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} J/m^{2}Hzsec.

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 Learmonth, Australia (LEAR) data reflect equipment problems. Fluxes measured either at Palehua on the Hawaiian Islands, or at San Vito, Italy, will be substituted for frequencies at which many Learmonth values are missing.

JUNE 1998 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	LEAR	LEAR	LEAR	Pentic	LEAR	LEAR	LEAR	LEAR	LEAR
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	49	100	546	228	137	103	96	73	43	33	14
02	57	105	556	236	145	108	103	76	44	34	16
03	55	113	529	231	150	116	107	82	48	37	15
04	74	112	538	233	152	115	113	85	50	37	15
05	79	115	558	240	156	118	117	90	50	37	22
06	68	115	557	242	154	118	114	90	52	40	35
07	66	113	550	245	156	116	112	90	51	36	15
08	66	117	550	240	155	121	113	88	51	38	17
09	81	112	556	245	153	115	113	88	51	38	18
10	77	112	417	215	143	115	111	86	40	35	15
11	76	112	536	237	153	115	114	87	52	37	16
12	83	112	543	239	153	115	114	87	51	37	36
13	91	111	557	247	163	115	120	90	51	36	17
14	69	102	548	238	148	105	105	83	48	36	16
15	53	100	546	239	142	103	98	79	48	34	14
16	49	104	---	239	143	107	100	80	---	---	---
17	67	101	540	237	148	104	103	81	48	34	14
18	55	100	547	240	143	103	100	80	49	35	14
19	52	99	545	235	140	102	98	75	45	33	13
20	60	101	542	237	142	104	99	76	47	34	13
21	64	102	553	243	148	105	103	77	46	34	38
22	51	101	552	242	147	104	102	76	45	32	14
23	53	96	546	245	144	99	99	73	45	32	14
24	45	105	547	245	145	108	97	70	43	31	12
25	75	106	550	248	153	109	101	73	43	32	12
26	83	109	531	242	152	113	105	76	44	32	12
27	100	115	555	249	156	119	114	83	47	33	13
28	108	122	563	247	157	126	112	84	47	33	14
29	109	119	559	246	156	123	118	88	52	43	42
30	101	121	---	---	---	125	---	---	---	---	---
31											
Mean	70.5	108	543	240	149	112	107	82	48	35	18

MAY 1998 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
113.4	115.1
117.0	118.8
117.4	119.3
121.1	123.2
133.4	135.7
130.1	132.4
123.3	125.6
118.0	120.2
110.7	112.8
107.2	109.3
108.0	110.2
112.1	114.4
116.6	119.1
117.2	119.8
116.0	118.6
117.7	120.4
110.4	113.0
102.2	104.6
99.2	101.5
91.9	94.1
89.0	91.2
87.4	89.6
90.3	92.6
95.6	98.0
92.3	94.7
92.5	94.9
94.0	96.6
98.4	101.1
94.9	97.6
96.1	98.8
94.2	96.8
106.7	109.0

♦ 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 June 1998 data combine observations from 42 stations. http://www.oma.be/KSB-ORB/SIDC/index.html.

♦ 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
1988	58	65	71	78	84	94	104	114	121	125	130	138	98
1989	142	145	150	154	157	158	159	158	157	157	158	154	154
1990	151	153	152	149	147	144	141	141	142	142	142	144	146
1991	148	148	147	147	146	145	146	147	145	142	138	132	144
1992	124	115	108	103	100	97	91	84	80	76	74	73	94
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	29	32	35	39	23
1998	44	50	55	61	66	72	79	86	93	100	105	110	77
	(2)	(4)	(6)	(9)	(12)	(14)	(16)	(19)	(22)	(25)	(28)	(31)	(16)
1999	114	118	123	129	134	139	143	146	148	152	155	157	138
	(34)	(34)	(33)	(33)	(33)	(34)	(35)	(37)	(39)	(42)	(43)	(45)	(37)
2000	157	157	158	157	155	153	151	150	148	146	143	141	151
	(48)	(51)	(53)	(54)	(55)	(54)	(53)	(53)	(54)	(54)	(53)	(53)	(53)

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

♦ 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 December 1997 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 December 1998 prediction. There exists a 90% chance that in December 1998 the actual smoothed sunspot number will fall somewhere between 79 and 141.

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.