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.

JANUARY 2003 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	PALE	PALE	PALE	Pentic	PALE	PALE	PALE	PALE	PALE
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	31	115	483	264	155	111	100	75	41	33	27
02	27	118	478	270	159	114	104	79	46	34	19
03	66	138	485	292	189	133	127	94	49	36	---
04	65	143	504	280	182	138	124	85	49	34	37
05	68	148	522	275	182	143	128	89	52	37	18
06	86	162	507	297	207	156	144	96	46	39	19
07	90	163	498	303	207	157	144	95	45	40	21
08	108	174	534	299	219	168	169	168	52	41	26
09	109	183	528	307	227	176	157	217	52	38	23
10	117	185	528	300	222	178	160	107	56	39	20
11	117	189	528	301	217	182	161	113	53	37	15
12	104	173	527	294	211	167	154	126	49	36	15
13	94	172	505	316	202	166	151	109	55	36	15
14	94	164	475	258	182	158	153	109	48	203	19
15	84	150	---	---	---	145	---	---	---	---	---
16	84	145	494	288	177	140	129	95	49	35	15
17	81	142	505	282	175	137	123	92	49	33	15
18	77	137	501	277	173	132	119	87	45	30	16
19	87	130	509	274	171	125	114	82	44	29	16
20	93	138	352	262	180	133	115	104	48	33	15
21	68	134	496	208	154	129	103	80	43	35	16
22	86	130	511	277	167	125	110	79	40	31	16
23	70	136	506	283	178	131	118	82	47	32	34
24	76	130	443	280	174	125	114	79	47	33	17
25	59	129	454	267	161	125	106	74	46	33	14
26	72	125	461	255	158	121	108	74	45	31	16
27	80	121	472	275	169	117	113	80	44	33	19
28	85	126	502	221	156	122	101	70	41	31	15
29	84	124	500	265	173	120	124	76	45	29	15
30	62	121	488	265	173	117	124	81	46	33	---
31	41	120	643	266	178	116	119	76	45	33	16
Mean	79.5	144	498	277	183	139	127	96	47	40	19

DEC 2002 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
149.6	145.5
146.1	142.0
145.9	141.8
148.7	144.5
148.7	144.4
148.2	143.9
151.1	146.6
154.4	149.8
156.3	151.6
161.4	156.5
152.3	147.7
153.1	148.4
166.9	161.8
185.9	180.1
203.0	196.6
202.9	196.5
212.5	205.8
196.9	190.6
192.9	186.7
196.6	190.3
183.9	177.9
172.0	166.4
158.9	153.7
147.3	142.5
131.9	127.6
127.4	123.2
116.5	112.7
116.9	113.1
114.8	111.0
113.8	110.1
115.1	111.3
157.2	152.3

♦ 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 January 2003 data combine observations from 39 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	100	96	94	90	87	103
								(4)	(7)	(10)	(10)	(10)	(3)
2003	83	79	77	74	71	68	66	65	62	60	58	57	68
	(9)	(8)	(8)	(9)	(10)	(10)	(11)	(11)	(12)	(13)	(14)	(16)	(11)
2004	56	55	54	53	51	49	47	44	42	41	40	38	47
	(18)	(19)	(20)	(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 September 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 July 2003 prediction. There exists a 90% chance that in July 2003 the actual smoothed sunspot number will fall somewhere between 55 and 77.

<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.