

# SOLAR INDICES BULLETIN

JUNE 2002

NATIONAL GEOPHYSICAL DATA CENTER  
Solar-Terrestrial Physics Division (E/GC2)  
Telephone (303) 497-6346

325 Broadway  
Boulder, Colorado 80305-3328 USA  
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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  $10^{-22} \text{ J/m}^2\text{Hzsec}$ . 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  $\pm 7\%$  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.

JUNE 2002 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number	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	124	179	550	356	247	184	176	127	60	40	17
02	129	175	540	362	262	180	190	132	73	48	---
03	133	170	529	331	224	174	156	120	60	42	41
04	150	170	533	321	220	174	163	142	71	47	29
05	126	159	486	301	199	163	145	116	55	39	18
06	135	155	548	325	204	159	152	117	59	40	29
07	135	158	505	276	197	162	149	116	56	38	21
08	127	155	536	319	208	159	159	112	55	40	---
09	113	157	536	327	210	161	156	112	52	42	40
10	88	152	525	310	204	156	148	135	55	55	64
11	68	148	520	319	210	152	137	113	54	75	53
12	75	142	510	314	235	146	142	106	52	47	---
13	55	133	605	313	188	137	136	91	47	52	---
14	73	131	516	310	186	135	128	99	49	41	---
15	70	135	566	307	186	139	131	140	48	43	35
16	80	137	576	307	207	141	127	119	52	36	24
17	60	143	523	306	194	147	140	118	52	38	25
18	87	143	527	312	191	147	133	132	50	31	---
19	79	146	524	305	191	150	135	179	59	36	20
20	74	145	528	316	197	149	134	122	53	37	---
21	63	140	511	317	198	144	141	103	54	39	17
22	57	142	529	307	198	146	137	126	54	38	24
23	65	143	524	325	203	147	134	102	57	39	25
24	74	150	519	331	209	154	134	100	56	38	11
25	76	145	508	319	206	149	136	101	56	40	11
26	74	144	562	320	197	148	132	101	58	47	---
27	66	139	543	319	220	143	---	124	62	64	59
28	60	137	547	312	218	141	132	131	59	40	39
29	66	143	498	328	199	147	133	110	59	45	35
30	72	147	526	324	202	151	133	100	53	39	31
31											
Mean	88.5	149	532	318	207	153	143	118	56	43	30

MAY 2002 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
162.4	164.9
169.0	171.7
179.1	182.0
189.5	192.7
180.0	183.2
190.8	194.3
186.8	190.3
186.6	190.2
190.0	193.7
191.0	194.8
188.0	191.8
183.3	187.1
172.0	175.6
160.7	164.2
159.2	162.7
158.4	162.0
157.1	160.7
163.0	166.8
170.9	175.0
171.3	175.4
185.9	190.4
181.1	185.6
180.3	184.8
189.1	193.9
182.6	187.4
183.1	188.0
186.7	191.6
186.4	191.4
184.8	189.8
180.1	185.1
181.9	187.0
178.4	182.4

## ◆ 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 of 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 2002 data combine observations from 38 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
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	73	78	62
1999	83	85	84	86	91	93	94	98	103	108	111	111	96
2000	113	117	120	121	119	119	120	119	116	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	115	115	111
2002	113 (5)	112 (9)	109 (11)	106 (14)	104 (15)	101 (16)	98 (16)	95 (17)	92 (18)	89 (18)	86 (18)	83 (15)	99 (14)
2003	79 (13)	76 (11)	74 (11)	71 (12)	68 (13)	66 (13)	64 (14)	62 (14)	60 (15)	57 (17)	55 (18)	54 (20)	66 (14)

\*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 March 2002 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 2002 prediction. There exists a 90% chance that in December 2002 the actual smoothed sunspot number will fall somewhere between 68 and 98.

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>.

Although every effort has been made to ensure that these data are correct, we can assume no liability for any damages their inaccuracies might cause. The charge for a 1-year subscription to this monthly bulletin is US\$17.00. To become a subscriber, you may either call (303) 497-6346 or write the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80305-3328 USA. Please include with your written order a cheque or money order payable in U.S. currency to the "Department of Commerce, NOAA/NGDC". Payment may also be made through VISA, MasterCard or American Express credit cards.