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.

DECEMBER 2004 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	32	111	483	245	163	107	110	63	42	27	12
02	29	106	490	241	158	103	106	61	44	29	13
03	30	101	501	236	154	98	103	58	39	28	13
04	26	97	—	—	—	94	—	—	—	—	—
05	29	96	470	236	150	93	98	57	42	30	12
06	22	93	494	235	148	90	93	53	39	27	11
07	9	90	484	229	142	87	90	52	39	27	12
08	15	82	490	232	145	79	91	52	40	27	12
09	13	87	483	226	138	84	87	50	38	25	11
10	15	85	495	229	139	82	87	49	38	24	11
11	13	90	499	230	145	87	90	50	38	26	11
12	22	91	501	231	147	88	92	50	38	26	11
13	16	90	502	230	142	87	89	49	37	26	11
14	12	89	493	237	145	86	90	50	37	26	12
15	8	89	483	224	139	86	91	49	38	27	13
16	10	90	477	233	145	87	90	50	38	27	12
17	24	90	494	234	146	87	92	50	38	26	13
18	21	91	495	232	144	88	92	50	36	26	13
19	17	94	501	232	146	90	95	53	42	27	13
20	11	94	492	224	142	90	95	52	39	28	15
21	15	101	471	225	151	97	99	58	50	33	27
22	26	99	370	196	135	95	101	58	33	23	13
23	14	96	477	225	143	92	95	53	—	—	—
24	22	97	455	224	148	93	99	57	40	28	13
25	12	93	463	231	143	89	95	55	41	27	13
26	10	92	490	228	145	88	95	56	42	28	13
27	10	97	429	197	133	93	99	54	18	13	8
28	17	105	509	235	153	101	101	58	43	28	12
29	12	99	497	235	156	95	101	56	41	27	12
30	20	100	504	239	159	96	101	56	41	51	39
31	24	99	450	223	155	95	101	56	41	30	14
Mean	17.9	95	481	229	147	91	96	54	39	27	14

NOV 2004 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
135.5	133.4
133.1	131.0
135.9	133.7
136.0	133.7
141.2	138.8
128.8	126.5
129.6	127.2
124.1	121.7
140.9	138.1
104.6	102.6
94.9	93.0
97.4	95.4
96.4	94.4
100.3	98.1
105.6	103.3
108.4	106.0
104.9	102.5
104.0	101.6
102.2	99.8
99.3	96.9
100.9	98.5
106.3	103.7
106.9	104.2
107.3	104.5
109.4	106.6
111.1	108.2
110.3	107.4
112.8	109.8
111.4	108.4
110.6	107.5
113.7	111.2

♦ 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 December 2004 data combine observations from 41 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	79	74	70	68	65	62	60	60	58	57	55	66
2004	52	49	47	46	44	42	40	38	36	35	34	32	41
							(3)	(6)	(8)	(9)	(11)	(13)	(4)
2005	31	30	29	27	26	25	24	23	23	22	21	20	25
	(14)	(15)	(16)	(16)	(16)	(16)	(16)	(16)	(17)	(16)	(16)	(15)	(16)
2006	19	18	17	16	16	15	15	14	13	12	12	11	15
	(14)	(14)	(15)	(15)	(16)	(16)	(15)	(14)	(14)	(13)	(13)	(13)	(14)

*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 September 2004 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 June 2005 prediction. There exists a 90% chance that in June 2005, the actual smoothed sunspot number will fall somewhere between 9 and 41.

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.