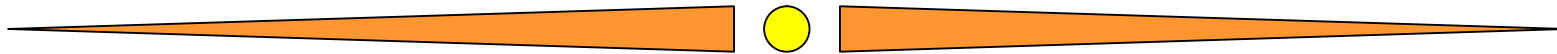
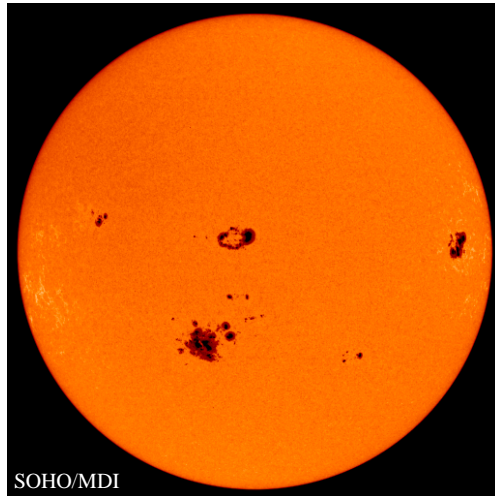


Big, Super en Giant Sunspotgroups



Jan Janssens

Situation



- Big groups were visible from late October till early November 2003
- First spotless day on 27 January 2004
 - Minimum SC23 possibly in October 2006 (+/- 4 months)
- How many big groups can we still expect until next SC-minimum?

Contents

- Database
- Distinction
- Results
- Examples
- Synoptic Map
- Relation with R_{max}
- Evolution phase SC
- Predictions
- Further research

Database

- Main source: MSFC-website
 - <http://science.nasa.gov/ssl/PAD/SOLAR/greenwch.htm>
- Period from 9 May 1874 till 31 December 2003
 - SC11 till SC23
 - Doublecounts (Dec → Jan) avoided
- **Prior to 1976: Greenwich; After 1976: NOAA**
 - Average area of groups differs!
 - Greenwich = 1,4* NOAA
 - All NOAA-data corrected
- Position of groups during maximum area was not evaluated

Distinction

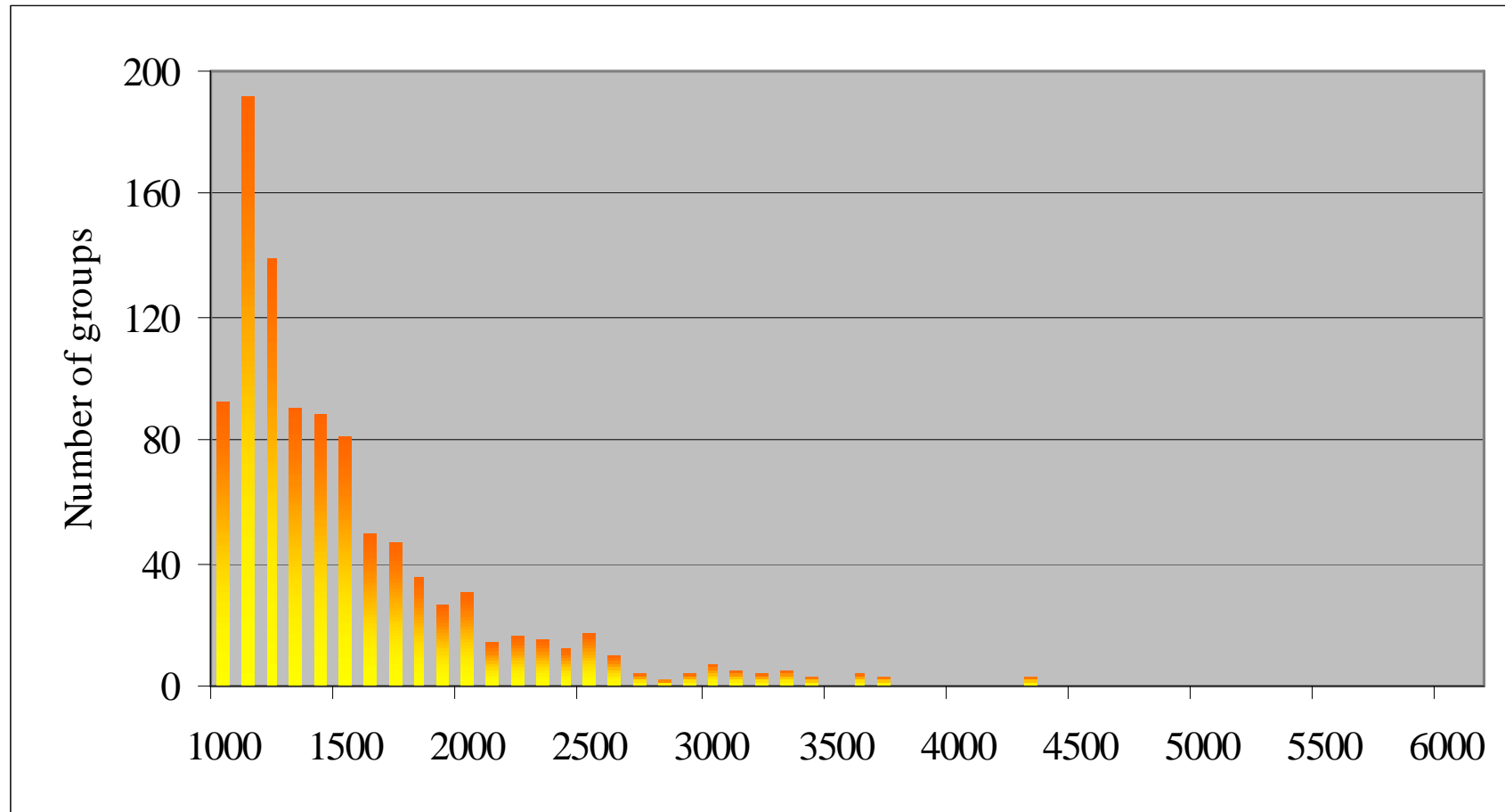
Group type	Greenwich	NOAA
<u>B</u> ig	1000 MH	720 MH
<u>S</u> uper	1500 MH	1080 MH
<u>G</u> iant	2500 MH	1790 MH

- 1000 MH = 3044 million km²
 - Surface Earth = 511 million km²
- Sunspotgroup can be Naked Eye Object
 - If area > +/- 400 MH NOAA (+/- 600 MH Greenwich)
- There can exist up to 25% difference in calculated sunspot area between individual observers

Summary 1a: Numbers

- Total number:
 - Big groups: 639
 - Super groups: 296
 - Giant groups: 71
 - **Groups with $A > 1000$: 1006**
- Per hemisphere:
 - Northern solar hemisphere: 534 (53%)
 - Southern solar hemisphere: 472 (47%)
 - On the southern hemisphere appeared 37 giant groups

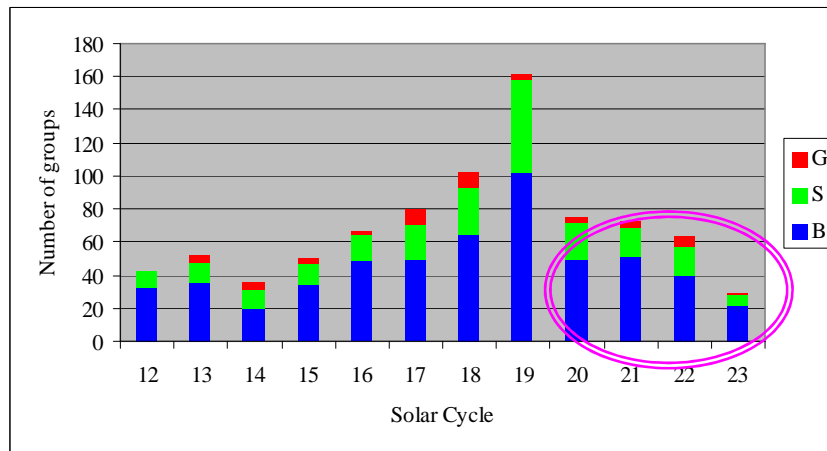
Summary 1b: Numbers per 100MH



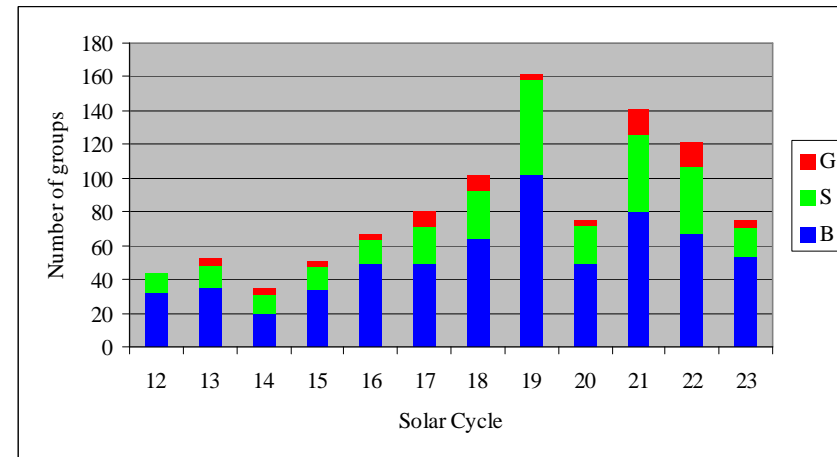
Summary 2: Solar Cycle

SC	B	S	G	Total
12	32	11		43
13	35	13	4	52
14	20	11	4	35
15	34	13	3	50
16	49	15	3	67
17	49	22	9	80
18	64	29	9	102
19	102	56	3	161
20	49	23	3	75
21	51	18	4	73
22	40	17	6	63
23	22	6	1	29
Total	547	234	49	830

SC	B	S	G	Total
12	32	11	0	43
13	35	13	4	52
14	20	11	4	35
15	34	13	3	50
16	49	15	3	67
17	49	22	9	80
18	64	29	9	102
19	102	56	3	161
20	49	23	3	75
21	80	46	15	141
22	67	40	14	121
23	54	17	4	75
Total	635	296	71	1002



Without 1,4* - correction factor



With 1,4* - correction factor

Summary 3

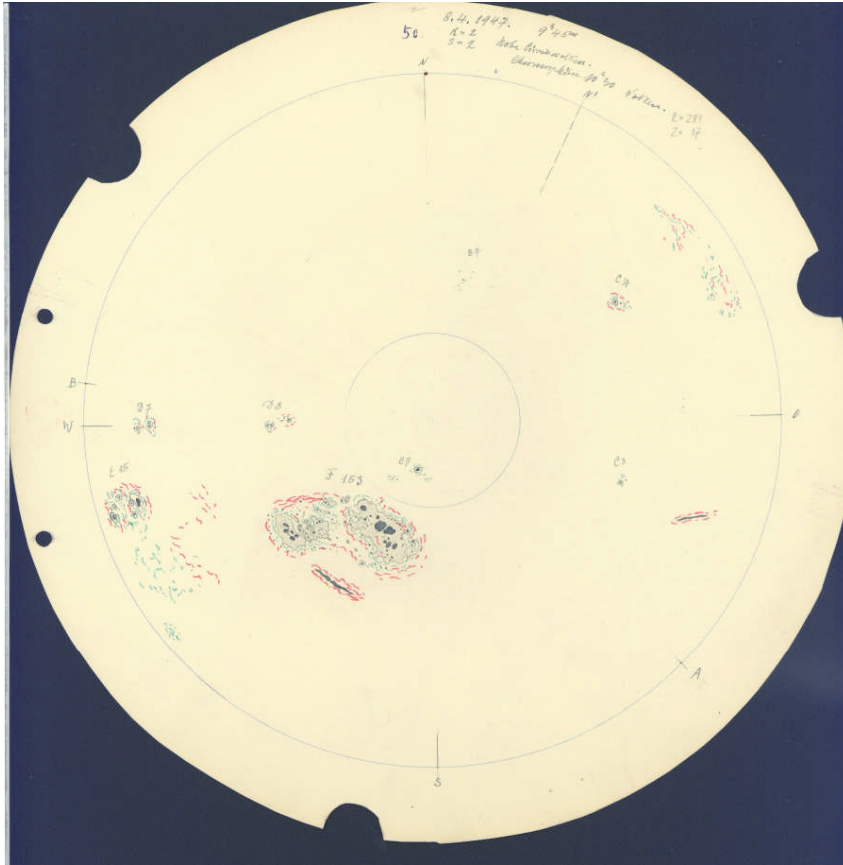
Top 20 of biggest sunspotgroups since 1874

Rank	Year	Month	Group	Corr.Area	Av.Lat.	Av.Long.	Corr.Fact.	Area	SC
1	1947	3	1488603	6132	-24	84	1	6132	18
2	1946	1	1441702	5202	26	298	1	5202	18
3	1989	3	5395	3600	17	254	1,4	5040	22
4	1951	5	1676304	4865	13	87	1	4865	18
5	1946	7	1458503	4720	22	196	1	4720	18
6	1947	3	1485104	4554	-23	91	1	4554	18
7	1982	6	3776	3100	13	314	1,4	4340	21
8	1989	8	5669	3080	-12	82	1,4	4312	22
8	1990	11	6368	3080	18	26	1,4	4312	22
10	1988	6	5060	2900	-19	5	1,4	4060	22
11	1982	7	3804	2870	15	321	1,4	4018	21
12	1926	1	986103	3716	21	35	1	3716	16
13	1982	2	3594	2640	-10	207	1,4	3696	21
14	2003	10	10486	2610	-16	284	1,4	3654	23
15	1938	1	1267304	3627	17	225	1	3627	17
16	1984	4	4474	2590	-13	343	1,4	3626	21
17	1917	2	797700	3590	-16	9	1	3590	15
18	1988	10	5175	2540	-15	154	1,4	3556	22
19	1991	3	6555	2530	-23	188	1,4	3542	22
20	1991	8	6891	2440	-10	195	1,4	3416	22
20	2001	3	9393	2440	17	153	1,4	3416	23

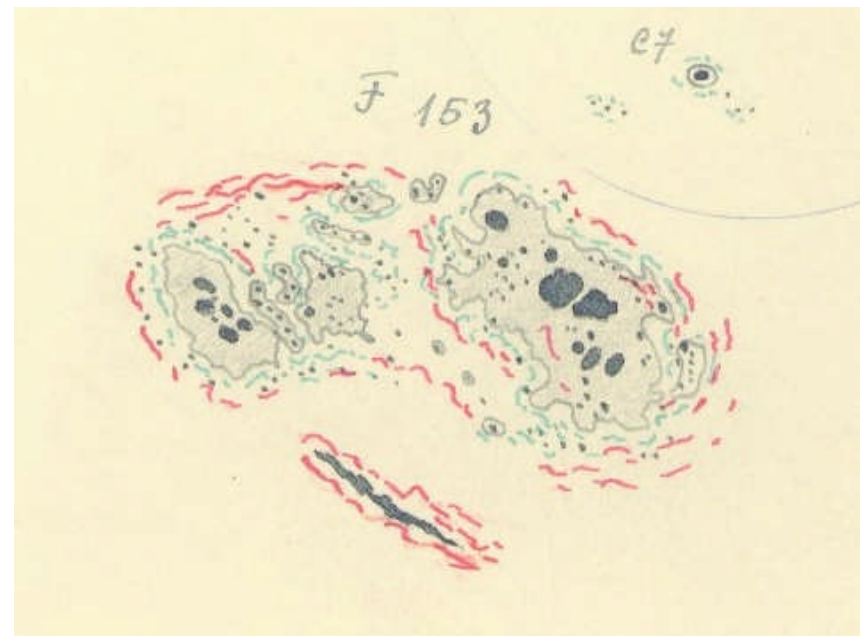
Examples of big groups

- Prominent sources of pictures & drawings
 - Websites of SOHO, MEES, ...
 - Mount Wilson: Historical Sunspot Drawing Resource Page: 20th century observers
 - <http://www.astro.ucla.edu/~obs/resource3.html>
 - Mount Wilson, Culgoora, Potsdam, Kandilli,...
 - **Contains also 3 observers of VVS/Solar Section**
 - Lieve Meeus (*[“Excellent drawings”](#)*)
 - Günther Groenez
 - Frans Van Loo
 - Kanzelhöhe Solar Observatory (1944)
 - http://www.solobskh.ac.at/docs/obs_frame_en.html
 - True treasure of excellent drawings!

Drawings big sunspotgroups - #1



Greenwich 1488603 – 30Mar-14Apr 1947
B = $-24,5^\circ$; L = $83,7^\circ$
Max.Area = 6132 MH on 08 Apr 1947



© *Kanzelhöhe Solar Observatory* – 08 Apr 47

Drawings big sunspotgroups

Greenwich 818100 – 03Aug-16Aug 1917

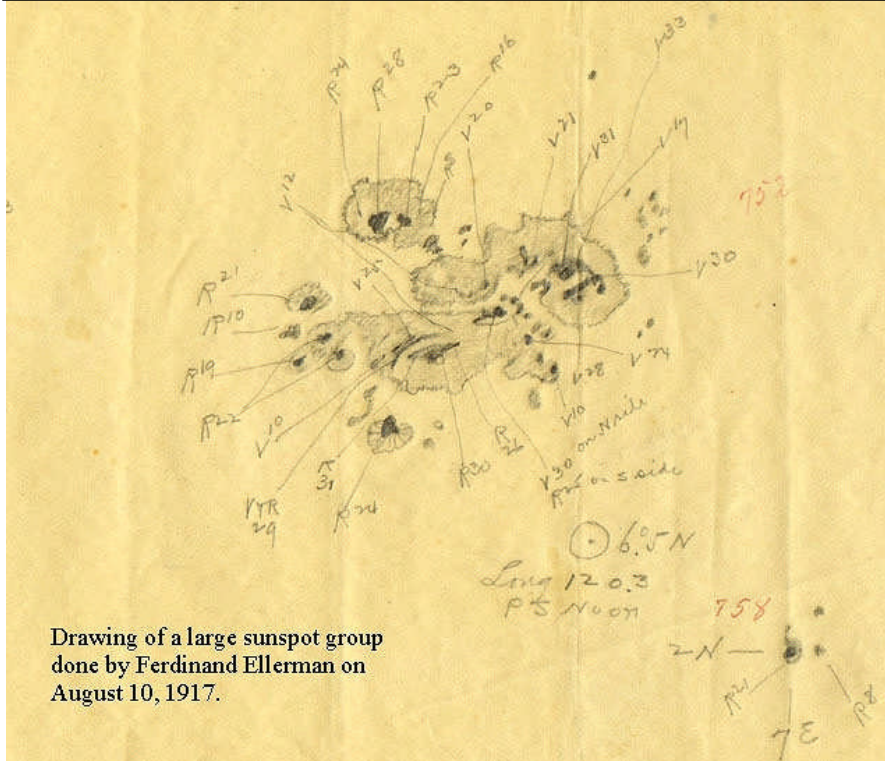
B = +16,3° ; L = 129,5°

Max.Area = 3178 MH on 09 Aug 1917

NOAA 9169 – 18Sep-30Sep 2000

B = +10,6° ; L = 76,9°

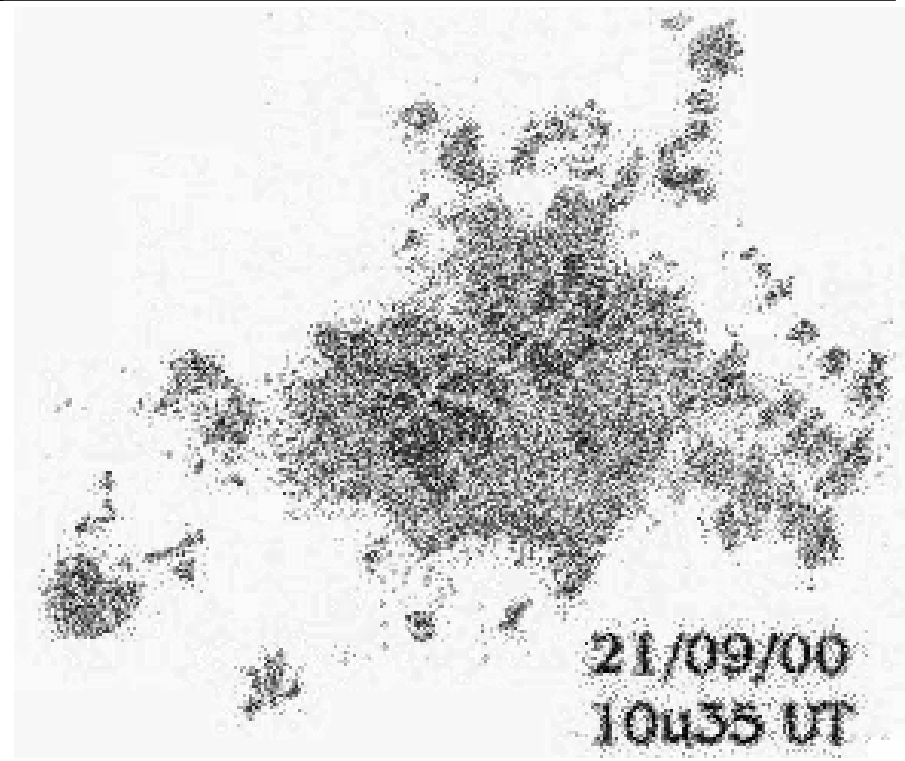
Max.Area = 2996 MH on 19 Sep 2000



Drawing of a large sunspot group done by Ferdinand Ellerman on August 10, 1917.

© *Mount Wilson* – 10 Aug 1917

03 July 2004

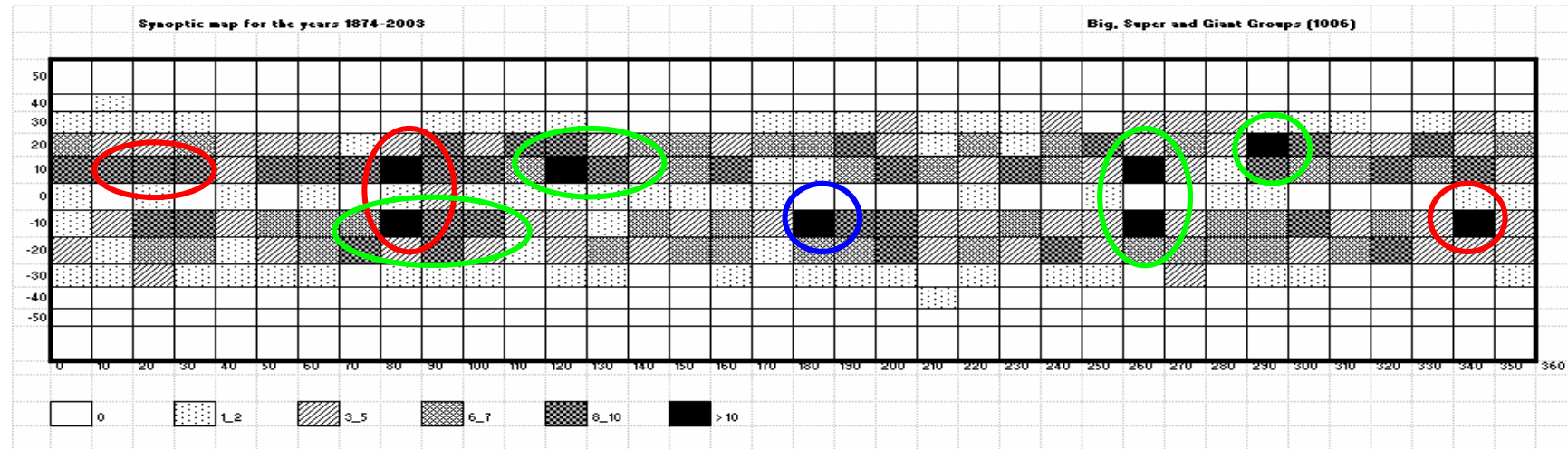


21/09/00
10u35 UT

© *Lieve Meeus* – 21 Sep 2000

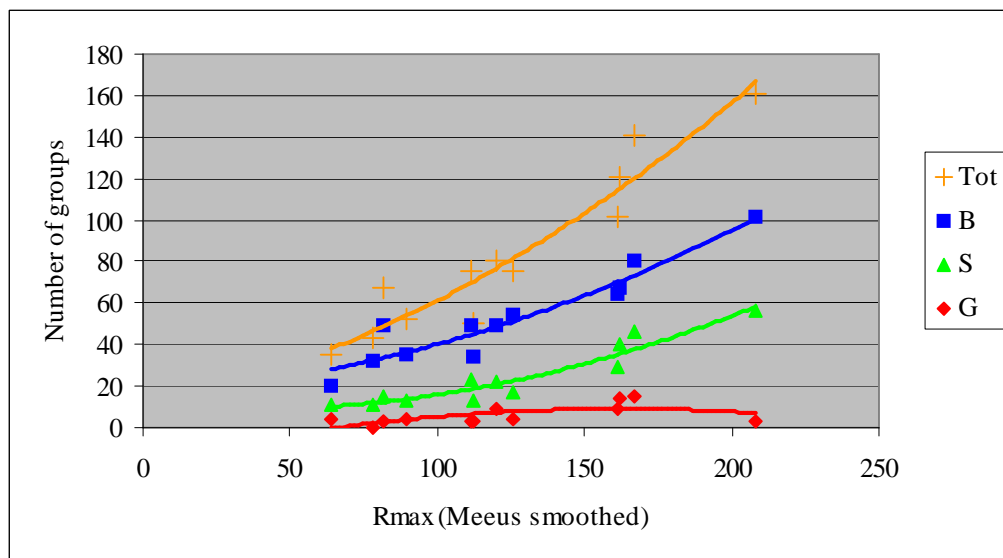
Big, Super en Giant Sunspotgroups

Synoptic Map



- Big groups especially appear in 2 bands parallel to the solar-equator
 - Between 5° and 25° in latitude
 - Clusters possible especially around $L = 100^\circ$ and $L = 280^\circ$
 - Diametrically opposed to each other
 - Relatively little big groups between $L = 130^\circ$ and $L = 250^\circ$
 - ○ Grote groepen ; ○ Supergroepen; ○ Reuzegroepen
- } Temporarily or physical?

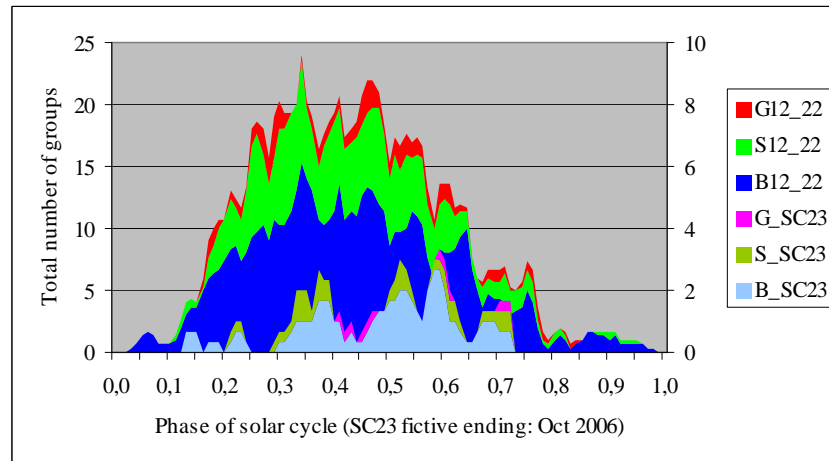
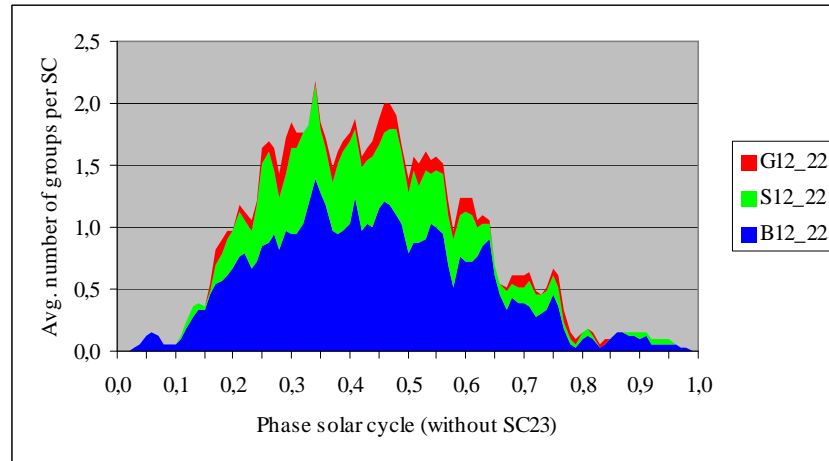
Correlation between Rmax and # B, S & G



- Remarkable correlation between Rmax of SC & # of B, S – groups of that SC
 - Much better than relation “Time of Rise – Rmax”
 - Relation lacking with Giant groups
 - Only 3 G’s in SC19
- Relations predict for SC23 (Rmax = 125,6)
 - Tot: 81
 - Dec 03: 75
 - B: 51; S: 23; G: 7
 - Dec 03: resp. 54, 17, 4

Type	Polynome	r ²
Tot	$y = 0,0022x^2 + 0,2781x + 11,048$	0,9152
B	$y = 0,0016x^2 + 0,0713x + 17,119$	0,9049
S	$y = 0,0016x^2 - 0,1089x + 10,497$	0,9101
G	$y = -0,001x^2 + 0,3157x - 16,567$	0,4238
Time of Rise	$y = -3,5159x + 291,63$	0,42

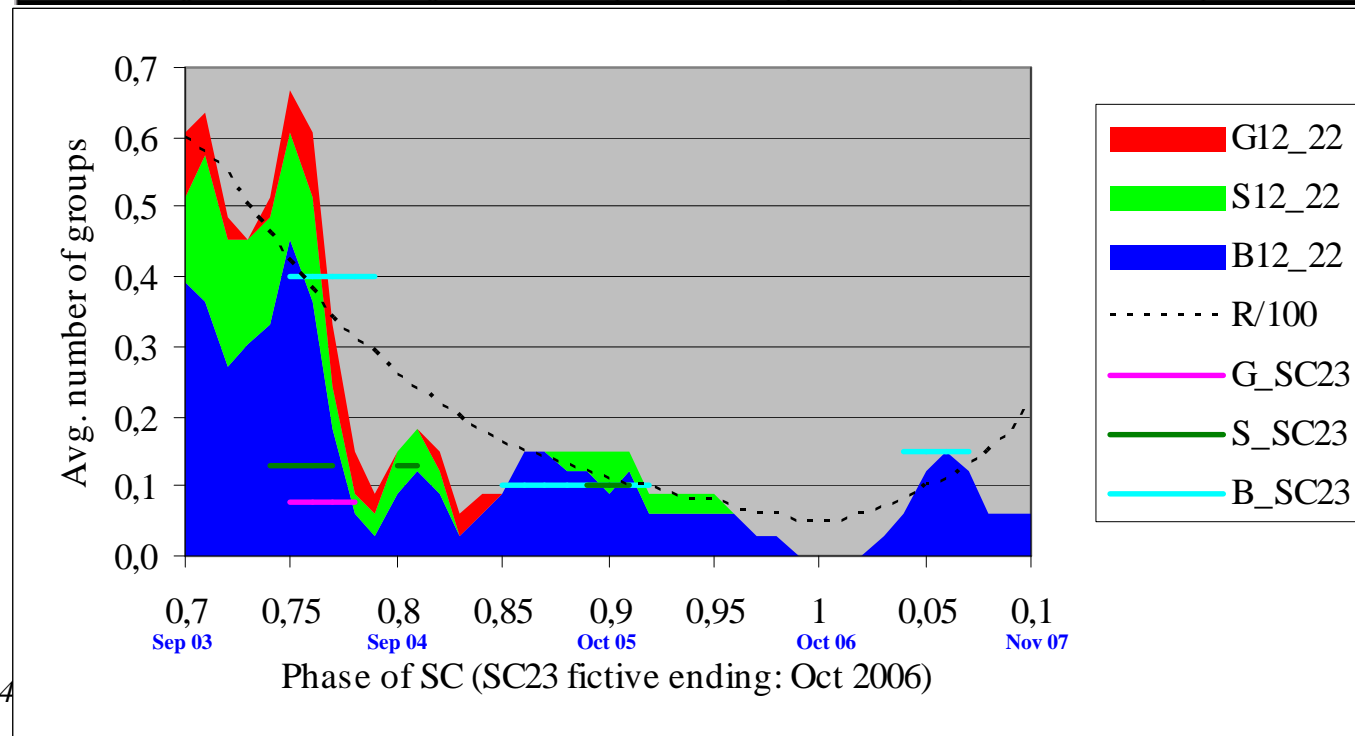
Evolution # groups with phase of SC



- Based on SC 12 thru 22
 - # groups / 11 and averaged over 3 months
 - Avg. SC-duration: 128 months
 - Avg. Rmax: 123,3
- During SCmax
 - Avg. 2 groups (phase ~0,34)
 - Giant groups absent!?
 - G's are prominent especially in increasing & decreasing branches of SC
 - Lots of big groups
 - Throughout entire SC
- SC23 (*assuming Rmin in Oct 2006*)
 - Big groups especially after SCmax

Verwachting SC23 tot volgend minimum

	Phase $\leq 0,73$	Predicted ($0,73 < \text{Phase} \leq 1$)				
Type	SC23	SC 12_22	Number	Phase	Time interval	Chance
B	-3	3	≥ 2	0,74-0,78	Jan04-Jul04	75%
			1	0,85-0,92	Mar05-Nov05	90%
			1	0,04-0,07	Mar07-Jul07	50%
S	6	1	≥ 1	0,74-0,77	Jan04-May04	50%
				0,80-0,81	Sep04-Nov04	25%
				0,89-0,91	Aug05-Nov05	25%
G	3	0,5	≤ 1	0,75-0,78	Feb04-Jul04	15%



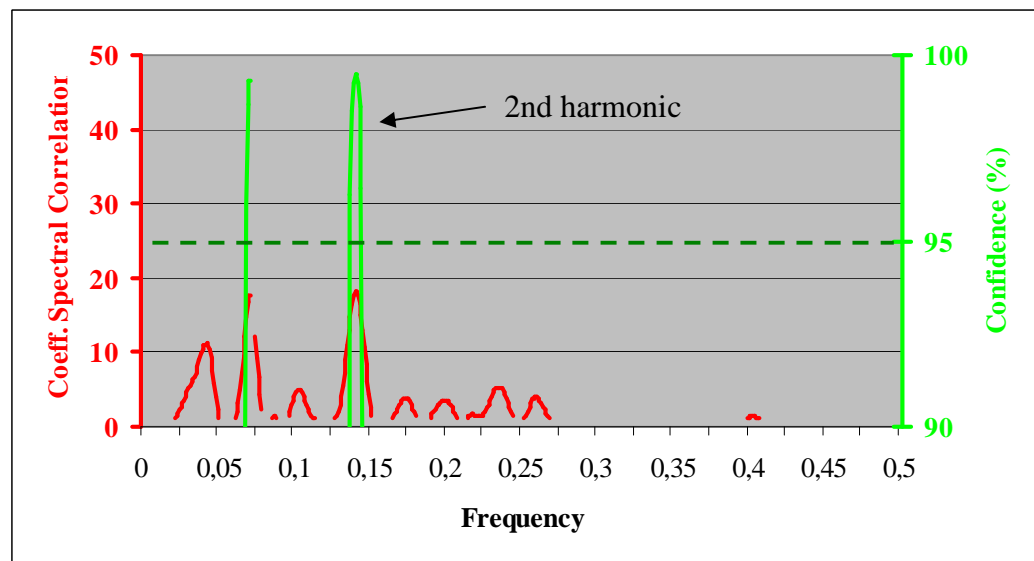
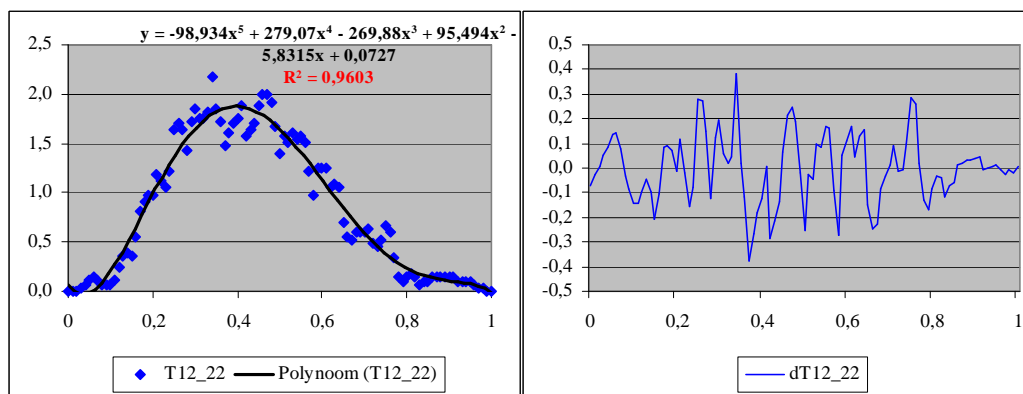
Conclusions

- Clustering of big groups over solar surface **NOT** excluded
- Remarkable relation between Rmax and the total number of big groups in a solar cycle
 - So far (Dec 2003), SC23 has -for the attained Rmax- produced too little super and giant sunspotgroups
 - **BUT 2 groups in Top 20 of biggest groups in last 130 years**
- From Jan 2004 till the next solar minimum (fictive ending Oct 2006), there are at least 5 big groups to be expected:
 - At least 3 big groups
 - **3 big groups already appeared in first half of 2004**
 - At least 1 super group ($A \geq 1080$ MH NOAA)
 - **NOAA 10536 (Jan 04): 980 MH**
 - Chances on another giant group: 15%

Further research

- Hemispheric evolutions
- Synoptic maps for other SC
 - Check for possible evolution in clustering
- Monitoring of big groups in SC23
- Periodicity and evolution in SC
- Check evolutions of other activity parameters
 - Solar flares, radio flux, Ap-index, aa-index, ...

Extra: Periodicity in phased SC



- Avg. total #groups with $A \geq 1000$ MH (T)
 - 5th degree polynome (P5)
 - $R^2 = 96\%$!!
 - In residu between T and P5
 - Remarkable periodicity
 - Low spectral coefficient
 - High “confidence-level”
- $F = 0,072 \rightarrow P = 17,8$ months
 - Very near to magnetic periodicity in Tachocline (14-16 maanden)!!
- SC23 (till phase = 0,72)
 - P1 = 24 months (99,9%)
 - » $S = 35$!
 - P2 = 14,9 months (70%)
 - » SOHO SC23

Extra: Periodicity big groups in SC

