LATITUDINAL DISTRIBUTION OF SUNSPOT AREAS DURING THE PERIOD 1874—1976

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ABSTRACT. The distribution of sunspot areas in heliographic latitude has been analysed, from the 12th to the 20th cycle, using Greenwich Observations. The resulting six-month sunspot area values of the latitudinal distribution are given for each 11-year cycle in tabular form and they are also plotted as contours in Figs 1 through 9. Within the solar cycles, there are numerous time variations, pulses of activity, which clearly show that the activity in certain latitudinal intervals is higher than in other heliographic latitudes. The width of these pulses is some tens of degrees in latitude and the duration from one half to two years. The times at which the pulses appear in both hemisphere do not coincide. There is no steady equatorward progression of a single maximum of activity throughout a given cycle, but the eleven-year cycle consists of the superposition of two or more pulses, which peak at different times and at different latitudes.

ШИРОТНОЕ РАСПРЕДЕЛЕНИЕ ПЛОЩАДЕЙ СОЛНЕЧНЫХ ПЯТЕН В 1874-1976 ГГ. На основе наблюдательных данных о солнечных пятнах Гринвичской обсерватории был сделан анализ широтного распределения площадей солнечных пятен с 12 по 20-й цикл солнечной активности. Итоговые полугодичные величины площадей пятен для пятиградусных широтных зон даны для каждого цикла в таблице 1 а также на Рис. 1-9.Тонкая структура широтного распределения площадей солнечных пятен указывает на наличие импульсной пятнообразовательной активности. Импульсы имеют масштаб нескольких десятков градусов широты и длительность от половины до двух лет. Импульсы на се-

верной и южной полусферах независимы. 11-летний цикл является суперпозицией двух и больше импульсов, которые возникают в разных интервалах широты и в разное время.

ŠÍRKOVÉ ROZDELENIE PLÔCH SLNEČNÝCH ŠKVŔN POČAS OBDOBIA ROKOV 1874-1976. Na základe pozorovacích údajov o slnečných škvrnách, publikovaných v Greenwich Observations, bolo analyzované časovo-šírkové rozdelenie plôch slnečných škvŕn od 12. do 20. cykla slnečnej činnosti. Výsledné polročné hodnoty plôch slnečných škvŕn, ktoré boli pozorované v päť stupňovej šírkovej zóne, sú pre každý cyklus uvedené tak v Tab. 1 ako aj na motýľovitých diagramoch (Obr. 1-9). Jemná štruktúra motýľovitých diagramov ukazuje na početné pulzy škvrnotvornej aktivity. Oblasť pulzu má rozmery niekoľko desiatok stupňov heliografickej šírky a trvanie od pol do dvoch rokov. Pulzy na severnej a južnej pologuli nie vždy koincidujú. Počas 11-ročného cykla nepozorujeme plynulý posuv jedného maxima aktivity postupne k rovníku. 11-ročný cyklus je superpozíciou dvoch, alebo viacerých pulzov, ktoré vznikajú v rôznych časoch a šírkach.

1. INTRODUCTION

The equatorial zone of the Sun is the site of the bipolar magnetic regions, where the most intense magnetic fields and magnetic activity are observed. A strong magnetic field controls the development and character of active-region phenomena in the photosphere, chromosphere and corona. Sunspots are the most easily observed indicator of solar activity and the source of the longest direct record of solar history.

The cyclic nature of solar activity was pointed out by Schwaabe in 1842 and recorded back to the early 1700´s. We should realize, however, that continuous and controlled sunspot records only cover a little more than one century and that extending the records back beyond 1850 becomes increasingly uncertain. It is interesting to note that during the 70-year period from 1645 to 1715 the Sun remained in a state of extreme minimum activity when practically no sunspots were reported (Spörer, 1887, 1889, Maunder, 1890, 1894, 1922, Eddy, 1976). After this the solar activity resumed its 11-year cycle.

The general irregularity of the amplitude and period of the sunspot cycle became well known. Waldmeier (1957) has shown that for most, but not all, of the observed cycles, the more rapid the onset of the spots of a new cycle and the higher the latitude at which the spots appear, the stronger the new cycle when it finally reaches its maximum. These characteristics are evident from the retrospective inspection of Maunder´s butterfly diagrams, showing the evolution of the latitudinal distribution of sunspots with the passage of time (Yallop and Hohenkerk, 1980).

In 1894, Sp"orer noted the tendency for the region of formation of sunspots to begin at relatively high latitudes and to drift towards the equator. This variation of sunspot latitude with phase of the solar cycle is known as

Spörer's Law. Gnevyshev(1963) has shown that, in the 19th cycle of solar activity, there were two maxima of the green coronal line intensity and the same effect was observed in the sunspot areas. Antalová and Gnevyshev (1965) have shown that there is no steady equatorward progression of a single maximum of activity throughout a given cycle, but that the 11-year cycle consists of the superposition of two maxima which peak at different times and different latitudes, the second peak occurring at a lower latitude than the first.

The purpose of this article is to publish in tabular form the latitudinal sunspot area data for the last nine solar cycles. Using this material, we can re-examine the behaviour of the sunspot cycle.

2. THE METHOD

Full details of the positions and areas of sunspots groups used in the analyses reported in this paper have been taken from the records of the Royal Greenwich Observatory, U.K., published as the annual volumes of Greenwich Observations for the period 1874-1955 and as Royal Observatory Bulletins, Series C for the years 1956 to 1961 and Royal Observatory Annals for the years 1962 to 1976. The daily positions of the centres of sunspot groups and areas of whole spots, corrected for the effect of surface foreshortening and expressed in millionths of the Sun's visible hemisphere, are published.

Let us review briefly the method of further investigation of the daily data. The solar disk was divided into latitudinal zones at intervals of 5° separately for the northern and southern hemispheres. For each latitudinal zone we have computed the daily values of the total area of all whole sunspots which occurred in the same latitudinal zone. The flux of the sunspot area for half a year has been calculated in each latitudinal strip, separately for the northern and southern hemispheres by dividing each year into two intervals, January-June and July-December, from 1 April 1874 onwards.

The period from 1874 to 1976 comprises nine complete 11-year cycles and the declining phase of the earliest 11th cycle with its minimum in 1878. The resulting six-month sunspot area values of the time-latitude distribution are given for each 11-year cycle in tabular form and they are also plotted as contours of the sunspot area.

Table 1 is arranged as follows:

Line 1 - The current number of the 11-year solar cycle.
Line 2 - The years of the maximum and minimum for the respective cycle as determined from the Zürich smoothed sunspot numbers.
Line 3 - The given year divided into two intervals, January-June and July-December, which are arranged in the respective columns.
Line 4 - Number of large sunspot groups with an average area larger than 500 millionths of the surface of the solar hemisphere, as observed during the half-year period in the northern hemisphere. The

data up to 1954 are taken from Sunspot and Geomagnetic Storm Data derived from Greenwich Observations and the numbers for the years 1955-1964 are taken from Kopecký et al. (1974).

Line 5 - The same as in line 4 for sunspot groups with average area larger than 1500 millionths.

Line 6 - Total six-month value of sunspot area for both hemispheres together, expressed in millionths of the Sun's visible hemisphere.

Line 7 - The same as in line 6, but for the northern hemisphere only.

Lines 8-16 - The six-month value of sunspot area, expressed in millionths of the Sun's visible hemisphere, in nine strips, from 45° N to 0° heliographic latitude, separately for the northern hemisphere.

Lines 17-25 - The same as in lines 8-16, but for the southern hemisphere.

Line 26 - Total six-month value of sunspot area for the southern hemisphere, expressed in millionths of the Sun's visible hemisphere.

Line 27 - Number of large sunspot groups N_{500} as in line 4, but for the southern hemisphere.

Line 28 - Number of large sunspot groups N_{1500} as in line 5, but for the southern hemisphere,

Table 1

Cycle 11

1870.6 max, 1878.9 min

	1874		1875		1876		1877		1878
N_{500}	0	3	2	0	0	0	0	0	0
N_{1500}	0	0	0	0	0	0	0	0	0
N+S	17987	66683	47848	16340	19013	13829	12554	12497	2090
N	7318	29372	28138	9065	6482	4225	7085	1785	2054
30-35							48		
25-30							172		
20-25	112	210	121	34					
15-20	1047	1797	12810	559	1564				
10-15	4090	11199	560	4168	3966	2849	2141	51	593
05-10	2069	10587	13105	4260	886	951	4386	1734	1223
00-05		5579	1542	44	66	425	338		238
00-05	488	1436	1073		146	1128	111	633	
05-10	5926	6945	6485	4938	1471	4902	963	6239	36
10-15	3497	16127	10467	2245	9924	3574	4145	3832	
15-20	758	11922	1685	92	990		250	8	
20-25		881							
S	10669	37311	19710	7275	12531	9604	5469	10712	36
N_{500}	0	3	1	0	1	0	1	0	0
N_{1500}	0	0	0	0	0	0	0	0	0

Cycle 12

1883.9 max, 1878.9 min

year	1878	1879		1880		1881		1882		1883	
N_{500}	0	0	0	1	3	1	2	0	5	2	3
N_{1500}	0	0	0	0	0	0	0	0	0	0	2
N+S	1538	1413	6113	24764	41512	43246	84121			150305	242066
N	1538	77	2648	15899	24622	21390	65837			52229	62856
35-40				73							
30-35			62		4	27	15			64	
25-30			1980	4160	728	3391	11058			29	
20-25				3602	16420	4709	13564			436	4045
15-20	11	3	215	4264	3020	5029	17112			1152	8874
10-15	222	74	138	3800	4134	6324	23069			27864	35600
05-10			253		316	1910	1919			16888	8703
00-05	1305									5796	5634
00-05							707			1766	1093
05-10					350	2771	111			26311	64312
10-15			49	470	1969	4748	1982			21599	56563
15-20			250	3429	11325	8016	11437			21952	28557
20-25		750	3069	3579	1864	2701	2080			21775	23774
25-30		586	97	688	264	2299	1842			4673	4911
30-35					421	1075	125				
35-40				229	697	246					
S	0	1336	3465	8865	16890	21856	18284			98076	179210
N_{500}	0	0	0	1	3	2	0	6	3	5	8
N_{1500}	0	0	0	0	0	0	0	3	0	0	2

year	1884		1885		1886		1887		1888
N_{500}	2	3	3	1	1	0	0	0	0
N_{1500}	0	1	1	0	0	0	0	0	0
N+S	213753	127368	174549	112192	108617	29467	23684	41041	16264
N	80199	70410	66419	33432	19363	9166	7610	8476	3019
20-25	97			138		5	23		
15-20	9576	7314	1589	6371	229	4218	12		
10-15	39368	31110	35598	12727	1513	4610	6161	320	106
05-10	29631	20141	20876	14101	14149	200	741	5593	192
00-05	1527	11845	8356	95	3472	133	673	2563	2721
00-05	3657	4674	13763	8439	16429	1897	2822	2751	2641
05-10	51555	24600	17591	12269	22714	8353	10412	24295	9715
10-15	49692	19968	44508	35809	29984	5418	2349	3732	889
15-20	19063	5962	22923	19908	19958	4336	491	1787	
20-25	7565	1708	9345	2335	169	297			
25-30	2022	46							
S	133554	56958	108130	78760	89254	20301	16074	32565	13245
N_{500}	6	2	4	4	5	0	1	2	0
N_{1500}	1	0	0	0	0	0	0	0	0

Cycle 13

1894.1 max, 1889.6 min

year	1888	1889		1890		1891		1892		1893	
N_{500}	0	0	0	0	1	0	3	3	3	0	5
N_{1500}	0	0	0	0	0	0	1	0	1	0	0
N+S	15586	9448	16519	4741	31214	64059	141877	221380	212192	212626	303203
N	4005	1401	240	3529	15794	41381	103352	97447	111055	71399	115292
40-45											23
35-40											9
30-35				2133		77	655	310	114		49
25-30				232	163	2208	19722	18570	1807	534	2073
20-25			35	1131	11137	10767	40340	13872	4282	19325	11363
15-20				10	4494	24412	31202	22548	14711	17503	38543
10-15	1880					3917	10860	28294	66760	20393	41076
05-10	2106	1075		17			387	13661	23172	11042	16956
00-05	19	326	205	6			186	192	209	2602	5200
00-05	3181	2264	350			100			18	112	20612
05-10	5125	5783	8243	297	1531		261	50	6399	19438	57828
10-15	3060		35	6	8	451	6493	9976	10904	47102	36559
15-20	215		2728		1607	8184	19463	35294	15644	30156	59265
20-25			4860	251	9861	7322	10100	27755	41934	36978	9377
25-30			63	500	2307	6052	2187	42546	11771	6688	3461
30-35				158	106	507	4	8301	14455	753	809
35-40						62	9	11	12		
40-45							8				
S	11581	8047	16279	1212	15420	22678	38525	123933	101137	141227	187911
N_{500}	0	1	0	0	1	0	2	3	4	4	8
N_{1500}	0	0	0	0	0	0	0	2	0	0	2

The resulting values of the time-latitude distribution of sunspot areas are given in Figs 1 through 9. The figures show the distribution of the six-month sunspot areas as a function of the heliographic latitude. The x-axis expresses the time in years. The lowest contour of the sunspot area is 10000 millionths of the Sun's visible hemisphere, the next four contour intervals are in steps of 10000 and after that in 20000 millionths. The contour ratings of sunspot area in Figs 1-9 are 10000, 20000, 30000, 40000, 60000 millionths, the values from 60000 up to 80000 are horizontally hatched and the vylues higher than 80000 are cross-hatched. The pattern for the spots in the northern hemisphere is shown in the upper part of the figures, while that for the southern hemisphere is shown in the bottom part of the figures. The discontinuity of the spot area for 1882 is due to the absence of the Greenwich Observations data.

3. THE LATITUDINAL DISTRIBUTION OF THE SUNSPOT AREA FOR INDIVIDUAL CYCLES.

Cycle 13 continued

year	1894		1895		1896		1897		1898		1899
N_{500}	5	2	3	5	3	1	0	1	0	1	0
N_{1500}	1	1	0	1	0	1	0	0	0	0	0
N+S	268695	198180	179496	173104	92765	102955	111933	74418	61161	75000	28459
N	101912	95737	106222	98634	32590	39575	34669	32215	14713	25472	5519
30-35	8	53	26								
25-30	850	479	1208	161			10				
20-25	13705	2198	19503	8144	1246	1944	13	30	2		
15-20	24708	15002	23453	27287	18481	7247	68	1371	369	3343	43
10-15	35866	30612	48169	46742	9304	18737	7243	14966	5743	7460	305
05-10	20802	39970	8416	14002	3531	8811	14492	14895	4359	11823	4868
00-05	5973	7423	5447	2298	28	2836	12843	953	4240	2792	303
00-05	13370	2742	3653	4938	275	109	16312	7178	1499	429	1526
05-10	13620	12105	14628	21067	6082	13107	43990	25776	20512	7906	8475
10-15	63110	50132	30481	26920	22426	21816	11682	8496	23195	40943	11860
15-20	37708	29850	18611	19512	22556	18121	4754	753	1242	250	1079
20-25	4453	7260	4754	2021	8836	10066	517				
25-30	17104	342	1137	12		161	6				
30-35	17356	12	10								
35-40	62						3				
S	166783	102443	73274	74470	60175	63380	77264	42203	46448	49528	22940
N_{500}	7	4	3	4	5	1	3	2	2	3	0
N_{1500}	2	1	0	1	0	0	1	0	1	1	0

Within the solar cycles, as determined by sunspot area, there are numerous time variations and pulses that greatly influence the total sunspot area at any specific time. The latitudinal distribution of sunspot areas was used to demonstrate pulses of activity, which clearly show that the activity distribution on the Sun's disk is not regular but on the contrary, the activity in certain latitudinal intervals is higher than at other heliographic latitudes. The width of these pulses is some tens of degrees in latitude and their duration is from one half to two years.

The comparison of solar activity during the years 1874-1976 provides abundant evidence that the individual 11-year solar cycles exhibit distinct differences in the time of their respective pulses.

CYCLE 12 (Fig. 1)

The 12th cycle is not complete because the 1882 volume of Greenwich Observations is missing. The following can be derived from Tab. 1:

1. The very beginning of the 12th cycle is different in both hemispheres.
   North: in 1879.5 zone 25°-30°
   South: in 1879.0 zone 20°-30°

The difference is 0.5 y, the southern activity began earlier and covered a bro-

ader area than northern.

2. The highest zone 35°- 40° was reached in the

North: in 1880.0 (+0.5 y after the beginning of the cycle). The activity in that zone was rather scarce.

South: between 1880.0 (+1.0 y) and 1881.5 (+2.5 y).

3. The first sunspots of the new cycle in the zone 0°- 5° were observed in the

North: in 1882.5 (+3.0 y)

South: in 1881.5 (+2.5 y)

4. A true pulse of activity with the sunspot area exceeding 60000 millionths over half a year was observed only once in the 12th cycle:

North: none

South: in 1883.5 (+4.5 y) in zone 5°- 10°.

5. The duration of the cycle

North: 1879.5-1890.0 = 10.5 y

South: 1879.0-1890.0 = 11.0 y

6. The epoch of the maximum as derived from the Zürich sunspot numbers is 1883.9. The duration of the ascending phase is 5.0 y and the duration of the descending is 5.7 y. Gnevyshev's maxima:

North: I - 1881.5 (+2.0 y) II - 1884.0 (+4.5 y)

South: I - 1882.0 (+3.0 y) II - 1884.0 (+5.0 y)

year	1899	1900		1901		1902		1903		1904		1905
N_{500}	0	0	0	1	0	0	0	0	1	0	3	4
N_{1500}	0	0	0	0	0	0	0	0	0	0	1	2
N+S	11877	19691	7255	8314	1931	9739	11975	25876	56393	77816	97801	180943
N	2968	8428	1029	7856	4	6681	7817	14431	32951	38257	57780	90199
40-45											21	
35-40		26		7			25				6	
30-35								12			1635	264
25-30				2		2570		43		53	5789	417
20-25						4092	660	9115	292	5303	5878	12015
15-20	3					19	1768	5229	4213	14218	15860	7618
10-15	29	1667	248	692			3220	28	18568	15774	25710	41135
05-10	2445	1430	473	6892			2144	4	9878	2904	2846	27437
00-05	491	5305	308	263	4					5	35	1313
00-05	59	58	1836	16	192		8	12				123
05-10	3233	5331	4274	203	290	3050		10	29	421	68	1664
10-15	5589	5871	1	7	2		2	1298	671	23509	4653	24460
15-20	28			82	219		344	8017	14639	10482	26275	56316
20-25			115	150	1224		3776	1771	4493	5127	8263	5010
25-30						8	7	112	3472	20	560	3087
30-35		3					21	225	138		202	84
S	8909	11263	6226	458	1927	3058	4158	11445	23442	39559	40021	90744
N_{500}	0	0	0	0	0	0	0	0	2	2	0	3
N_{1500}	0	0	0	0	0	0	0	0	1	0	0	1

Cycle 14

1901.7 min, 1907.0 max

year	1905	1906		1907		1908		1909		1910
N_{500}	7	6	1	3	5	0	6	2	2	0
N_{1500}	3	0	0	0	1	0	0	0	0	0
N+S	252808	143698	170590	200233	195493	86229	168930	128677	122777	54238
N	183562	107434	84821	72999	105294	20777	94716	61750	46758	12833
30-35	5	25								
25-30	237	1643	160	91	980	208				
20-25	6690	10441	22761	11807	581	1727	27			382
15-20	16049	26614	18461	4564	2790	408	2765	243	2962	4374
10-15	93891	43608	16471	24625	26913	13696	48531	19260	19443	884
05-10	59600	21225	19630	23517	67639	4458	36967	40023	19564	2200
00-05	7090	3878	7338	8395	6391	280	6426	2224	4789	4993
00-05	101	44	1796	2560	7736	14917	9133	6709	24747	4293
05-10	7435	10536	18451	9146	31365	19610	24707	21958	13636	14061
10-15	33580	14366	31510	62869	10816	14711	21855	19132	28934	12648
15-20	24982	4255	22465	48548	22341	15838	17061	16271	8665	10323
20-25	1825	6197	10580	4006	15892	376	1458	2857	37	80
25-30	1174	801	902	105	2049					
30-35	149	65	65							
S	69246	36264	85769	127234	90199	65452	74214	66927	76019	41405
N_{500}	3	1	2	8	4	0	6	2	2	0
N_{1500}	1	0	0	2	0	0	0	0	0	0

The absolutely highest value of the six-month sunspot area:

North: in 1884.0 (+4.5 y) 80199 mil.

South: in 1883.5 (+4.5 y) 179210 mil.

7. In the 12th cycle the total sunspot area was larger in the southern hemisphere.

CYCLE 13 (Fig. 2)

1. The very beginning of the 13th cycle again lagged in the northern hemisphere:

North: in 1890.0 zone 20°- 35°

South: in 1889.5 zone 15°- 30°

The difference is +0.5 y, the activity in the northern hemisphere was delayed.

2. The highest zone 40°-45° was reached, in the

North: in 1893.5 (+3.5 y)

South: in 1891.5 (+2.5 y)

3. The first sunspots of the 13th cycle in zone 0°- 5° were observed, in the North: in 1891.5 (+1.5 y)

South: in 1892.5 (+3.0 y)

4. The pulses of the half-year sunspot area value higher than 60000 mi-

llionths were observed, in the

North: in 1892.5 (+2.5 y) zone 10°-15°

South: in 1894.0 (+4.5 y) zone 10°-15°

5. The duration of the 13th cycle, in the

North: 1890.0 - 1901.5 = 11.5 y

South: 1889.5 - 1902.0 = 12.5 y

6. The epoch of the maximum of the 13th cycle as derived from the Zürich sunspot numbers is 1894.1 . The duration of the ascending part of the cycle is 4.5 y and of the descending part is 7.6 y. From Tab. 1 we can see that in the half year 1893.5 there was a total of 303203 millionth of the Sun's visible hemisphere in both hemispheres, i.e. 11.6 per cent of the sunspot area observed during the whole cycle.

As regards Gnevyshev's maxima separately for the two hemispheres we can derive:

North: I - 1893.5 (+3.5 y) II - 1895.0 (+5.0 y)

South: I - 1893.5 (+4.0 y) II - ? III - 1897.0 (+7.5 y)

The absolutely highest value of the six-month sunspot area, in the

North: in 1893.5 (+3.5 y) 115292 mil.

South: in 1893.5 (+4.0 y) 187911 mil.

7. In the 13th cycle the total sunspot area was larger in the southern hemisphere /see Tab. 2/. The difference between S and N is 279955 millionth, i.e. 10.7 per cent of the total N+S sunspot area.

According to Brown and Evans (1980) and also Willis and Tulunay (1979), the 13th cycle is the second highest cycle in faculae area of the nine considered.

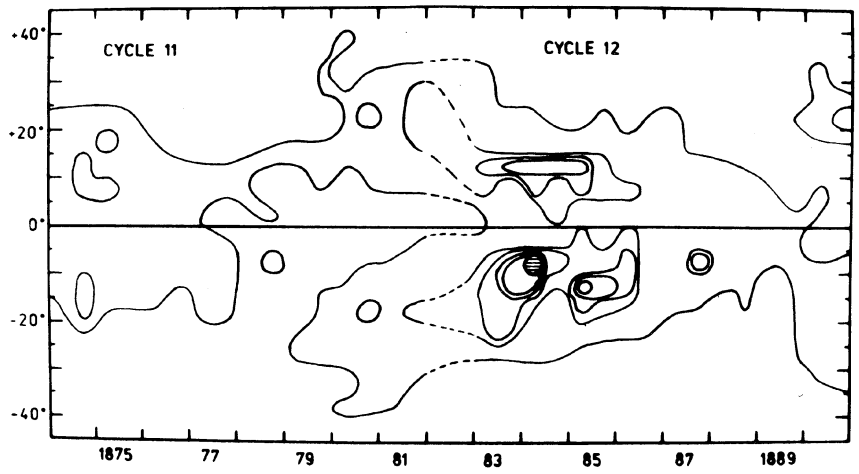

Fig. 1. The distribution of the six-month sunspot area as a function of the heliographic latitude in the 12th cycle. The lowest contour of the sunspot area is 10000 millionths of the Sun's visible hemisphere. The contour ratings of sunspot area are 20000, 30000, 40000 millionths. The values from 60000 to 80000 are horizontally hatched and values higher than 80000 are cross-hatched. The pulse of activity was observed in 1883.5 in zone S 5°- 10°.

Cycle 15

1913.6 min, 1917.6 max

year	1910	1911		1912		1913		1914		1915		1916
N_{500}	1	0	0	0	0	0	0	1	1	5	1	3
N_{1500}	0	0	0	0	0	0	0	0	0	0	0	0
N+S	34955	17737	5558	7619	5965	1224	1485	16735	37515	115548	136987	155750
N	10884	3438	2745	60	157	909	901	10763	24301	77291	58340	86996
40-45								299				
35-40									6	6	181	318
30-35						651		21	19	41	658	428
25-30					37	206	210	5725	787	908	1452	919
20-25			30		91		252	820	4307	32899	18750	7501
15-20	51				29	52	322	3855	19058	34902	11254	19739
10-15	365	829	76	28			9	41	100	5386	18770	48436
05-10	9605	2552	2456	32			13		6	120	7148	9285
00-05	863	57	183				95	2	18	3029	127	370
00-05	1274	6515	1831	4	2877	98		11	7	346	26	5
05-10	7331	4733	51	2851	2883	8			4	10	15	70
10-15	8280	2971	886	4666	48	192		318	78	399	2699	30244
15-20	7186	80	45	38				189	3690	13703	47625	29376
20-25							405	5148	5290	20245	25779	4416
25-30							180	276	2965	3523	2384	4643
30-35								17	927	31	94	
35-40						17		13	253		20	
S	24071	14299	2813	7559	5808	315	585	5972	13214	38257	78647	68754
N_{500}	1	0	0	0	0	0	0	0	0	1	4	3
N_{1500}	0	0	0	0	0	0	0	0	0	0	2	1

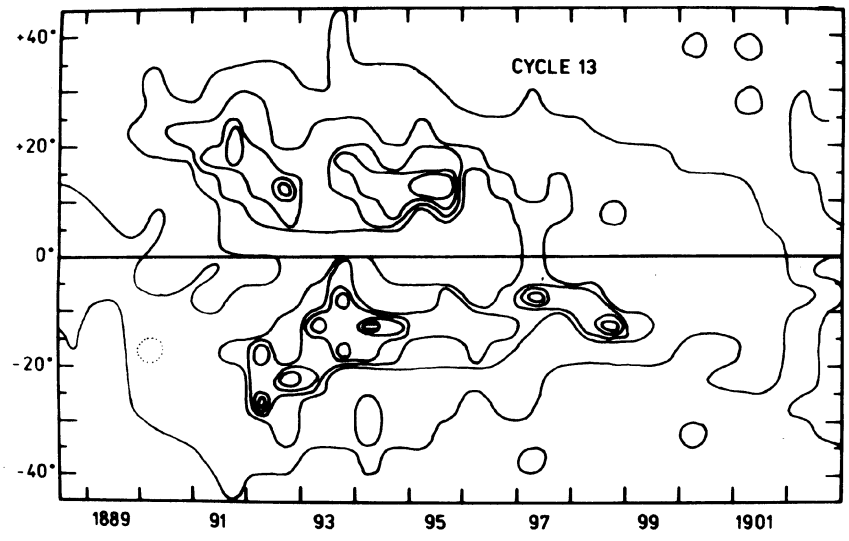

Fig. 2. The 13th cycle. The pulses of activity in 1892.5 zone N 10°-15° and in 1894.0 zone S 10°-15°.

Cycle 15 continued

year	1916	1917		1918		1919		1920		1921
N_{500}	2	3	6	5	3	7	3	0	1	2
N_{1500}	0	1	3	0	0	1	1	0	0	1
N+S	108448	231837	328628	180097	226412	222573	160722	131191	93860	79169
N	84446	123904	189852	102228	119190	135737	67517	43833	32087	43679
40-45	3						3			
35-40	99									
30-35	53	76	44		4		44			
25-30	11204	3016	784	1896	4	99	5		2	
20-25	9615	10507	14530	3315	4286	4832	138	45		
15-20	22571	34023	61557	31619	35374	7192	948	5920	6570	2382
10-15	21422	51005	54972	27367	26720	54524	26745	16205	12617	7322
05-10	18663	24142	49093	23499	45670	66030	7199	14646	12390	16226
00-05	836	1135	8872	14532	7132	3060	32435	6594	463	17749
00-05	5	930	236	5311	451	1419	14778	20985	93	3466
05-10	1445	10773	19491	17894	27923	28769	33589	49334	11779	19333
10-15	3249	16852	51692	15630	41683	11398	26385	6617	41262	8612
15-20	8482	56299	44408	27059	26991	42714	17002	9212	5930	4079
20-25	10066	20093	22347	9492	9499	2524	1451	1142	2704	
25-30	396	2865	593	1594	675	12		28	5	
30-35	339	121	9	889				40		
S	23982	107933	138776	77869	107222	86836	93205	87358	61773	35490
N_{500}	0	1	4	2	6	1	4	4	3	1
N_{1500}	0	1	0	1	1	0	0	2	1	0

CYCLE 14 (Fig. 3)

1. It is interesting to note that in this cycle the regions of large sunspot origin were at lower heliographic latitudes than its predecessors. The 14th cycle is the smallest in sunspot number and also in total sunspot area.

The beginnings of the 14th cycle in both hemispheres did not coincide:
in the North: in 1902.0 zone 20°-30°
South: in 1902.5 zone 15°-35°
The difference is +0.5 y, in this case the activity in the southern hemisphere was delayed.

2. The highest zone 40°-45° was reached only in the northern hemisphere in 1904.5 (+2.5 y).

3. The first sunspots of the 14th cycle in zone 0°-5° were observed in the North: in 1904.0 (+2.0 y)
South: in 1905.0 (+2.5 y)

4. The pulses of activity with the half-year sunspot area value higher than 60000 millionths are as follows:
North: in 1905.5 (+3.5 y) zone 5°-15°
in 1907.5 (+5.5 y) zone 5°-10°
South: in 1907.0 (+4.5 y) zone 10°-15°

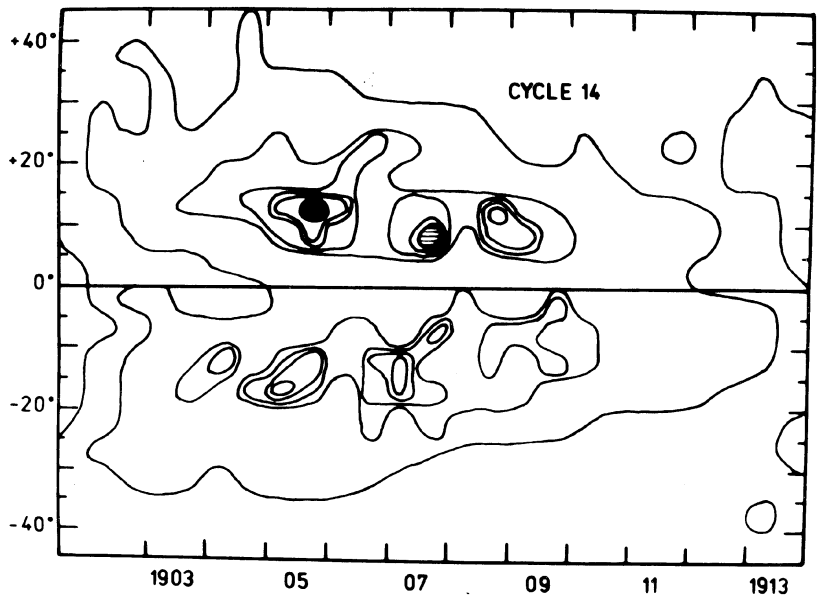

Fig. 3. The 14th cycle. The pulses of activity were observed in 1905.5 zone N 5°-10°, in 1907.0 zone S 10°-15° and in 1907.5 zone N 5°-10°.

5. The duration of the 14th cycle, in the

North: 1902.0 - 1912.0 = 10.0 y

South: 1902.5 - 1913.5 = 11.0 y

6. From the Zürich sunspot numbers the epoch of the maximum of the 14th cycle was derived as 1907.0, but this epoch is very indefinite. Originally it was given as 1906.4, later revised to 1907.0 . The Greenwich areas (smoothed mean values for each synodic rotation) give a double maximum, the first peak occurring in 1905.7 and the second (about 10 per cent lower) in 1907.3 . The duration of the ascending part of the cycle is 5.3 y and the descending part is 6.6 y.

The epochs of Gnevyshev's maxima can be distinguished clearly in the 14th cycle:

North: I - 1905.5 (+3.5 y) II - 1907.5 (+5.5 y) III - 1908.5

South: I 1905.0 (+2.5 y) II - 1907.0 (+4.5 y)

The absolutely highest value of the six-month sunspot area, in the

North: in 1905.5 (+3.5 y) 183562 mil.

South: in 1907.0 (+4.5 y) 127234 mil.

7. In the 14th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is 59256 millionths, i.e. only 2.9 per cent of the total N+S sunspot area in both hemispheres.

In faculae areas, the 14th cycle was comparable to the 19th cycle, so that the amplitude of the peaks is quite different for the sunspots and the faculae (Brown and Evans, 1980).

Cycle 16

1923.6 min, 1928.4 max

year	1921	1922		1923		1924		1925		1926	
N_{500}	0	3	1	0	0	1	4	1	6	4	5
N_{1500}	0	0	0	0	0	0	0	0	2	1	1
N+S	73229	61802	30104	7171	12807	28643	73079	67533	234996	261802	193501
N	46926	44876	13762	5902	6049	19824	65408	46753	142357	129310	108557
40-45							2				
35-40						1083	100	27	177	460	
30-35	3	5			154	14121	2932	2623	612	41	2
25-30				13	2850	2945	2316	6721	11319	7823	2506
20-25			1	7	1212	1549	36932	16573	79077	84099	38714
15-20	12	18	96		12	116	12887	17018	42321	17249	41645
10-15	12704	15320	617	45			921	2349	8697	7650	9521
05-10	24497	29487	12248	5110	827	2	6826	1442	154	11976	16160
00-05	9710	46	800	727	994	8	2492			12	9
00-05	2646	3637	3540	436		12					86
05-10	20953	12655	8949	688	1165	5				3384	9358
10-15	1876	250	3841	138		5		2453	24576	10168	43538
15-20	828	361			2697	6	61	8576	26999	66507	22368
20-25		23	4		214	4383	2785	4991	34524	25624	5969
25-30					2682	4308	4825	2988	3889	26337	3539
30-35				7		100		1278	2529	472	86
35-40								494	122		
S	26303	16926	16342	1269	6758	8819	7671	20780	92639	132492	84944
N_{500}	1	1	0	0	0	0	0	0	4	7	3
N_{1500}	0	0	0	0	0	0	0	0	1	2	1

CYCLE 15 (Fig. 4)

1. The beginnings of the 15th cycle were, in the

North: in 1912.5 zone 20°-30°

South: in 1913.5 zone 20°-30°

The activity in the northern hemisphere begins 1.0 year earlier.

2. The highest zone 40°-45° was reached only in the northern hemisphere in 1914.0 (+1.5 y).

3. The first sunspots of the 15th cycle in zone 0°-5° were observed, in the North: in 1914.5 (+2.0 y)

South: in 1914.5 (+1.0 y)

4. The pulses of the half-year sunspot area value exceeding 60000 millionths were observed only in the northern hemisphere

North: in 1917.5 (+5.0 y) zone 15°-20°

in 1919.0 (+6.5 y) zone 5°-10°

5. The duration of the 15th cycle

North: 1912.5 - 1923.5 = 11.0 y

South: 1913.5 - 1923.5 = 10.0 y

Cycle 16 continued

year	1927		1928		1929		1930		1931	
N_{500}	5	1	5	6	3	9	2	1	3	1
N_{1500}	2	0	0	2	0	2	0	1	1	0
N+S	219604	166071	251578	253643	179134	272491	115337	72521	72582	27552
N	99672	38494	115131	148176	80062	156710	64424	39805	53987	18903
30-35	16798			5						
25-30	3221	35	412	5			239			3
20-25	12648	9368	4144	1512	1700	2716	66	7	490	5
15-20	34021	9999	29437	41893	4178	37904	16039	4461	225	1312
10-15	20986	14864	26140	44140	23065	58280	31149	5489	5885	9372
05-10	9977	3355	52387	57270	40020	44856	14137	22764	37134	6694
00-05	2021	873	2611	3351	11099	12954	2794	7084	10263	1517
00-05	11	1209	2262	719	5382	21298	11328	2990	6000	1009
05-10	19818	49977	22134	4749	54402	34056	15732	27274	5908	2999
10-15	48061	35499	54800	25373	28549	32956	6524	1821	1669	3407
15-20	40607	39577	36732	62003	8609	15740	16923	422	5006	1015
20-25	5135	1021	19795	5779	2130	11726	406	19	12	219
25-30	6300	159	704	6835		5		190		
30-35		135	12	9						
35-40			8							
S	119932	127577	136447	105467	99072	115781	50913	32716	18595	8649
N_{500}	6	7	5	6	4	7	1	2	0	0
N_{1500}	0	0	0	1	0	0	0	0	0	0

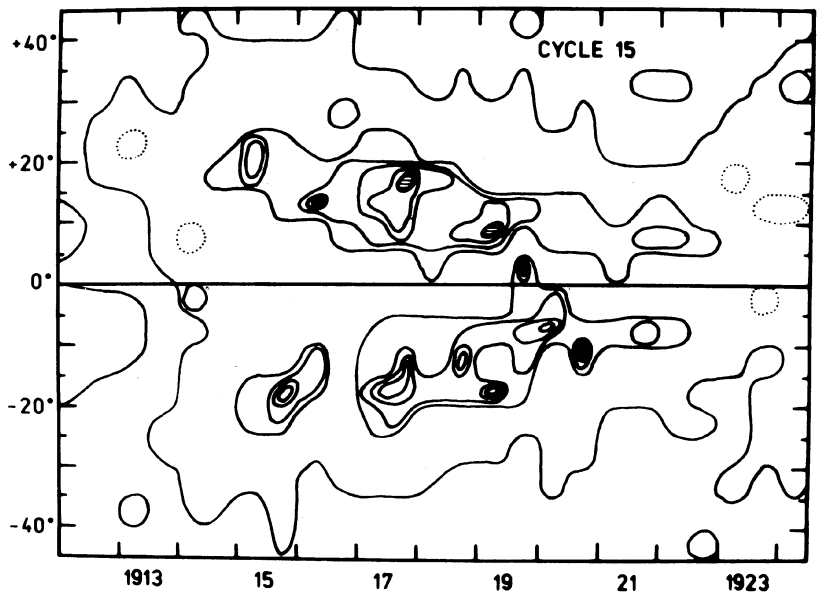

Fig.4. The 15th cycle. The pulses of activity were observed only on the northern hemisphere in 1917.5 zone 15°-20° and in 1919.0 zone 5°- 10° .

Cycle 17

1933.8 min, 1937.4 max

year	1932		1933		1934		1935		1936		1937
N_{500}	1	1	1	0	0	0	0	1	5	3	9
N_{1500}	0	0	1	0	0	0	0	0	0	0	2
N+S	38777	20553	29761	2284	28547	14754	58605	168341	193820	222182	392001
N	30112	14317	29643	1768	9366	6764	11298	62379	67119	101684	229779
35-40									724	11	
30-35					20		103	4381	7102	4743	674
25-30				2	4308	792	6262	12102	10254	5305	14650
20-25					14	4165	2869	31023	15399	22170	33499
15-20	39	4	944	2		35	360	10711	17533	51890	75878
10-15	11813	5590	18476	102	24	7	162	4156	15727	13339	40391
05-10	5278	8219	6570	1635	1127	448		6	380	4221	64043
00-05	12982	504	3653	27	3873	1317	1542			5	644
00-05	229	171	2	146	240		469			4	
05-10	5915	6026	61	183			7	351	2345	9427	30445
10-15	2438	39	55	172		27	133	10354	16293	33810	48389
15-20	77					593	12444	18394	25734	29226	49815
20-25					1437	1948	12160	32626	24740	28097	24531
25-30					11574	5209	11198	38943	28715	13406	4083
30-35	6			15	5930	186	8378	5262	28861	4727	176
35-40							2018	32	13	1781	232
S	8665	6236	118	516	19181	7990	47307	105962	126701	120498	162222
N_{500}	0	0	0	0	1	0	2	4	3	4	7
N_{1500}	0	0	0	0	0	0	0	1	1	0	2

6. From the Zürich sunspot numbers the epoch of the maximum of the 15th cycle was derived as 1917.6 . The duration of the ascending phase is 4.0 y and descending phase is 6.0 y .

The spochs of Gnevyshev´s maxima are as follows:

North: I - 1917.5 (+5.0 y) II - 1919.0 (+6.5 y)

South: I - 1917.5 (+4.0 y) II - 1918.5 ? (+5.0 y ?)

The pulse of the sunspot area in zone N 0° - 5° in 1919.5 is exceedingly high.

The absolutely highest value of the six-month sunspot area, in the

North: in 1917.5 (+5.0) 189852 mil.

South: in 1917.5 (+4.0) 138776 mil.

7. In the 15th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is 230083 millionths, i.e. 9.6 per cent of the total N+S sunspot area.

CYCLE 16 (Fig. 5)

1. The beginnings of the 16th cycle were, in the

North: in 1923.0 zone 25°- 30° , South: in 1923.5 zone 25°- 30° .

Cycle 17 continued

year	1937	1938		1939		1940		1941		1942
N_{500}	12	9	4	3	5	3	5	0	5	2
N_{1500}	3	4	2	0	0	2	0	0	1	1
N+S	363536	347257	389611	236306	339251	188325	191686	85609	155218	107981
N	250129	164616	160039	119494	117218	92524	90542	50836	107344	76190
35-40	827	1196								
30-35	58016	25	76	960		12				
25-30	15971	19213	9669	15017	3502		284	24		
20-25	25783	28819	8035	16647	12714	2832	1332	1356	6	4
15-20	14904	52771	47130	11164	29425	4819	30848	2924	10336	7749
10-15	85368	30996	69883	42523	44739	64928	19710	31021	73976	19266
05-10	48856	29404	17426	29452	16863	18726	34705	11551	8999	47946
00-05	404	2192	7820	3731	9975	1219	3651	3960	14027	1225
00-05	146	2372	6885	3320	20774	10013	7556	6255	17264	3096
05-10	9840	40699	70330	24108	58537	32811	39456	17999	13503	18897
10-15	46733	63319	86557	29523	93731	34998	39433	7023	9750	9757
15-20	26350	20504	38575	48661	40463	15300	14148	3496	7357	33
20-25	21830	33447	22698	11043	6750	2623	551			
25-30	8325	19714	4415	157	12	56				
30-35	1840	112			1766					8
35-40	7	746								
S	113407	182641	229572	116812	222033	95801	101144	34773	47874	31791
N_{500}	3	7	10	2	6	3	6	0	2	1
N_{1500}	0	1	4	0	5	0	0	0	0	0

The activity began in the northern hemisphere 0.5 year earlier.

2. Sunspots were not observed in the highest zone 40° - 45° .

3. The first sunspots of the 16th cycle in zone 0° - 5° were observed, in the North: in 1926.0 (+3.0 y)
South: in 1926.5 (+3.0 y)

4. The pulses of sunspot activity with half-year sunspot area value exceeding 60000 millionths are as follows:

North: in 1925.5 (+2.5 y) zone 20° - 25°
in 1926.0 (+3.0 y) zone 20° - 25°
South: in 1926.0 (+2.5 y) zone 15° - 20°
in 1928.5 (+5.0 y) zone 15° - 20°.

5. The duration of the 16th cycle, in the
North: 1923.0 - 1935.0 = 12.0 y
South: 1923.5 - 1935.0 = 11.5 y

6. From the Zürich sunspot numbers the epoch of the maximum of the 16th cycle was derived as 1928.4 . The duration of the ascending phase of the cycle is 4.8 y and descending phase is 5.4 y . The years of Gnevyshev's maxima are as follows:

North: I - 1925.5 (+2.5 y) II - 1928.5 (+5.5 y) III - 1929.5 (+6.5 y)
South: I - 1926.0 (+2.5 y) II - 1928.0 (+4.5 y) III - 1929.5 (+6.0 y)

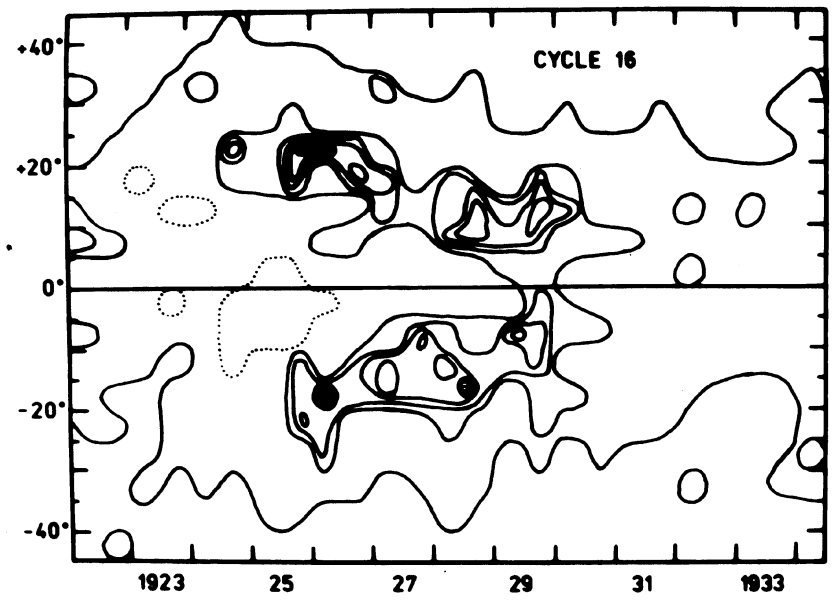

Fig. 5. The 16th cycle. The pulses of activity were observed in the northern hemisphere from 1925.5 to 1926.0 in zone 20°- 25° , in the southern hemisphere in 1926.0 zone 15° - 20° and in 1928.5 zone 15° - 20°.

The absolutely highest value of the six-month sunspot area, in the
North: in 1929.5 (+6.5 y) 156710 mil.
South: in 1928.0 (+4.5 y) 136447 mil.

7. In the 16th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is 231721 millionths, i.e. 8.9 per cent of the total N+S sunspot area.

CYCLE 17 (Fig. 6)

1. The 17th cycle is the largest on the faculae area scale of the nine cycles considered (Brown and Evans, 1980). The 17th cycle is symmetric in the total north-south sunspot area, but the northern hemisphere is influenced more by larger sunspots than the southern. The beginnings of the 17th cycle were, in the North: in 1934.0 zone 25°- 30°
South: in 1934.0 zone 25° -30°.

2. The highest zone 40° - 45° was not reached.

3. The first sunspots of the new cycle in zone 0° - 5° were observed, in the North: in 1936.5 (+2.5 y)
South: in 1936.5 (+2.5 y)

4. The pulses of sunspot activity with half-year sunspot area exceeding 60000 millionths are as follows:
North: in 1937.0 (+3.0 y) zone 5° - 20°

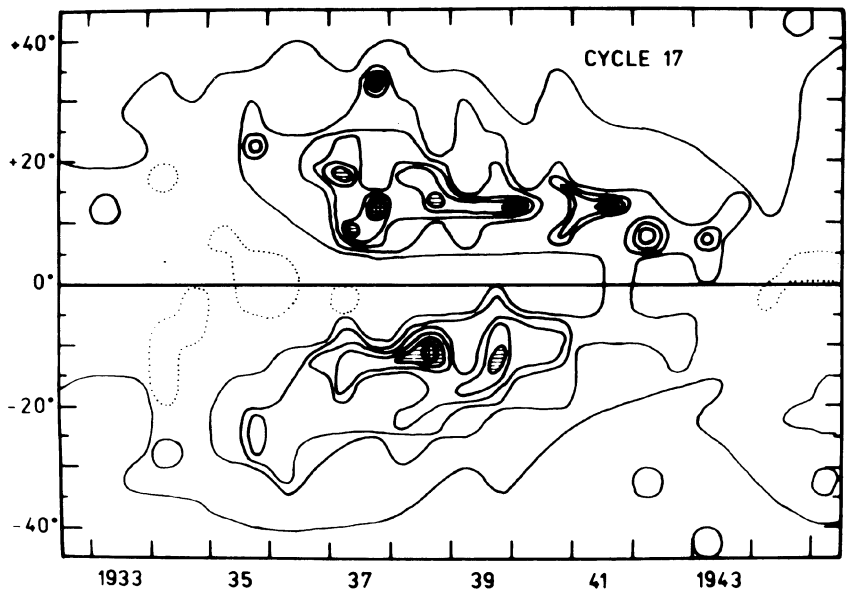

Fig. 6. The 17th cycle. Note the pulse in 1937.5 in the northern zone 30° - 35°.

	in 1937.5	(+3.5 y)	zones 10° - 15° , 30° - 35°
	in 1938.5	(+4.5 y)	zone 10° - 15°
	in 1940.0	(+6.0 y)	zone 10° - 15°
	in 1941.5	(+7.5 y)	zone 10° - 15°
South:	in 1938.0	(+4.0 y)	zone 10° - 15°
	in 1938.5	(+4.5 y)	zone 5° - 15°
	in 1939.5	(+5.5 y)	zone 10° - 15°

5. The duration of the 17th cycle, in the

North: 1934.0 - 1944.0 = 10.0 y

South: 1934.0 - 1945.5 = 11.5 y

6. From the Zürich sunspot numbers the epoch of the maximum of the 17th cycle was derived as 1937.4 . The duration of the ascending phase of the cycle is 3.6 y and descending phase is 6.8 y . The epochs of Gnevyshev´s maxima are very indefinite in the 17th cycle.

North: I - 1937.5 (+3.5 y) II - 1938.5 (+4.5 y) III - 1941.5 (+7.5 y)

South: I - 1938.5 (+4.5 y) II - 1939.5 (+5.5 y)

The absolutely highest value of the six-month sunspot area, in the

North: in 1937.5 (+3.5 y) 250129 mil.

South: in 1938.5 (+4.5 y) 229572 mil.

7. In the 17th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is only 9585 millionths, i.e. 0.3 per cent of the total sunspot area N+S.

Cycle 18

1944.2 min, 1947.5 max

year	1942	1943		1944		1945		1946		1947	
N_{500}	1	4	3	0	0	0	2	5	9	7	7
N_{1500}	0	2	0	0	0	0	0	2	2	2	2
N+S	46207	68730	39097	7215	38925	62524	94154	270637	392203	546754	410290
N	15650	60870	30122	2552	13143	5815	38171	165823	238267	167450	196268
40-45					35				9	135	
35-40							5	22	401	144	
30-35	12				38	964	68	12135	2113	1870	1086
25-30					780	680	14089	94424	7615	5364	8007
20-25	515				6015	3988	18247	28641	107679	57790	20879
15-20	614	18	7129		5868	156	5294	25088	39616	46475	69820
10-15	1235	722	19529		28	10	94	5425	62493	45395	81073
05-10	11934	38005	2989	877	187	17	374	81	18341	9794	15268
00-05	1340	22125	475	1675				7		483	135
00-05	6119	1347	1986	39	192	82	141		484	11737	4708
05-10	10802	5116	980	12	1704	1815	14	34	36194	20163	38517
10-15	13547	71	228	5	311	6094	3214	7059	37911	58416	65483
15-20	89		15	3566	134	14753	25112	37960	37291	91918	57625
20-25		3	5711	1025	18941	17818	18388	23380	24356	177148	28593
25-30			55	16	3237	3459	6508	18045	15848	16321	8525
30-35					1234	12680	1835	12297	1474	1731	10306
35-40					29	8	771	5904	230	440	97
40-45		1323							148	1430	168
S	30557	7860	8975	4663	25782	56709	55983	104814	153936	379304	214022
N_{500}	1	0	0	0	1	3	3	3	4	17	7
N_{1500}	0	0	0	0	0	0	0	0	1	4	0

CYCLE 18 (Fig. 7)

In the 18th cycle the absolutely largest pulse of the sunspot area of the nine considered cycles was observed in 1947.0 in the southern interval 15° - 25° . There were 17 transition of sunspot groups with a mean area larger than 500 millionths.

1. The beginning of the sunspot activity of the 18th cycle, in the
North: in 1944.5 zone 15°- 25°
South: in 1944.0 zone 15°- 25°.

2. The highest zone 40°- 45° was reached , in the
North: in 1946.5 (+2.0 y)
South: in 1946.5 (+2.5 y)

3. The first sunspots of the new cycle in zone 0° - 5° was observed, in the North: in 1946.0 (+1.5 y)
South: in 1946.5 (+2.5 y)

4. The pulses of sunspot activity with half-year sunspot area exceeding 60000 millionths area as follows:
North: in 1946.0 (+1.5 y) zone 25° - 30°

Cycle 18 continued

year	1948		1949		1950		1951		1952	
N_{500}	9	3	10	7	9	3	9	3	0	1
N_{1500}	4	0	2	1	2	0	3	0	0	0
N+S	387160	335726	346536	358675	298173	145625	277667	133826	57912	89479
N	189456	152270	157189	202641	201040	78171	197215	67131	21704	49844
35-40		24			170	485				
30-35	372	286		999	910					
25-30	4482	3402	13	7820	13698	213	149	5		
20-25	58317	12042	828	26969	18085	8441	10747	2315	142	224
15-20	43638	25332	30249	30017	20667	15993	16541	5428	2397	153
10-15	52470	75594	52703	59038	78417	35190	123486	16168	4097	15523
05-10	28975	30010	44483	57983	61984	14942	42247	39074	10495	18839
00-05	202	5580	28913	19815	7109	2907	4045	4141	573	15105
00-05	8583	10398	34696	16060	10702	4438	4643	10788	8130	15437
05-10	41382	66754	56425	33285	7474	20450	17350	38039	15182	10030
10-15	63504	65753	47681	68679	22753	27296	42123	12393	8553	14066
15-20	43442	30450	41031	25106	48749	13531	7150	5307	2237	82
20-25	31117	5772	8710	9853	7283	1596	9186	168	2106	20
25-30	8000	3537	804	2196	149	143				
30-35	1676	792		811	23					
35-40				26						
S	197704	183456	189347	156034	97133	67454	80452	66695	36208	39635
N_{500}	6	6	6	7	5	2	4	3	2	1
N_{1500}	2	3	1	3	0	0	2	0	0	0

North: in 1946.5 (+2.0 y) zones 20° - 25° , 10° - 15°

The location of these pulses agree with the time-latitude distribution of the flares of the largest importance (Křivský, Knoška, 1967).

North: in 1947.5 (+3.0 y) zone 10° - 20°

The location of this pulse agree with the time-latitude distribution of the less important flares (Křivský, Knoška, 1967).

North: in 1948.5 (+4.0 y) zone 10° - 15°
in 1950.0 (+5.5 y) zone 5° - 15°
in 1951.0 (+6.5 y) zone 10° - 15°

South: in 1947.0 (+3.0 y) zone 15° - 25°
in 1947.5 (+3.5 y) zone 10° - 15°

The active regions in these two pulses also agree with the time-latitude distribution of the less important flares (Křivský, Knoška, 1967) and also with the time-latitude distribution of the green coronal intensity emission (Sýkora, 1980).

South: in 1948.0 (+4.0 y) zone 10° - 15°
in 1948.5 (+4.5 y) zone 5° - 15°
in 1949.5 (+5.5 y) zone 10° - 15°

We can also see this last pulse in the green coronal emission (Sýkora, 1980) and also in the occurrence of the less important flares (Křivský, Knoška,1967).

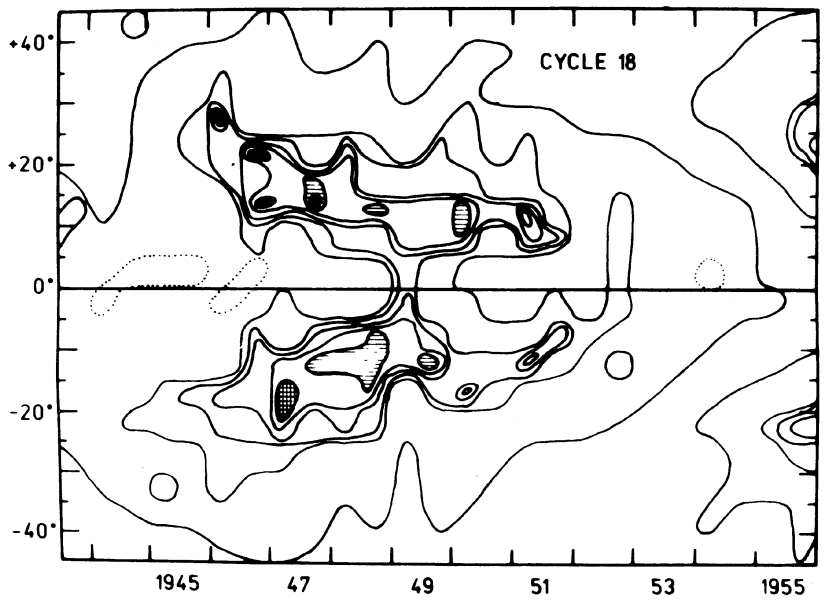

Fig. 7. The 18th cycle. The pulses from 1946.0 to 1946.5 zone N 20° - 30° coincide with the occurrence of the less important flares. The pulses on the southern hemisphere coincide with the time-latitude distribution of flares and of green coronal emission.

5. The duration of the 18th cycle, in the
North: 1944.5 - 1955.5 = 10.0 y
South: 1944.0 - 1955.0 = 11.0 y

6. From the Zürich sunspot numbers the epoch of the maximum of the 18th cycle was derived as 1947.5 . The duaration of the ascending phase of the cycle is 3.3 y and descending phase is 6.8 y . The epochs of Gnevyshev´s maxima, in the North: I - 1946.5 (+2.0 y) II - 1949.5 (+5.0 y)
South: I - 1947.0 (+3.0 y) II - 1948.5 (+4.5 y)
The absolutely highest value of the six-month sunspot area, in the
North: in 1946.5 (+2.0 y) 238267 mil.
South: in 1947.0 (+3.0 y) 379304 mil.

7. In the 18th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is only 23248 millionths, i.e. 0.5 per cent of the total sunspot area N+S.

CYCLE 19 (Fig.8)

The 19th cycle is the largest of the last nine cycles on the sunspot number scale and also in the total sunspot area. The results of Brown and Evans (1980) indicate that in the faculae area, the 19th cycle was not exceptional and that it is only comparable to the previous 18th cycle. The two photosphe-

Cycle 19

1954.3 min, 1957.9 max

year	1953		1954		1955		1956		1957		1958
N_{500}	1	0	0	0	1	2	12	10	7	17	15
N_{1500}	0	0	0	0	0	0	2	2	2	3	3
N+S	33816	16468	5116	7703	52428	149141	351189	530404	444472	663928	580367
N	24976	11401	161	4205	31750	88094	228221	223419	176548	350288	315887
40-45					28	2080	32	1612	656	2260	8724
35-40				35	10369	55	654	1834	883	363	6397
30-35			53	2464	3800	3639	23043	21255	27124	9976	21914
25-30			9	870	2440	27641	26565	34402	16304	47096	54865
20-25	13			629	8864	44898	122800	74208	33291	87026	66929
15-20	50				6249	9530	47676	56846	42008	74881	49628
10-15	15475	7748	46	24		251	7451	33222	45051	89797	86921
05-10	1659	2056	53	178				40	11133	38511	18663
00-05	7779	72		5					98	378	1846
00-05	437	837	77	8	76				2311	1437	3437
05-10	3537	4099	4455					1195	6296	12931	19704
10-15	4683	631				18	9824	43567	45193	53078	83823
15-20	183			11	10	8964	32370	85731	67392	84462	84541
20-25			419	1514	17880	33601	58601	132472	81341	88372	63124
25-30				76	538	12499	13412	41277	42943	53902	8623
30-35				1889	2174	5614	7336	1736	1239	11964	415
35-40			4			60	1045	50	20688	2216	813
40-45						291		957	521	5278	
S	8840	5567	4955	3498	20678	61047	122968	306985	267924	313640	264480
N_{500}	0	0	0	0	1	3	4	15	7	18	12
N_{1500}	0	0	0	0	0	0	1	5	2	4	6

ric features thus yield different information concerning the solar activity. The highest mean value of facular area was observed in the 17th cycle (Willis and Tulunay, 1979). An interesting result was published by Sýkora (1980). He found that the green corona intensity was approximately the same in the 18th, 19th and 20th cycles.

1. The onset of the sunspot activity of the 19th cycle, in the

North: in 1954.0 zone 25° - 35°

South: in 1954.0 zone 20° - 25°.

2. The highest zone 40° - 45° was reached, in the

North: in 1955.5 (+1.5 y)

South: in 1955.5 (+1.5 y)

3. The first sunspots of the 19th cycle in zone 0° - 5° were observed, in the North: in 1957.0 (+3.0 y)

South: in 1957.0 (+3.0 y)

4. The pulses of sunspot activity with half-year sunspot area exceeding 60000 millionths are as follows:

North: in 1956.0 (+2.0 y) zone 20° - 25°

Cycle 19 continued

year	1958	1959		1960		1961		1962		1963
N_{500}	6	21	17	7	9	4	2	4	0	2
N_{1500}	0	9	7	2	2	0	0	1	0	0
N+S	524610	631554	469208	327333	306267	111876	112273	109343	57882	52621
N	205771	501779	354307	201235	215401	77187	85290	73319	42002	39345
40-45	1719									
35-40	4855	609	2911		31					
30-35	6390	4833	4171	2486	218					
25-30	23250	46810	16510	22018	28758	7				
20-25	36554	60978	28486	30327	74688	8068	1521	979	3889	
15-20	58150	131911	88012	25439	53665	9742	17874	5274	1894	3686
10-15	27255	170642	78280	64723	18051	10005	37550	21499	4056	17138
05-10	42012	77137	114710	53496	38303	22362	24120	44386	23283	16847
00-05	5586	8859	21227	2746	1687	27003	4225	1181	8884	1674
00-05	31535	4286	13824	5860	6331	3665	5215	4487	957	74
05-10	61776	23013	21742	32516	28542	18213	19983	14333	722	4541
10-15	77247	41215	34680	54238	29344	7673	1314	14557	13061	5938
15-20	99911	40426	43073	23269	25928	4721	437	2378	769	2723
20-25	30878	15181	1525	10058	719	360	34	269	371	
25-30	13261	944	47	157	2	57				
30-35	4196	4521								
35-40	35	189								
S	318839	129775	114901	126098	90866	34689	26983	36024	15880	13276
N_{500}	18	4	2	3	2	0	1	3	0	0
N_{1500}	6	0	2	0	0	0	0	0	0	0

North: in 1956.5 (+2.5 y) zone 20° - 25°
in 1957.5 (+3.5 y) zone 10° - 25°
in 1958.0 (+4.0 y) zone 10° - 25°

All these four pulses have responses in the green line coronal intensity (Sýkora, 1980) and the last two are visible in the time-latitude distribution of flares (Křivský, Knoška, 1967).

North: in 1959.0 (+5.0 y) zone 5° - 25°
in 1959.5 (+5.5 y) zone 5° - 20°
in 1960.0 (+6.0 y) zone 10° - 15°

These three pulses, but namely the first, are observed in the time-latitude distribution of flares, especially of the important ones.

North: in 1960.5 (+6.5 y) zone 20° - 25°
South: in 1956.5 (+2.5 y) zone 15° - 25°
in 1957.0 (+3.0 y) zone 15° - 25°
in 1957.5 (+3.5 y) zone 15° - 25°

These three pulses correlate quite well with the pulse of the green coronal line intensity (Sýkora, 1980) observed in corresponding latitude zones.

South: in 1958.0 (+4.0 y) zone 10° - 25°
in 1958.5 (+4.5 y) zone 5° - 20°

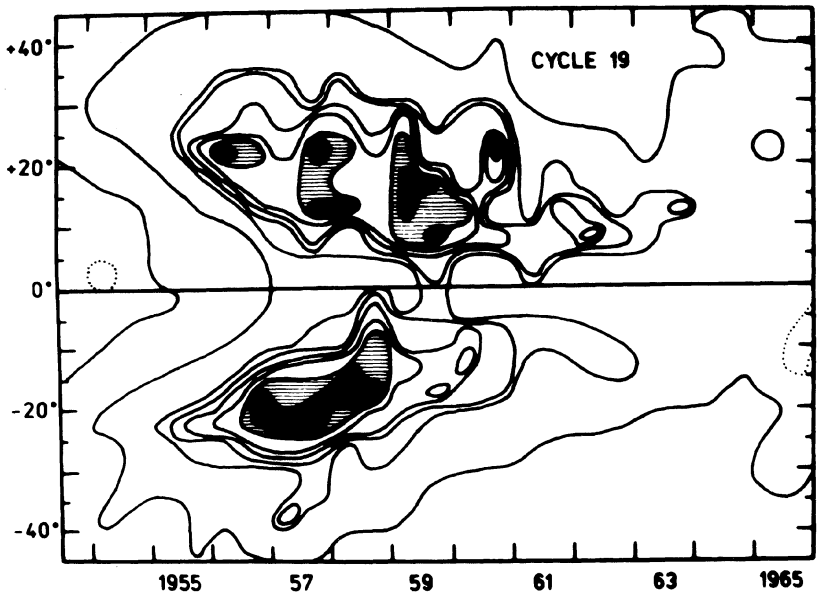

Fig. 8. The 19th cycle. The largest northern asymmetry in the sunspot area from the 14th cycle. The pulses of the sunspot activity up to 1958.5 correlate quite well with the pulse of the green coronal line intensity and with the location of the flare occurrence.

These two pulses are strongly expressed in the location of the flare occurrence and also in the green coronal line intensity.

5. The duration of the 19th cycle, in the
North: 1954.0 - 1964.5 = 10.5 y
South: 1954.0 - 1965.5 = 11.5 y

6. From the Zürich sunspot numbers the epoch of the maximum of the 19th cycle was derived as 1957.9 . The epochs of Gnevyshev´s maxima, in the
North: I - 1956.5 (+2.5 y) II - 1958.0 (+4.0 y) III - 1959.0 (+5.0 y)
South: I - 1956.5 (+2.5 y) II - 1958.0 (+4.0 y)
The absolutely highest value of the six-month sunspot area, in the
North: in 1959.0 (+5.0 y) 501779 mil.
South: in 1958.5 (+4.5 y) 318839 mil.

7. In the 19th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is 988982 millionths, i.e. 17.8 per cent of the total N+S sunspot area. This N-S asymmetry of the 19th cycle is the largest observed since 1874. The northern asymmetry in sunspot area lasted continuously from the 14th cycle.

Cycle 20

1964.6 min, 1970.3 max

year	1963	1964		1965		1966		1967		1968	
N+S	53653	12587	7382	19817	19004	96488	159321	274841	343565	329259	264895
N	45346	9823	6544	17196	15783	91068	144260	189320	195412	217549	147983
40-45		389	8								
35-40			394	157	158	819	3515	64	17	13	
30-35	1202	27	2436	750	241	3616	9976	1402	8652	8975	584
25-30	312	422	418	1745	5430	22722	13297	27933	33676	6512	4317
20-25	382	61	2059	10939	4582	24495	58523	89790	37412	45098	6913
15-20	50	85	567	801	2015	35565	5893	41052	52640	46750	48154
10-15	29993	1235	7	135	1680	3469	11802	25857	49835	101813	63891
05-10	8423	6533	633	2324	1009	3	41254	2848	13108	7973	19013
00-05	4984	1071	22	345	668	379		374	72	415	5111
00-05	1033	2077	40	192	3			5	14	59	4584
05-10	3152	623	686	10			76	242	3437	703	7160
10-15	4077	40	112	1978		5	7	1466	12943	33452	45714
15-20	45	24		7	2370	158	1712	31045	59075	18175	44086
20-25					4	4944	13018	49447	47198	24583	4468
25-30				409	584	313	225	3127	23375	20545	3980
30-35				25	260		23	82	1977	12984	6883
35-40									111	1209	37
40-45								107	23		
S	8307	2764	838	2621	3221	5420	15061	85521	148153	111710	116912

year	1969		1970		1971		1972		1973	
N+S	293513	239307	364753	233304	188162	176516	133459	149180	96724	76286
N	193509	144670	173759	166715	101809	68201	9658	53051	47595	38499
35-40	808	5						4		
30-35	1846				30					
25-30	982	1688	1519	42	678					4
20-25	35804	12891	13984	29712	4417		66	1207		4242
15-20	34469	14227	93519	59662	29809		97	9162	2729	1688
10-15	58084	87095	31899	41798	23224	28	442	28803	25722	26441
05-10	51534	25743	23764	15176	32746	27134	8643	11713	18974	4640
00-05	9932	3021	9074	10255	10905	2994	410	2162	170	1484
00-05	544	3689	17099	3192	7456	11531	3408	5364	6771	965
05-10	13293	19285	47934	30115	35746	31853	50980	28010	23366	6478
10-15	48627	37548	75165	24789	25484	55534	42860	48401	12600	21158
15-20	26235	22201	32018	6903	16436	9091	22621	12179	6363	9173
20-25	4500	6698	14866	1349	1199	18	3892	2083	24	9
25-30	2709	719	1330	228	4	267	36	86	5	
30-35	4085	4150	2472			21	4	6		
35-40	11	347	110	13	28					4
S	100004	94637	190994	66589	86353	108315	123801	96129	49129	37787

Cycle 20 continued

year	1974		1975		1976	
N+S	56855	112608	17832	66412	29888	29529
N	9163	46527	12077	33206	10488	22344
35-40	3	18				5
30-35				1684		301
25-30	8	1		206		1983
20-25				5	3	200
15-20	120	72	10		1	12222
10-15	1386	21347	2784	109		5420
05-10	5655	23321	5562	24361	280	443
00-05	1991	1768	3721	6841	10204	1770
00-05	2311	3143	18	1091	912	577
05-10	5251	28363	3144	8322	13107	292
10-15	28207	30316	2365	1807	4100	548
15-20	11883	4258	177			1588
20-25	34	1	51		65	967
25-30					921	3175
30-35	6			7	247	
35-40				2	19	38
40-45					29	
S	47692	66081	5755	11229	19400	7185

CYCLE 20 (Fig. 9)

1. The onset of sunspot activity of the 20th cycle, in the

North: in 1963.5 zone 20° - 35°

South: in 1965.0 zone 25° - 35°

The sunspot activity began in the northern hemisphere 1.5 y earlier. According to Sýkora (1980), the green corona brightness displayed a similar delay.

2. The highest zone 40° - 45° was reached, in the

North: in 1964.0 (+0.5 y)

South: in 1967.0 (+2.0 y)

3. The first sunspots of the 20th cycle in zone 0° - 5° were observed, in the North: in 1965.0 (+1.5)

South: in 1967.0 (+2.0)

4. The pulses of sunspot activity with half-year sunspot area exceeding 60000 millionths are as follows:

North: in 1967.0 (+3.5 y) zone 20° - 25°

We can also see this pulse in the occurrence of the important flares (see Fig. 3 in Knoška, Křivský, 1978) and also in the pulse of the green corona brightness (Sýkora, 1980).

North: in 1968.0 (+4.5 y) zone 10° - 15°

in 1968.5 (+5.0 y) zone 10° - 15°

in 1969.5 (+6.0 y) zone 10° - 15°

in 1970.0 (+6.5 y) zone 15° - 20°

in 1970.5 (+7.0 y) zone 15° - 20°

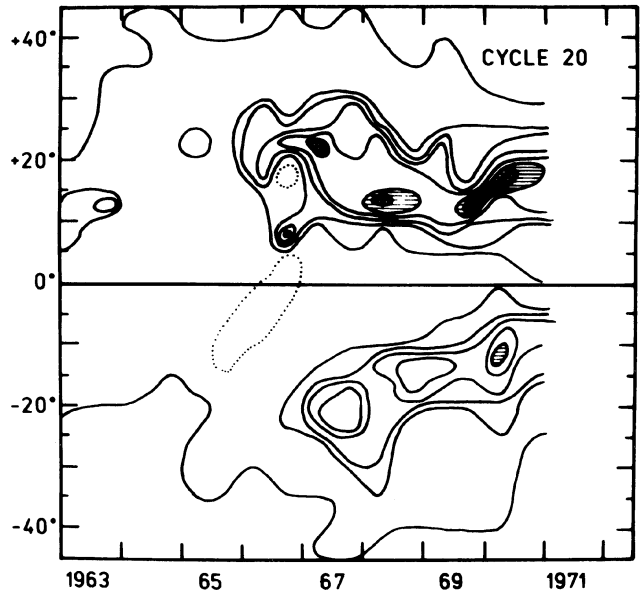

Fig. 9. The 20th cycle. The pulses of the sunspot activity were observed in 1967.0 and from 1969.5 to 1970.5 in the northern hemisphere, in 1970.0 in the southern hemisphere. These pulses are clearly distinguisable in the flare occurrence and in the green corona brightness.

These last three pulses of activity are clearly distinguisable in flare occurrence as well as in green corona brightness.

South: in 1970.0 (+5.0 y) zone 10° - 15°

This southern pulse has a response in flare and corona activity.

5. The duration of the 20th cycle , in the

North: 1963.5 - 1976.5 = 13.0 y

South: 1965.0 - 1976.5 = 11.5 y

6. From Zürich sunspot numbers, the epoch of the maximum of the 20th cycle was derived as 1970.3 y . The epochs of Gnevyshev's maxima in the 20th cycle are, in the

North: I - 1968.0 (+4.5 y) II - 1970.0 (+6.5 y)

South: I - 1967.5 (+2.5 y) II - 1970.0 (+5.0 y)

The absolutely highest vylue of the six-month sunspot area, in the

North: in 1968.0 (+6.5 y) 217549 mil.

South: in 1970.0 (+5.0 y) 190994 mil.

7. In the 20th cycle the total sunspot area was higher in the northern hemisphere. The difference between N and S is 503231 millionths, i.e. 13.6 per cent of the total N+S sunspot area.

Table 2

Zone	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
				Cycle 13					
				N: 1166727					
Area	59896	222427	399083	274852	159037	48007	3425		
%	5.14	19.06	34.21	23.56	13.63	4.11	0.29		
				S: 1446682					
Area	75034	287625	434065	326805	186345	94337	42471		
%	5.19	19.88	30.00	22.59	12.88	6.52	2.94		
				Cycle 14					
				N: 1056104					
Area	54260	354681	413055	128205	91771	12191	1941		
%	5.14	33.58	39.11	12.14	8.69	1.15	0.18		
				S: 996848					
Area	84680	190954	322057	314171	71748	12289	949		
%	8.50	19.16	32.31	31.52	7.20	1.23	0.10		
				Cycle 15					
				N: 1317980					
Area	111226	366299	400327	297493	112419	27254	2047	610	305
%	8.44	27.79	30.37	22.57	8.53	2.07	0.16	0.05	0.02
				S: 1087897					
Area	58340	264844	263228	337948	140628	20139	2467	303	
%	5.36	24.35	24.20	31.06	12.93	1.85	0.23	0.03	
				Cycle 16					
				N: 1416006					
Area	80936	348431	304520	311706	290820	40408	37288	1847	
%	5.72	24.61	21.51	22.01	20.54	2.85	2.63	0.13	
				S: 1184295					
Area	53551	261976	322098	353925	124732	62761	4628	624	
%	4.52	22.12	27.20	29.89	10.53	5.30	0.39	0.05	
				Cycle 17					
				N: 1818864					
Area	74468	387042	577709	376238	207182	117355	76112	2758	
%	4.09	21.28	31.76	20.69	11.39	6.45	4.19	0.15	
				S: 1809279					
Area	87552	389225	543688	351197	224481	145807	62500	4829	
%	4.84	21.51	30.05	19.41	12.41	8.06	3.45	0.27	
				Cycle 18					
				N: 2177213					
Area	100871	396381	731459	384307	381362	160741	20841	1251	
%	4.63	18.21	33.60	17.65	17.52	7.38	0.96	0.06	
				S: 2153965					
Area	142239	413370	556621	486048	410487	89283	47620	8297	
%	6.60	19.19	25.84	22.57	19.06	4.14	2.21	0.39	

Table 2 continued

Cycle 19

N: 3271964

Area	92863	543928	743127	682515	684513	347545	131366	28996	17111
%	2.84	16.62	22.71	20.86	20.92	10.62	4.02	0.89	0.52

S: 2282982

Area	86764	269978	520987	607185	537099	187738	41084	25100	7047
%	3.80	11.83	22.82	26.60	23.53	8.22	1.80	1.10	0.31

4. CONCLUSION

The total area of spots, as shown by Kopecký and Kuklin (1969), changes in the 11-year cycle not only due to changes in the frequency of the formation of spot groups, but also due to changes in their average importance. The contribution of small groups, no matter how large they are in number, is not so important in comparison with the large groups whose contribution to the total area of spots is basical due to their area.

From the distribution of sunspot area in heliographic latitude (Figs.1-9) the following main conclusions can be drawn:

1. The outer contour of the time-latitudinal distribution of sunspot area has the typical "butterfly" shape with poleward progression in the rising phase and equatorward progression in the declining phase of the nine considered cycles. However, the outer contour of the "wings" reflects the pulses and lacks of sunspot activity (see 1949.0 y in the 18th cycle).

2. The pulses in sunspot area are strongly affected by the periodicity of large sunspot groups.

3. The total latitudinal distribution of sunspot area during the seven cycles is given in Table 2, separately for the northern and southern hemisphere. The total sunspot area in zone 0°-5° is almost the same in these cycles, with the exception of the pulse in 1919.5 and a smaller increase of activity in the 18th cycle.

4. On the basis Table 2, we can see that the north-south sunspot area asymmetry lasted from the 14th cycle to the 20th.

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