Development of the current 24 solar cycles (77 months)

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1. At the moment, within already realized history of reliable cycles SA, it becomes clear that, since a maximum 22 and on the end 23 SC, conditions of magnetic fields generation on the Sun significantly changed and gave rise to a new epoch of the "lowered" SA – an epoch of average and low solar cycles. The previous epoch “lowered” SA began with 12 SC (XII 1878) and continued prior to beginning of SC 17 (IX 1933). Begun under such conditions current 24 SC to VI 2015 is developed as “normal” low solar cycle (W^*_{max}= 82). Fundamental characteristics low SC (on the average):

– the low initial values W^*_{min} = 3.4 and large duration (11.1^Y);
– the more prolonged (4.6^Y)of increase branches and the shorter (5^Y) of the decrease branches;
– the narrower zone of spot-formation on the latitude ±35°;
– a quantity of spotless days around the phase of the minimum, on the average, 785^d;
– the average smoothed area of the sunspot groups for the epoch of “lowered” SA ~1200 msh;
– the low number of dunspot groups from Sp ≥1000 msh;
– the more tightened phases of the minimum between the cycles ($56–60^M$) and, especially, before low SC, and in 2 cases of 3 (23–24 and 14–15) the most extensive phases of the minimum;
– the maximum value of the polar magnetic field of ±100 T;
– inside the epochs of SA unconditionally are carried out the observant rules of development SC, including the Gnevyshev-Ol' rule.

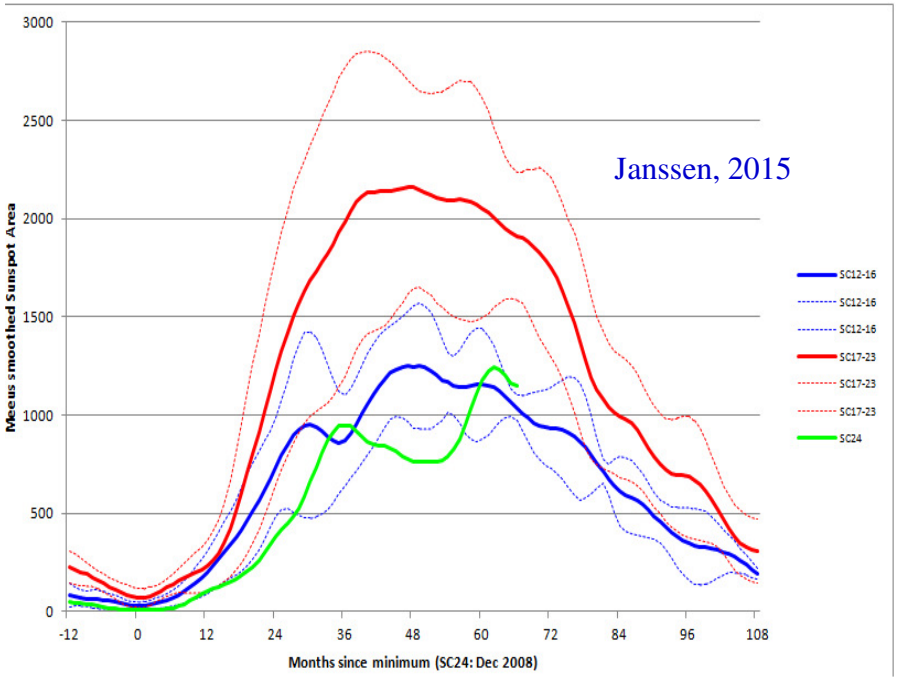
Table 1. Cycles SA of the first epoch of "lowered" SA

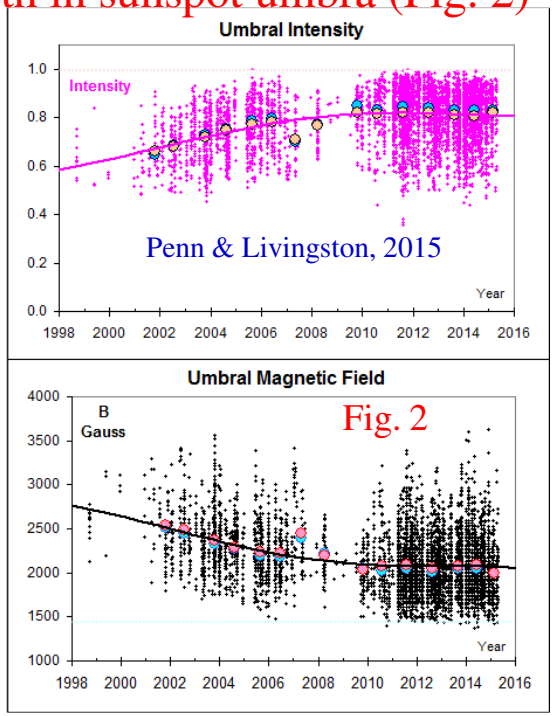
.N	To	W^*_{min}	Tmax	Te	W^*_{max}	$T_{Y\uparrow}$	$T_{Y\downarrow}$	T_Y	T_{1min}	T_{2min}	Б/П
12	1878/12	2.2	1883/12	1890/2	74.6	5.0	6.3	11.3	64^m	59^m	732
13	1890/3	5.0	1894/1	1901/12	87.9	4.5	8.2	12.1	59^m	77^m	937
14	1902/1	2.6	1906/2	1913/7	64.2	4.1	7.6	11.7	77^m	59^m	1045
15	1913/8	1.5	1917/8	1923/7	105.4	4.0	6.1	10.1	59^m	48^m	526
16	*1923/8*	*5.6*	*1928/4*	*1933/8*	*78.1*	*4.7*	*5.6*	*10.3*	48^m	54^m	666
Σ						4.5	6.5	10.9	61.4^m		781
24	2009 I	1.7	2014/04	*2020–21*	83	5.5	*6+.7*	*11,9*	68^m	*59m*	

1. SA passed the transition period of the change of the magnetic fields generation regime in the solar convective zone and left into steady state of the low and average solar cycles alternation similar to time interval of SC 12 – 16.

2. Reflection of this process – reduction of the general magnetic field strength to new average values, characteristic for an epoch of the "lowered" SA, respectively and the average areas of sunspot groups (Fig. 1) and the magnetic field strength in sunspot umbra (Fig. 2)

Fig. 1. Smoothed average Sp* for the epoch of "increased" SA (red curve) and for the epoch of "lowered" SA (dark-blue curve) with the boundaries of the values spread. 24 SC (green curve)





2. Fundamental characteristics of solar cycle 24:

– beginning I 2009. from W*min= 1.7;
– the first sunspot group of the current cycle appeared in the N- hemisphere at I 2009, and in the S- hemisphere only at V 2009; - the beginning of the phase of increase – IV 2011 (W= 54.4, F10.7 = 112.6);
– the appearance of the first large (Sp≥ 500 msh sunspots group – II 2011, and by the first very large (Sp≥ 1500 msh) – XI 2011;
– the record tightened branch of increase SA (5.4);
– the radio fluxes on 10 cm and solar constant is substantially less than in the previous cycles (Fig. 3a, b);
– after the passage of the maximum current SC point is most close to 16 SC (Fig. 4).

http://www.spaceweather.gc.ca/solarflux/sx-6-mavg-eng.php

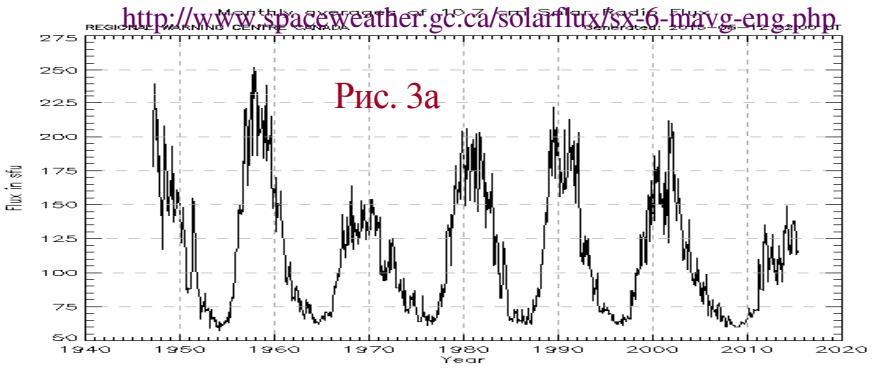


Рис. 3а

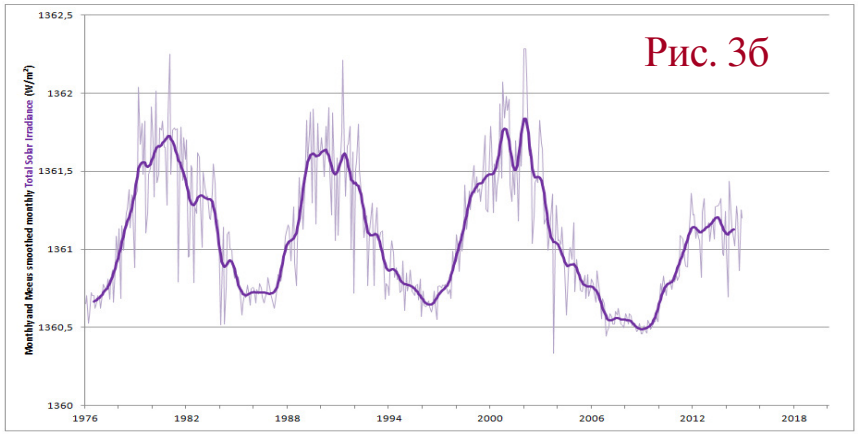


Рис. 3б

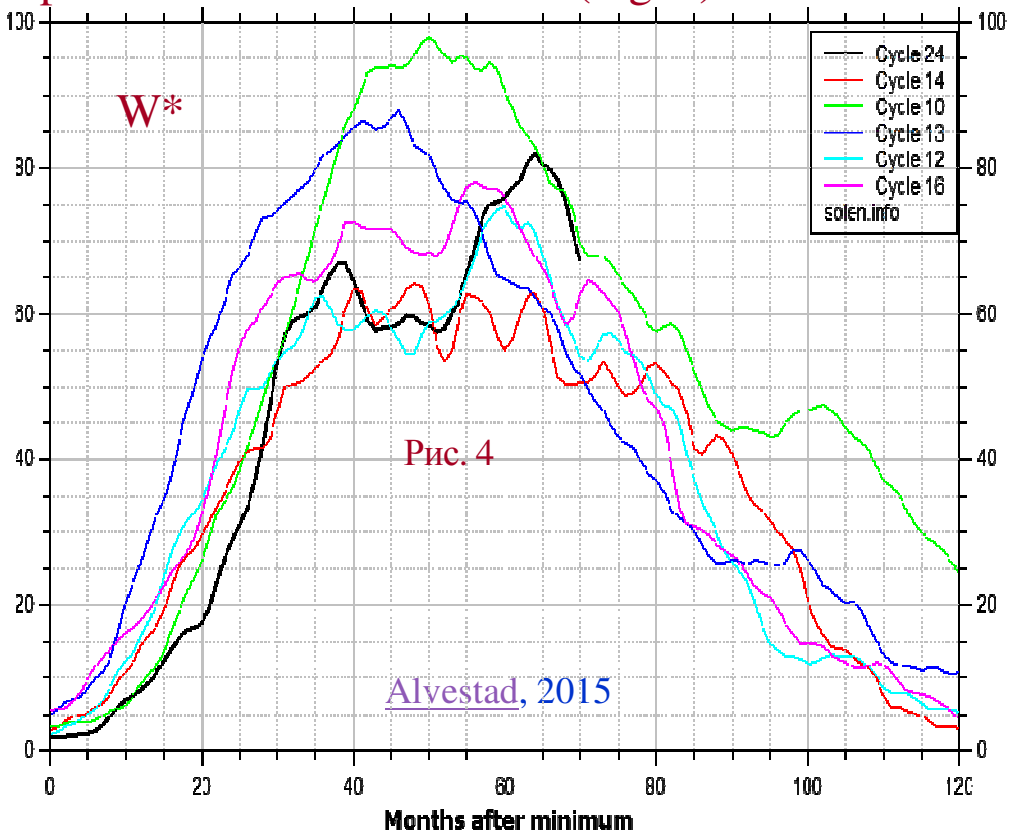


Рис. 4

Alvestad, 2015

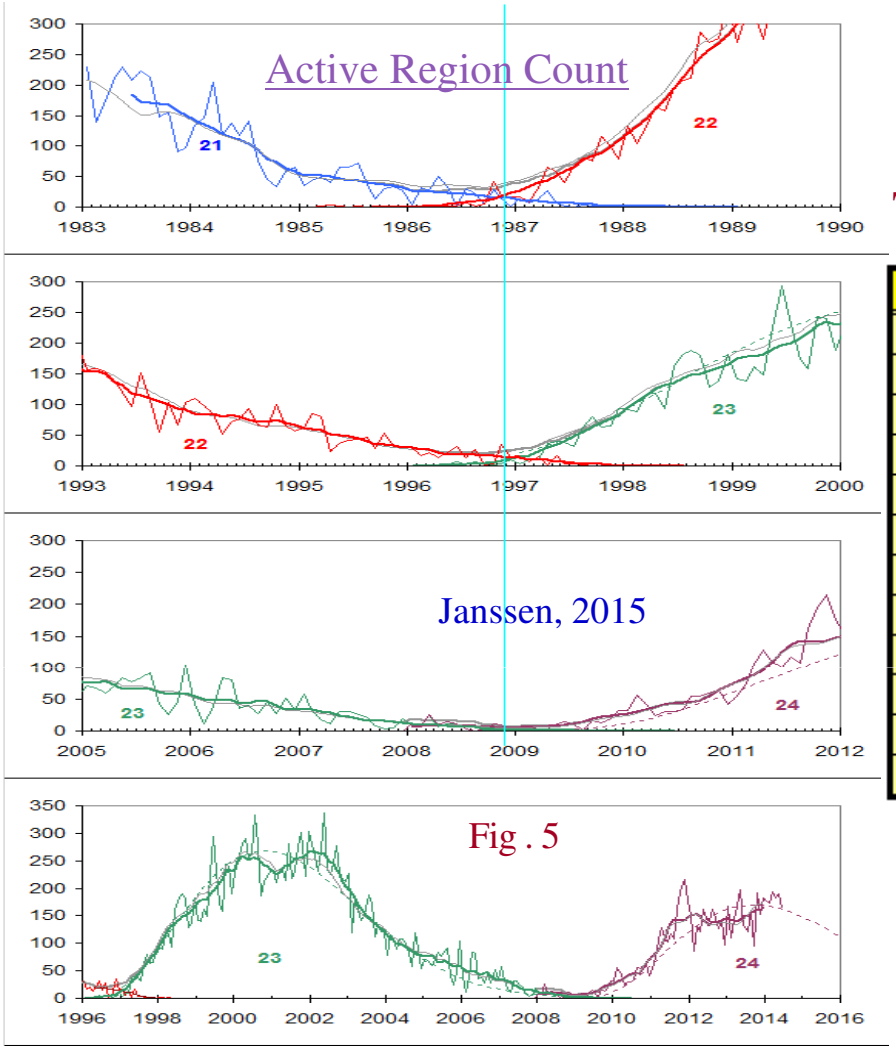
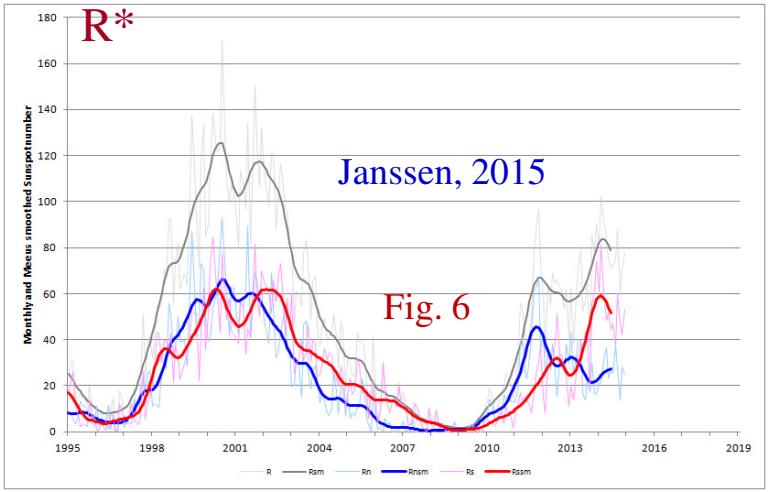


Table 2. Largest on area of the sunspot groups SC 24.

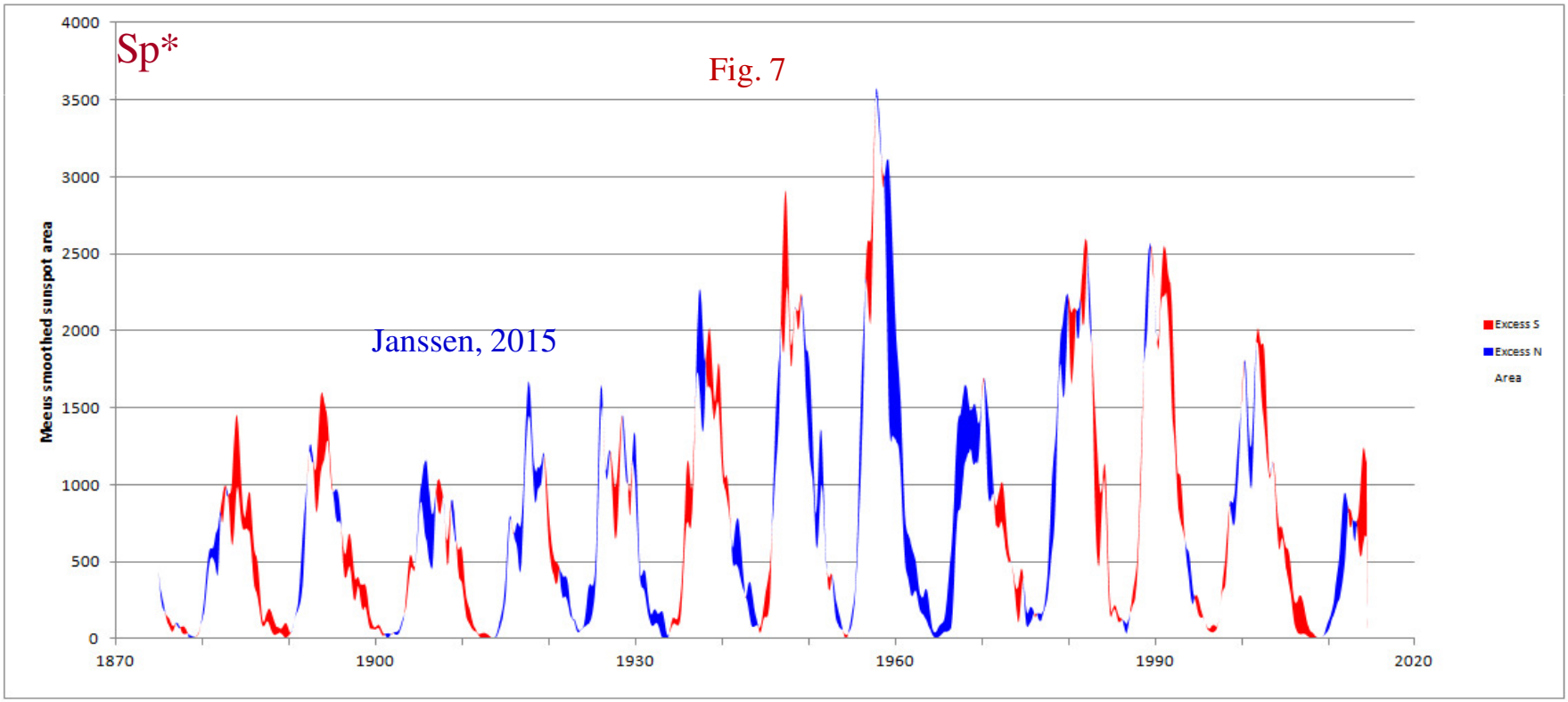
YY	MM	NOAA	Long	Lat	Area	Class	Flare
2014	10	12192	248	-13	2750	Giant	X3
2014	1	11967	113	-13	1580	Super	M6
2014	1	11944	99	-9	1560	Super	X1
2011	11	11339	102	19	1540	Super	X1
2012	7	11520	85	-16	1460	Super	X2
2011	9	11302	282	12	1300	Super	X1
2012	3	11429	300	18	1270	Super	X5
2013	1	11654	148	8	1100	Super	M1
2014	11	12209	251	-15	1100	Super	M5
2014	12	12242	239	-18	1080	Super	X1
2012	5	11476	183	11	1050	Big	M6
2013	4	11726	327	13	1000	Big	M1

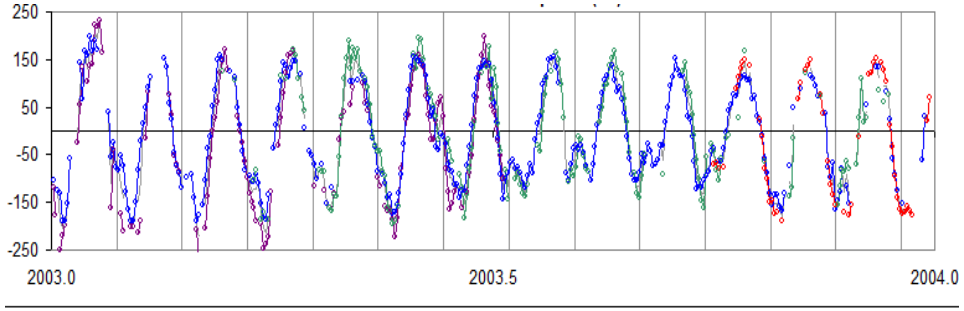
Janssen, 2015

– rate and a quantity AR sharply decreased in comparison with previous SCs (Fig. 5);
– in 6.5 years on the solar disk appeared only of 12 sunspot groups Sp≥1000 msh, 4 – Sp≥1500 msh and one – Sp≥2500 msh (table 2).

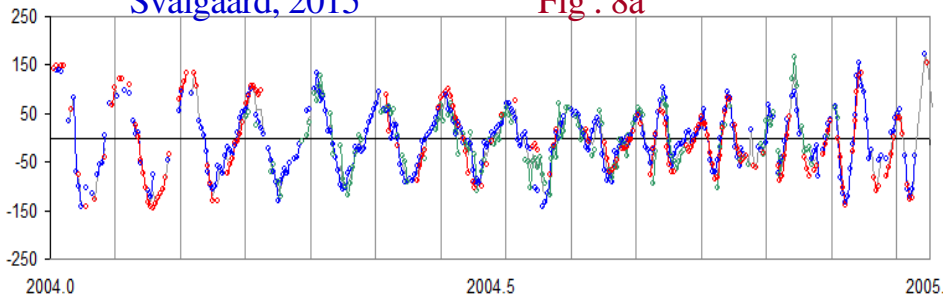


– the predominance of spot-forming activity the N-hemisphere of the sun prior to the middle 2013 (**Rn*max = 45,5 at X 2011**), then picture sharply changes and the sunspot groups more frequently appear in the S- hemisphere (**Rs*max = 59,0 at II 2014**), (**Fig. 6, 7**; N- hemisphere – dark-blue);





Svalgaard, 2015 Fig . 8a



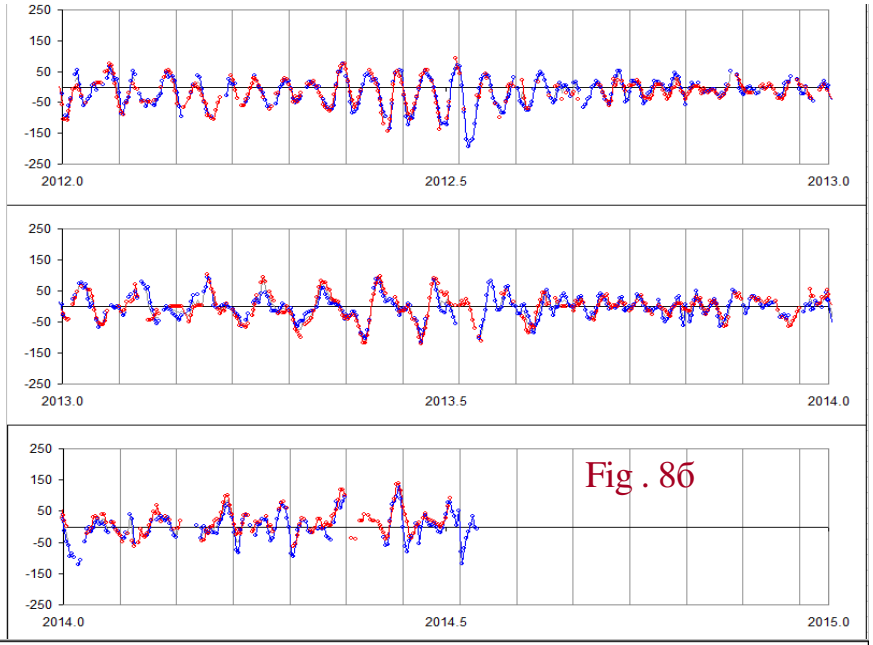


Fig . 8б

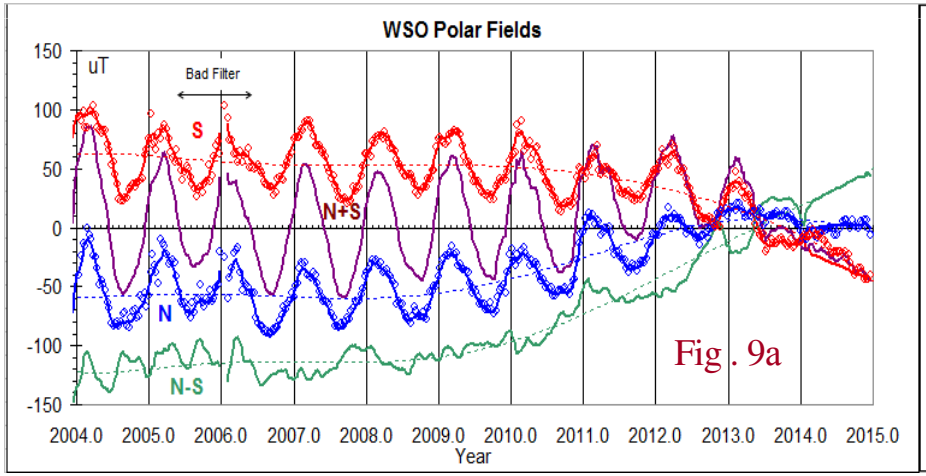


Fig . 9a

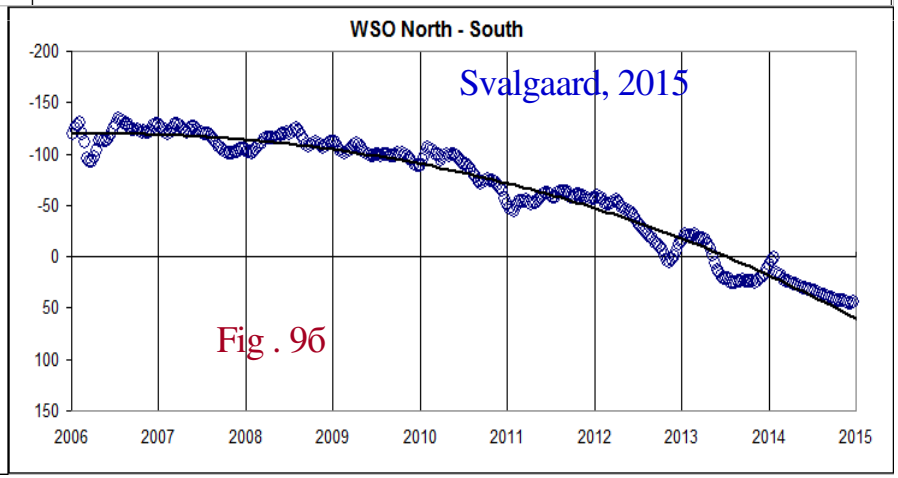
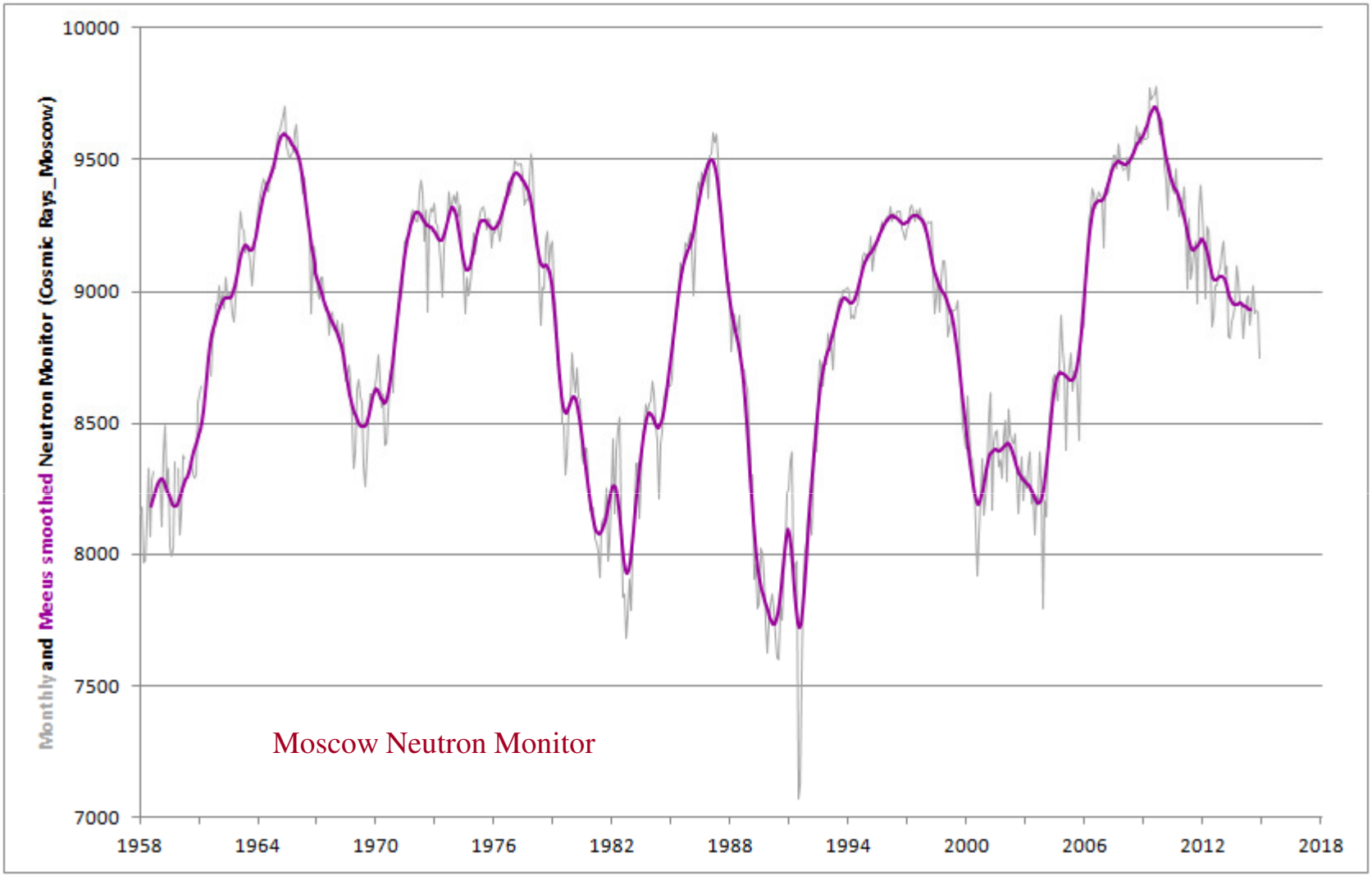


Fig . 9б

– the same processes led also to the significant decrease of the total magnetic field of the Sun (Fig. 8a – for max of SC 23; 8b – for max of SC 24) and to “the leap-frog” of changes in the polar magnetic field (Fig. 9); S- polarity is already past reversal of polarity, but N- polarity by June 2015 still none;



– the decrease of the total magnetic field of the Sun led to the significant decrease and interplanetary magnetic field, which led to raising of galactic cosmic rays background;

– the first large flare (M≥5) was occurrence at II 2010;
– the first **powerful** solar flare **X6.9/2B** was observed by 9.08.2011;
– flare activity at the **lowest level** in the last 70 years (18 – 23 SCs) – for 74^{M} of the cycle development was occurrences: – 626 solar flares with class **M ≥1**, – **109** large flares (Fig. 10), among which: **2** – class **X> 5**; **45** – class **X≥1.0** (Fig 11), **23** of last in the S- hemisphere;
– **3** SPE with the fluxes of the protons ≥1000 pfu, **7** SPE with the fluxes of the protons ≥100 pfu, **2** – GLE;
– not less than **7** flares with solar **ºn** (Table 3.);
– geoeffectivity of solar active event and coronal holes remains anomalously low: for 5.8^{Y} are registered **two large magnetic storms (Ap≥70).**

Table 3

20110307	1943	2012	>2058	**M3.7/**	.12	S22W67	11164
20110607	0616	0641	0809	**M2.5/2N**	.04	S21W54	11226
20110924	1909	1921	>1941	**M3.0/**	.05	n14e54	11302
20111103	2016	2027	2140	**X1.9/2B**	.10	N22E63	11339
20120123	0338	0359	0553	**M8.7/2B**	.20	N28W21	11402
20120517	0125	0147	0308	**M5.1/1F**	.10	N11W76	11476
20120904	B/S						

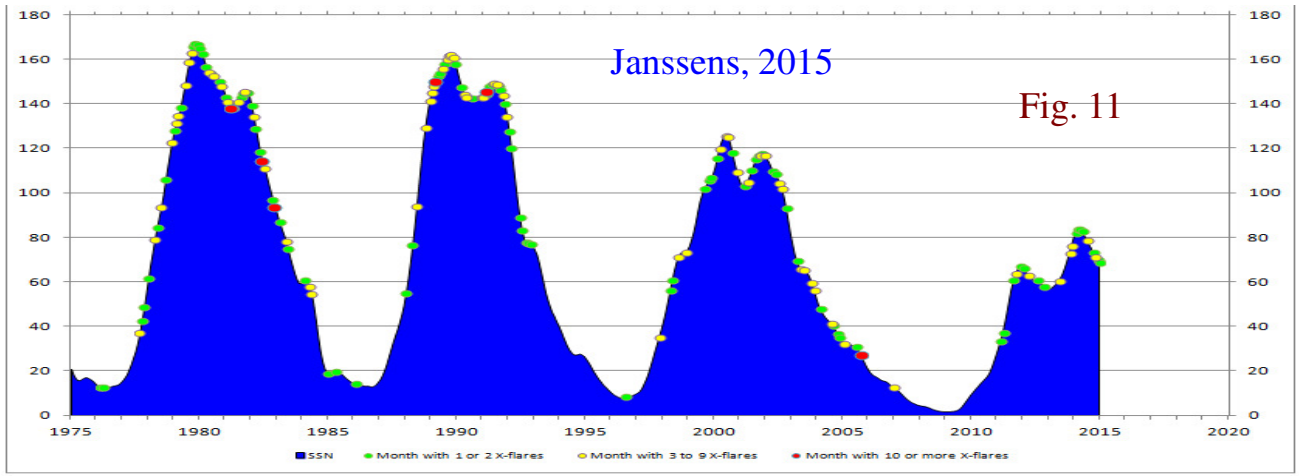


Fig. 11

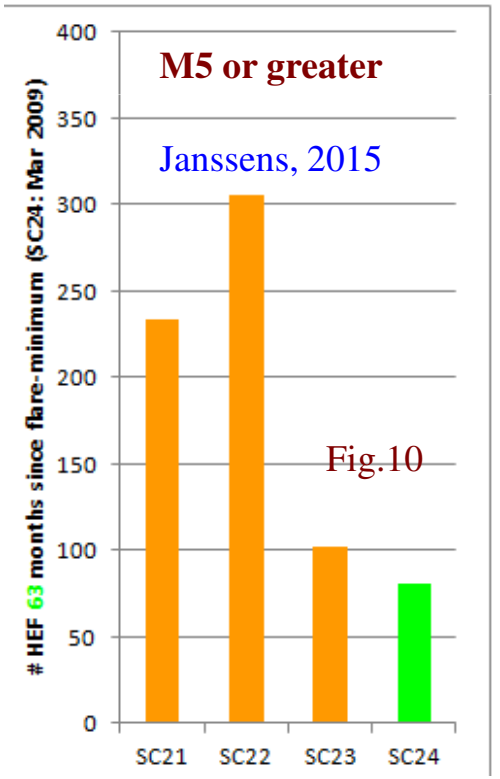
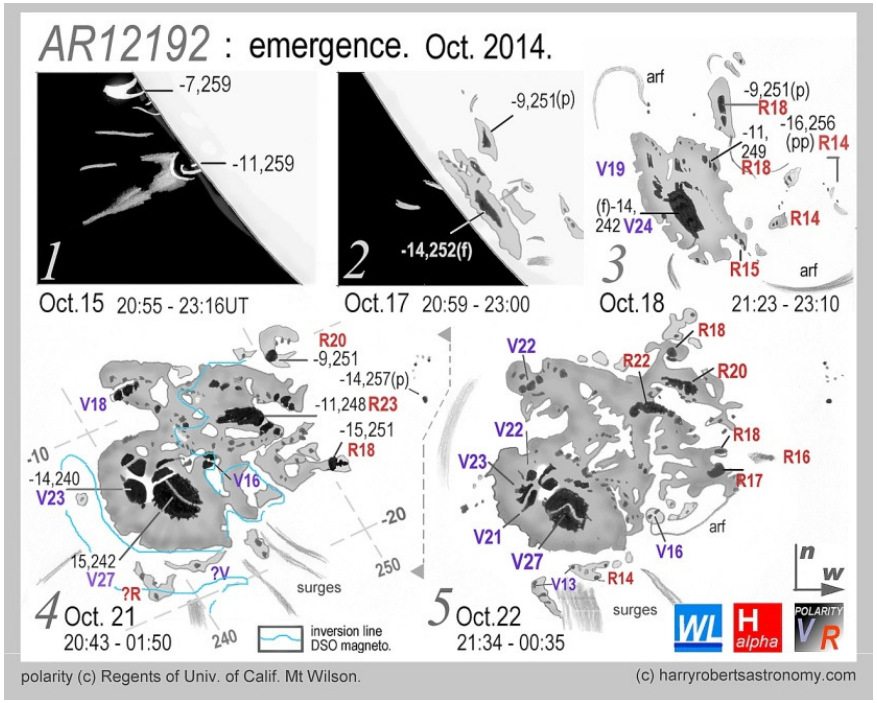
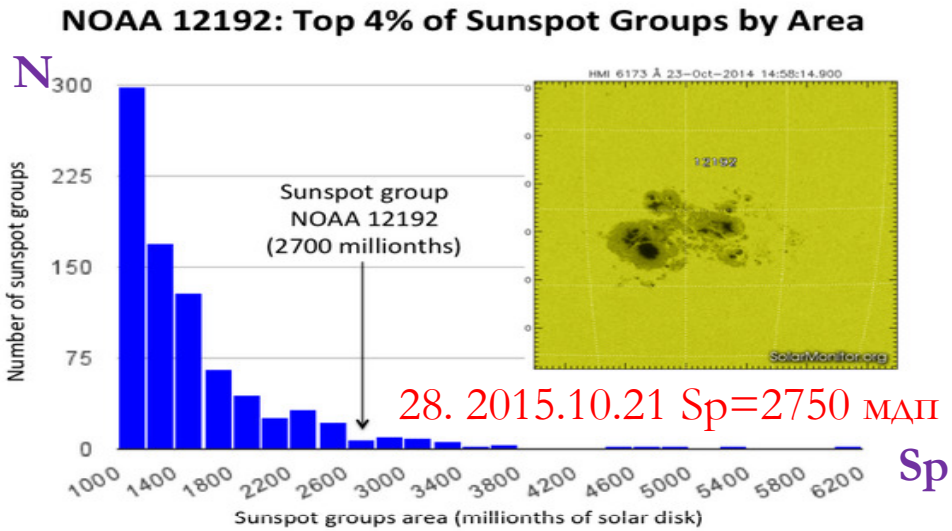


Fig.10



3. "Extreme" phenomena and event current SC

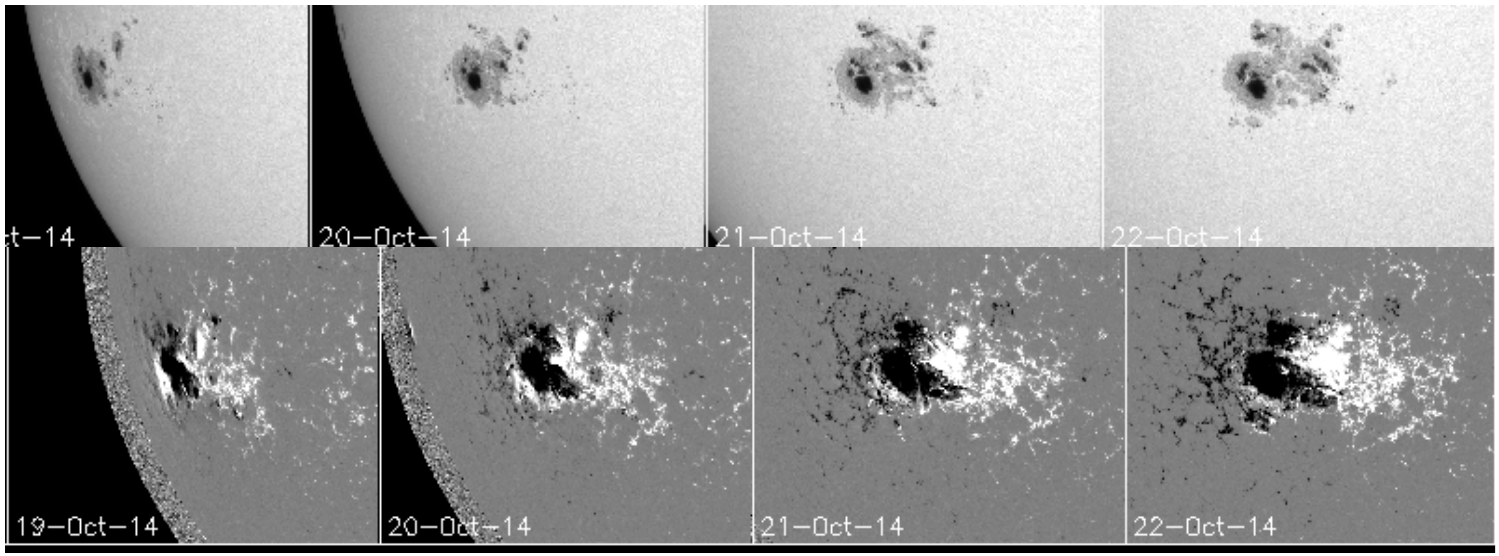


28. 2015.10.21 Sp=2750 мдп

spot areas (1874-2001): www.spaceweather.com/sunspots/history.html

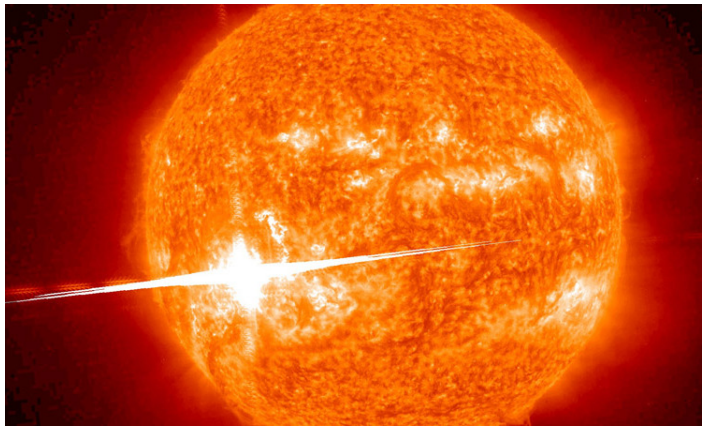
Images AR12192 for 15 – 22.10. 2014

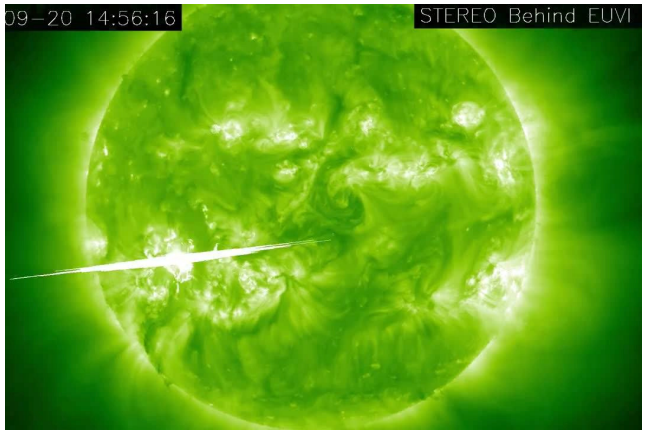
Sp^{max}=2740 msh

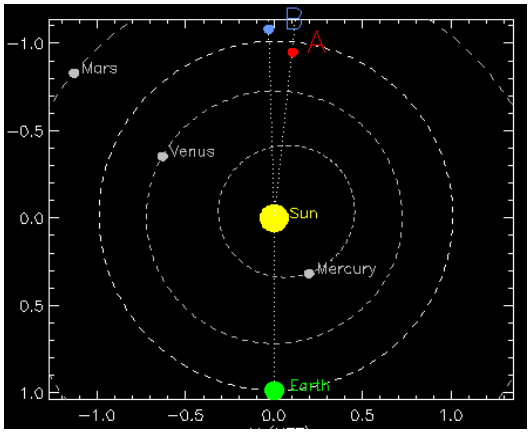


AR12192 за 19 – 22 October 2014 г. : photosphere and magnetic fields

Backside solar flare event 20.09.2012: X3 – X12, S15E156







STEREO 15.02.2014

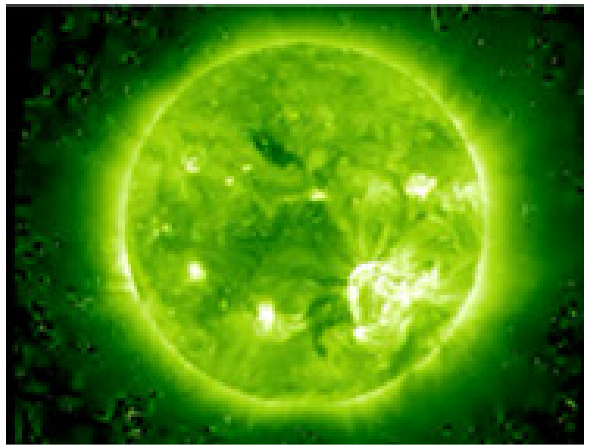
CME: V≥2000 km/s – 9; V≥2600 km/s - 2

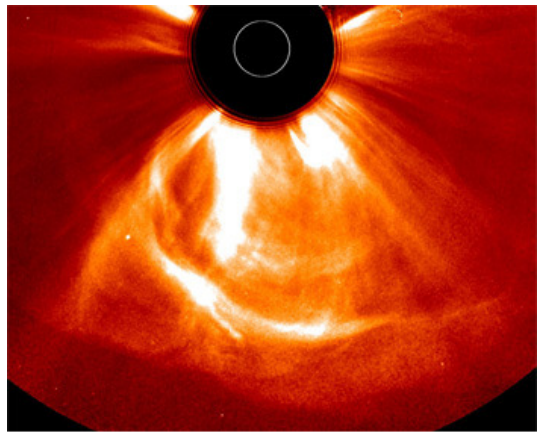
2012/03/07	00:24:06	Halo	360	2684	2982	2379	2594	X5.4
2013/05/14	01:25:51	Halo	360	2625	2738	2505	2548	X3.2
2012/07/23	02:36:05	Halo	360	2003	2103	1901	1972	b/s

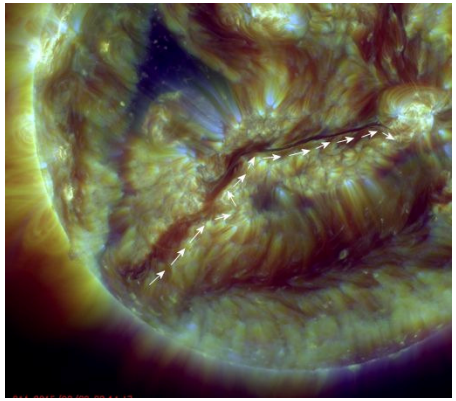
20120723 – Backside event in NOAA 11520

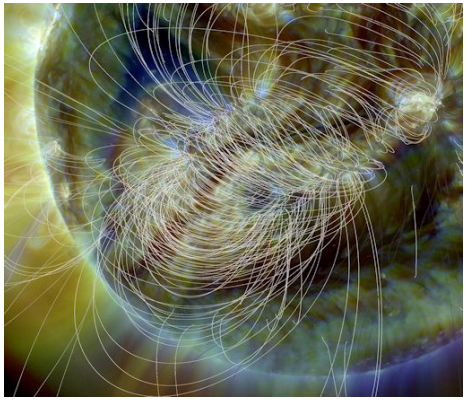
STEREO-A CME/2103 (*3400*) km/s

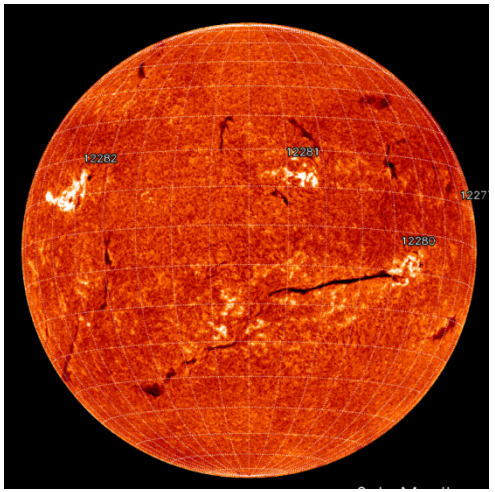
AR11520 (S16L084, CMP 12.07.12
Sp=1460 msh; FKC, δ)
XRI=2.93; $X_1^{1.4}$+$M_5^{7.7}$+C_{26}), 2_1 +1_7 +S_{64}





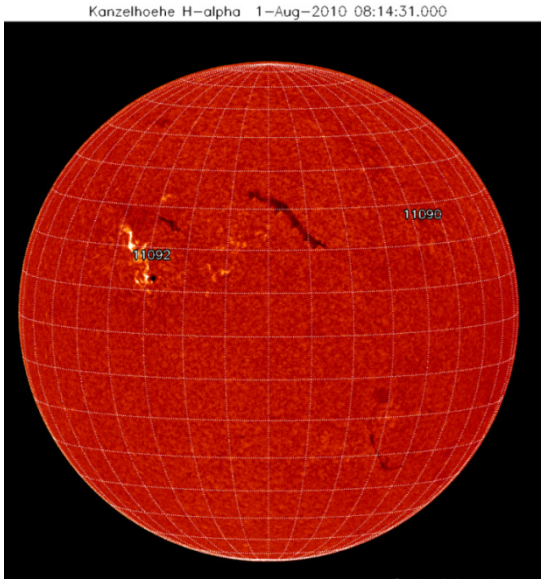


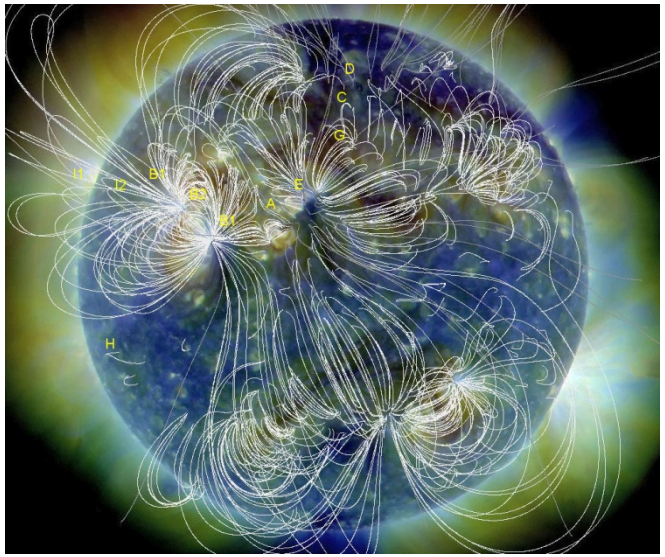


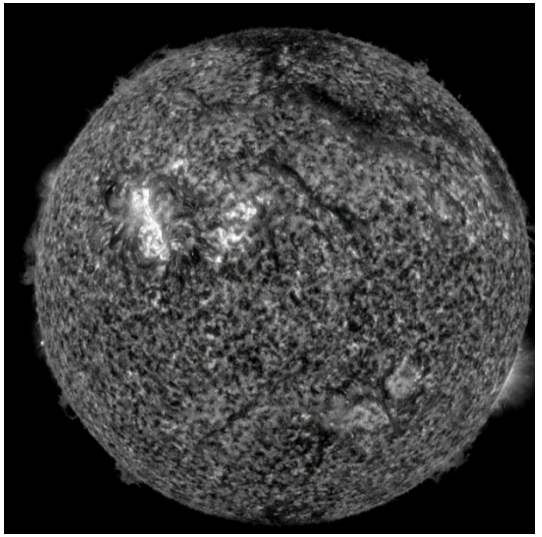


Gigantic filament October 2015 – 10^6 km

Global flare event:
1.08.2010 - C3.2, 08:26 - (AR11092);
22.09.2010 - 3 DSF 02– 06 UT







SUMMARY

– the maximum of the current solar cycle according to the monthly smoothed relative numbers of sunspots came in April 2014 than established the record of the an increase branches duration in the reliable cycles of SA.

– degree and nature of solar active phenomena geoeffectivity clearly it fell in comparison with previous SC of the Space Age – of the last epoch of "increased" SA (SCs 19 – 22) and transition period (23 SC).

– decreased time between the first signs of a significant new magnetic flux emergence and the beginning of flare energy release period (15^h – 36^h) though the period of changes didn't undergo – ~ 55^h.

– on the scenario of development SCs inside the epochs the most powerful flare events occur on the phase of the decrease.

– the current cycle – the first component of physical 22-year solar cycle and according to the Gnevyshev- Ol' rule the following 25 solar cycle must be above, average in the value.

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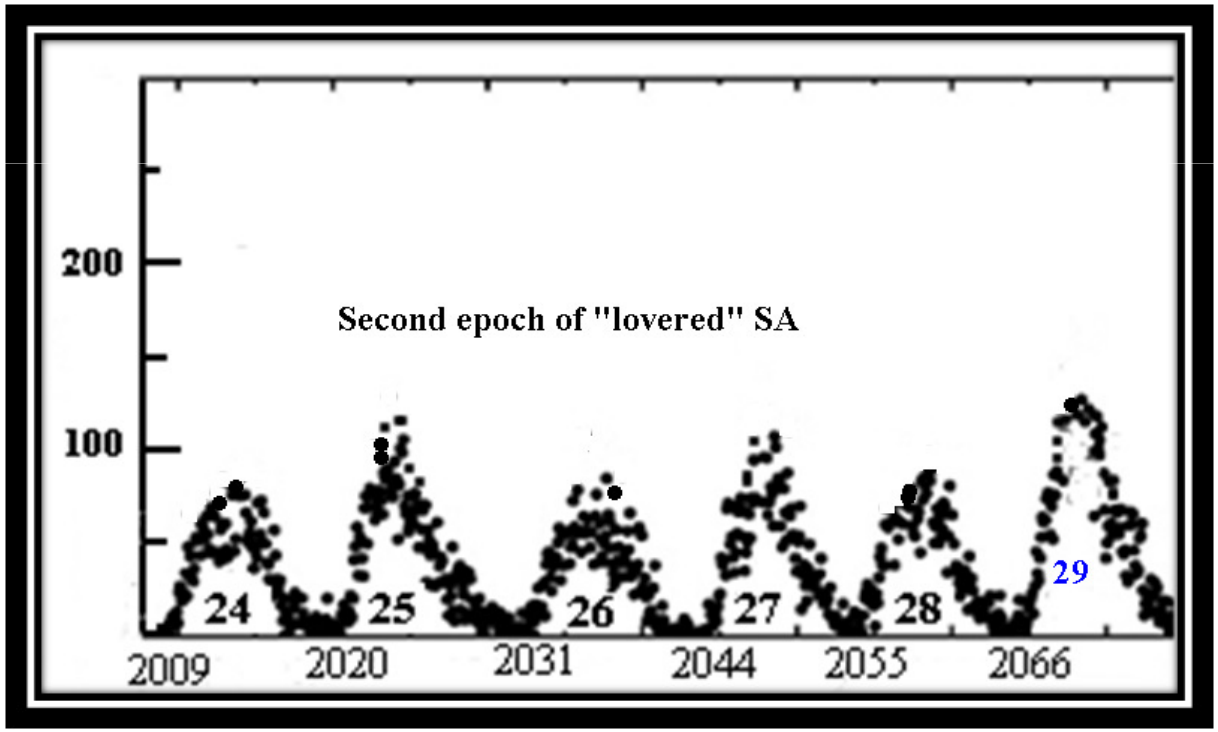


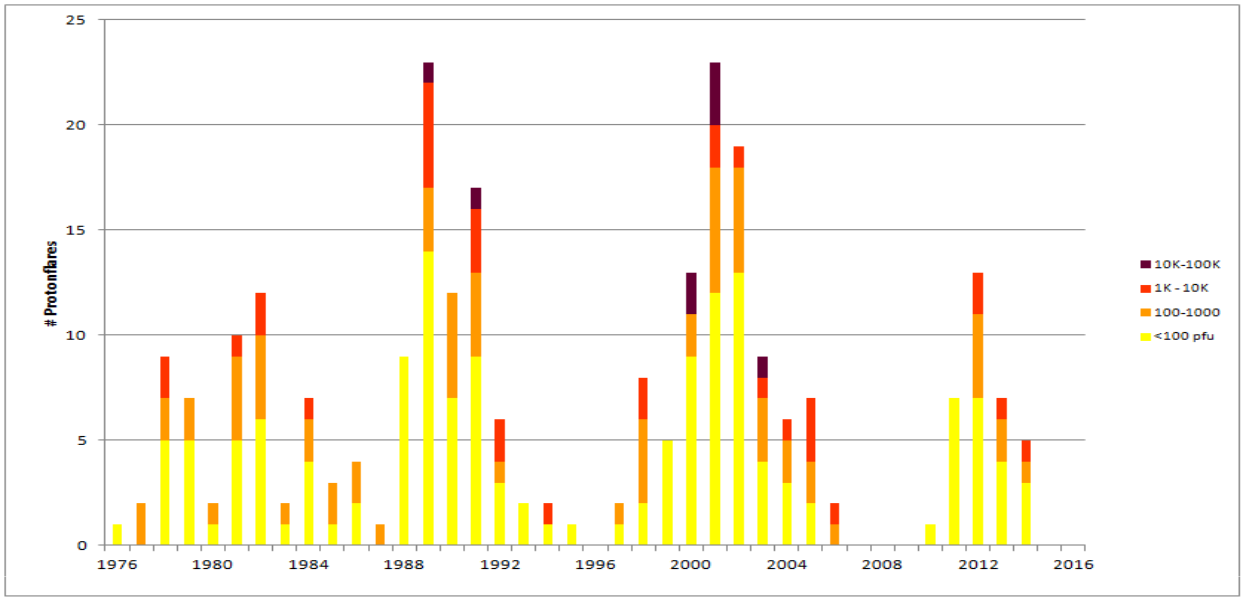
СПАСИБО ЗА ВНИМАНИЕ!

So far (30 May 2015), SC24 has produced (already) 626 M- and (only) 45 X-flares. The southern hemisphere contributed to 24 of the 45 X-class flares. Note the strongest X-class flare of SC24 is still the X6,9 flare produced by NOAA 1263 on 9 August 2011.

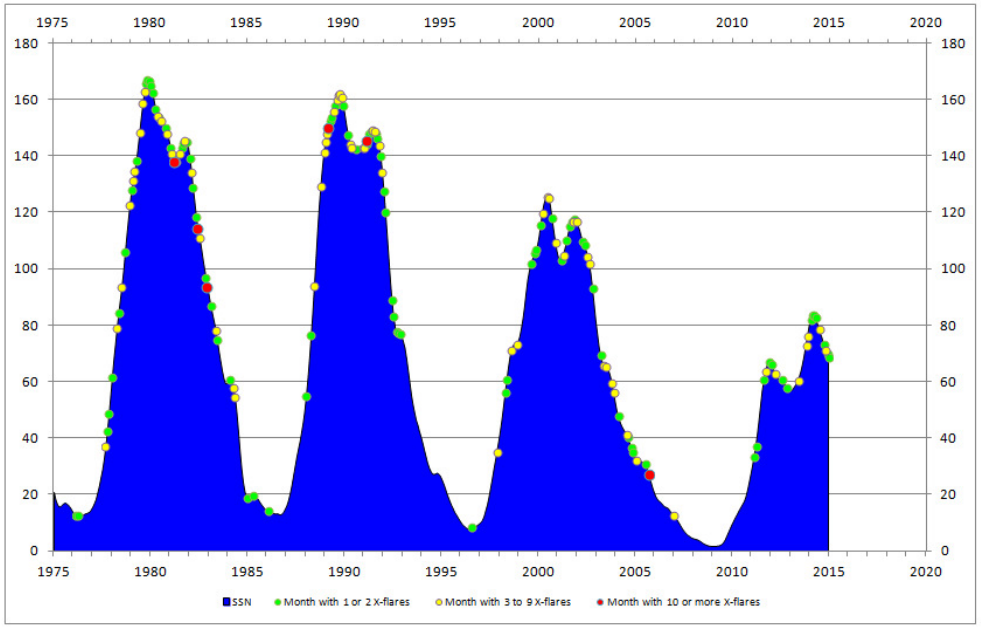
Number	Year	Month	Day	NOAA	Hem	Class	Proton	Kp
1	2011	8	9	11263	N	X 6.9	26	No
2	2012	3	7	11429	N	X 5.4	6530	7
3	2013	11	5	11890	S	X 3.3	Enhanced	4?
4	2013	5	14	11748	N	X 3.2	41	No
5	2013	5	13	11748	N	X 2.8	Enhanced	No
6	2013	10	29	11875	N	X 2.3	Enhanced	No
7	2011	2	15	11158	S	X 2.2	Enhanced	5
8	2011	9	6	11283	N	X 2.1	Enhanced	7
9	2013	10	25	11882	S	X 2.1	Enhanced	3*
10	2011	9	24	11302	N	X 1.9	In progress	8*
11	2011	11	3	11339	N	X 1.9	Enhanced	No
12	2011	9	7	11283	N	X 1.8	No	7
13	2012	10	23	11598	S	X 1.8	No	No
14	2012	1	27	11402	N	X 1.7	796	3
15	2013	10	25	11882	S	X 1.7	Enhanced	3
16	2013	5	13	11748	N	X 1.7	No	No
17	2011	3	9	11166	N	X 1.5	In progress	No
18	2012	7	12	11520	S	X 1.4	96	7
19	2011	9	22	11302	N	X 1.4	35	No
20	2012	3	7	11430	N	X 1.3	In progress	7*
21	2013	5	15	11748	N	X 1.2	In progress	5
22	2012	7	6	11515	S	X 1.1	25	5*
23	2012	3	5	11429	N	X 1.1	Enhanced	6
24	2013	11	8	11890	S	X 1.1	Enhanced	TBD
25	2013	11	10	11890	S	X 1.1	TBD	TBD
26	2013	10	28	11875	N	X 1.0	Enhanced	No
27	2013	11	19	11893	S	X 1.0	Enhanced	No

ГАО Пулково 2014

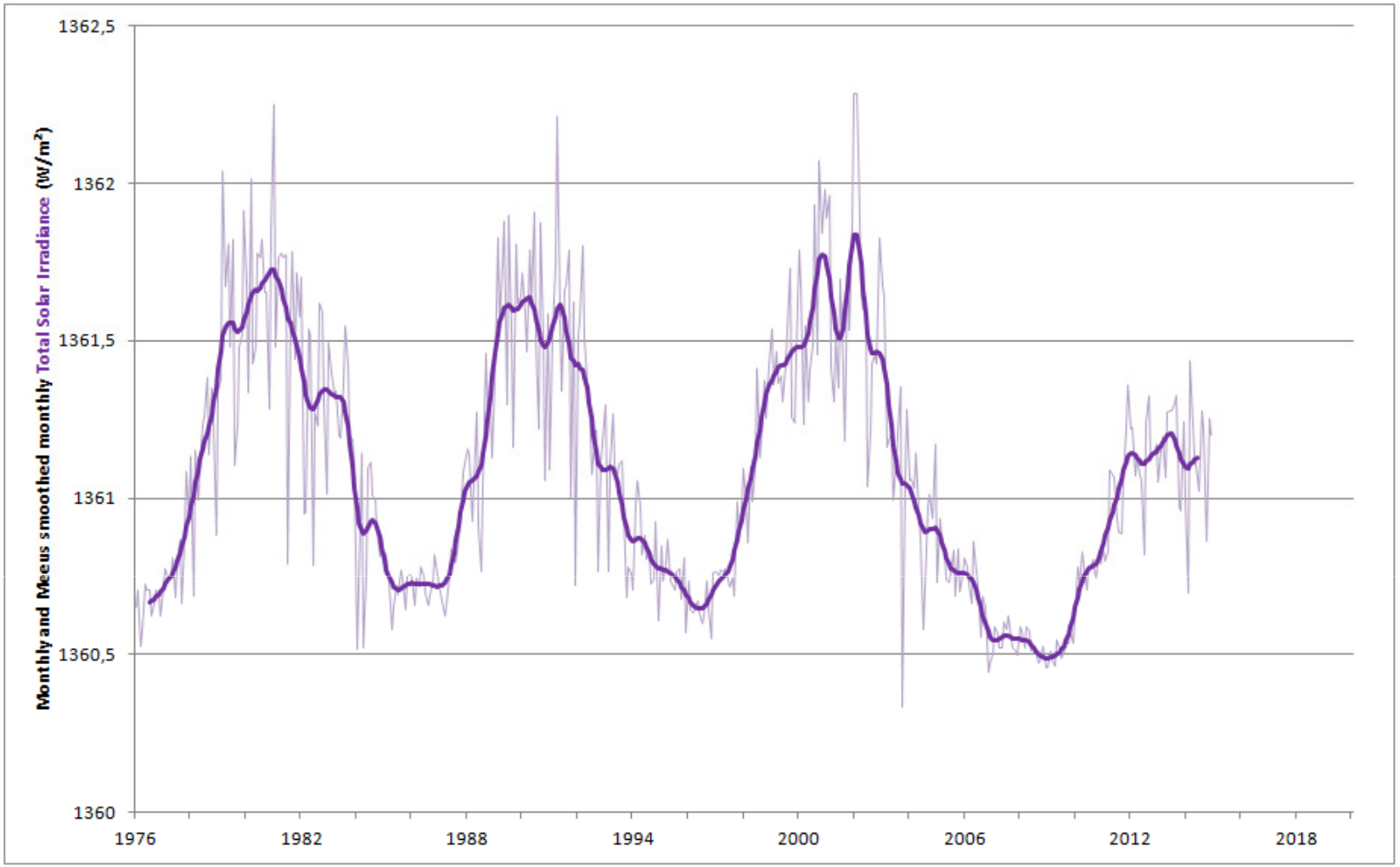
Основные характеристики 24 цикла СА:



Солнечные протонные события в последние 4 СЦ
В 24 СЦ :
2010– 1; 2011 - 7
2012- 13; 2013-7
2014 - 8



Based on the previous 2 solar cycles, the maximum number of prominences seems to precede the maximum number of CMX-flares by about 1 year (+/- 3 months). **The smoothed maximum of prominences was reached in January 2013, which now seems to precede the imminent maximum of CMX-flares by about a year. Note the first flare maximum can not clearly be distinguished in the BAA prominence data, which seems to have only one maximum.**

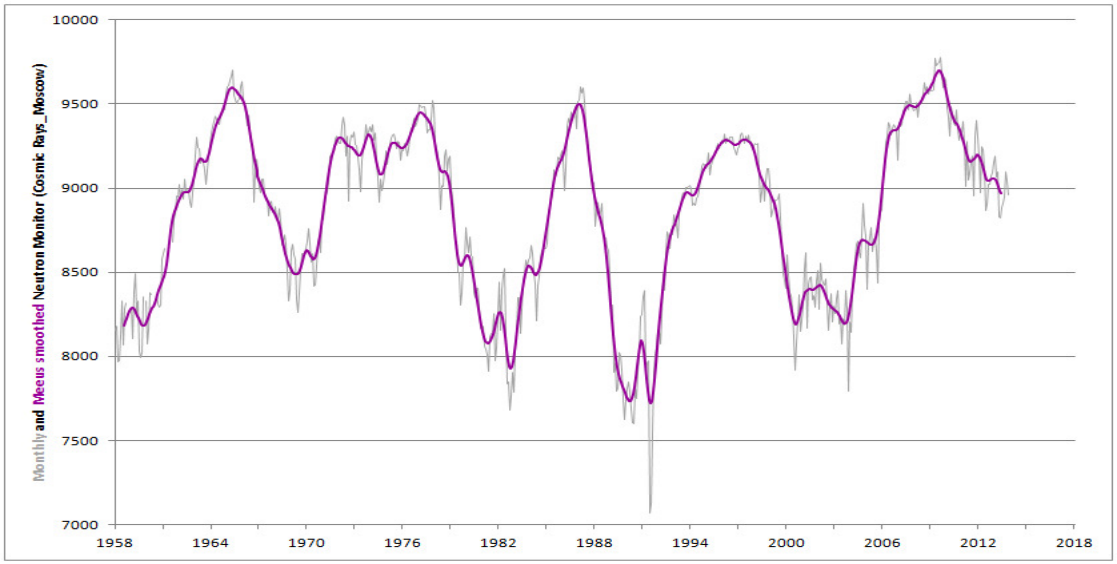


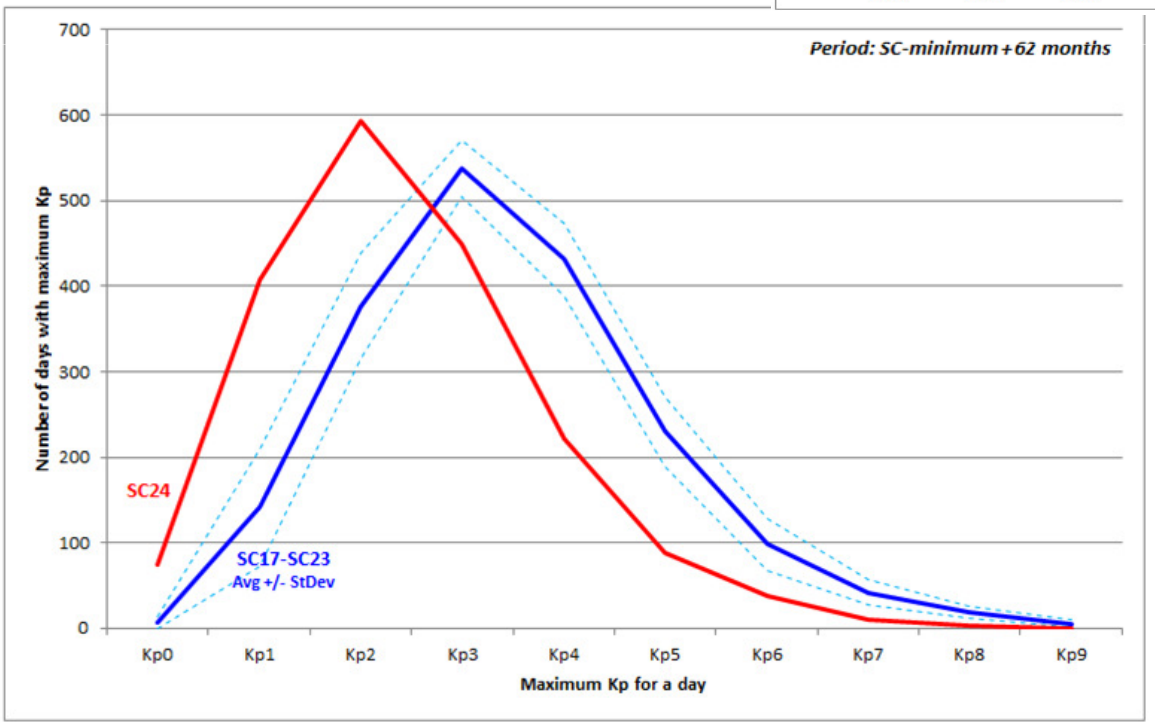
Absolute data till December 2014 (smoothed till June 2014).

ГАО Пулково 2014

Основные характеристики 24 цикла СА:

Данные нейтронного монитора ИЗМИРАН за 6 СЦ

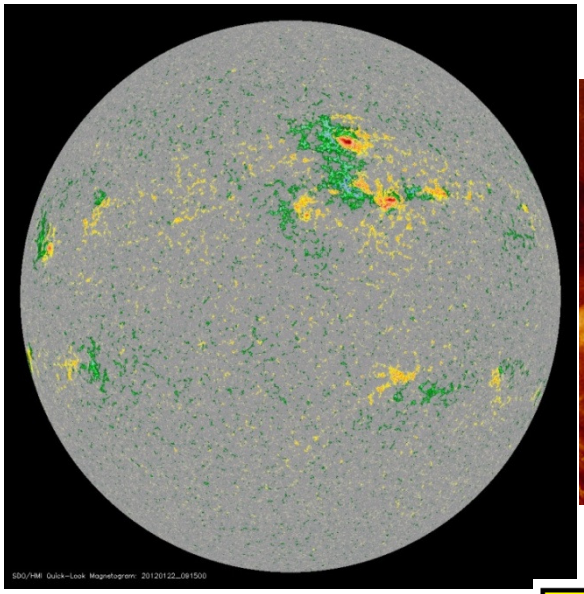


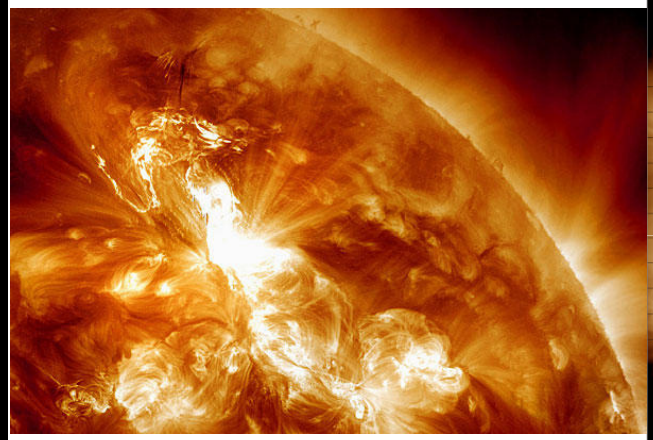


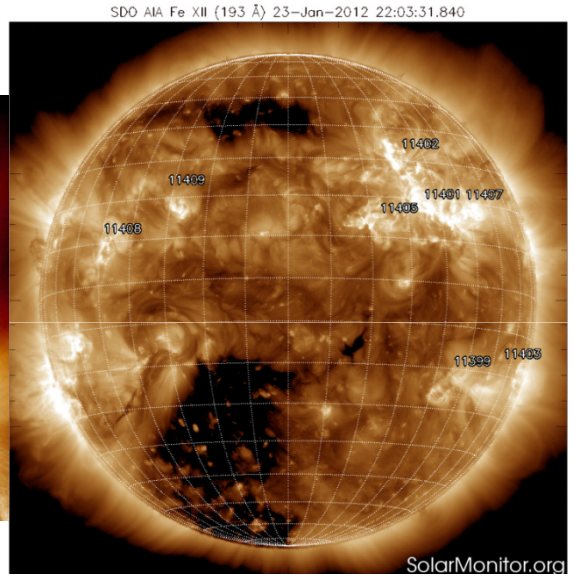
Число дней с максимальным значением Кр на 62 месяца развития СЦ; Синяя кривая - среднее за СЦ (17 – 23).

Основные характеристики 24 цикла СА:

Одной из самых интересных особенностей 24 цикла является необычно большое количество комплексов активных областей (КАО), промежуточной структуры между АО и комплексами активности.



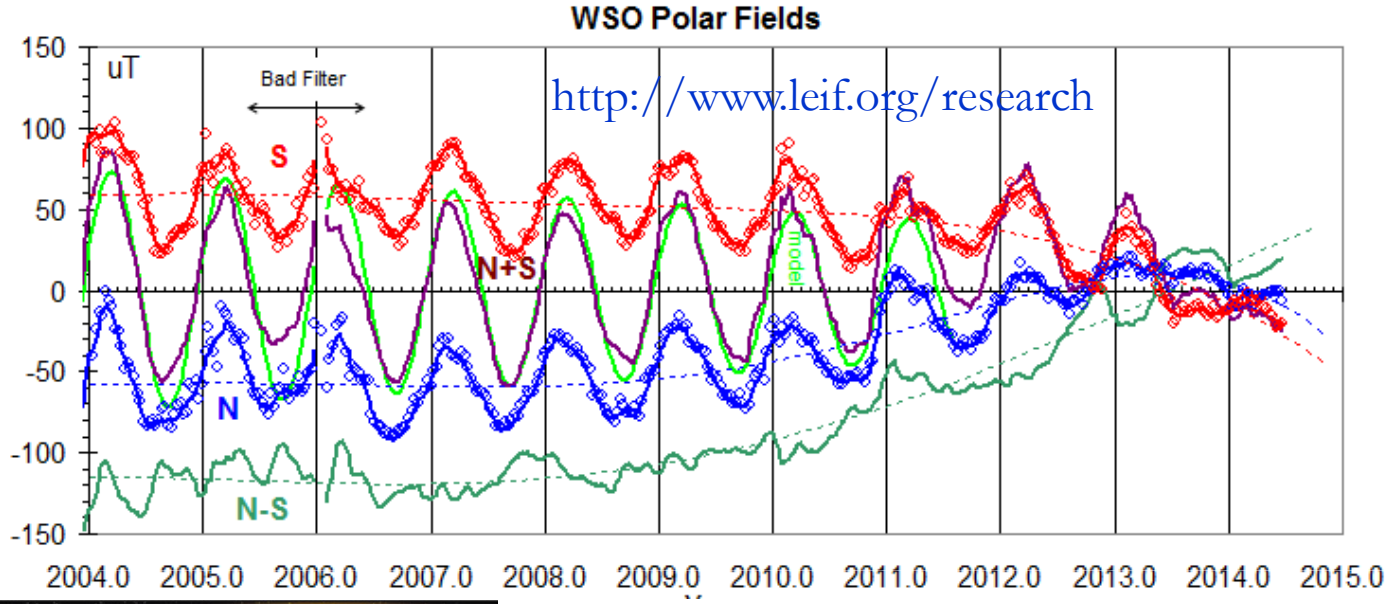


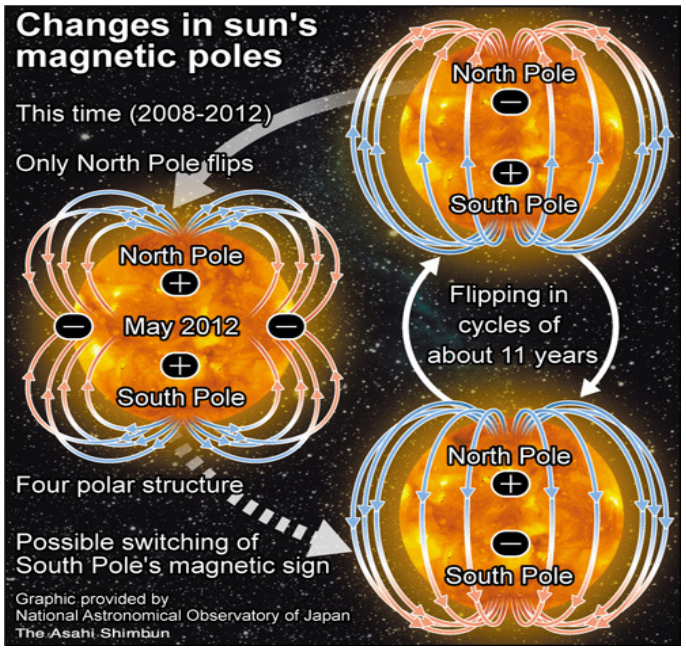


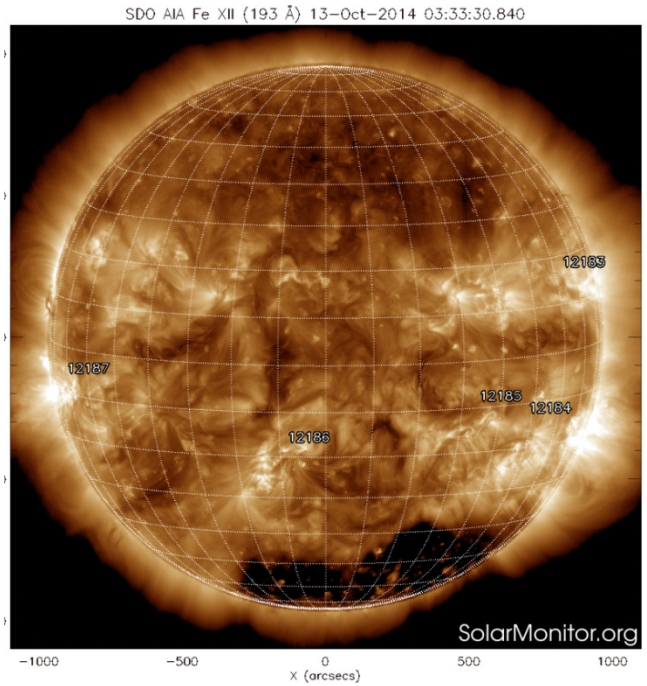
Janssens, 2013

YY	MM	NOAA	Long	Lat	Area	Class	Flare
2011	11	11339	102	19	1540	Super	X1
2012	7	11520	85	-16	1460	Super	X2
2011	9	11302	282	12	1300	Super	X1
2012	3	11429	300	18	1270	Super	X5
2013	1	11654	148	8	1100	Super	M1
2012	5	11476	183	11	1050	Big	M6
2013	4	11726	327	13	1000	Big	M1
2012	6	11515	205	-17	900	Big	X2
2011	3	11166	91	9	770	Big	X1
2011	3	11164	165	24	770	Big	M3
2012	6	11504	86	-17	750	Big	M2
2011	8	11263	301	17	720	Big	X6
2013	7	11785	8	-11	720	Big	C9

Основные характеристики 24 цикла СА:



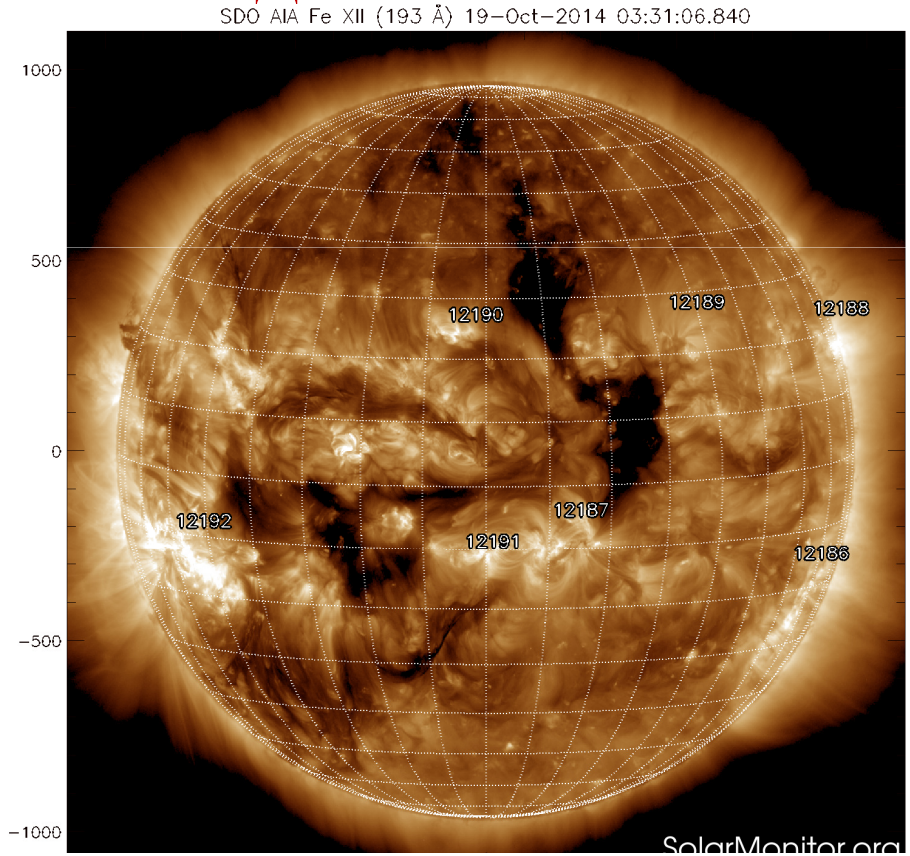




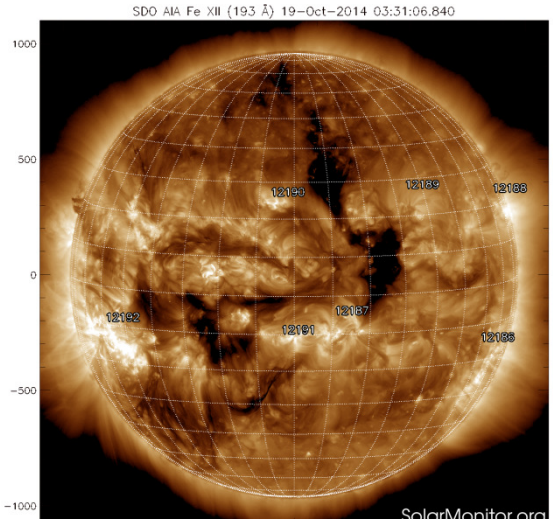
ГАО Пулково 2014

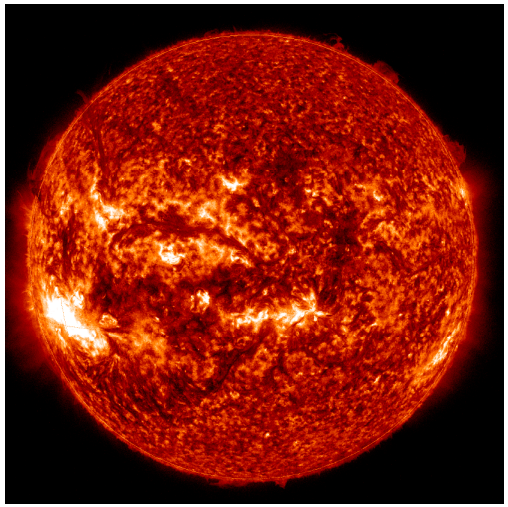
Основные характеристики 24 цикла СА:

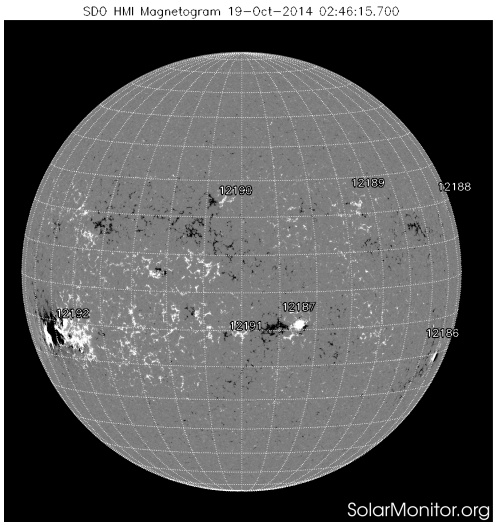
286 КД проходили видимый диск Солнца из них 86 в N; 85 в S и 115 приэкваториальные. Все эти прохождения обеспечили 132 вновь образованные КД.



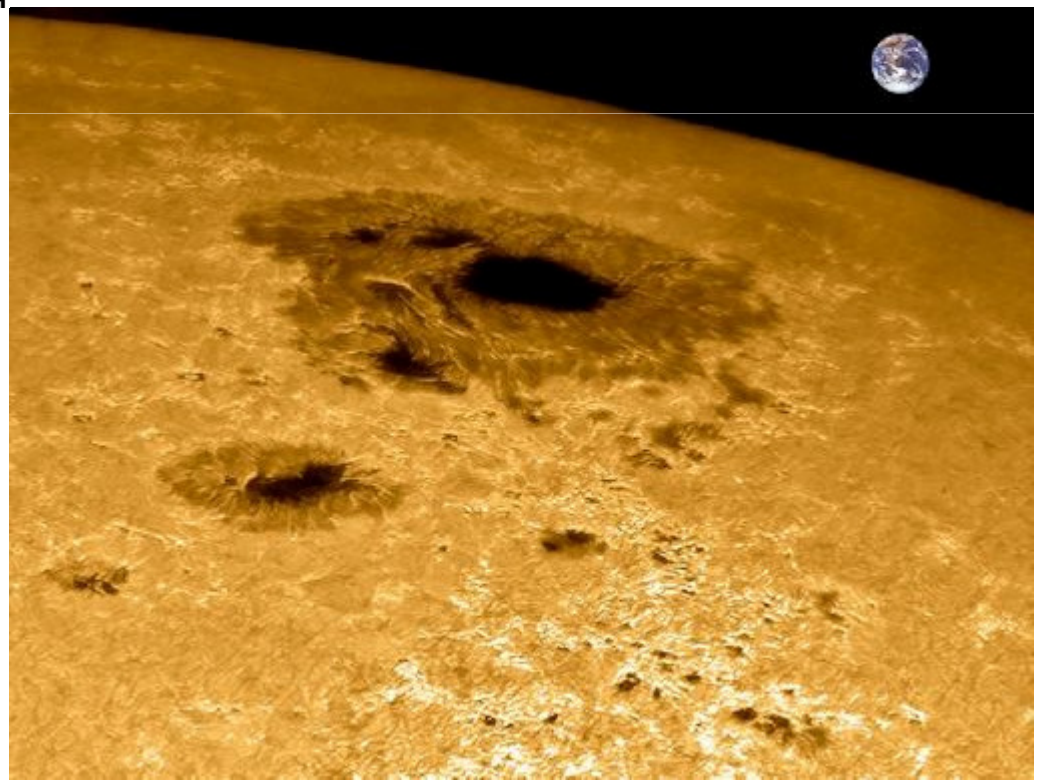
Основные характеристики 24 цикла СА:







Солнце 18.10.2014



ГАО Пулково 2014

FLARE ACTIVE REGIONS OF XXIV SOLAR CYCLE

– AR11041 (S25L052; CMP Sp=200) ; XRI= 1.18; $M_6^{3.4}$; ПВЭ (14^h)– 20.01.10

– AR11045 (N24L250; CMP Sp=420); XRI= 1.52; $M_8^{6.4}$+C; ПВЭ (72^h)6– 9.02.10

– AR11046 (N24L186; CMP Sp=190); XRI= 0.83; $M_1^{8.3}$+C; Rapid evolution after 10.02 and flare M8.3 — 12.02.2010

– AR11079 (S26L117; CMP Sp= 010); XRI= 0.3; $M_2^{2.0}$+C; ПВЭ(29^h) 12–13.06.10

– AR11081 (N22L098, 11.06_{W43}; Sp=090); XRI=0.3; $M_2^{2.0}$;

ПВЭ(29^h) 12-13.06

– AR11093 (N10L355; CMP 10,1.08.10; Sp=250.); XRI = 0.1; M1+C1; П ВЭ(45^h) 6 -7.08

– AR11112 (S20L204, CMP 14.10,5.10, Sp= 180); XRI=0.29; $M_1^{2.6}$.

– AR11121 (S19L121, CMP 10.11.10, Sp= 090); XRI=0.74; $M_3^{5.4}$; ПВЭ(16^h) 5-6.10;

– AR11166 (N10L095, CMP 8.03.11;Sp=750 m.v.h.); XRI=2.16; $X_1^{1.5}$+M_4+C_{24}; ПВЭ (45^h) 8-9.03

– AR11149 (N18L070, CMP 20.01.11, Sp=160); XRI=0.13; M11.3;

– AR11153 (N15L172, CMP 03.02.11, Sp=180); XRI=0.19; M11.9; Appearance at 04.02 on W18, flare M1.9 - 09.02

– AR 11158 (S19L036, CMP 13,4.02.11), Sp=620); XRI=3.59; X12.2+M66.6+C48; ПВЭ (69h) 13-16.02; Appearance at 11.02 on E25;

– AR11165 (S22L181, CMP 2,3.03.11; Sp=420) XRI=1.53; M65.3+C25 ПВЭ (22h) 7-8.03; Appearance at 26.02 on E43;

– AR11166 (N10L095, CMP 8.03.11;Sp=750); XRI=2.16; X11.5+M4+C24; ПВЭ (45) 8-9.03;

–AR11261 (N16L330, CMP 01.08.11; Sp=390); XRI=2.71; M59.3+C36 ПВЭ1 30.04 - M9.3; ПВЭ 2 (23h) 3-4.08 - M2 ;

–AR11263 (N17L301, CMP 3.08.11, Sp=720); XRI=7.67; X16.9+M3+C33 ПВЭ (13h) 8–9.08 - X16.9+M2;

– AR11283 (N12L227, CMP 6.09.11, Sp=230; XRI= 5.60; X22.1+M5), ПВЭ (61h) 6–8.09 - X21.8+M2;

– AR11302 (N13L280, Sp=1300; XRI=8.73; X21.9+M17+C72 ПВЭ (66h)

– AR11339 (N19L103, Sp=1540; XRI=4.18; X11.9+M9+C38),

ПВЭ (59h) 2 -5.11 - X11.9+M5

DATE	TIME			IMP		LOCAL-N	AR		RADIO	CME
y m d	to	tm	te	Xray/opt	L	lt lg	L		SWEEP	to/pa
					J*m-2					
100207	0220	0234	0303	M6.4/1N	.037	N20E09L250	11045	IV/2	0354/	
100212	1119	1126	>1140	M8.3/1N	.019	N26E11L186	11046			
101106	1527	1536	1711	M5.4/1N	.026	S19E58L211	11121			
111128	0044	0103	>0110	M1.3/	.093	N18W90L070	11149	II/1		Pr/2
110213	1728	1738	1846	M6.6/1N	.04	S20E04L036	11158	II/1		
110215	0144	0156	>0206	X2.2/	.16	S20W15L036	11158	II/2	CME/H	Pr/2.6
110218	0955	1011	>1015	M6.6/SF	.019	N22E10L336	11162			
110308	1035	1044	>1055	M5.3/1F	.034	S17W86L181	11165			
110309	2313	2323	0016	X1.5/2B	.067	N08W09L095	11166			
110730	0204	0209	>0212	M9.3/SF	.020	N21W68L330	11161		R/0209/50-100	
110804	0341	0 357	0505	M9.3/2B	.054	N19W36L358	11261	II/2	R3/0347/50-100	
110809	0748	0805	0904	X6.9/2B	.190	N17W69L3O1	11263	II/1	R3/0805/25-50	Pr
110906	0135	0150	0236	M5.3/1B	.054	N14W07L224	11283	II/3 IV/1	R/0146/25-50	
110906	2212	2220	0029	X2.1/2B	.058	N14W18L224	11283	II/2 IV/3	CME R2220/100-300	
110907	2232	2238	>2348	X1.8/3B	.069	N14W28L224	11283	II/1 IV/1	CME R 2303/06-12	
110908	1532	1546	1632	M6.7/1N	.042	N14W40L224	11283	IV/1	R/1544/50-100	
110922	1029	1101	1227	X1.4/2N	.450	N13E78L279	11302	II/2	R3/1054/25-50	
110924	0921	0940	1010	X1.9/2B	.110	N12E60L279	11302	II/2 IV/3	R2/0940/100-300	
110924	1233	1320	>1410	M7.1/1B	.290	n12e58L279	11302		R2/1310/12-25	
110924	2029	2036	>2042	M5.8/	.024	n13e52L279	11302		R2/2035/25-50	
110925	0431	0450	0541	M7.4/2N	.096	N11E47L279	11302	IV/2	R /0445/25-50	
111103	2016	2027	2140	X1.9/2B	.100	N22E63L117	11339		CME/2312	
120123	0256	0359	0553	M8.7/2B	.2	N28W21L212	11402	IV/2	CME/H	Pr6310
120127	1737	1837	1913	X1.7/1F	.15	N27W71L212	11402	II/3 IV/2	CME/H	Pr796

SUMMA SINE LAUDA

Если бы это было так, это бы еще ничего, А если бы ничего, оно бы так и было. Но так как это не так, так оно и не этак! Такова логика вещей

(***Л.Кэролл Алиса в Зазеркалье***)

СПАСИБО ЗА ВНИМАНИЕ!