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.

JUN 2004 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	PALE	PALE	PALE	Pentic	PALE	PALE	PALE	PALE	PALE
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	35	90	494	241	143	92	97	53	31	27	11
02	36	90	500	233	143	92	98	53	32	25	11
03	37	90	500	229	145	92	99	55	29	25	11
04	36	89	493	241	143	91	97	54	33	26	11
05	36	85	501	238	145	87	98	55	32	25	11
06	29	88	476	—	—	90	—	—	31	26	11
07	37	89	492	238	145	91	97	56	34	27	11
08	33	86	495	237	144	88	98	54	32	26	11
09	34	85	494	236	142	87	94	52	31	29	11
10	31	83	496	240	145	85	92	52	32	27	11
11	26	84	484	236	144	86	92	52	33	27	12
12	18	88	496	237	148	90	98	54	32	30	17
13	28	95	495	245	158	98	106	56	33	30	20
14	35	100	506	250	165	103	110	57	35	33	22
15	44	109	494	251	170	112	120	62	37	33	17
16	64	112	500	255	167	115	122	66	36	33	24
17	62	111	500	256	170	114	124	66	34	35	25
18	67	108	493	250	164	111	120	64	38	42	—
19	69	113	394	259	173	116	125	65	40	36	24
20	86	119	502	257	179	122	126	67	36	32	34
21	87	116	494	257	173	119	127	66	36	31	76
22	76	117	497	253	177	120	129	67	35	29	13
23	61	113	513	254	171	116	123	65	29	28	13
24	52	108	504	253	164	111	117	62	34	27	12
25	37	103	502	250	164	106	115	61	26	28	12
26	34	99	473	242	159	102	109	58	34	28	12
27	31	97	495	235	150	100	104	56	33	28	12
28	30	89	495	232	144	92	96	54	31	26	12
29	26	85	501	234	141	87	91	52	32	26	11
30	20	82	483	201	126	84	84	49	33	26	11
31											
Mean	43.2	97	492	243	155	100	107	58	33	29	17

MAY 2004 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
94.2	95.7
97.5	99.1
91.3	92.8
87.4	88.9
88.5	90.1
86.4	88.0
85.2	86.8
87.2	88.9
93.2	95.0
93.0	94.8
90.2	92.0
98.8	100.9
100.8	103.0
109.6	112.1
115.3	117.9
118.3	121.0
111.1	113.7
107.8	110.4
108.8	111.4
104.6	107.2
106.9	109.6
102.4	105.0
104.0	106.6
105.2	107.9
102.4	105.1
103.3	106.1
101.8	104.6
102.4	105.2
101.2	104.0
99.6	102.4
95.4	98.1
99.8	102.1

♦ 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 2004 data combine observations from 46 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	54	53	52	51	49	48	46	43	41	40	39	37	46
	(3)	(4)	(6)	(7)	(8)	(9)	(11)	(13)	(15)	(16)	(17)	(18)	(11)
2005	36	34	32	31	30	28	27	26	26	25	23	22	28
	(19)	(19)	(19)	(20)	(20)	(19)	(19)	(19)	(19)	(19)	(18)	(17)	(19)

*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 <u>smoothed</u> 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 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 December 2004 prediction. There exists a 90% chance that in December 2004, the actual smoothed sunspot number will fall somewhere between 19 and 53.

<u>The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead.</u> 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.