SOLAR INDICES BULLETIN

MARCH 2002

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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.

MARCH 2002 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	109	188	513	330	222	184	163	129	62	42	22
02	78	191	524	328	220	187	161	126	60	40	38
03	112	183	532	317	216	179	159	128	61	51	22
04	114	175	540	322	217	172	154	118	61	46	21
05	106	172	525	322	213	169	155	124	63	69	---
06	112	178	518	323	212	175	155	116	63	42	18
07	93	180	517	338	226	177	161	128	63	40	15
08	79	177	518	324	214	174	168	126	66	56	45
09	74	184	540	355	239	181	169	132	64	42	22
10	78	179	532	353	234	176	170	146	66	45	23
11	103	182	538	335	225	179	157	133	66	49	32
12	90	178	520	335	227	175	163	121	67	67	46
13	92	184	533	314	218	181	156	127	63	46	19
14	87	181	523	331	222	179	171	124	65	51	23
15	100	176	548	388	290	174	223	155	69	60	84
16	94	185	514	331	226	183	170	125	71	55	21
17	88	184	522	327	220	182	186	125	69	53	25
18	92	178	532	327	220	176	186	125	69	41	21
19	76	175	537	325	211	173	151	122	63	74	19
20	85	188	570	333	221	186	168	128	66	51	28
21	95	174	504	316	207	172	152	122	63	31	32
22	93	172	527	322	212	170	158	121	59	45	20
23	106	170	535	320	211	168	151	122	56	42	11
24	104	175	526	324	216	173	155	123	61	52	20
25	109	170	512	311	200	169	147	118	61	47	21
26	101	166	525	314	205	165	151	122	59	42	19
27	115	169	596	328	218	168	161	122	61	48	27
28	107	176	540	329	219	175	163	120	60	57	77
29	114	181	547	337	232	180	169	125	60	47	34
30	111	189	544	341	243	188	170	124	62	48	24
31	125	204	526	333	246	203	177	130	68	47	22
Mean	98.1	179	532	330	223	177	165	126	63	49	28

FEB 2002 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
245.6	238.5
240.6	233.7
232.9	226.3
234.6	228.1
220.6	214.5
202.5	196.9
191.7	186.6
191.5	186.4
199.4	194.1
216.5	210.9
201.7	196.6
208.3	203.1
203.5	198.5
196.1	191.3
195.0	190.3
193.5	188.9
196.6	192.0
192.8	188.4
189.4	185.1
193.4	189.1
201.1	196.7
191.9	187.9
188.2	184.2
192.8	188.9
210.6	206.4
207.5	203.5
198.6	194.9
204.2	200.4
205.0	200.1

♦ 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
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 2002 data combine observations from 36 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
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	113 (3)	112 (6)	111 (9)	110 (2)
2002	109 (12)	108 (15)	105 (17)	103 (19)	100 (19)	98 (19)	95 (19)	92 (19)	89 (20)	87 (20)	84 (19)	81 (16)	96 (18)
2003	77 (13)	75 (12)	72 (12)	70 (13)	67 (13)	64 (14)	62 (15)	61 (16)	59 (17)	56 (18)	54 (19)	53 (21)	64 (15)

*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 2001 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 September 2002 prediction. There exists a 90% chance that in September 2002 the actual smoothed sunspot number will fall somewhere between 69 and 109.

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.