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 $10^{-22}\ \mathrm{J/m^2 Hz\,sec}$. 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.

JUNE 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	42	112	509	278	178	115	121	68	41	32	16
02	38	121	480	280	183	124	127	71	40	32	20
03	40	115	502	274	172	118	122	69	38	30	18
04	47	106	510	270	166	109	112	65	37	28	15
05	59	114	507	276	175	117	119	68	39	30	19
06	86	126	492	286	196	129	131	69	39	25	--
07	98	133	515	307	216	136	143	74	43	42	77
08	101	153	498	328	226	157	156	79	38	42	60
09	111	158	540	412	326	162	194	91	46	43	33
10	111	177	551	360	266	182	182	96	49	40	29
11	116	193	552	362	285	198	206	108	53	42	28
12	115	164	546	319	245	169	177	97	50	39	4
13	96	151	540	310	227	155	167	94	49	44	21
14	81	134	611	289	207	138	143	97	45	34	20
15	63	129	509	272	190	133	136	92	43	33	18
16	57	123	510	281	183	126	129	73	44	33	17
17	56	122	450	265	183	125	130	73	42	33	19
18	68	120	510	281	185	123	131	77	45	33	18
19	76	123	507	266	180	127	130	76	44	34	23
20	74	117	567	262	169	120	117	77	42	38	18
21	62	115	549	256	166	118	117	78	46	36	24
22	61	110	--	--	--	113	--	--	--	--	--
23	66	114	511	271	176	117	124	82	37	17	4
24	68	115	519	271	175	118	125	72	33	28	16
25	76	116	508	281	183	119	127	73	38	31	19
26	82	119	525	275	178	123	129	74	39	31	22
27	93	124	503	277	184	128	133	76	42	34	21
28	93	124	293	271	185	128	129	75	34	30	17
29	94	127	521	288	199	131	140	80	43	35	26
30	92	128	522	305	194	132	136	80	43	35	25
31											
Mean	77.4	129	512	292	200	133	139	79	42	34	23

MAY 2003 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
148.7	151.0
143.0*	145.3*
147.7	150.1
142.0	144.4
128.8	131.1
*1700UT Reading	
122.0	124.1
110.2	112.2
100.9	102.8
97.1	98.9
92.7	94.5
91.5	93.4
93.9	95.8
96.1	98.1
96.3	98.3
99.2	101.4
102.6	104.9
102.4	104.7
109.0	111.5
114.7	117.4
117.1	120.0
119.3	122.2
118.4	121.3
117.9	120.9
116.8	119.8
121.1	124.3
125.1	128.4
128.8	132.3
130.2	133.7
137.8	141.6
117.2	120.4
113.1	116.3
116.2	118.7

◆ 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 June 2003 data combine observations from 44 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
1992	124	115	108	103	100	97	91	84	80	76	74	73	94
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	79	76	73	71	68	65	63	62	59	57	55	54	65
	(2)	(3)	(5)	(6)	(8)	(9)	(10)	(11)	(13)	(14)	(16)	(18)	(7)
2004	53	52	51	49	48	47	44	42	40	39	38	36	45
	(19)	(20)	(20)	(21)	(21)	(21)	(22)	(23)	(24)	(24)	(25)	(25)	(22)

*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 Dec 2003 prediction. There exists a 90% chance that in Dec 2003 the actual smoothed sunspot number will fall somewhere between 36 and 72.

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.