SOLAR INDICES BULLETIN

FEBRUARY 2002

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

325 Broadway
Boulder, Colorado 80305-3328 USA
ISSN 1046-1914

♦ 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.

FEBRUARY 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	113	246	534	357	278	238	226	156	69	45	27
02	135	241	510	335	267	234	206	162	67	43	28
03	159	233	528	336	261	226	203	145	64	42	26
04	153	235	521	338	263	228	199	144	65	69	22
05	151	221	524	334	248	214	197	143	---	---	---
06	125	203	512	326	234	197	185	131	63	41	28
07	104	192	516	321	225	186	178	123	67	44	25
08	104	192	326	268	201	186	169	116	63	41	20
09	118	199	525	338	243	193	180	122	66	46	25
10	105	217	508	324	239	211	182	125	66	50	26
11	109	202	515	326	232	196	178	128	66	47	26
12	110	208	509	321	235	202	174	132	65	48	20
13	104	204	507	330	243	198	184	127	65	47	56
14	98	196	404	330	235	191	171	132	67	45	53
15	103	195	550	329	227	190	171	125	65	64	---
16	79	194	510	315	219	189	162	124	65	42	27
17	91	197	526	325	233	192	173	133	63	44	22
18	80	193	509	328	236	188	189	134	67	46	23
19	78	189	344	335	154	184	182	134	67	43	---
20	95	193	386	333	238	188	170	125	65	42	17
21	86	201	394	337	242	196	172	206	67	44	24
22	84	192	377	342	239	187	170	134	67	43	24
23	94	188	373	336	233	184	161	127	65	42	19
24	99	193	378	331	235	188	184	129	65	52	72
25	121	211	373	342	245	206	190	132	65	47	---
26	123	208	385	341	241	203	183	130	66	55	47
27	107	199	387	338	---	195	167	126	66	42	24
28	97	204	552	352	245	200	175	126	64	---	27
29											
30											
31											
Mean	108.0	205	464	331	237	200	181	135	66	47	30

JAN 2002 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	232.2	224.5
02	231.1	223.5
03	220.3	213.0
04	218.2	211.0
05	212.2	205.2
06	196.6	190.1
07	188.6	182.4
08	199.2	192.6
09	228.5	220.9
10	224.6	217.3
11	228.9	221.4
12	233.3	225.7
13	240.7	232.9
14	229.0	221.6
15	218.3	211.2
16	216.1	209.1
17	211.8	205.0
18	210.5	203.8
19	213.7	206.9
20	222.2	215.2
21	224.5	217.5
22	228.7	221.5
23	226.5	219.4
24	230.8	223.6
25	234.8	227.6
26	256.5	248.7
27	248.0	240.5
28	259.8	252.0
29	261.0	253.2
30	256.3	248.8
31	242.6	235.5
Mean	227.3	220.1

♦ 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 February 2002 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
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	113	113 (4)	112 (7)	110 (8)	109 (10)	110 (2)
2002	108 (12)	106 (15)	104 (17)	102 (19)	99 (19)	97 (19)	94 (18)	91 (19)	88 (19)	86 (19)	83 (18)	80 (16)	95 (18)
2003	77 (13)	74 (11)	72 (12)	69 (13)	66 (14)	64 (14)	62 (15)	60 (16)	58 (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 <u>smoothed</u> 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 August 2002 prediction. There exists a 90% chance that in August 2002 the actual smoothed sunspot number will fall somewhere between 72 and 110.

<u>The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead.</u> 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.