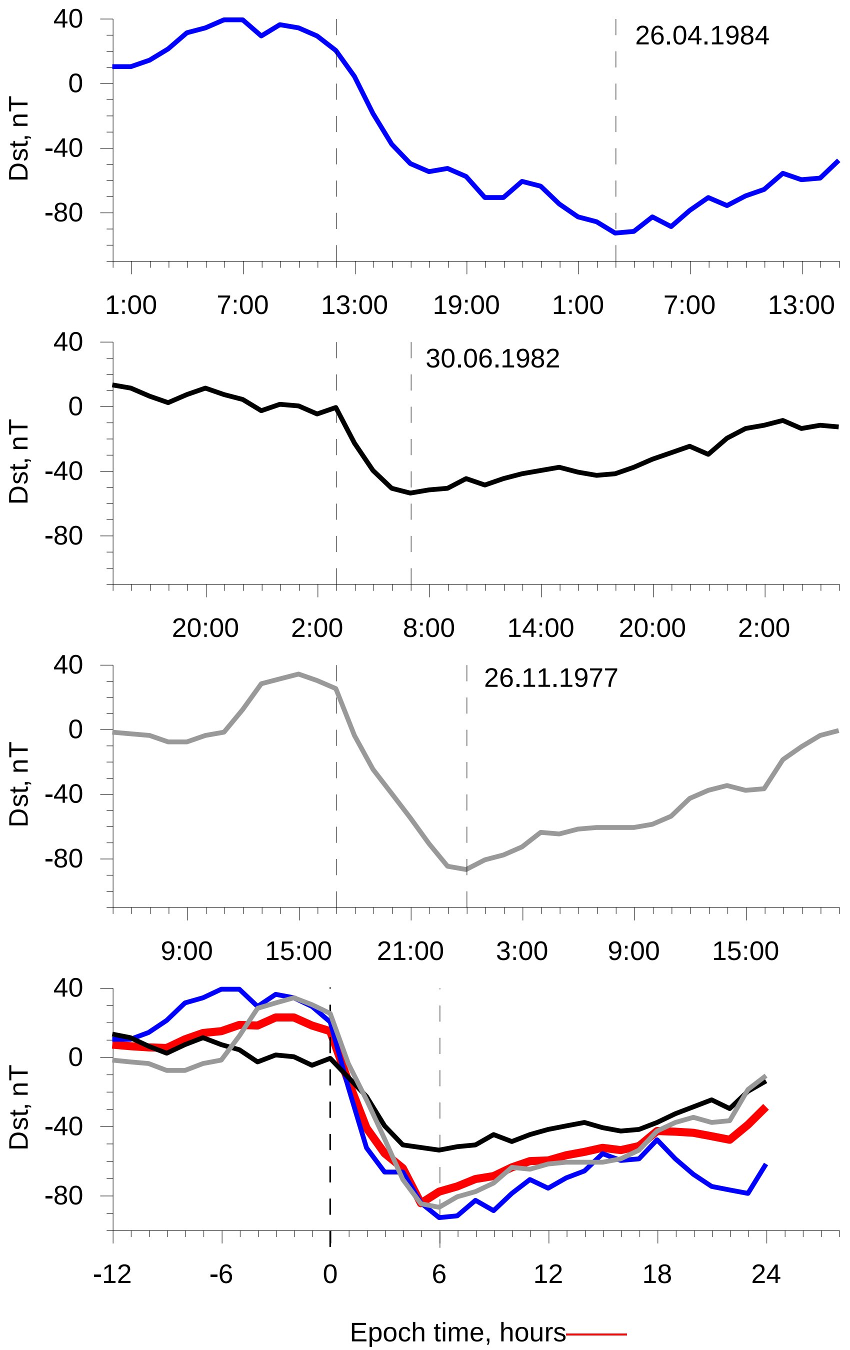
(1) SW/CIR/SW,
(2) SW/IS/CIR/SW,
(3) SW/Ejecta/SW,
(4) SW/Sheath/Ejecta/SW,
(5) SW/IS/Sheath/Ejecta/SW,
(6) SW/MC/SW,
(7) SW/Sheath/MC/SW, and
(8) SW/IS/Sheath/MC/SW



Several cases are shown in Figure from Kilpua et al., 2015

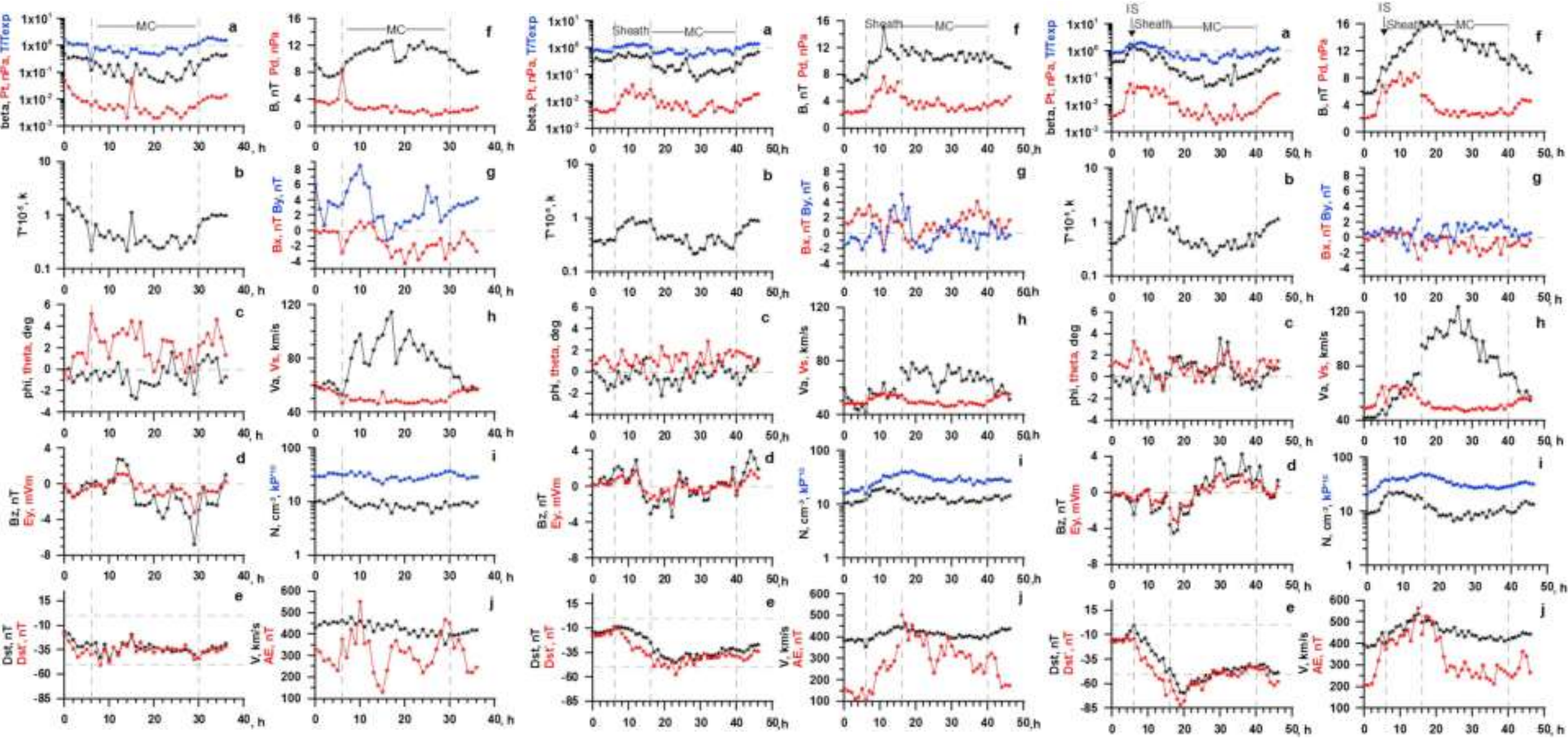
Method

- To take into account the different durations of SW types, we use the double superposed epoch analysis (DSEA) method: rescaling the duration of the interval for all types in such a manner that, respectively, beginning and end for all intervals of selected type coincide.



Yermolaev et al., AnnGeoPhys. 2010

Magnetic Cloud



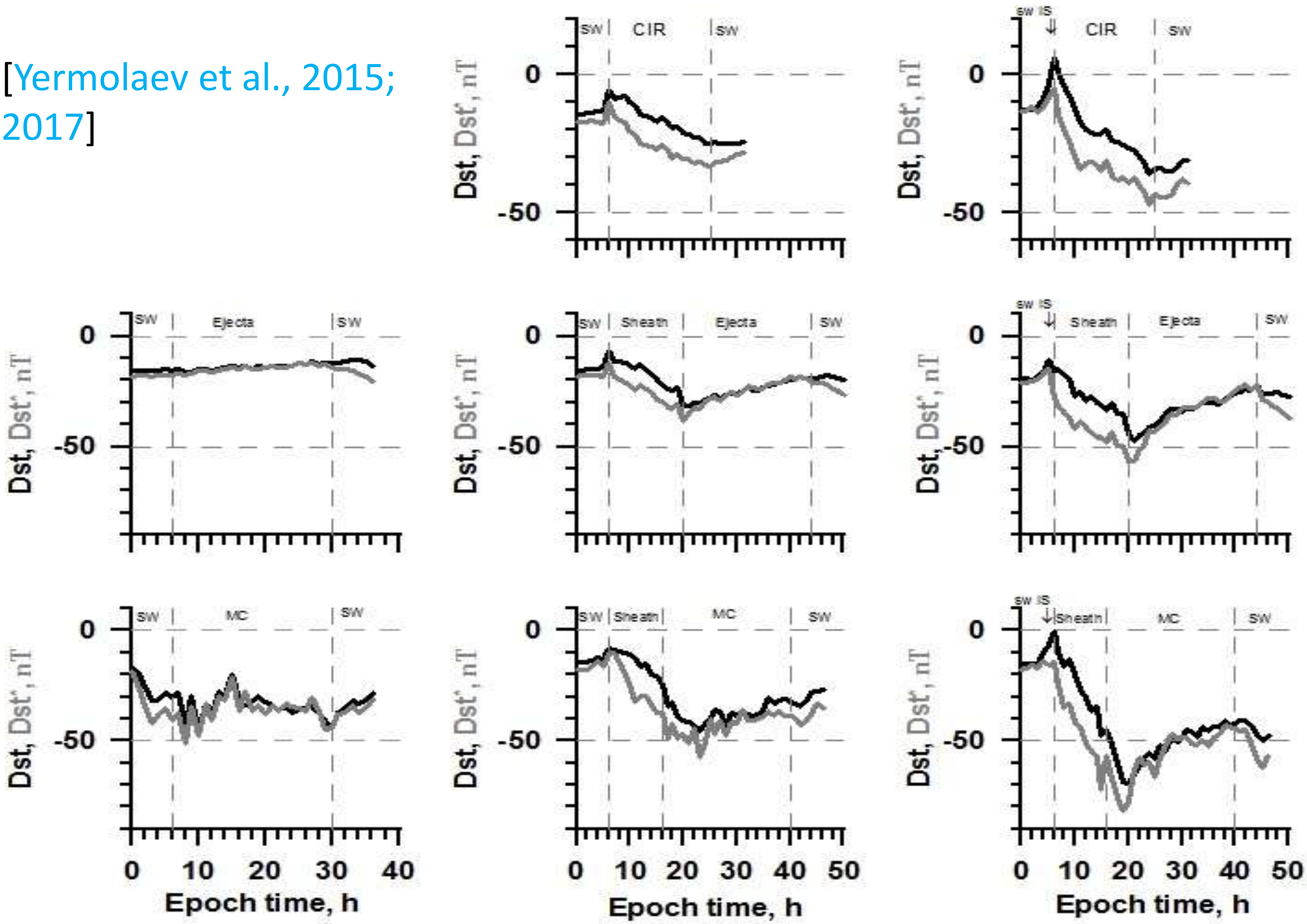
MC

Sheath + MC

IS + Sheath + MC

Average behavior of Dst (black) and Dst*(gray) indices

[Yermolaev et al., 2015; 2017]

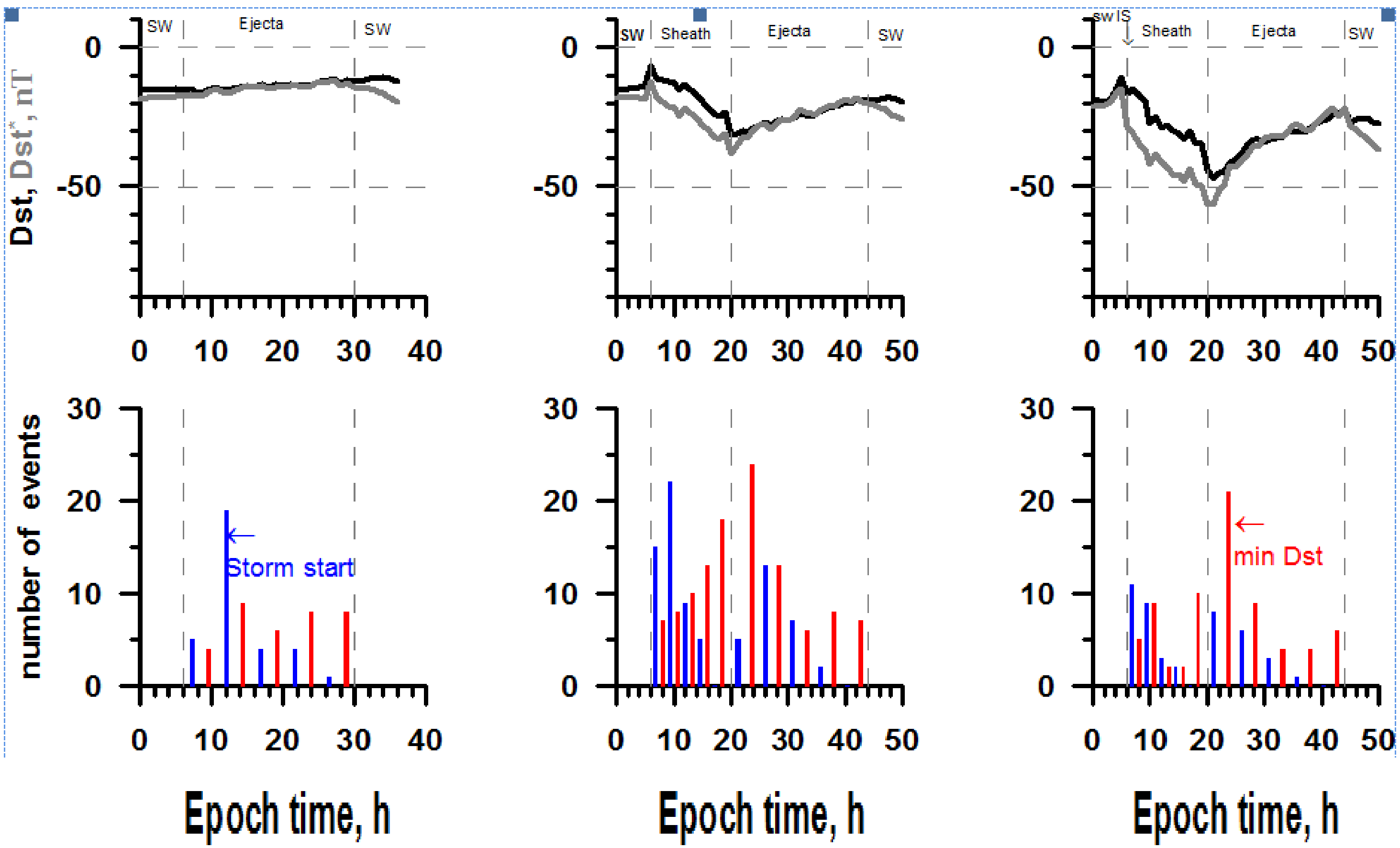


CIR

Ejecta

MC

Average behavior of Dst and Dst* indices and time distributions of storm start and min Dst



Ejecta

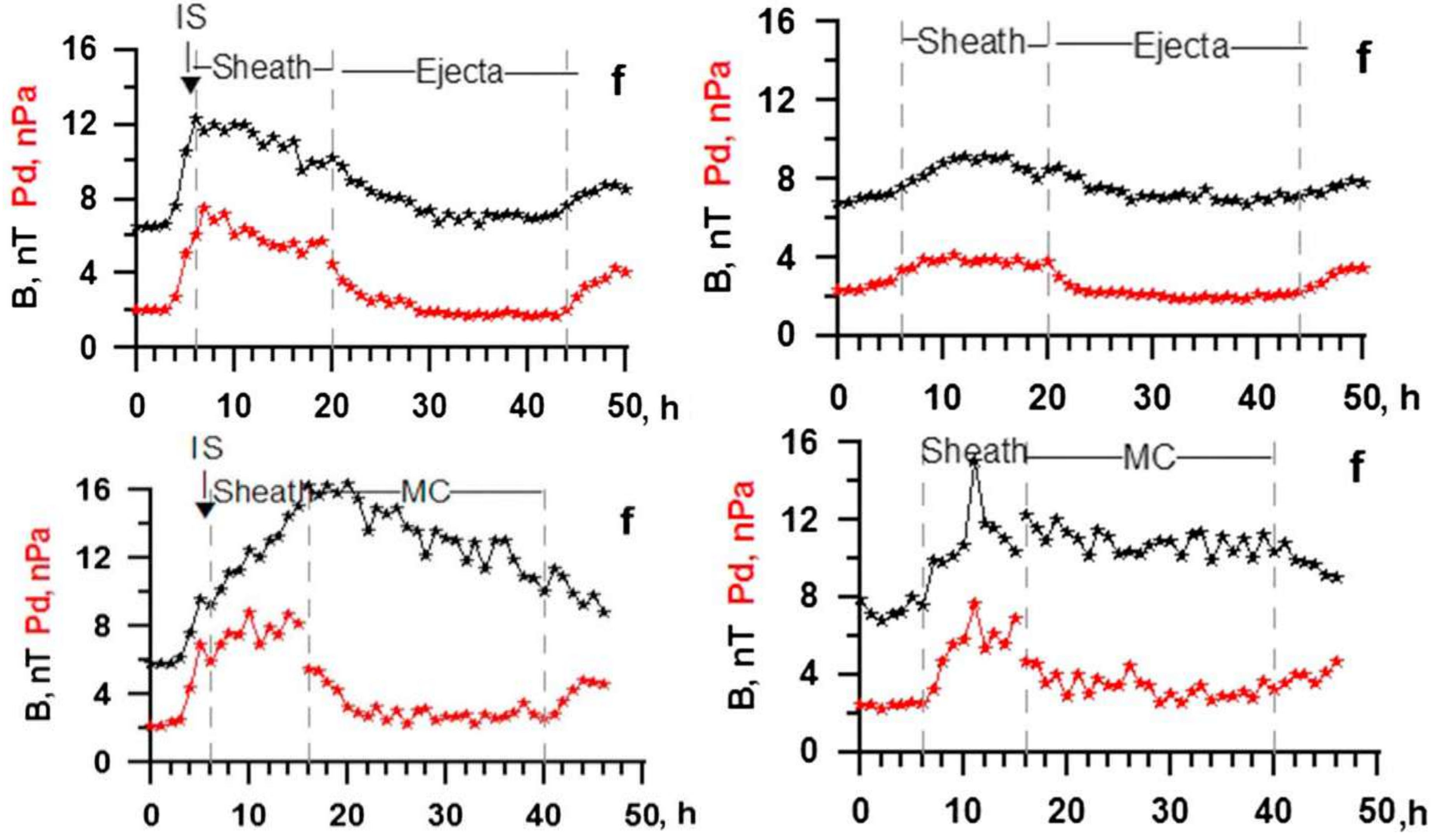
Sheath + Ejecta

IS + Sheath +Ejecta

(Yermolaev et al., 2015; 2017)

Average magnetic field in Sheath is higher than in Ejecta and close to MC

(Yermolaev et al., 2015)



Conclusions

Our study of OMNI data allowed us to make the following conclusions:

- **The generation of magnetic storms depends on type of solar wind stream.**
- **Sheath can contain value of magnetic field that is larger than in ICME** [Yermolaev et al., 2018]
- **Sheath is more geoeffective (higher "output/input" ratio) than ICME** [Nikolaeva et al., 2013, 2014, 2015; Dremukhina et al. 2018].
- **Most part of so-called "CME-induced" storms is really "Sheath-induced" storms** [Yermolaev et al., 2018]**.**

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