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.

MAY 2010 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	8	69	541	227	127	70	86	67	42	31	13
02	13	80	455	146	96	81	53	58	38	29	13
03	25	80	528	230	126	81	86	68	43	32	14
04	32	82	547	232	132	83	90	69	42	32	14
05	29	83	563	235	133	84	93	71	42	29	10
06	12	79	525	229	128	80	87	68	43	31	14
07	10	79	536	230	130	80	87	67	42	32	14
08	10	79	535	230	129	80	87	68	42	31	14
09	0	75	531	226	126	76	84	66	42	32	14
10	0	74	530	226	125	75	82	64	40	32	14
11	0	74	542	226	123	75	82	62	40	31	14
12	0	71	527	223	123	72	79	59	40	31	14
13	0	72	538	225	119	73	77	58	39	31	14
14	0	70	528	220	119	71	76	58	40	30	15
15	0	70	535	223	120	71	77	58	40	32	14
16	0	69	521	217	117	70	73	57	40	31	15
17	0	69	520	222	121	70	74	57	40	30	15
18	0	69	533	222	119	70	76	57	40	31	15
19	0	69	535	222	119	70	75	58	41	32	14
20	0	69	539	224	120	70	77	58	42	32	15
21	9	71	531	225	122	72	79	60	42	31	15
22	13	73	531	226	126	74	82	60	41	34	17
23	14	75	535	228	124	76	84	62	43	33	18
24	12	73	542	225	122	74	80	61	42	32	15
25	15	73	---	---	---	74	---	---	---	---	---
26	10	72	524	225	123	73	83	62	41	32	14
27	8	73	520	225	124	74	82	63	39	30	13
28	8	73	525	227	125	74	82	64	42	32	13
29	16	74	529	227	124	76	83	63	42	33	12
30	18	73	522	222	122	75	80	62	41	31	13
31	11	72	540	227	122	74	82	63	41	31	13
Mean	8.8	74	530	223	123	75	81	62	41	31	14

APR 2010 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
79.2	79.1
76.2	76.1
77.4	77.4
78.7	78.7
79.3	79.3
77.5	77.7
76.3	76.5
75.7	75.9
76.0	76.3
75.0	75.3
74.6	74.9
74.5	74.9
74.9	75.3
75.1	75.6
74.5	75.0
74.8	75.4
73.9	74.5
74.7	75.3
75.4	76.1
75.6	76.4
76.1	76.9
76.1	76.9
75.0	75.8
74.2	75.0
75.4	76.4
76.0	77.0
74.8	75.7
76.1	77.2
76.2	77.3
78.6	79.8
75.9	76.5

♦ 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 2010 observations were from 66 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	4	5	6	7	8	9	4
												(1)	(0)
2010	10	11	13	15	17	20	22	25	28	31	34	37	22
	(3)	(5)	(7)	(9)	(12)	(15)	(18)	(20)	(23)	(27)	(31)	(34)	(17)
2011	40	42	44	47	49	52	53	55	58	60	62	64	52
	(37)	(40)	(42)	(43)	(44)	(45)	(46)	(47)	(49)	(49)	(50)	(53)	(45)

*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.

- 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 <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 September 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 November 2010 prediction. There exists a 90% chance that in November 2010, the actual smoothed sunspot number will fall somewhere between 3 and 65.

<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 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.