The development of magnetic storms driven by different solar wind streams and for various solar wind-magnetosphere coupling functions

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Efficiency of magnetic storm generation by different SW types

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]

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)

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

The main purpose

For different solar wind drivers:

- **the response of Dst and Dst* indices on variations of SW parameters for various coupling functions;**
- **the possible dependence of efficiency of magnetic storm generation on type of the stream using various coupling functions;**

Data and methods

- **«Catalog of the large-scale solar wind phenomena during 1976-2000» ftp://ftp.iki.rssi.ru/pub/omni/, created on the OMNI dataset (1- hour resolution).**
- **The main phases of independent moderate and strong (*Dst* ≤ – 50 nT) magnetic storms generated by:**

  10 MC- storms (77 points),

  31 Ejecta- storms (324 points),

  21 Sheath- storms (166 points),

  31 CIR-storms (279 points),
- **The set of 12 coupling functions;**

The set of 12 coupling functions

12 Coupling Functions	References
FC1= $\sin^2(\theta/2)$	Sonnerup, 1974; Wygant et al, 1983; Gonzalez, 1990; Shepherd et al, 2002; Wilder et al, 2011; Borovsky and Birn, 2014.
FC2= vByz	Borovsky and Birn, 2014
FC3= vBz	Hardy et al., 1981; Borovsky and Birn, 2014.
FC4 = vBs	Burton et al, 1975; Holzer and Slavin, 1982; Borovsky and Birn, 2014
FC5 = vByz $\sin^2(\theta/2)$	Kan and Lee, 1979; Borovsky and Birn, 2014.
FC6 = vByz $\sin^4(\theta/2)$	Wygant et al, 1983; Borovsky and Birn, 2014.
FC7 = $v^{4/3}\ Byz^{2/3} \sin^{8/3}(\theta/2)$	Newell et al, 2007; Borovsky and Birn, 2014.
FC8 = $p^{1/2}\ v^{4/3}\ Byz^{2/3} \sin^{8/3}(\theta/2)$	Newell et al, 2007;
FC9 = Rquick Rquick ~ $\sin^2(\theta/2)\ C^{-1/2}\ n^{1/2}\ v_{sw}^{\ 2}\ (1+\beta_s)^{-3/4}$	Borovsky, 2008; Borovsky and Birn, 2014;
FC10 = $p^{1/2}\ v^{4/3}$ Byz $\sin^6(\theta/2)$	Temerin and Li, 2006; Balikhin et al., 2010;
FC11 = vsw +56Bs	Borovsky, 2014;
FC12 = M_A (~v/V_A)	

Efficiency of magnetic storm generation

- **Linear approximations of Dst и Dst* indices:**

  $$Dst_i = C_0 + C_{FCN}\ FCN_i$$

  $$Dst_i^* = C_0^* + C^*_{FCN}\ FCN_i$$

  where i – is the 1-hour point number at the main phase of magnetic storms induced by given type of SW, and

  FCN – are coupling functions FC1, …FC12.

Approximation coefficients C_{FCN} и C^*_{FCN} are interpreted as efficiencies of Dst и Dst* generation.

Coefficients of linear relation between Dst and Dst* indices and coupling functions values at the main phase of magnetic storms driven by 4 types of the SW

FC type	MC, 77 points C_{FCN}	MC, 77 points C^*_{FCN}	Ejecta, 324 points C_{FCN}	Ejecta, 324 points C^*_{FCN}	Sheath, 166 points C_{FCN}	Sheath, 166 points C^*_{FCN}	CIR, 279 points C_{FCN}	CIR, 279 points C^*_{FCN}
FC1	-8.01 (2)	0.26 (1)	-20.6 (4)	-12.8 (4)	-14.4 (3)	-9.11 (3)	-1.79 (1)	4.58 (2)
FC2	-3.77 (1)	-4.41 (1)	-5.88 (3)	-7.35 (2)	-5.35 (2)	-7.38 (3)	-7.16 (4)	-9.20 (4)
FC3	-6.35 (4)	-7.23 (3)	-5.19 (2)	-5.18 (2)	-6.09 (3)	-7.44 (4)	-3.03 (1)	-3.75 (1)
FC4	-6.37 (4)	-7.42 (2)	-6.23 (2)	-7.18 (1)	-7.20 (4)	-9.25 (4)	-5.81 (1)	-8.05 (3)
FC5	-5.29 (1)	-6.10 (1)	-7.13 (4)	-7.91 (2)	-6.86 (3)	-8.96 (4)	-6.42 (2)	-8.19 (3)
FC6	-6.26 (2)	-7.14 (3)	-6.65 (3)	-7.13 (2)	-7.17 (4)	-9.16 (4)	-5.36 (1)	-6.92 (1)
FC7	-1.68 (1)	-1.99 (1)	-2.06 (3)	-2.25 (2)	-2.25 (4)	-2.95 (4)	-1.95 (2)	-2.46 (3)
FC8	-0.25 (1)	-0.61 (1)	-0.55 (3)	-0.91 (4)	-0.42 (2)	-0.63 (2)	-0.56 (4)	-0.85 (3)
FC9	-0.12 (1)	-0.16 (1)	-0.16 (2)	-0.20 (2)	-0.17 (4)	-0.23 (4)	-0.16 (3)	-0.20 (3)
FC10	-0.23 (3)	-0.36 (3)	-0.26 (4)	-0.37 (4)	-0.21 (1)	-0.31 (1)	-0.22 (2)	-0.32 (2)
FC11	-0.05 (3)	-0.06 (3)	-0.05 (2)	-0.06 (2)	-0.06 (4)	-0.08 (4)	-0.04 (1)	-0.05 (1)
FC12	4.38 (4)	3.86 (4)	1.59 (1)	0.25 (1)	3.75 (3)	2.86 (3)	2.76 (2)	2.28 (2)
rel. aver	2.17	2.00	2.75	2.33	3.08	3.33	2.00	2.33

• rel.aver:	2.17	2.00	2.75	2.33	3.08	3.33	2.00	2.33
• Rank:	(2)	(1)	(3)	(2)	(4)	(4)	(1)	(3)

Conclusion

On the OMNI data for interval 1976-2000, we study the generation of magnetic storms, induced by MC (10 - storms, 77 points), Ejecta (31 storms, 324 points), Sheath (21 storms, 166 points), CIR (31 storms, 279 points), and evaluate the dependence of efficiency of magnetic storm generation on type of SW stream using 12 coupling functions.

Our study allowed us to make the following preliminary conclusions:

- The generation of magnetic storms depends on type of solar wind stream in agreement with previous results obtained by various methods and for various SW classifications.
- Most of the coupling functions have high efficiency for Sheath (in agreement with our result obtained for one coupling function not including in the list of 12 coupling functions).
- In contrast with Sheaths most of the coupling functions for MCs have the lower efficiency (this also confirm our results obtained for one coupling function out of the list of 12 coupling functions).
- Efficiencies of magnetic storm generation by CIR and Ejecta are intermediate

We consider that the results presented here are preliminary: the confirmation of these results, increase in their reliability require further investigation.

Thank You for Attention!