Solar energetic events, solar energetic proton flux and geomagnetic storms

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CMEs are generally recognized as a crucial link between activity at the Sun and its propagation through the heliosphere to the Earth, with impact on the geomagnetic activity. As the CMEs are most frequently associated with solar energetic events, we have carried out a systematic study of the relation between solar energetic events and their response in geomagnetic activity. Our attention was concentrated on X-ray events (XRA) in combination with sweep frequency radio bursts (RSP) of type II (shock waves propagating outwards), type IV (moving plasmoids or expanding bottles) and type CMT (broadband, long-lived, dekametric continuum). According to our previous results (Bochníček et al.: Geoeffectivness of irregular events versus their location on the solar disc, EGU General Assembly, 2005, EGU05-A-04482), RSP CTM is a weak precursor of geomagnetic activity and was not included in the recent analysis. Data on irregular events were extracted from daily reports issued by NOAA, Space Environment Center.

Enhancement of solar energetic proton (SEP) flux is often treated as another precursor of geomagnetic disturbances. In accordance with Gleisner and Watermann (Solar energetic particle flux as discriminator for halo CME's generating magnetic storm, IAGA scientific Assembly 2005, IAGA2005-A-00577) the flux on level >10 MeV was used. The flux P is considered enhanced if $\log(P/P^{pre}) > 0.7$, where P^{pre} denotes the previous quiet level.

The disturbances of geomagnetic field are classified by three levels:

1 - Low – at least one value Kp=5 and another two values Kp=4

2 - Medium – at least three values Kp=5

3 - Strong – at least three values Kp=6

X-ray flares are marked as follows:

\+ - class B or C

× – class M

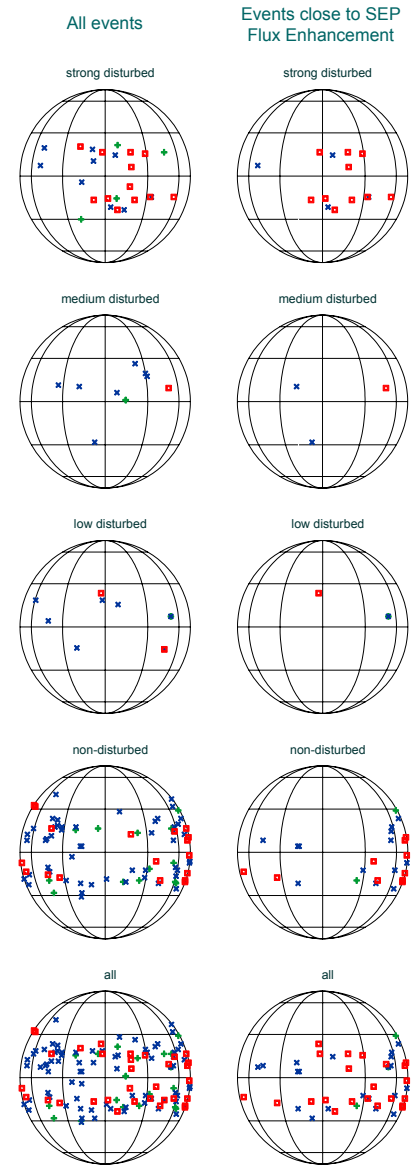
□ - class X

Number of XRA and their classification in period 1996-2004.

Black (left) figures show number of events on the entire solar disc, red (right) figures denote number of events occurring in the solar central region (30°E - 30° W; 30°N - 30° S).

XRA	XRA class	All events										Events close to SEP Flux Enhancement									
				level of geomagnetic activity										level of geomagnetic activity							
		all		no		low		medium		strong		all		no		low		medium		strong	
RSP II & IV	B,C	20	9	14	5	1	0	1	1	4	3	3	1	2	1	1	0	0	0	0	0
	M	75	29	52	15	7	3	7	5	9	6	19	8	13	4	1	0	2	2	4	2
	X	33	12	18	1	2	1	1	0	12	10	22	9	10	0	1	1	1	0	10	8
only RSP II	B,C	127	46	117	36	1	1	5	5	4	4	16	7	16	7	0	0	0	0	0	0
	M	116	40	96	31	6	4	9	2	5	3	25	9	23	9	1	0	1	0	0	0
	X	24	10	15	4	2	1	1	0	6	5	9	6	3	2	1	0	0	0	5	4
only RSP IV	B,C	8	5	6	4	1	1	0	0	1	0	2	1	1	1	0	0	0	0	1	0
	M	27	16	20	11	3	3	1	1	3	1	10	5	8	4	1	1	0	0	1	0
	X	5	3	2	1	0	0	2	2	1	0	2	2	0	0	0	0	1	1	1	1
others	B,C	3549	1416	3509	1382	15	14	11	8	14	12	85	39	80	35	2	2	1	0	2	2
	M	770	299	745	279	10	7	8	7	7	6	33	2	30	14	1	0	1	0	1	1
	X	29	10	25	8	1	0	1	1	1	1	4	2	2	1	1	0	1	1	0	0

XRA in combination with RSP II and IV



The highest geoeffectivness was demonstrated by X-ray flares (XRA) associated with sweep frequency radio bursts (RSP) of type II (shock waves propagating outwards) and IV (moving plasmoids or expanding bottles). The geoeffectivness was decreasing from XRA class X to class B. Vast majority of geoeffective energetic events occurs in the region (30°E - 30° W; 30°N - 30° S).

The occurrence of SEP flux enhancement for RSP II & IV is closely related to the class of XRA (highest for class X and lowest for class B). The substantial information is thus included already in the class of XRA and the SEP flux behavior has just a subsidiary role.

The geoeffectivness of single RSP II or RSP IV is much lower and the relation to SEP flux enhancement is rather spurious.

Discursion: The classification of geomagnetic storms

NOAA recently issued new Space Weather Scales Tables. Their classification of geomagnetic storms is based on daily maximum Kp index with following thresholds :

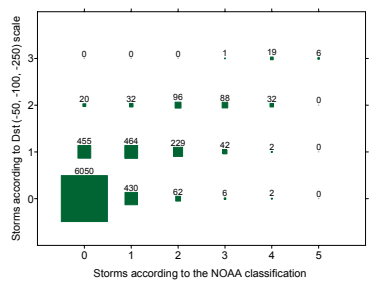
Geomagnetic storm	G1 minor	G2 moderate	G3 strong	G4 severe	G5 extreme
Maximum of Kp	5	6	7	8	9

http://www.spaceweather.noaa.gov/NOAAscales/index.html

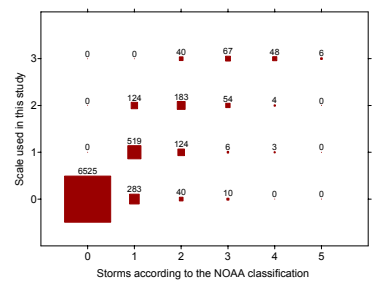
The Space Weather Scales were subject of a special session during the MCM of COST 724 in October 2005. Scale for geomagnetic storms based on Dst indices was suggested by J. Watermann:

Geomagnetic storm	1	2	3
Minimum of Dst	<-50	<-100	<-250

Relation between these scales is shown in following graph. The statistics comprises data between 1983-2004 (two solar cycles). The figures denote number of days in each category.



Our classification eliminates isolated singular increases in geomagnetic activity. In general, the scale is closely related to NOAA scale with merged levels 3 – 5.



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