The influence of interplanetary conditions on geomagnetic storm development

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Aims of the work

- Investigation of main phase development of magnetic storms driven by different solar wind structures and possible influence of the dynamic pressure and the level of IMF fluctuations on their evolution.
- An estimation of thresholds when *Dst* index achieves levels of moderate *Dst*≤-50 nT and strong *Dst*≤-100 nT storms in depending on source type in a solar wind.

The initial data

«The catalogue of SW events for time 1976-2000» (ftp://ftp.iki.rssi.ru/omni/) [Yermolaev et al., Cos. Res., №2, 2009] obtained with OMNI data base [King and Papitashvili, JGR, v.110, A2, 2004].

A total 190 magnetic storms with *Dst* ≤–50 nT are classified according to the next types of SW drivers:

- Corotating Interaction Region **CIR** – 49 magnetic storms;
- Interplanetary Coronal Mass Ejection **ICME=MC+Ejecta** – 67 magnetic storms, including subtypes:
  a) Magnetic Clouds **MC** – 17 storms
  b) **Ejecta** – 50 magnetic storms

– The compression region before ICME,

Sheath=Sh_E+Sh_{MC} – 40 storms including subtypes:

a) Sheath before MC, **Sh_{MC}** – 6 magnetic storms,

b) Sheath before Ejecta, **Sh_E** – 34 magnetic storms.

– Indeterminate type **IND** – 34 magnetic storms, the sources of which were difficult to determine because of absent of SW parameter or complex character of the phenomenon.

The method of analysis

Comparison of *Dst(i)* index in given point *i* of main phase with integrated interplanetary electric field *sumEy(i)=Ey(1)+Ey(2)+…+Ey(i)* (summarized from storm onset *i=1* to given point *i* of main phase), and on Dst. vs. sumEy background the analysis of *Dst* index dependence on:

- dynamic pressure *Pd* and
- level of IMF fluctuations σB.

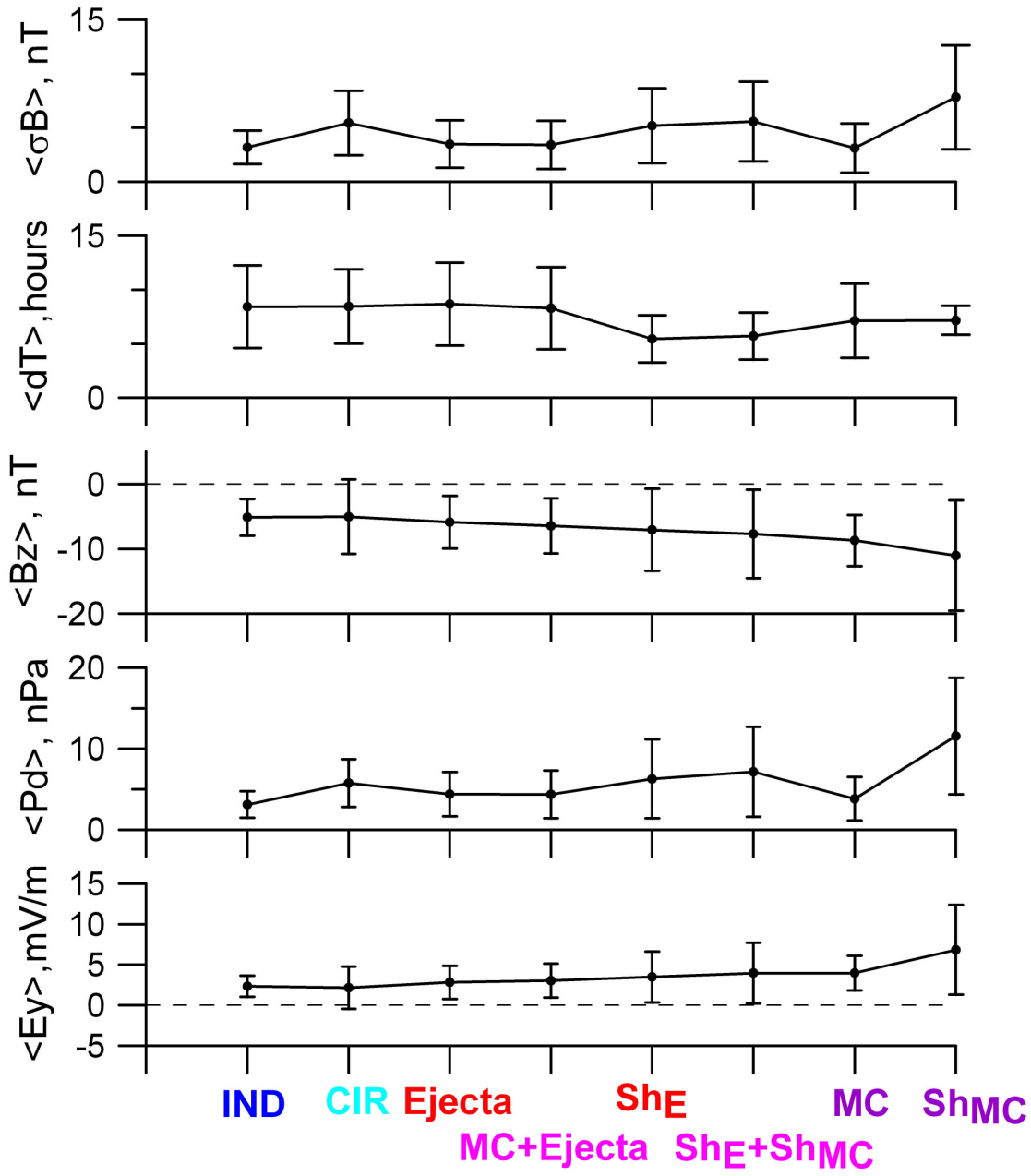

Figure 1. *The dependence of SW parameters and the main phase duration on type of magnetic storm driver.*

At the main phase of storms initiated by **Sheath** before ICME (**Sh_E**, **Sh_{MC}**, **Sh_{MC}+Sh_E**):

- southward component of IMF, convective electric field *Ey*,
- dynamic pressure *Pd* and the fluctuation level σB of IMF

are in 1.5–3 times stronger, and the main phase duration is in 1.5 time shorter, than for storms with ICME driver (MC, Ejecta, MC+Ejecta).

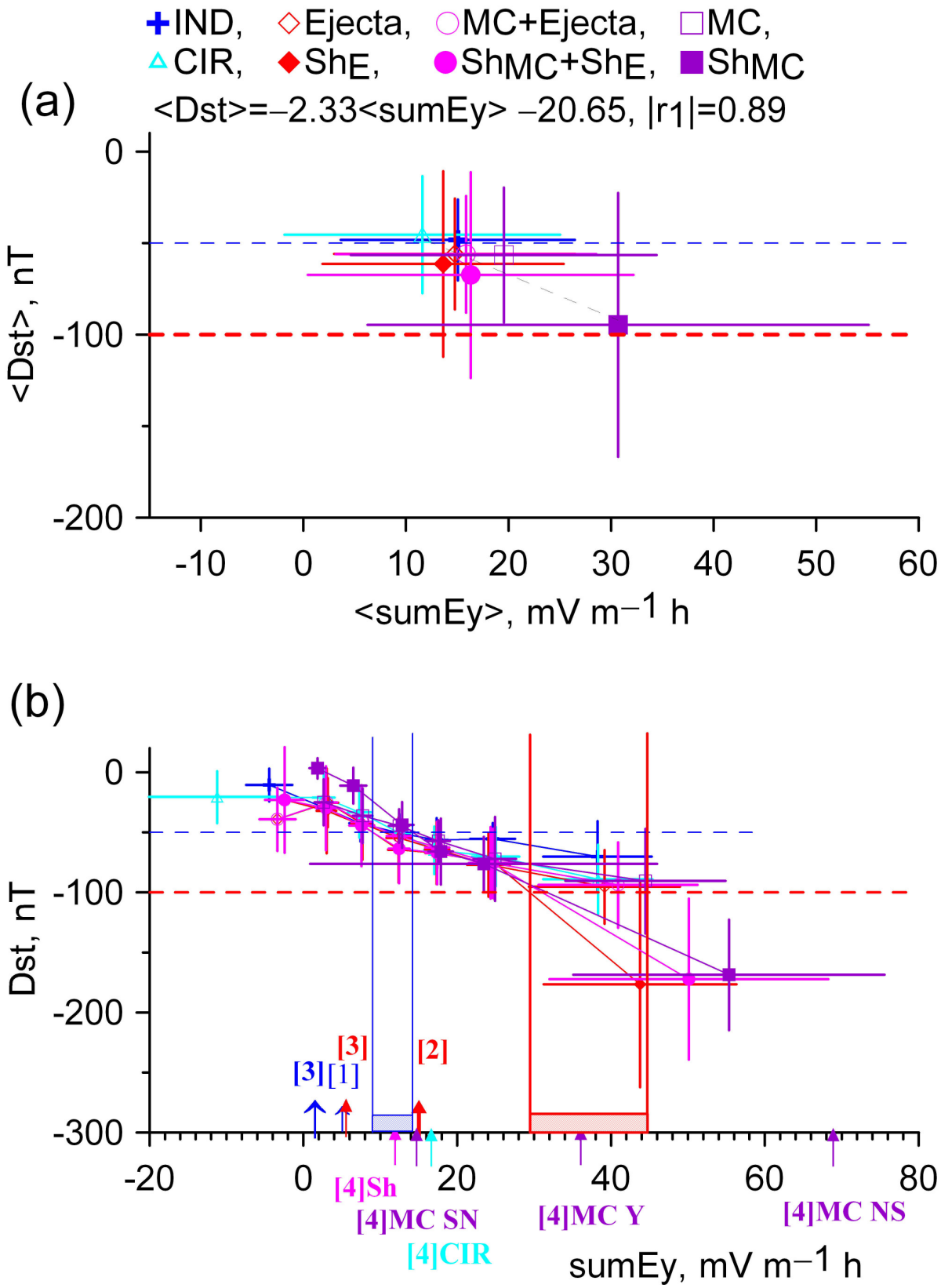

Figure 2. *The dependence of Dst index on integrated electric field sumEy during the main phase of magnetic storms initiated by different SW drivers: (a) with average for SW type driver;(b) with average over sumEy intervals separately for different SW drivers.*

Table *Storm intensity criteria for different types of driving interplanetary structures.*

Type of SW structure	Threshold criteria *sumEy* (mV m^{-1} h) [*Ey* (mV m^{-1}) and duration *Δt* (h)]	
	Dst≤–50 nT	Dst≤–100 nT
MC Vieira et al, 2004: MC (SN) MC (NS) MC Y	14	45 14.4 [Ey=3.3 Δt=4.3] 69.1 [Ey=3.4 Δt=20.1] 36 [Ey=3.7 Δt=9.6]
CIR Vieira et al., 2004	14	39 16.7 [Ey=5.4 Δt=3.1]
Sh_E	9	29
Ejecta	12	40
Sh_{MC} Vieira et al., 2004	13	32 12.2 [Ey=9.4 Δt=1.3]
Sh_{MC}+Sh_E	9	32
MC+Ejecta	12	41
IND	14	
Russell et al., 1974	5 [Ey=2.5 Δt=2]	
Gonzalez and Tsurutani, 1987		15 [Ey=5 Δt=3]
Wang et al., 2003	1.5 [Ey=1.5 Δt=1]	6 [Ey=3 Δt=2]

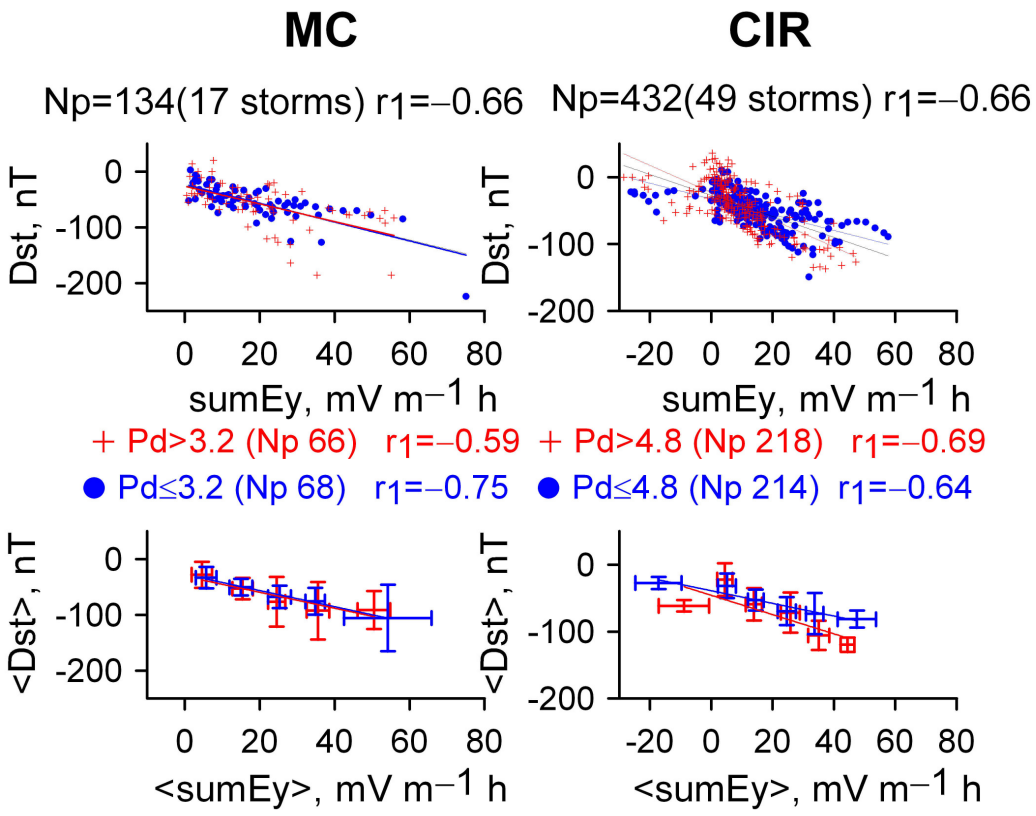

Figure 3. *Dependence of the Dst index on integrated electric field sumEy and dynamic pressure Pd at the main phase of storms initiated by MC, CIR.*

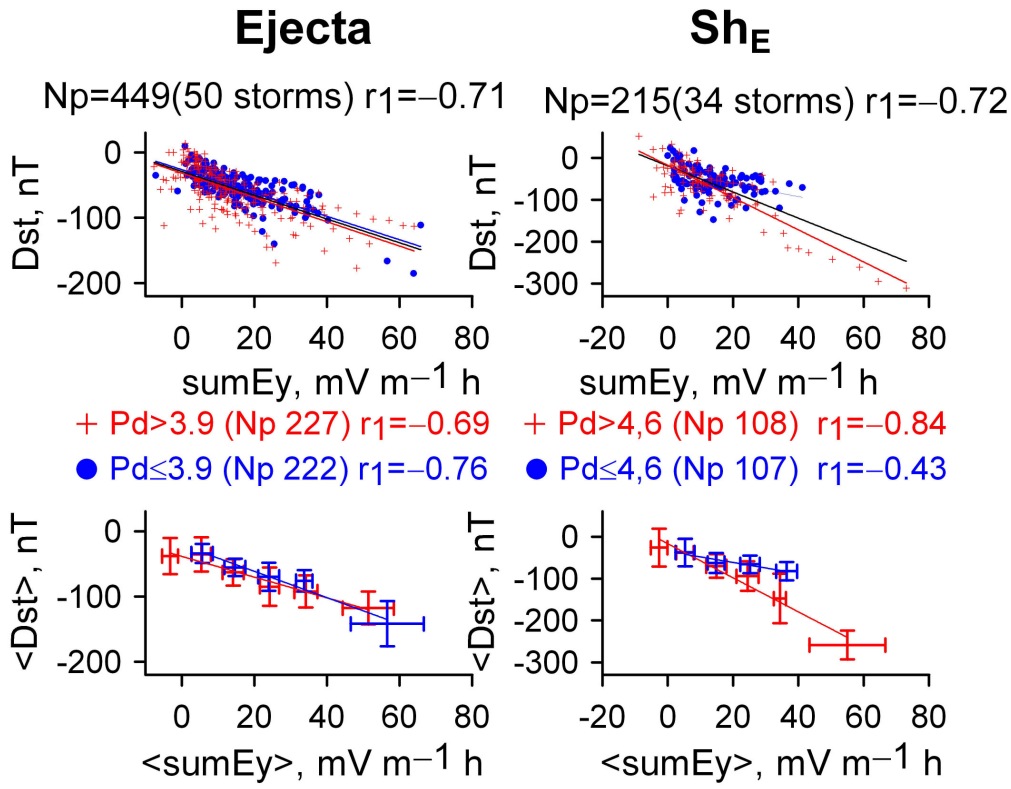

Figure 4. *The same as in Fig.3, but for Ejecta and* $\boldsymbol{Sh_E}$.

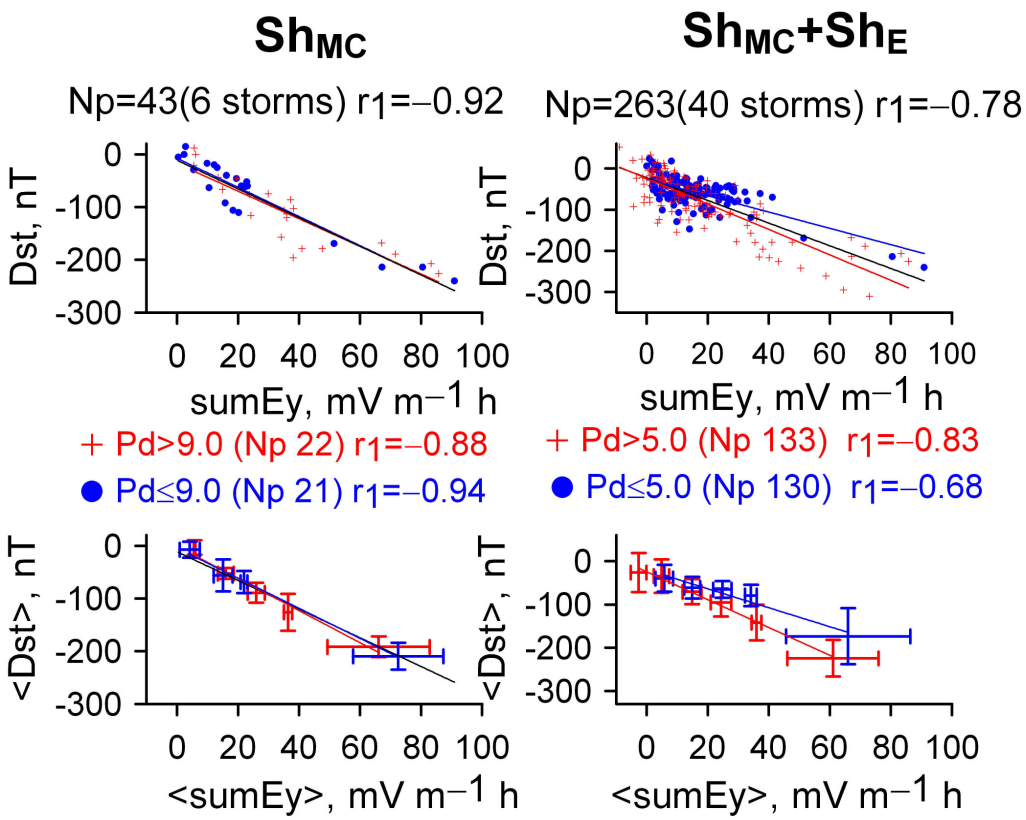

Figure 5. *The same as in Fig.3-4, but for* ***Sh_{MC}*** *and* ***Sh_{MC}+Sh_E****.*

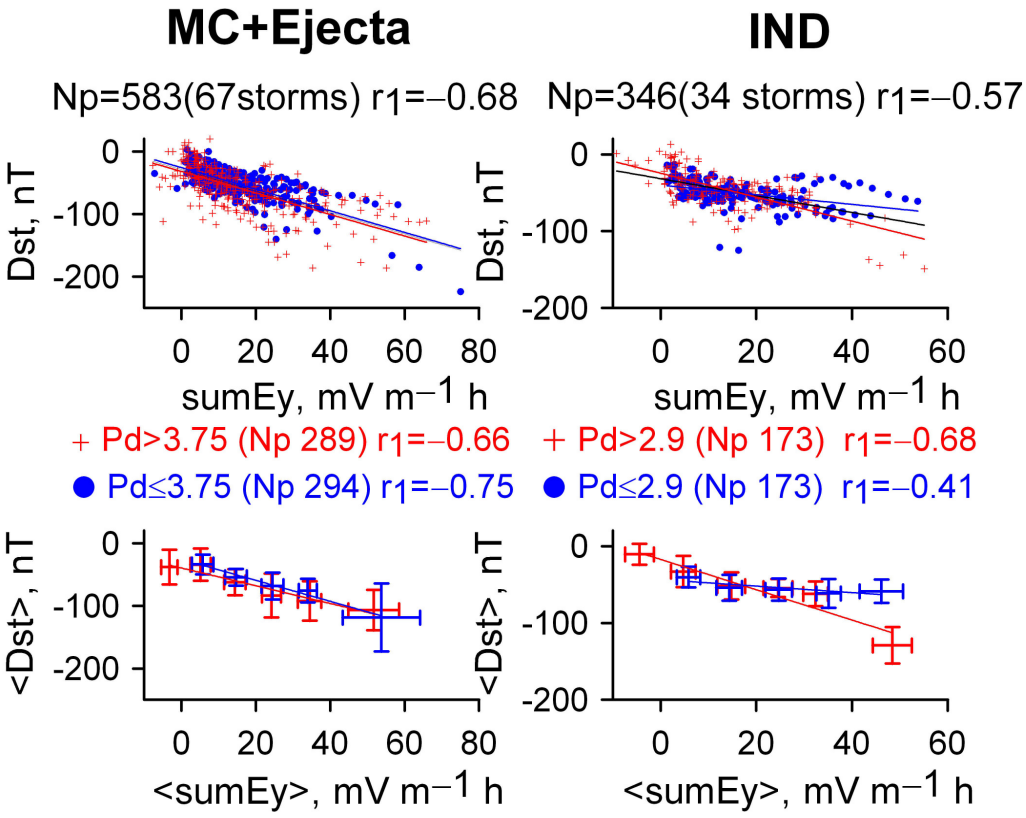

Figure 6. *The same as in Fig.3-5, but for MC+Ejecta and IND.*

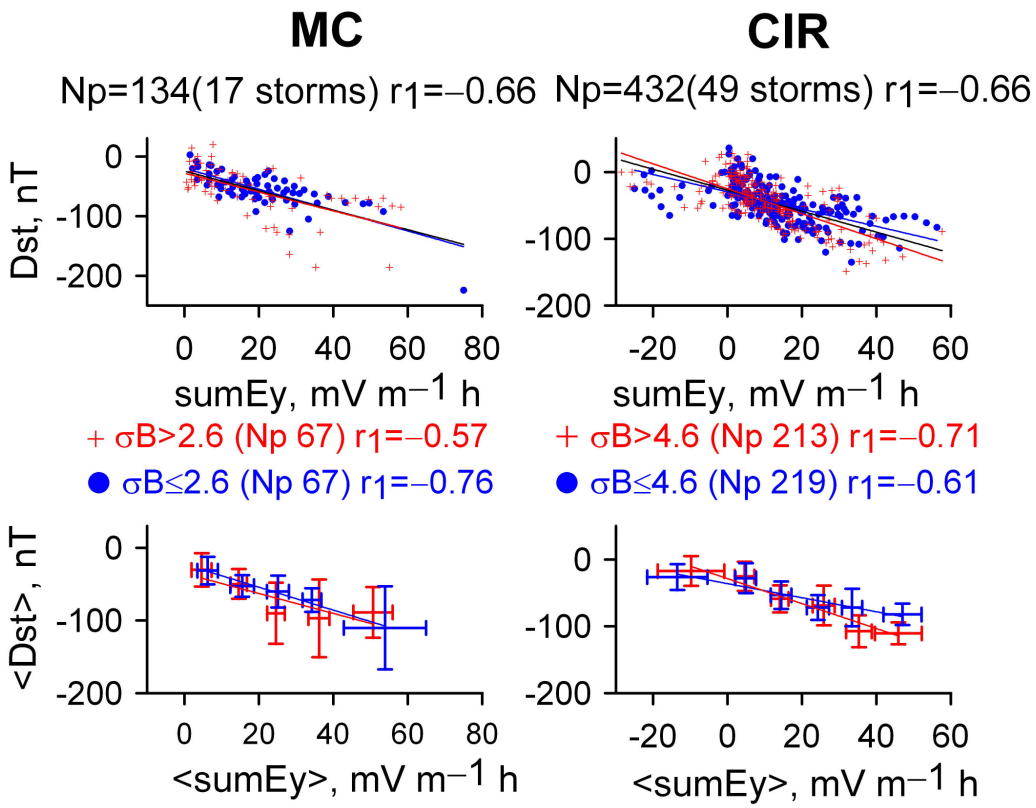

Figure 7. *Dependence of the Dst index on integrated electric field sumEy and on the fluctuation level σB IMF at the main phase of storms initiated by* ***MC****,* ***CIR****.*

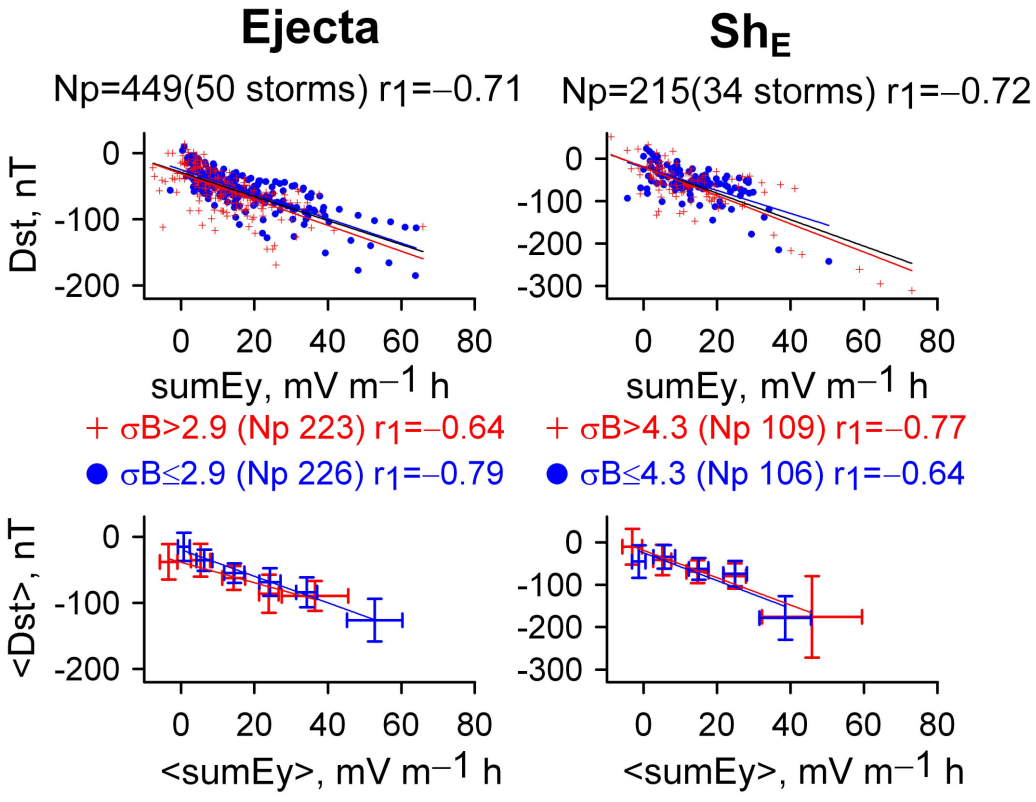

Figure 8. *The same as in Fig.7, but for* ***Ejecta*** *and* ***Sh_E****.*

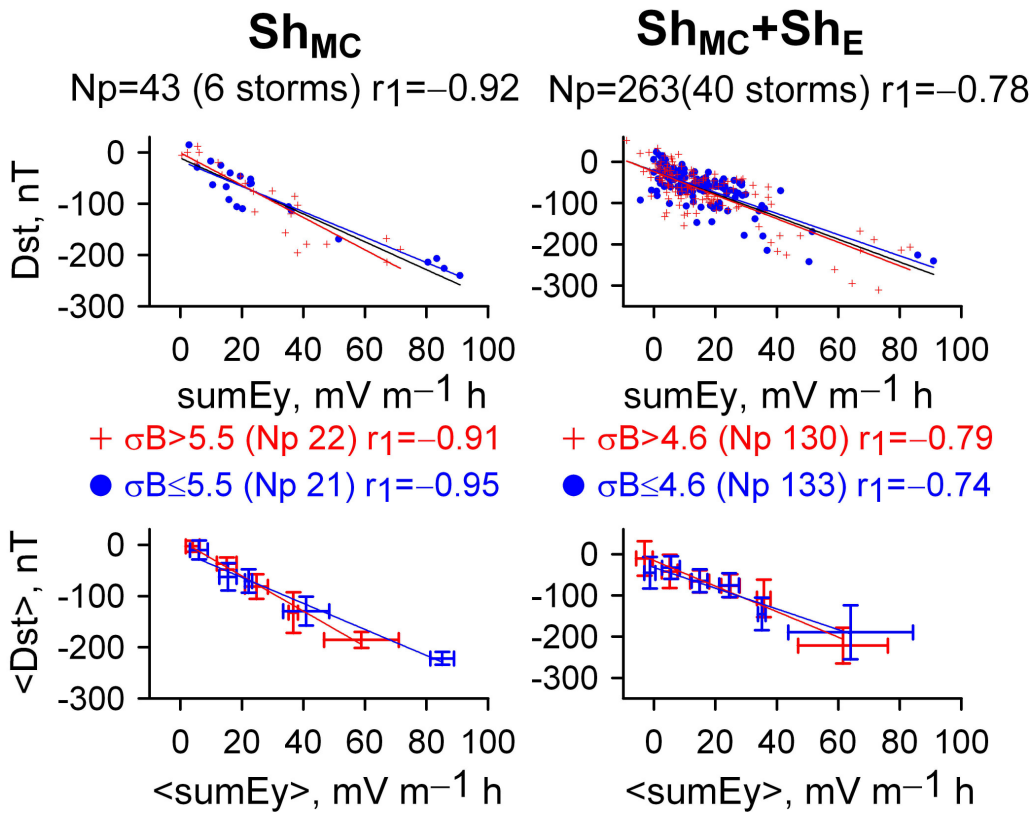

Figure 9. *The same as in Fig.7-8, but for* ***Sh_{MC}*** *and* ***Sh_{MC}+Sh_E****.*

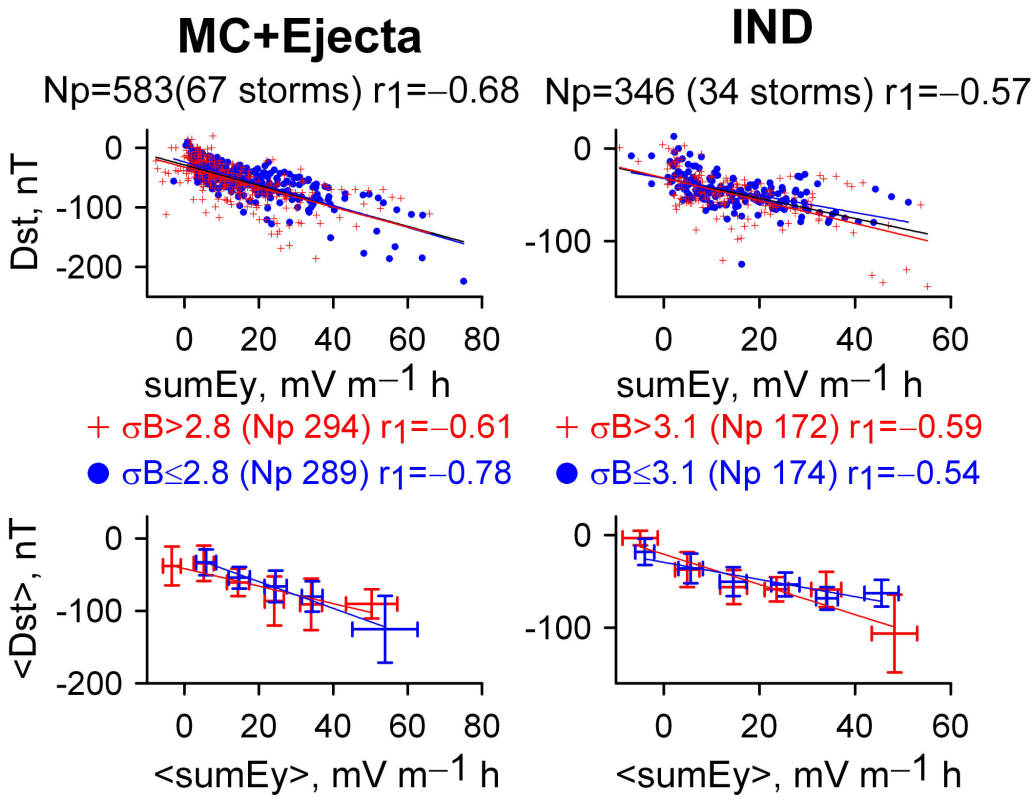

Figure 10. *The same as in Fig.7-9, but for MC+Ejecta and IND.*

Conclusion

1. For both moderate $Dst \leq -50$ nT and strong $Dst \leq -100$ nT storms the lowest threshold level of integrated electric field *sumEy* have **Sheath**; ICME have threshold criterion in ~1.5 time larger. Magnetic storms associated with **Sheath** events evolve faster than those driven by ICME. It is possible that threshold criteria level is dependent on type of SW stream.

2. Irrespective of source type threshold level for strong ($Dst \leq -100$ nT) storms (*sumEy*=29-45 mV m^{-1} h) is in ~3 times higher than for moderate ($Dst \leq -50$ nT) storms (*sumEy* = 9-14 mV m^{-1} h).

3. At the main phase of all types of magnetic storms *Dst* index is well approximated by linear dependence on integrated electric field *sumEy* with significant coefficient of correlation $|r_1|>0.6$ that is larger for **Sheath** ($|r_1|=0.78$) than for ICME ($|r_1|=0.68$).

4. It is possible that dynamic pressure *Pd* increases the geoefficiency (*Dst* decreasing) of storms associated with **Sheath** regions, **CIR** and indeterminate type IND.

1. At the main phase of almost all types of storms (with except IND) there is no dependence of *Dst* index on level of IMF fluctuations σB (distinctions are within data scattering at rather small range of changing of parameter σB IMF).