

# SOLAR INDICES BULLETIN

MAY 2009

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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<sup>2</sup>Hzsec. 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  $\pm 7\%$  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 2009 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	0	69	535	218	118	70	68	54	34	27	11
02	0	68	541	215	117	69	71	54	35	26	11
03	0	69	539	217	117	70	70	55	34	26	11
04	7	68	540	218	117	69	72	54	35	27	12
05	0	68	538	218	117	69	70	54	35	25	12
06	0	69	548	223	120	70	75	56	36	28	12
07	0	70	525	225	119	71	77	56	36	30	13
08	0	71	---	---	---	72	---	---	---	---	---
09	0	72	534	220	122	73	77	60	36	28	12
10	0	72	531	226	122	73	79	58	36	28	12
11	0	72	531	219	120	73	78	59	36	28	12
12	0	74	530	223	119	75	78	60	37	27	11
13	7	74	534	---	122	75	79	62	38	28	10
14	9	74	540	224	122	75	81	62	38	28	11
15	8	74	539	223	122	75	80	61	39	30	12
16	8	74	533	221	121	75	81	61	37	29	12
17	9	74	535	222	122	75	81	61	38	28	12
18	8	73	531	221	121	74	80	61	38	29	12
19	7	72	540	225	124	73	79	60	38	30	21
20	0	72	523	222	121	73	76	59	37	---	13
21	0	72	518	217	121	73	76	58	37	28	12
22	8	72	514	217	120	73	77	59	37	29	11
23	8	70	510	217	117	71	76	57	37	28	12
24	0	69	513	220	120	70	76	56	36	28	12
25	0	69	511	219	119	70	74	56	36	28	12
26	0	68	506	218	117	69	72	56	36	29	13
27	0	67	500	217	117	68	70	54	36	27	11
28	0	68	506	214	117	69	72	55	34	21	12
29	0	68	511	219	117	69	75	56	36	26	11
30	0	69	506	218	120	70	73	56	35	26	12
31	11	69	509	219	120	70	76	56	36	28	13
Mean	2.9	71	526	220	120	72	76	58	36	28	12

APRIL 2009 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
70.8	70.7
70.6	70.6
70.4	70.4
70.1	70.1
70.4	70.5
68.8	68.9
70.2	70.4
70.0	70.2
70.1	70.3
69.4	69.7
69.3	69.7
69.3	69.7
68.4	68.8
69.4	69.9
69.4	69.9
69.9	70.5
69.8	70.4
69.9	70.5
70.1	70.8
69.8	70.4
71.0	71.8
71.1	71.9
70.6	71.4
69.7	70.5
69.4	70.3
69.2	70.1
67.7	68.6
68.8	69.8
69.5	70.5
69.4	70.5
69.7	70.3

◆ **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 May 2009 observations were from 63 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	1.8###	2	3
												(1)	(0)
2009	2	2	3	3	4	5	6	7	8	10	11	13	6
	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(10)	(12)	(14)	(17)	(8)
2010	15	17	20	23	25	29	33	36	39	43	46	49	31
	(19)	(22)	(25)	(28)	(31)	(34)	(37)	(41)	(45)	(49)	(53)	(56)	(37)

\*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 maximum.

## SPECIAL NOTE: Predicted values for Cycle 24 are **PRELIMINARY** based on NOVEMBER 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 November 2009 prediction. There exists a 90% chance that in November 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.

Although every effort has been made to ensure that these data are correct, we can assume no liability for any damages any inaccuracies might cause. Subscriptions to this monthly bulletin are available free of charge. To become a subscriber either call (303) 497-6761, or write the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80305, USA.