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} $J/m^2 Hz\,sec$.

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 1999 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	44	103	539	250	141	102	97	84	52	38	16
02	39	100	538	247	144	99	102	86	52	39	19
03	48	103	525	235	149	103	109	91	50	37	15
04	71	116	532	236	155	116	118	100	54	45	19
05	81	133	545	253	159	133	123	100	56	44	--
06	92	137	509	279	159	137	129	109	--	40	18
07	82	141	538	257	166	141	134	114	63	50	28
08	89	139	544	271	169	139	132	113	62	43	17
09	104	136	544	271	169	136	132	113	62	43	17
10	90	136	522	217	152	136	119	110	52	38	7
11	75	131	538	260	156	131	122	110	62	41	17
12	76	130	530	257	157	130	126	112	61	43	17
13	81	130	494	278	151	130	123	111	96	41	15
14	74	120	509	273	149	120	114	111	80	41	16
15	63	122	529	258	153	122	112	104	57	43	22
16	67	123	542	260	155	123	113	102	57	42	25
17	75	116	539	255	148	116	113	97	53	42	22
18	55	113	522	248	141	114	112	92	60	--	12
19	50	110	535	256	147	110	105	90	53	35	--
20	50	105	509	229	136	106	98	81	50	40	23
21	45	103	532	238	136	104	93	84	49	40	29
22	40	100	527	221	130	101	92	86	44	36	20
23	42	98	528	244	135	99	94	79	52	38	18
24	51	101	529	247	140	102	95	79	53	41	22
25	48	103	531	250	141	104	99	84	53	40	23
26	47	105	526	247	143	106	100	84	51	38	17
27	55	109	498	261	141	110	107	79	--	38	18
28	55	110	541	258	156	111	110	85	52	38	15
29	61	122	541	258	156	123	110	85	52	38	15
30	66	124	535	263	159	125	114	93	54	38	15
31											
Mean	64	117	529	253	150	118	112	96	57	40	18

MAR 1999 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
120.2	118.0
129.9	127.6
137.0	134.6
144.1	141.6
127.5	125.4
114.4	112.6
110.0	108.3
126.9	125.0
127.1	125.3
135.4	133.6
137.0	135.3
140.3	138.5
144.4	142.7
150.4	148.7
150.1	148.4
155.7	154.1
154.5	152.9
148.1	146.7
139.3	138.1
132.7	131.6
124.0	123.1
115.9	115.0
112.9	112.2
108.2	107.6
107.0	106.4
103.6	103.1
104.5	104.1
103.0	102.7
104.2	103.8
104.7	104.4
101.9	101.7
126.3	124.9

♦ 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 March 1999 data combine observations from 37 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
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	28	32	35	39	23
1998	44	49	53	57	59	62	65	68	70	71	75	78	63
											(4)	(7)	(1)
1999	82	85	89	93	97	100	103	106	108	111	113	115	100
	(9)	(10)	(10)	(10)	(12)	(14)	(18)	(23)	(27)	(31)	(33)	(35)	(19)
2000	116	117	118	118	118	118	118	119	118	117	117	116	118
	(38)	(39)	(40)	(41)	(41)	(41)	(40)	(40)	(40)	(40)	(40)	(40)	(40)

*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 June 1998 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 1999 prediction. There exists a 90% chance that in October 1999 the actual smoothed sunspot number will fall somewhere between 80 and 142.

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.