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.

MAY 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	44	94	506	251	153	95	102	57	35	33	48
02	28	98	505	259	157	99	103	58	34	30	17
03	32	91	504	253	146	92	98	55	34	29	15
04	33	87	496	247	148	88	94	52	36	30	20
05	29	89	489	247	149	90	96	54	35	30	16
06	20	86	---	---	---	87	---	---	34	30	15
07	16	85	492	240	143	86	94	52	33	30	14
08	17	87	500	243	145	88	94	52	33	29	23
09	24	93	492	245	147	94	99	55	34	30	18
10	29	93	496	249	148	94	99	56	34	28	15
11	25	90	503	252	150	91	100	57	35	29	11
12	40	99	487	251	151	101	105	61	35	29	13
13	37	101	492	251	164	103	112	62	35	31	14
14	54	110	466	253	167	112	121	62	35	32	16
15	58	115	370	207	152	117	115	64	37	31	28
16	73	118	499	261	176	120	127	68	35	31	16
17	69	111	498	262	174	113	123	66	36	30	13
18	60	108	501	267	161	110	115	67	36	29	12
19	58	109	497	249	164	111	118	65	35	30	12
20	59	105	486	242	161	107	112	62	31	25	12
21	52	107	499	255	163	109	114	61	34	27	16
22	47	102	501	252	164	104	114	61	34	30	27
23	59	104	490	244	163	106	114	61	32	27	13
24	62	105	501	245	201	107	127	64	34	29	21
25	55	102	496	247	163	104	111	60	33	28	18
26	43	103	507	240	161	105	112	59	32	29	11
27	32	102	507	246	161	104	112	58	33	26	11
28	30	102	498	249	165	104	114	58	33	27	12
29	31	101	507	243	160	103	108	56	31	26	10
30	35	100	496	244	157	102	107	56	32	27	11
31	34	95	494	244	151	97	105	54	32	26	11
Mean	41.5	100	493	248	159	101	109	59	34	29	16

APR 2004 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
112.8	112.6
108.1	108.1
107.4	107.4
108.9	109.0
108.7	108.9
101.4	101.6
98.1	98.4
93.5	93.8
90.0	90.3
87.7	88.1
89.6	90.0
91.3	91.8
93.1	93.6
95.2	95.8
96.7	97.4
96.9	97.6
98.2	99.0
109.0	110.0
113.4	114.5
110.7	111.8
112.7	113.9
117.1	118.4
115.3	116.6
111.6	112.9
107.1	108.4
99.6	100.9
95.1	96.4
89.5	90.7
88.5	89.8
89.4	90.8
101.2	101.9

♦ 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 May 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	56 (3)	66 (0)
2004	55 (6)	54 (8)	52 (9)	51 (10)	50 (10)	49 (11)	46 (13)	44 (15)	42 (16)	41 (18)	40 (18)	38 (19)	47 (13)
2005	36 (20)	34 (20)	33 (20)	31 (20)	30 (20)	29 (20)	28 (19)	27 (20)	26 (20)	25 (19)	24 (18)	23 (18)	29 (20)

*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 December 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 November 2004 prediction. There exists a 90% chance that in November 2004, the actual smoothed sunspot number will fall somewhere between 22 and 58.

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.