SOLAR INDICES BULLETIN

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♦ SOLAR RADIO EMISSIONS

The quiet Sun emits radio energy with a slowly varying intensity. These radio fluxes, which stem from atmospheric layers high in the chromosphere and low in the corona, change gradually from day-to-day, in response to the number and size of spot groups on the solar disk. The table below gives daily measurements of this slowly varying emission at selected wavelengths between about 1 and 100 centimeters. Many observatories record quiet-sun radio fluxes at the same local time each day and correct them to within a few percent for factors such as antenna gain, bursts in progress, atmospheric absorption, and sky background temperature. At 2800 megahertz (10.7 centimeters) flux observations summed over the Sun's disk have been made continuously since February 1947.

♦ SOLAR FLUX TABLE

Numbers in parentheses in the column headings below denote frequencies in megahertz. Each entry is given in solar flux units--a measure of energy received per unit time, per unit area, per unit frequency interval. One solar flux unit equals $10^{-22}\ J/m^2 Hz\,sec$. During low periods of solar activity, the flux never falls to zero, because the Sun emits at all wavelengths with or without the presence of spots. The lowest daily Ottawa flux since 1947 occurred on November 3, 1954. On that day the observed noon value dropped to 62.6 units; the highest observed value of 457.0 occurred on April 7, 1947.

The preliminary observed and adjusted Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. Observed numbers are less refined, since they contain fluctuations as large as ±7% from the continuously changing sun-earth distance. Adjusted fluxes have this variation removed; they show the energy received at the mean distance between the Sun and Earth. Gaps in the Palehua, Hawaii (PALE), data reflect equipment problems. Fluxes measured either at Sagamore Hill, Massachusetts, or at San Vito, Italy, will be substituted for frequencies at which many Palehua values are missing.

JULY 2003 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	100	131	517	292	197	135	143	83	42	33	19
02	97	135	520	292	197	139	142	83	43	34	24
03	80	132	524	299	211	136	142	85	44	34	23
04	67	140	516	301	212	144	143	81	44	38	32
05	56	142	512	302	221	146	151	80	45	38	28
06	63	130	499	294	201	134	140	85	43	33	19
07	85	133	515	284	198	137	137	81	43	36	17
08	89	131	507	274	195	135	143	83	44	33	17
09	90	126	511	277	191	130	136	81	43	33	20
10	74	123	512	284	187	127	131	80	42	33	16
11	61	122	507	277	183	126	130	76	43	35	16
12	68	122	510	283	186	126	130	80	42	33	16
13	96	127	512	289	190	131	133	79	42	30	15
14	96	127	513	281	186	131	140	80	40	29	11
15	105	126	466	283	191	130	137	78	40	31	15
16	105	133	501	278	190	137	141	80	41	29	15
17	112	139	512	283	192	143	145	83	42	34	23
18	121	140	518	281	197	144	150	89	45	36	31
19	128	146	513	290	216	150	160	94	45	39	51
20	161	157	517	302	229	162	159	92	44	42	46
21	146	156	517	305	232	160	166	92	46	41	37
22	123	153	512	310	231	157	164	92	42	39	49
23	100	144	526	300	217	148	157	87	43	35	22
24	78	125	504	292	197	129	139	77	44	34	--
25	43	112	544	247	159	115	114	74	43	33	26
26	28	103	540	244	152	106	98	70	40	29	13
27	91	102	--	257	164	105	107	68	--	--	--
28	50	103	--	269	163	106	110	66	39	29	11
29	43	100	--	263	159	103	109	65	41	30	14
30	38	99	405	264	158	102	108	68	41	31	14
31	42	102	469	246	154	105	110	70	40	30	15
Mean	85.0	128	508	282	192	132	136	80	43	34	23

JUNE 2003 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
112.3	115.5
121.4	124.8
114.5	117.8
105.6	108.7
113.6	117.0
125.6	129.4
133.2	137.2
153.4	158.0
158.3	163.1
176.5	182.0
192.9	198.9
163.5	168.6
151.0	155.8
133.5	137.7
128.7	132.8
122.6	126.5
121.9	125.8
120.4	124.3
122.9	126.8
116.9	120.8
115.0	118.8
110.2	113.9
113.5	117.2
114.5	118.3
116.3	120.2
118.9	122.9
123.9	128.1
123.9	128.1
127.3	131.6
128.2	132.5
129.3	133.4

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolph Wolf introduced a daily measurement of sunspot number. His method, which is still used today, counts the total number of spots visible on the face of the Sun and the number of groups into which they cluster, because neither quantity alone satisfactorily measures the level of sunspot activity.

An observer computes a daily sunspot number by multiplying his estimated number of groups by ten and then adding this product to his total count of individual spots. Results, however, vary greatly, since the measurement strongly depends on observer interpretation and experience and on the stability of the Earth's atmosphere above the observing site. Moreover, the use of Earth as a platform from which to record these numbers contributes to their variability, too, because the Sun rotates and the evolving spot groups are distributed unevenly across solar longitudes. To compensate for these limitations, each daily international number is computed as a weighted average of measurements made from a network of cooperating observatories. The international sunspot numbers tabulated on page 1 are provisional values taken from a bulletin prepared monthly by Pierre Cugnon of the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The July 2003 data combine observations from 31 stations. (http://sidc.oma.be)

♦ HISTORICAL SUNSPOT COUNTS

How do sunspot numbers in the table on page 1 compare to the largest values ever recorded? The highest daily count on record occurred December 24-25, 1957. On each of those days the sunspot number totaled 355. In contrast, during years near the spot cycle minimum, the count can fall to zero. Today, much more sophisticated measurements of solar activity are made routinely, but none has the link with the past that sunspot numbers have. Our archives, for example, include reconstructed daily values from January 8, 1818; monthly means from January 1749; and yearly means beginning in 1700.

SMOOTHED (OBSERVED AND PREDICTED) SUNSPOT NUMBERS: CYCLES 22 AND 23

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1993	71	69	67	64	60	56	55	52	48	45	41	38	56
1994	37	35	34	34	33	31	29	27	27	27	26	26	30
1995	24	23	22	21	19	18	17	15	13	12	11	11	17
1996	10	10	10	9	8*	9	8	8	8	9**	10	10	9
1997	10	11	14	17	18	20	23	25	28	32	35	39	23
1998	44	49	53	57	59	62	65	68	70	71	73	78	62
1999	83	85	84	86	91	93	94	98	103	108	111	111	96
2000	113	117	120	120.7#	119	119	120	119	116	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	115	115	111
2002	114	115	113	111	109	106	103	99	95	91	85	82	102
2003	81	78	75	73	70	67	65	63	61	58	56	55	67
		(2)	(4)	(6)	(8)	(9)	(10)	(11)	(13)	(15)	(16)	(18)	(9)
2004	54	53	52	51	50	48	45	43	41	40	39	37	46
	(20)	(21)	(21)	(21)	(22)	(22)	(22)	(23)	(24)	(25)	(25)	(25)	(23)
2005	35	33	32	30	29	28	27	26	25	24	23	22	28
	(25)	(24)	(24)	(24)	(24)	(23)	(22)	(22)	(22)	(21)	(20)	(19)	(23)

*May 1996 marks Cycle 22's mathematical minimum. **October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 22, and the beginning of Cycle 23, the table gives smoothed sunspot numbers up to the one calculated that first uses the most recently measured monthly mean. These smoothed, observed values are based on final, unsmoothed monthly means through March 2003 and on provisional ones thereafter. We compute a smoothed monthly mean by forming the arithmetic average of two sequential 12-month running means of monthly means.

Table entries with numbers in parentheses below them denote predictions by the McNish-Lincoln method. This method estimates future numbers by adding a correction to the mean of all cycles that is proportional to the departure of earlier values of the current cycle from the mean cycle. (See page 9 in the July 1987 supplement to *Solar-Geophysical Data*). We use and predict only smoothed monthly means, because we believe the errors are too great to estimate any values more precise. In the table above, adding the number in parentheses to the predicted value generates the upper limit of the 90% confidence interval; subtracting the number from the predicted value generates the lower limit. Consider, for example the Jan 2004 prediction. There exists a 90% chance that in Jan 2004 the actual smoothed sunspot number will fall somewhere between 34 and 74.

The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead. Beyond a year these predictions regress rapidly toward the mean of all 13 cycles used in the computation. Moreover, the method is very sensitive to the date defined as the beginning of the current sunspot cycle, that is, to the date of the most recent sunspot minimum. The new cycle predictions tabulated above are based on the consensus minimum value of 8.8 that occurred in October 1996. For solar maximum discussions, visit http://www.sec.noaa.gov.

Although every effort has been made to ensure that these data are correct, we can assume no liability for any damages their inaccuracies might cause. The charge for a 1-year subscription to this monthly bulletin is US$17.00. To become a subscriber, you may either call (303) 497-6346 or write the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80305-3328 USA. Please include with your written order a cheque or money order payable in U.S. currency to the "Department of Commerce, NOAA/NGDC". Payment may also be made through VISA, MasterCard or American Express credit cards.