SOLAR INDICES BULLETIN

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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 $10^{-22}\ J/m^2 Hz\,sec$. 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 2003 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	40	126	336	264	173	122	124	73	43	31	14
02	43	127	471	277	188	123	128	87	40	30	14
03	36	133	461	236	167	129	121	75	43	33	14
04	35	135	504	270	182	131	131	81	45	31	13
05	54	140	508	274	193	136	150	89	51	35	13
06	68	150	463	257	186	145	145	89	49	34	12
07	82	147	511	250	172	143	139	103	44	35	13
08	87	139	517	273	181	135	139	88	48	35	---
09	93	141	484	259	175	137	133	86	43	32	13
10	73	136	515	274	180	132	137	91	49	35	7
11	73	135	505	272	180	131	135	89	51	35	7
12	71	132	506	271	178	128	132	83	48	34	14
13	59	131	484	275	186	127	131	113	48	34	11
14	45	131	527	273	187	127	132	107	44	35	13
15	31	124	504	270	178	120	122	74	43	33	13
16	22	119	505	262	172	116	117	69	35	27	11
17	10	112	501	258	164	109	109	65	40	31	12
18	20	110	509	260	164	107	111	66	41	32	13
19	33	116	498	268	174	113	117	68	45	47	13
20	44	118	---	---	---	115	---	---	---	---	---
21	46	120	463	225	156	117	111	66	43	42	25
22	34	107	489	221	151	104	107	63	41	17	16
23	28	104	494	252	156	101	106	62	38	28	9
24	28	102	480	252	153	99	104	63	39	31	10
25	32	102	472	249	155	99	103	62	41	32	19
26	30	109	497	265	168	106	111	65	41	30	21
27	43	118	595	258	202	115	126	139	38	30	12
28	34	125	484	271	180	122	130	---	---	---	---
29											
30											
31											
Mean	46.2	125	492	261	174	121	124	81	44	33	13

JAN 2003 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	115.0	111.2
02	118.3	114.4
03	137.6	133.1
04	143.0	138.2
05	148.1	143.2
06	162.1	156.8
07	163.2	157.8
08	173.7	168.0
09	182.9	176.9
10	184.7	178.7
11	188.8	182.6
12	173.4	167.7
13	171.8	166.2
14	164.0	158.6
15	149.9	145.0
16	144.6	139.9
17	141.7	137.1
18	137.4	133.0
19	130.2	126.1
20	138.0	133.7
21	133.6	129.4
22	129.5	125.4
23	135.9	131.6
24	129.8	125.8
25	128.9	124.9
26	125.0	121.2
27	121.3	117.7
28	125.6	121.8
29	124.4	120.7
30	121.2	117.6
31	120.4	116.9
Mean	144.0	139.4

♦ 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
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 2003 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
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	114	115	113	111	109	106	103	99	96	93	90	86	103
									(4)	(7)	(8)	(8)	(2)
2003	82	78	76	73	70	68	66	64	62	59	57	56	68
	(8)	(8)	(8)	(9)	(10)	(11)	(11)	(11)	(12)	(13)	(15)	(16)	(11)
2004	55	54	53	52	51	49	46	44	42	41	40	38	47
	(18)	(19)	(19)	(20)	(20)	(20)	(21)	(22)	(23)	(24)	(24)	(25)	(21)

*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 December 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 Aug 2003 prediction. There exists a 90% chance that in Aug 2003 the actual smoothed sunspot number will fall somewhere between 53 and 75.

<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.