Solar Influences Data analysis Center

Data Analysis Service supported by the FAGS

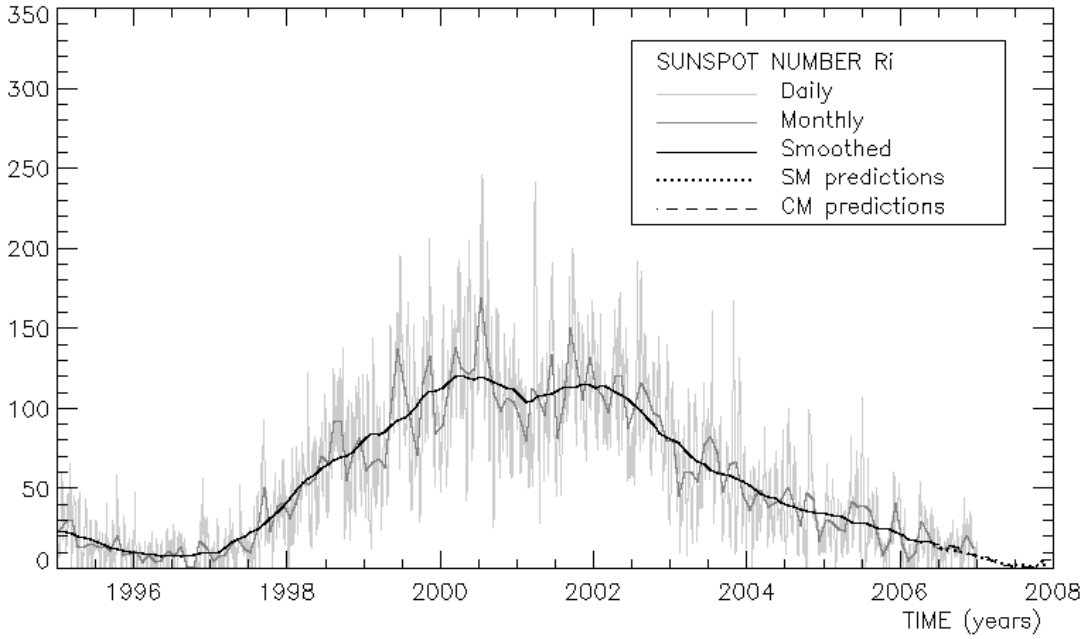
SUNSPOT BULLETIN

2006 n°12

Provisional international and normalized hemispheric daily sunspot numbers for December 2006

computed at the *Royal Observatory of Belgium* using observations from an international network with the *Locarno Specola Solare* as reference station.

Date	R'_I	R'_N	R'_S
1	34	12	22
2	32	9	23
3	28	8	20
4	24	9	15
5	28	8	20
6	33	8	25
7	31	8	23
8	17	6	11
9	13	0	13
10	14	0	14
11	17	0	17
12	17	0	17
13	16	0	16
14	14	0	14
15	13	0	13
16	12	0	12
17	9	0	9
18	0	0	0
19	0	0	0
20	0	0	0
21	0	0	0
22	0	0	0
23	0	0	0
24	8	4	4
25	10	5	5
26	13	0	13
27	12	6	6
28	0	0	0
29	0	0	0
30	10	0	10
31	17	8	9
Monthly mean	**13.6**	**2.9**	**10.7**
Cooperating stations	**47**	**41**	**41**



Predictions of the monthly smoothed Sunspot Number
using the last provisional value, calculated for June 2006 : 16.3 (± 5%)

	SM	CM		SM	CM		SM	CM
2006 Jul	16	16	2007 Jan	11	8	2007 Jul	5	2
Aug	16	15	Feb	10	8	Aug	4	2
Sep	14	14	Mar	9	5	Sep	3	2
Oct	13	12	Apr	8	5	Oct	2	3
Nov	13	10	May	7	3	Nov	2	5
Dec	12	9	Jun	6	2	Dec	2	6

SM : SIDC classical method : based on an interpolation of Waldmeier's standard curves; the estimated error ranges from 7% (first month) to 35% (last month)
CM : Combined method : the combined method is a regression technique coupling a dynamo-based estimator with Waldmeier's idea of standard curves, due to K. Denkmayr.
ref. : **K. Denkmayr, P. Cugnon**, 1997 : "About Sunspot Number Medium-Term Predictions", in "Solar-Terrestrial Prediction Workshop V", eds G. Heckman et al., Hiraiso Solar Terrestrial Research Center, Japan, 103

Brussels, January 1, 2007 11:05 UT

Ed. Ronald Van der Linden, Ass. Ed. Petra Vanlommel
Editing contributions from various members of the SIDC team

Fax 32-(0)2-373 02 24 Tel 32-(0)2-373 04 91
e-mail : arille@oma.be, ronald@oma.be
ftp anonymous : omaftp.oma.be, directory dist/astro/sidcdata
http://sidc.oma.be

S.I.D.C. SUMMARY OF THE URSIGRAMS

Date	R'_i	PPSI	600	2800	COS	SFI	XI	Ak	SEA
30	35	68	-	84	////	0	0/0	28	
1	34	54	-	84	////	1	0/0	7	
2	32	45	-	87	////	5	0/0	3	
3	28	30	-	87	////	2	0/0	5	
4	24	18	-	92	////	1	0/0	1	
5	28	14	-	102	////	117	1/1	5	
6	33	21	-	103	////	110	3/1	26	
7	31	60	-	96	////	23	1/0	28	
8	17	///	-	96	////	0	0/0	24	
9	13	92	-	92	////	0	0/0	13	
10	14	55	-	90	////	2	0/0	24	
11	17	61	-	92	////	14	0/0	12	
12	17	111	-	102	////	104	0/0	32	
13	16	103	-	94	////	///	0/1	8	
14	14	41	-	93	////	6	0/1	45	
15	13	38	-	87	////	3	0/0	82	
16	12	19	-	82	////	3	0/0	14	
17	9	1	-	81	////	0	0/0	8	
18	0	0	-	75	///	0	/0	4	
19	0	0	-	73	///	0	/0	4	
20	0	0	-	72	///	0	/0	2	
21	0	0	-	72	////	0	0/0	21	
22	0	0	-	73	///	0	/0	1	
23	0	0	-	73	///	0	/0	9	
24	8	1	-	74	////	0	0/0	14	
25	10	0	-	76	////	0	0/0	10	
26	13	3	-	75	////	0	0/0	6	
27	12	3	-	73	////	0	0/0	3	
28	0	0	-	76	///	0	/0	4	
29	0	0	-	78	///	0	/0	3	
30	10	0	-	80	////	0	0/0	4	
31	17	5	-	83	////	1	0/0	2	

R'_i : provisional international sunspot numbers from the S.I.D.C.

PPSI : prompt photometric sunspot index from the S.I.D.C. in 10-5 w/m^2 : the quantity to be subtracted from the mean solar constant to account for the sunspot contribution.

600 : 600 Mhz solar flux from the station at Humain (Belgium).

2800 : 2800 Mhz solar flux from Ottawa (origin : Ursigrams - UGEOI). The 10.7cm Flux data are a service of the National Research Council of Canada.

COS : thousands of the cosmic ray counts (origin : Ursigrams - UCOSE Terre Adélie).

SFI : From October 1992, Solar Flare Index from the S.I.D.C. (origin : Ursigrams – UGEOR, evaluation : 1 x Sn+10 x "1"+100 x ">1".

XI : X-flares index from the Ursigrams (M-flares/X-flares) (origin : Ursigrams – UGEOR, UGEOI).

Ak : geomagnetic index from Wingst, Germany (origin : Ursigrams).

SEA : sudden enhancements of atmospherics from Uccle & Humain (Royal Observatory, Belgium).

Note that due to problems of interferences saturating our receivers, no SEA could be detected this month.

SOLAR PHYSICS DEPARTMENT

UCCLE DAILY PROVISIONAL RELATIVE SUNSPOT NUMBERS FOR DECEMBER 2006

DATE	UT	NUMBER OF GROUPS	NUMBER OF SPOTS	RELATIVE SUNSPOT NUMBERS TOTAL	NORTH	SOUTH	CENTRAL	PPSI 10-5 WM-2	QUAL	OBS
1	900	4	9	49	14	35	38	25.3	1	AE
3	1000	3	7	37	11	26	37	9.8	2	AE
4	1135	3	10	40	11	29	11	3.7	3	OB
5	930	4	8	48	11	37	0	6.5	2	OB
6	1415	4	25	65	11	54	0	11.4	3	OB
9	905	2	13	33	13	20	33	27.1	3	DB
10	950	1	14	24	0	24	24	30.1	3	DB
12	1230	1	14	24	0	24	24	29.8	3	AE
14	1345	1	11	21	0	21	0	20.5	3	AE
15	900	1	6	16	0	16	0	15.6	2	AE
17	945	1	3	13	0	13	0	0.3	2	AE
19	1310	0	0	0	0	0	0	0.0	2	OB
22	1250	0	0	0	0	0	0	0.0	3	OB
29	1100	0	0	0	0	0	0	0.0	2	AE

The relative mean sunspot number is 26.4.

NORMALISED UCCLE OBSERVATIONAL SUNSPOT NUMBERS U'=K'U FOR DECEMBER 2006

K'= 0.868 (*)

1	43	7	***	13	***	19	0	25	***
2	***	8	***	14	18	20	***	26	***
3	32	9	29	15	14	21	***	27	***
4	35	10	21	16	***	22	0	28	***
5	42	11	***	17	11	23	***	29	0
6	56	12	21	18	***	24	***	30	***
								31	***

The normalised relative monthly mean sunspot number is 23.

(*) K' is the mean of the monthly K' for the last five years.

The Sun has been observed 14 days on 31 possible.

UCCLE OBSERVATIONAL MAJOR SUNSPOT GROUPS FOR DECEMBER 2006
E AND F BRUNNER'S TYPE GROUPS

NONE

PROBABLE RETURN OF MAJOR GROUPS FOR JANUARY 2007
NONE

MONTHLY SUMMARY OF SOLAR AND GEOMAGNETIC ACTIVITY

I. Solar Activity

Solar activity was highly atypical this month. Catania sunspot group 06 (NOAA AR 0930) was the source of some extreme flares and storm events. This group was rather persistent. When the group rotated over the east limb on Dec 04, it started already its second journey over the visible side of the solar disk. The group came into view for a third rotation at the solar east limb on Dec 31. Its second transit was the most violent one.

Almost immediately when Catania group 06 (NOAA AR 0930) was visible in SOHO/MDI on Dec 04, the background soft X-ray and 10.7cm radio fluxes increased, and C-class flares were detected by GOES satellites. Unlike its previous rotation as NOAA AR 0923, the region did not decay; rather it unleashed a very un-minimum-like impulsive X9.0 flare on Dec 05. SOHO/EIT and SOHO/LASCO were not operating because of spacecraft manoeuvres but the flare was observed by GOES SXI. The flare was accompanied by a Type II radio burst. A few hours later, the proton fluxes increased. An explanation for the late arrival of the protons at earth may be the fact that those protons are accelerated by the CME driven shock. The plasma cloud or CME associated with the flare moves with a large speed through the interplanetary space creating a shock in front of it. The CME driven shock is capable of accelerating particles. This CME was east-directed. At first sight one would think that the protons are predominantly ejected in the east direction and would never arrive at earth. But, the shock intersects with the magnetic field lines emanating from the sun forming the Parker spiral. The charged particles are accelerated at the shock front and move further along these field lines, away from the sun. When those magnetic field lines are connected with the near-earth environment, they can reach our neighbourhood. Only after a few hours when the shock was extended in space and intersects with magnetic field lines connected to earth, the protons were detected by GOES.

On Dec 06, after an M1.1 and an M6.0 flare, the group yielded an X6.5 flare, along with a new enhancement of the proton fluxes. On Dec 07, an M2.0 flare was released. The flaring activity of Dec 05-06 made the proton levels steadily increase with finally all three energy bands surpassing the 10pfu threshold on Dec 07. From Dec 08 onwards, the group seemed to calm down with only a few C-class flares. This was only a short flaring silence before a new storm. The small bipolar sunspot in front of the big bipolar sunspot of the group could be identified as the trigger for the exceptional strong solar flares on Dec 13 and 14. The mixing of magnetic fields cleared the way for the energy stored in the big sunspot group to be released. The group exploded into an X3.4 flare on Dec 13 peaking at 02:39UT. CACTus detected a full halo CME coming into the field of view at 02:54UT with a median velocity of 1140 km/s. A big, nicely radially propagating EIT wave was detected. Since there were no other active regions present on the Sun, the EIT wave could propagate radially without any obstacles on its path. The event caused a proton storm with all three energy levels passing the 10 pfu threshold.

On Dec 14, the same group fired an X1.5 flare peaking at 22:14UT. This event again pushed up the proton levels. The >100MeV curve did not pass the threshold, the >50MeV curve was only for a short time above the threshold, while the >10MeV stayed well above it until mid Dec 15. An EIT wave was visible in EIT195. The associated halo CME was also seen in LASCO pictures. CACTus split the event in three parts and was as such not recognized as a halo.

On Dec 17, GOES detected a C-flare originating from this group. In view of the past turbulent circumstances, a C-flare is not worth mentioning but this one was. The X-ray radiation curve shows a flat bulb rather than a peak. This is due to the fact that the event happened when the group was already behind the limb. Large post-flare loops were clearly visible in EIT. Only the radiation associated with these loops was measured by GOES. This indicates that the actual event was much stronger then only a C-flare. It was possibly another extreme flare, missed because of the position of Catania 06 (NOAA AR 0930) behind the limb. A CME was associated with this event, but it was no threat since it was not earth directed.

After the large active sunspot group Catania 06 had just disappeared at the west limb on Dec 17, not a single sunspot was observed during the next 6 days. The GOES X-ray flux was extremely low and remained at or often below the A level. On Dec 31, NOAA AR 0930 reappeared at the east, now with NOAA number 0933. The numbers 0931 and 0932 were assigned to two smaller active regions evolving into inactive plages. NOAA AR 0933 pushed the X-ray background radiation to a slightly higher level, but the overall activity stayed low. The group had decayed considerable when it crossed the backside of the solar disk.

The remaining solar features to be discussed are coronal holes. From Dec 11 onwards, when EIT was again operational, a few holes could be identified. A first small one was located in front of the big sunspot group Catania 06. On Dec 12, it was already situated at 45° to the west. A second hole was recurrent and southern. A first part crossed the central meridian on Dec 16. The hole was fairly extended in longitude (>60°). The third coronal hole was small and located in the southern hemisphere. It passed the central meridian on Dec 25. The last hole was clearly visible in EIT195 in the south. A first part reached the central meridian on Dec 30.

II. Geomagnetic Activity

The extreme geomagnetic conditions this month were caused by the arrival of the full halo CMEs associated with the energetic X-flares. Other geomagnetic disturbances were less extreme and caused by the passage of coronal holes.

Geomagnetic conditions were at minor storm level on Dec 06-09 following the arrival of a fast stream from a recurrent coronal hole. The solar wind speed eventually reached a level in excess of 600 km/s, though energetic particles contaminated ACE plasma data. It was very difficult to identify any signatures in the solar wind data that could be related to the CMEs associated with the flares between Dec 05 and 07. On Dec 11-12, active to minor storm conditions were reached. They were possibly caused by the first coronal hole mentioned in the previous section. From Dec 14, geomagnetic conditions were completely ruled by the arrival of the halo CMEs associated with the X-flares. On Dec 14 around 14:00UT, a shock arrived at earth. The shock was clearly visible in both SOHO/CELIAS and ACE data. The arrival triggered a major geomagnetic storm. The passage of the shock was also visible in the proton flux curve measured by GOES. The curve of the low energy elements (>10MeV) shows a small discontinuity followed with a relatively faster decrease of the flux.

The halo CME associated with the X1.5 flare of Dec 14 arrived at earth on Dec 16 around 17:30UT. Because of the northwards orientation of Bz, geomagnetic consequences were limited. NOAA estimated one period with a Kp-index of 4.

On Dec 18, the solar wind speed increased due to the arrival of a recurrent fast stream associated with the southern hemisphere coronal hole mentioned above. This fast stream arrived at least one day earlier than in previous solar rotations, possibly because of a change of the background interplanetary medium in the wake of the major CME that just preceded the fast stream. As a consequence, the fast stream lasted for an entire week and maintained unsettled to active geomagnetic conditions at the earth until Dec 23. Two periods were particularly active, with minor geomagnetic storms recorded at many stations. The first one came late on Dec 18, due to the co-rotating interaction region. The second one took place late on Dec 20, when the fast stream reached an exceptional top speed of 700km/s, leading to a large dynamic pressure. It was only from Dec 24 onwards that the geomagnetic field finally returned to quiet to unsettled conditions. The signature of the third, small southern coronal hole was visible in ACE data, although not pronounced. The influence was limited. The interaction region associated with the fast coronal hole wind stream emanating from the last mentioned coronal hole arrived the first day of 2007.

III. Noticeable solar events

DAY	BEGIN	MAX	END	LOC	XRAY	OP	10CM	RADIO TYPE	Cat	NOAA	NOTE
05	0745	0803	0806	S05E71	M1.8	SF			06	0930	No LASCO/EIT
05	1018	1035	1045	S06E59	X9.0	2N	12000	III/2,II/3,IV/2	06	0930	No LASCO/EIT
06	0130	0220	0254	S06E67	M1.1	SF		III/2	06	0930	No LASCO/EIT
06	0802	0823	0903	S02E65	M6.0	SF	340	III/1,IV/1	06	0930	No LASCO/EIT
06	1829	1847	1900	S06E63	X6.5	3B	5800	III/2,II/3,IV/3	06	0930	No LASCO/EIT, p
06	2014	2019	2022	S03E55	M3.5				06	0930	No LASCO/EIT
07	1820	1913	1933	S07E47	M2.0	1N	2600	CTM/2	06	0930	No EIT, CME
13	0214	0240	0257	S06W24	X3.4	4B	44000	II/3,III/3,IV/2	06	0930	halo CME, p
14	2107	2215	2226	S05W31	X1.5	SF	620	II/2	06	0930	halo CME, p

LOC: approximate heliographic location
XRAY: X-ray flare class
OP: optical flare class
10CM: peak 10 cm radio flux

RADIO TYPE: radio burst type
Cat: Catania sunspot group number
NOAA: NOAA active region number
NOTES: **p** = proton event
CME = coronal mass ejection

IV. Halo CME list

onset time	e-mail time CACTus	da	e-mail time LASCO	e-mail time FF	Ass. Events	consequences
12/07 17:48	12/08 17:37	360	-	-	False alert	-
12/08 09:14	12/10 16:01	360	-	-	False alert	-
12/13 02:54	12/13 16:52	360	12/13 15:25	-	X3.4, dimming+EIT wave	major geostorm on 12/14, SEP
12/14 22:06	-	-	12/15 17:00	-	X1.5, dimming+EIT wave	one interval of Kp=4 on 12/16
12/24 15:30	12/26 09:33	180	-	-	backsided	none

Onset time: Utime first visible in C2 field of view
CACTus: Computer Aided CME Tracking (software developed by the SIDC)
LASCO: SOHO-LASCO Operations, G. Stenborg

FF: Fearless Forecast (a NOAA trial service)
e-mail time CACTus/LASCO/FF: Utime alert e-mail sent by group
da: angular width of CME, measured by CACTus
Ass. Events: Associated Events, Long Duration Event (LDE), flare class