

SOLAR INDICES BULLETIN

DECEMBER 2009

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ISSN 1046-1914

◆ 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/m²Hzsec. 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.

DECEMBER 2009 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Obs Flux		Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic (2800)	PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	0	72	523	222	118	69	76	57	39	29	12
02	0	71	525	216	118	69	74	57	39	29	12
03	0	72	522	219	118	69	74	56	39	29	13
04	0	72	522	228	118	69	74	56	38	28	12
05	0	72	525	216	116	69	77	56	38	28	14
06	0	72	525	220	118	69	74	57	38	29	13
07	0	71	520	219	118	68	73	56	37	29	12
08	0	72	526	226	119	69	77	57	38	28	12
09	0	73	523	218	119	70	77	58	39	28	12
10	8	74	523	219	118	71	76	59	39	29	12
11	7	72	525	221	120	69	77	58	39	28	12
12	8	75	534	218	118	72	79	60	40	29	13
13	9	76	533	221	120	73	79	60	40	29	13
14	20	79	533	225	125	76	83	63	41	30	14
15	24	82	529	225	127	79	86	65	42	30	14
16	23	83	533	231	134	80	92	68	43	31	16
17	20	87	532	232	134	84	92	69	43	32	22
18	15	84	530	232	130	81	90	69	44	41	34
19	15	82	524	228	127	79	87	67	44	42	19
20	30	84	527	227	130	81	92	71	43	34	21
21	29	83	527	225	129	80	89	69	44	35	15
22	23	82	532	227	128	79	86	68	44	33	17
23	16	78	525	224	125	75	86	66	42	32	16
24	12	77	525	224	124	74	83	63	42	29	15
25	0	76	519	224	124	73	81	63	41	32	14
26	9	76	522	221	122	73	83	62	40	30	14
27	10	77	527	220	122	74	80	63	40	29	14
28	12	76	533	220	122	73	80	62	40	31	14
29	13	75	517	223	122	72	80	61	40	29	12
30	11	77	512	222	125	74	86	61	40	29	13
31	14	80	524	225	125	77	84	63	41	32	13
Mean	10.6	77	526	223	123	74	82	62	41	31	15

NOV 2009 FINAL FLUX

	Observed Adjusted	
	Pentic (2800)	Pentic (2800)
	72.3	71.2
	71.4	70.3
	71.5	70.3
	71.4	70.2
	70.5	69.3
	70.9	69.6
	70.6	69.3
	70.9	69.6
	72.1	70.7
	72.8	71.3
	72.4	71.0
	73.2	71.7
	74.1	72.6
	74.8	73.2
	75.1	73.5
	76.2	74.5
	77.2	75.4
	76.1	74.4
	76.7	74.9
	76.2	74.4
	75.8	74.0
	76.3	74.4
	75.7	73.8
	74.7	72.8
	74.2	72.3
	74.7	72.7
	73.7	71.7
	72.9	70.9
	72.1	70.1
	72.4	70.4
	73.6	72.0

◆ **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 December 2009 observations were from 58 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	2	2	3	3	4	4	5	6	7	4
							(1)	(3)	(4)	(5)	(6)	(8)	(2)
2010	9	10	12	14	16	19	22	25	28	30	33	36	21
	(10)	(12)	(14)	(17)	(20)	(23)	(26)	(29)	(32)	(36)	(40)	(43)	(25)
2011	39	42	44	47	50	52	54	56	58	60	63	65	52
	(47)	(50)	(52)	(54)	(54)	(57)	(58)	(60)	(62)	(63)	(64)	(68)	(57)

*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.

- Predicted values for Cycle 24 are 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 June 2010 prediction. There exists a 90% chance that in June 2010, the actual smoothed sunspot number will fall somewhere between 0 and 42.

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.