

SOLAR INDICES BULLETIN

FEBRUARY 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.

FEBRUARY 2000 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Obs Flux		Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic (2800)	PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	71	138	579	264	162	133	123	114	66	46	15
02	64	144	573	242	170	139	135	121	66	38	16
03	81	154	555	276	183	149	142	130	---	---	---
04	99	167	587	274	189	162	160	138	---	---	---
05	104	168	574	260	188	163	143	138	---	---	---
06	129	178	583	251	195	173	155	156	---	---	---
07	130	182	545	289	209	177	163	151	---	---	---
08	128	174	579	290	208	169	169	150	---	---	---
09	109	199	585	276	203	193	161	146	---	---	---
10	122	176	592	280	203	171	161	149	---	---	---
11	114	170	584	281	195	165	---	147	---	---	---
12	113	163	580	274	189	158	---	141	---	---	---
13	108	160	577	278	188	156	---	146	---	---	---
14	119	159	567	281	180	155	141	131	---	---	---
15	118	156	576	279	182	152	139	134	---	---	---
16	131	160	522	309	191	156	145	133	77	42	35
17	109	168	572	254	175	163	136	128	56	43	23
18	104	141	556	275	183	137	132	117	69	47	17
19	89	145	576	271	187	141	134	116	68	43	17
20	76	153	577	260	199	149	142	117	64	39	---
21	92	152	581	291	190	148	146	117	66	48	---
22	100	164	316	197	155	160	88	98	75	60	58
23	102	185	587	305	197	181	161	137	68	51	33
24	123	192	598	289	228	187	177	141	74	49	33
25	131	210	599	301	240	205	185	153	82	65	30
26	144	215	609	362	337	210	213	161	77	54	41
27	150	227	611	393	282	222	204	170	69	71	67
28	143	219	611	393	282	214	204	170	69	---	---
29	153	219	587	338	258	215	196	165	79	72	38
30											
31											
Mean	112.3	174	570	287	205	169	156	138	70	51	33

JAN 2000 FINAL FLUX

Observed Adjusted	
Pentic (2800)	Pentic (2800)
129.9	125.6
132.9	128.5
133.1	128.7
134.7	130.3
136.5	132.0
144.8	140.0
149.8	144.8
154.7	149.6
160.6	155.3
163.2	157.8
177.6	171.8
195.7	189.3
202.0	195.4
201.3	194.7
210.7	203.9
207.7	201.0
196.4	190.1
194.6	188.4
178.6	172.9
170.7	165.3
159.3	154.3
150.6	145.8
140.5	136.1
140.7	136.3
137.4	133.1
140.7	136.4
132.4	128.4
152.0	147.4
127.7	123.9
132.7	128.7
138.6	134.5
159.0	153.9

♦ **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 November 1999 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	85	90	93	94	98	100 (5)	102 (8)	105 (10)	107 (12)	94 (3)
2000	108 (15)	109 (18)	110 (20)	110 (22)	111 (24)	111 (24)	111 (25)	112 (27)	112 (29)	111 (31)	110 (33)	110 (35)	110 (25)
2001	110 (35)	110 (36)	110 (37)	109 (39)	109 (41)	108 (41)	107 (39)	106 (39)	105 (39)	104 (39)	103 (38)	102 (37)	107 (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 September 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 August 2000 prediction. There exists a 90% chance that in August 2000 the actual smoothed sunspot number will fall somewhere between 85 and 139.

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.