SOLAR INDICES BULLETIN

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

APRIL 2008 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX — MAR 2008 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)	Observed Pentic (2800)	Adjusted Pentic (2800)
01	16	78	488	216	124	77	73	63	37	29	15	68.6	67.4
02	9	76	493	215	122	75	74	62	38	26	13	69.2	68.0
03	9	76	489	213	121	76	73	61	40	28	12	68.4	67.3
04	7	73	475	213	120	73	70	58	38	26	10	68.3	67.2
05	0	71	486	215	115	71	67	56	36	25	12	69.3	68.2
06	0	69	483	215	114	69	67	56	38	35	12	70.3	69.3
07	0	69	---	---	---	69	---	---	---	---	---	70.5	69.5
08	0	70	483	211	116	70	65	54	35	26	11	69.8	68.8
09	0	68	382	186	101	68	60	51	35	33	12	69.5	68.5
10	0	68	449	200	109	68	60	51	35	31	12	70.3	69.4
11	0	67	467	208	113	67	63	53	35	31	12	70.2	69.3
12	0	68	480	208	116	68	63	54	35	24	10	69.4	68.5
13	7	69	485	213	118	69	66	54	36	21	11	69.5	68.7
14	7	69	483	215	116	69	64	54	36	25	11	69.9	69.1
15	0	71	473	210	118	71	64	55	36	23	11	69.5	68.8
16	0	70	472	215	118	70	65	55	38	26	12	70.3	69.6
17	0	69	474	213	117	69	66	55	37	26	13	69.8	69.1
18	0	70	488	211	118	70	67	57	38	28	12	69.6	69.0
19	8	71	484	212	120	71	67	57	37	26	12	69.0	68.4
20	0	71	489	214	120	71	68	57	37	24	12	68.4	67.9
21	0	71	490	212	120	71	68	58	39	24	11	68.2	67.7
22	8	71	485	214	120	71	71	59	40	26	11	69.6	69.1
23	8	71	486	211	118	71	67	58	38	27	12	72.0	71.5
24	7	70	486	210	117	70	67	58	39	25	12	79.4	79.0
25	0	70	484	208	117	70	66	57	37	24	12	88.6	88.2
26	0	69	484	208	117	69	66	57	37	24	12	81.6	81.2
27	0	68	480	209	116	68	66	56	37	18	12	84.8	84.5
28	0	69	485	207	118	69	65	55	37	19	13	82.9	82.6
29	0	69	482	210	117	70	68	56	37	25	11	82.6	82.4
30	0	67	485	210	117	68	65	56	36	24	13	80.5	80.4
31												79.2	79.1
Mean	2.9	70	478	210	117	70	67	56	37	26	12	72.9	72.2

♦ **SUNSPOT COUNTS**

In 1848 the Swiss astronomer Johann Rudolph 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 April 2008 observations from 64 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	7	8
											(1)	(2)	(0)
2008	8	8	9	10	12	13	15	16	18	21	24	27	15
	(3)	(4)	(5)	(6)	(7)	(8)	(10)	(11)	(13)	(16)	(18)	(20)	(10)
2009	30	34	37	41	45	49	53	58	62	65	69	72	51
	(23)	(26)	(29)	(32)	(35)	(38)	(42)	(46)	(49)	(52)	(55)	(58)	(40)

*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 September 2007 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 2007 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 precise. 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 October 2008 prediction. There exists a 90% chance that in October 2008, the actual smoothed sunspot number will fall somewhere between 5 and 37.

<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.