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.

NOVEMBER 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	76	136	484	254	188	133	137	71	45	44	17
02	74	133	500	262	191	130	137	68	45	41	19
03	67	136	464	243	189	133	134	67	44	38	16
04	58	136	---	---	---	133	---	---	---	---	---
05	55	141	490	307	223	138	147	70	57	82	58
06	62	129	489	277	201	126	131	66	46	40	23
07	63	130	501	274	197	127	133	69	47	34	29
08	57	124	496	264	190	121	125	64	42	34	14
09	52	127	503	257	186	124	126	65	42	35	25
10	36	105	491	246	164	102	104	54	36	26	11
11	38	95	489	236	146	93	92	51	37	26	10
12	38	97	499	237	153	94	98	53	38	26	11
13	42	96	500	236	149	93	100	54	37	60	11
14	48	100	---	---	---	97	---	---	---	---	---
15	44	106	480	241	161	103	107	59	40	29	15
16	41	108	497	242	163	105	111	60	37	26	13
17	41	105	465	236	166	102	108	62	39	27	11
18	38	104	499	251	159	101	108	60	39	26	10
19	38	102	---	---	---	99	---	---	---	---	---
20	33	99	490	232	148	96	100	58	39	28	12
21	26	101	481	233	152	98	101	58	36	27	11
22	29	106	500	245	159	103	108	64	42	28	12
23	28	107	491	247	163	104	112	64	42	29	13
24	34	107	484	249	165	104	113	66	41	29	13
25	34	109	476	231	160	106	112	65	44	29	12
26	34	111	502	237	161	108	116	67	41	27	12
27	37	110	500	243	161	107	113	65	42	27	11
28	29	113	282	205	155	109	112	64	22	18	10
29	28	111	500	242	161	108	113	66	44	30	12
30	32	111	492	218	151	107	107	62	42	30	13
31											
Mean	43.7	113	483	246	169	110	115	63	41	33	16

OCT 2004 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
88.0	88.1
88.0	88.1
89.0	89.1
90.7	90.7
90.8	90.8
92.1	92.0
93.8	93.7
90.6	90.4
88.0	87.7
89.0	88.7
86.9	86.6
87.6	87.2
87.1*	86.7*
90.7	90.2
89.2	88.6
*1700UT Reading	
91.7	91.1
91.9	91.2
96.2	95.5
99.1	98.2
111.3	110.3
112.1	111.0
122.5	121.2
131.6	130.2
140.2	138.7
139.6*	137.9*
*1700UT Reading	
136.7	135.0
129.5	127.8
133.4	131.6
128.8	127.0
136.4	134.4
139.2	137.1
105.9	105.1

♦ 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 November 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	43	41	39	37	36	35	33	42
						(2)	(5)	(8)	(10)	(11)	(12)	(14)	(5)
2005	32	31	29	28	27	26	25	24	23	22	21	20	26
	(15)	(16)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(16)	(16)	(17)
2006	19	19	18	17	16	16	15	14	14	13	12	12	15
	(15)	(15)	(15)	(16)	(16)	(16)	(16)	(15)	(14)	(14)	(14)	(13)	(15)

*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 June 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 May 2005 prediction. There exists a 90% chance that in May 2005, the actual smoothed sunspot number will fall somewhere between 10 and 44.

<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.

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.