SOLAR INDICES BULLETIN

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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.

MAY 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	99	149	523	304	237	151	155	86	48	43	20
02	86	144	518	301	226	146	160	85	46	36	32
03	95	148	515	297	225	150	154	86	44	33	16
04	96	142	498	298	222	144	146	78	42	30	17
05	93	129	510	289	209	131	135	72	40	33	21
06	78	122	514	281	197	124	135	69	54	37	20
07	65	110	513	268	174	112	113	65	40	27	25
08	33	101	502	269	168	102	108	63	39	31	19
09	20	97	513	264	161	98	106	62	37	30	13
10	17	93	491	258	152	94	98	58	36	38	17
11	36	92	501	254	155	93	98	60	36	28	16
12	38	94	495	262	155	95	99	59	38	30	8
13	41	96	372	249	148	98	100	59	37	28	18
14	43	96	506	256	153	98	103	61	38	28	14
15	50	99	512	262	160	101	110	64	38	29	13
16	51	103	489	296	204	105	109	67	40	30	15
17	48	102	--	--	--	104	--	--	--	--	--
18	44	109	--	--	--	111	--	--	--	--	--
19	54	115	510	273	173	117	122	78	35	27	16
20	61	117	506	273	173	119	117	77	43	33	16
21	50	119	517	277	176	121	123	79	45	32	16
22	65	118	514	285	185	120	132	80	46	31	17
23	57	118	514	278	177	121	124	78	44	32	16
24	40	117	509	284	180	120	126	81	45	33	16
25	39	121	537	262	176	124	126	79	39	24	--
26	52	125	524	283	199	128	134	85	42	38	--
27	57	129	506	262	189	132	137	84	50	--	--
28	62	130	531	304	207	133	137	78	43	43	--
29	56	138	512	294	193	141	128	82	45	34	22
30	44	117	511	292	191	120	127	74	42	38	23
31	42	113	517	280	181	116	121	71	40	31	17
Mean	55.2	116	506	278	184	118	124	73	42	32	18

APR 2003 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
153.0	152.8
157.5	157.3
155.7	155.7
148.6*	148.8*
137.4	137.5
* 1700UT Reading	
125.9	126.1
115.6	115.9
112.3	112.6
109.4	109.7
103.7	104.1
102.6	103.0
102.1	102.6
102.4	103.0
102.0	102.6
100.5	101.1
98.5	99.2
101.0	101.8
107.8	108.7
112.1	113.1
118.5	119.7
125.8	127.0
132.4	133.8
132.8	134.3
128.3	129.8
143.6	145.3
143.7	145.5
154.1	156.1
152.2	154.3
155.1	157.4
153.5	155.8
126.3	127.2

♦ 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 May 2003 data combine observations from 34 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	120.7#	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	95	91	85	82	102
												(3)	0
2003	78	75	73	71	68	65	63	61	59	57	55	54	65
	(5)	(5)	(6)	(8)	(9)	(10)	(10)	(11)	(12)	(14)	(16)	(17)	(10)
2004	53	52	51	49	48	47	44	42	40	39	38	36	45
	(19)	(20)	(20)	(20)	(21)	(21)	(22)	(23)	(24)	(24)	(25)	(25)	(22)

*May 1996 marks Cycle 22's mathematical minimum. **October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

♦ 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 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 Nov 2003 prediction. There exists a 90% chance that in Nov 2003 the actual smoothed sunspot number will fall somewhere between 39 and 71.

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.