

SOLAR INDICES BULLETIN

APRIL 2000

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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/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 $\pm 7\%$ 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.

APRIL 2000 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit								
	Intl		PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	187	223	583	316	248	222	205	174	84	52	24
02	193	219	583	316	248	218	205	174	84	52	24
03	177	215	549	—	—	215	190	170	84	52	24
04	164	207	586	274	220	207	193	167	87	69	45
05	129	194	584	—	203	194	162	150	81	57	41
06	108	178	581	290	202	178	161	151	78	51	20
07	94	175	589	293	200	175	163	147	78	49	98
08	100	182	567	304	207	182	171	151	78	49	17
09	108	176	583	294	197	176	163	150	78	47	20
10	102	178	594	—	177	178	162	146	78	48	18
11	96	182	593	207	172	182	166	163	80	49	18
12	107	173	569	289	196	173	167	153	74	44	17
13	118	164	575	294	194	164	161	158	76	46	39
14	114	165	581	276	180	165	153	150	77	46	17
15	105	164	581	294	193	165	162	149	81	52	28
16	98	159	563	255	184	160	163	144	71	48	—
17	110	158	—	253	177	159	142	132	72	46	25
18	94	160	585	283	185	161	153	142	74	52	37
19	103	168	567	300	202	169	160	141	77	58	57
20	121	181	601	302	204	182	160	143	76	51	63
21	128	187	605	316	226	188	174	150	84	52	44
22	145	202	455	260	219	204	177	149	79	54	23
23	170	206	—	—	219	208	177	149	79	54	—
24	160	206	583	319	248	208	185	160	87	—	—
25	151	203	584	347	257	205	192	161	83	73	65
26	136	190	573	281	219	192	177	154	76	56	66
27	118	184	578	325	233	186	181	150	77	69	185
28	124	183	582	224	200	185	169	149	72	52	50
29	100	175	584	291	205	177	159	129	74	58	36
30	100	170	—	—	—	172	—	—	—	—	—
31											
Mean	125.3	184	576	288	208	185	171	152	79	53	42

MAR 2000 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
232.8	228.7
213.2	209.6
203.8	200.4
200.2	197.0
220.3	216.8
222.4	219.1
221.8	218.5
214.9	211.8
205.8	203.0
203.4	200.7
203.2	200.6
203.2	200.8
188.1	186.0
182.6	180.6
177.8	175.9
184.4	182.5
192.4	190.6
194.8	193.0
208.2	206.5
210.3	208.7
230.5	228.9
233.8	232.2
224.1	222.7
218.9	217.7
205.1	204.1
211.3	210.4
204.9	204.1
200.9	200.3
208.8	208.3
205.5	205.1
225.4	225.1
208.2	206.1

◆ 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 April 2000 data combine observations from 38 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
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	73	78	62
1999	83	85	84	86	91	93	94	98	102	108	110 (3)	112 (6)	95 (1)
2000	113 (9)	114 (12)	115 (14)	116 (16)	116 (19)	116 (20)	116 (21)	116 (24)	116 (27)	115 (29)	114 (32)	114 (34)	115 (21)
2001	114 (35)	114 (36)	113 (37)	113 (39)	112 (41)	112 (41)	111 (39)	110 (39)	109 (39)	107 (39)	106 (38)	105 (37)	111 (38)

*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 1999 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 2000 prediction. There exists a 90% chance that in October 2000 the actual smoothed sunspot number will fall somewhere between 86 and 144.

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 80303 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.