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 2006 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	34	84	487	232	136	81	93	47	34	23	11
02	32	87	470	217	---	84	93	47	32	23	10
03	28	87	485	230	137	84	91	50	31	23	10
04	24	92	500	255	151	89	101	48	30	26	11
05	28	102	500	252	151	99	101	48	29	22	10
06	33	103	486	245	147	100	102	52	27	20	9
07	31	96	499	249	147	93	99	52	27	21	10
08	17	96	493	247	148	93	100	52	27	20	9
09	13	92	503	256	148	89	97	50	28	20	9
10	14	90	488	261	151	87	97	50	25	20	10
11	17	92	485	260	150	89	98	49	23	19	9
12	17	102	501	271	168	98	113	61	46	87	---
13	16	94	495	256	155	91	101	50	34	23	---
14	14	93	510	262	160	90	111	52	46	43	---
15	13	87	495	239	142	84	94	46	32	23	13
16	12	82	475	234	134	79	88	42	31	25	11
17	9	81	485	240	131	78	83	42	31	23	11
18	0	75	475	224	124	72	79	40	30	21	11
19	0	73	478	230	124	70	75	40	29	21	11
20	0	72	480	225	122	69	78	39	30	23	11
21	0	72	485	227	125	69	79	40	29	24	11
22	0	73	481	231	128	70	79	40	32	23	11
23	0	73	484	221	123	70	79	41	28	22	11
24	8	74	479	231	124	71	79	41	31	22	11
25	10	76	485	233	131	73	80	43	29	24	11
26	13	75	476	229	126	72	79	43	30	22	10
27	12	73	488	233	131	70	78	43	32	22	10
28	0	76	481	230	126	73	79	41	30	21	11
29	0	78	429	207	125	75	81	44	31	24	10
30	10	80	484	230	133	77	87	42	33	22	10
31	17	83	485	236	134	80	90	44	29	22	10
Mean	13.6	84	485	238	138	81	90	46	31	25	10

NOV 2006 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
86.7	85.3
88.2	86.8
87.4	86.0
85.5	84.0
84.7	83.2
83.5	82.1
87.1	85.6
86.4	84.8
89.4	87.7
91.1	89.3
97.0	95.0
96.7	94.7
95.2	93.2
94.5	92.5
96.1	94.0
94.1	92.0
89.5	87.4
88.8	86.8
84.9	82.9
80.5	78.6
77.5	75.6
76.5	74.6
76.8	74.9
77.4	75.5
78.6	76.5
78.2	76.2
82.4	80.2
85.5	83.2
85.0	82.7
84.1	81.8
86.3	84.4

♦ 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 2006 data combine observations from 47 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	39	38	36	35	34	42
2005	35	34	34	32	29	29	29	27	26	26	25	23	29
2006	21	19	17	17	17	16	16	15	14	13	12	12	16
							(2)	(3)	(4)	(5)	(6)	(6)	(2)
2007	11	11	11	11	11	12	12	13	14	15	16	17	13
	(6)	(6)	(7)	(8)	(9)	(10)	(12)	(14)	(16)	(17)	(19)	(21)	(12)

***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 2006 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 2007 prediction. There exists a 90% chance that in June 2007, the actual smoothed sunspot number will fall somewhere between 2 and 22.

<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.