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.

JULY 2009 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX — JUNE 2009 FINAL 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)	June 2009 Observed Pentic (2800)	June 2009 Adjusted Pentic (2800)
01	0	68	511	221	119	70	74	57	36	27	12	72.5	74.6
02	0	67	492	221	118	69	73	55	36	29	12	71.9	74.0
03	0	67	504	218	116	69	73	56	37	28	11	72.5	74.6
04	16	71	512	220	124	73	81	58	37	28	13	71.0	73.1
05	16	72	513	220	122	74	79	60	37	27	12	70.1	72.2
06	16	70	515	220	122	72	79	58	37	28	14	69.0	71.1
07	13	71	512	221	122	73	79	59	36	32	20	68.9	71.0
08	13	71	510	218	119	73	79	57	35	28	23	69.0	71.1
09	11	69	513	218	121	71	77	57	36	29	22	69.1	71.2
10	9	68	510	218	120	70	73	56	36	27	13	69.2	71.3
11	0	68	511	220	120	70	74	57	36	29	13	69.3	71.4
12	0	68	513	220	122	70	73	56	37	27	11	69.0	71.2
13	0	67	510	217	117	69	71	55	37	28	11	68.2	70.4
14	0	67	512	230	118	69	71	55	36	27	11	68.1	70.3
15	0	67	510	217	118	69	69	55	36	28	11	67.4	69.5
16	0	67	509	224	118	69	70	55	36	29	12	68.3	70.5
17	0	66	506	217	115	68	69	54	35	26	11	67.8	70.0
18	0	67	493	208	114	69	69	53	36	26	11	67.7	69.9
19	0	68	512	221	118	70	73	56	37	27	10	67.0	69.2
20	0	68	515	219	118	70	73	57	37	27	11	66.7	68.8
21	0	68	512	221	119	70	73	55	37	28	11	67.0	69.2
22	0	68	509	218	118	70	72	56	37	27	11	68.0	70.2
23	8	68	494	215	118	70	70	54	36	28	11	67.9	70.2
24	0	68	509	218	119	70	75	56	37	28	10	66.8	69.1
25	0	69	510	219	121	71	76	56	37	28	11	68.0	70.3
26	0	68	507	216	118	70	72	55	36	27	11	66.8	69.0
27	0	68	510	216	119	70	75	56	35	27	11	67.0	69.3
28	0	69	513	215	121	71	73	57	37	28	11	67.0	69.2
29	0	68	499	218	119	70	74	57	37	29	12	68.5	70.8
30	8	68	514	218	119	70	75	56	37	28	12	68.2	70.5
31	0	69	501	216	119	71	72	56	37	28	12		
Mean	3.5	68	508	219	119	70	74	56	36	28	12	68.6	70.8

♦ 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 July 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	2	1.7###	3
2009	2	2	2	3	4	4	5	6	7	8	10	11	5
		(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 March 2009 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 January 2010 prediction. There exists a 90% chance that in January 2010, the actual smoothed sunspot number will fall somewhere between 0 and 30.

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.