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 $10^{-22}\ \mathrm{J/m^2 Hz\,sec}$. During periods of low 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.

JUNE 2009 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	11	73	500	220	121	75	81	59	36	24	12
02	11	72	515	220	120	74	81	58	37	24	13
03	10	73	510	221	120	75	79	59	37	27	12
04	9	71	508	217	120	73	78	59	38	24	12
05	8	70	513	220	120	72	79	58	36	28	12
06	0	69	515	219	119	71	76	57	37	25	13
07	0	69	515	220	120	71	76	57	37	24	12
08	0	69	510	221	120	71	78	58	37	26	12
09	0	69	506	220	120	71	76	57	38	27	12
10	0	69	508	220	120	71	75	56	38	28	12
11	0	69	509	220	120	71	76	59	37	29	13
12	0	69	507	220	120	71	73	58	38	28	13
13	0	68	508	220	117	70	73	56	37	29	12
14	0	68	505	218	117	70	75	56	37	28	13
15	0	67	505	220	119	69	76	56	38	28	13
16	0	68	511	229	119	70	73	57	38	28	12
17	0	68	508	235	119	70	73	57	37	27	13
18	0	68	511	219	119	70	72	55	36	28	13
19	0	67	511	219	119	69	72	55	36	28	13
20	0	67	510	219	118	69	72	56	36	27	12
21	7	67	509	219	119	69	72	55	36	28	13
22	8	68	511	222	118	70	75	55	36	26	12
23	7	68	513	222	118	70	73	57	36	26	12
24	8	67	513	219	118	69	72	56	37	27	13
25	0	68	505	233	118	70	72	56	37	26	14
26	0	67	510	218	118	69	70	55	36	28	12
27	0	67	511	218	118	69	73	56	37	27	12
28	0	67	516	218	118	69	72	56	36	27	11
29	0	69	516	222	119	71	75	57	37	28	12
30	0	68	511	218	119	70	76	57	37	29	11
31											
Mean	2.6	69	510	221	119	71	75	57	37	27	12

MAY 2009 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	68.5	69.6
02	68.3	69.4
03	68.6	69.7
04	68.0	69.2
05	68.0	69.2
06	68.7	70.0
07	69.5	70.8
08	70.8	72.2
09	72.3	73.7
10	71.8	73.2
11	71.9	73.3
12	73.9	75.5
13	73.8	75.3
14	73.9	75.5
15	73.7	75.4
16	74.2	75.8
17	74.0	75.7
18	72.9	74.6
19	72.3	74.0
20	71.5	73.2
21	71.8	73.5
22	72.1	73.9
23	70.4	72.2
24	69.2	71.0
25	68.9	70.7
26	68.1	69.9
27	66.7	68.5
28	67.7	69.6
29	68.2	70.1
30	68.5	70.4
31	68.5	70.4
Mean	70.5	72.1

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolf 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 the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The June 2009 observations were from 65 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 23 AND 24

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
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	15	16	16	14	13	12	16
2007	12	12	11	10	9	8	7	6	6	6	6	5	8
2008	4	4	3	3	4	3	3	3	2	2	2	1.7###	3
2009	2	2	2	3	4	4	5	6	7	8	10	11	5
	(1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(9)	(10)	(12)	(14)	(6)
2010	13	15	17	20	23	25	29	33	36	39	43	46	28
	(17)	(19)	(21)	(24)	(27)	(30)	(33)	(37)	(40)	(44)	(48)	(52)	(33)
2011	49	52	55	58	61	64	66	68	70	73	75	78	64
	(55)	(58)	(61)	(62)	(63)	(66)	(68)	(70)	(71)	(72)	(74)	(77)	(66)

*May 1996 marks Cycle 23's mathematical minimum. **October 1996 marks the consensus Cycle 23 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

SPECIAL NOTE: Predicted values for Cycle 24 are **PRELIMINARY** based on DECEMBER 2008 being minimum.

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 23, and the beginning of Cycle 24, 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 2008 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 precisely. 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 2009 prediction. There exists a 90% chance that in December 2009, the actual smoothed sunspot number will fall somewhere between 0 and 25.

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 14 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.