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/m²Hzsec. 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.

OCTOBER 2004 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	20	88	490	237	143	88	92	54	40	28	11
02	16	88	502	235	138	88	92	55	39	29	11
03	28	89	500	238	147	89	96	54	36	27	12
04	27	91	489	239	147	91	99	55	39	30	10
05	21	91	490	221	138	91	93	69	33	25	7
06	17	92	483	232	146	91	99	53	40	28	11
07	22	94	494	243	148	93	104	—	43	30	11
08	23	91	504	237	145	90	97	52	38	30	10
09	10	88	495	240	145	87	94	128	39	27	10
10	0	89	496	239	145	88	94	—	40	27	10
11	12	87	466	232	134	86	89	50	39	28	10
12	12	88	490	236	143	87	89	51	39	30	11
13	20	87	497	238	144	86	95	51	37	27	11
14	20	91	493	232	142	90	95	51	37	26	11
15	16	89	488	232	144	88	95	50	37	27	10
16	18	92	487	235	147	91	98	50	35	25	11
17	44	92	490	235	144	91	99	52	38	27	10
18	54	96	496	237	147	95	109	55	40	27	11
19	60	99	501	240	151	98	104	56	35	21	5
20	66	111	505	243	166	110	122	64	40	27	11
21	76	112	504	254	166	110	120	64	38	28	11
22	80	123	509	260	177	121	135	67	41	29	13
23	93	132	509	258	194	130	140	69	43	31	17
24	99	135	498	259	194	133	147	75	44	37	24
25	90	140	492	265	188	138	145	73	44	32	14
26	91	137	499	248	175	135	141	69	45	25	14
27	94	130	508	257	176	128	135	73	41	32	21
28	96	133	503	262	180	131	88	72	43	31	14
29	89	129	511	264	183	127	134	71	47	41	16
30	96	136	508	267	192	134	141	73	47	40	16
	91	139	474	256	192	136	138	73	44	33	16
Mean	48.4	106	496	244	159	105	110	63	40	29	12

SEP 2004 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
89.9	91.5
93.9	95.6
96.7	98.3
99.3	100.9
103.2	104.8
106.5	108.2
118.9	120.7
124.5	126.3
131.0	132.8
130.0	131.8
116.4	117.9
114.6	116.0
117.7	119.1
114.7	116.0
109.6	110.8
108.3	109.4
104.5	105.5
102.7	103.6
105.2	106.1
100.5	101.3
94.9	95.6
91.4	92.0
90.2	90.8
89.4	89.9
89.5	89.9
89.5	89.9
89.8	90.2
89.9	90.2
89.8	90.0
88.2	88.4
103.0	104.1

◆ 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 Pierre Cugnon of the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The October 2004 data combine observations from 45 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 22 AND 23

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1993	71	69	67	64	60	56	55	52	48	45	41	38	56
1994	37	35	34	34	33	31	29	27	27	27	26	26	30
1995	24	23	22	21	19	18	17	15	13	12	11	11	17
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	43	41	39	37	36	35	34	42
					(3)	(5)	(7)	(10)	(11)	(12)	(14)	(15)	(6)
2005	32	31	30	28	27	26	25	24	23	22	21	21	26
	(17)	(17)	(18)	(18)	(18)	(18)	(17)	(17)	(18)	(17)	(17)	(16)	(17)

*May 1996 marks Cycle 22's mathematical minimum.   **October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

◆ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 22, and the beginning of Cycle 23, 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 June 2004 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 April 2005 prediction. There exists a 90% chance that in April 2005, the actual smoothed sunspot number will fall somewhere between 10 and 46.

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 13 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. The new cycle predictions tabulated above are based on the consensus minimum value of 8.8 that occurred in October 1996. For solar maximum discussions, visit http://www.sec.noaa.gov.