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.

DECEMBER 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	98	143	187	190	167	138	139	82	42	34	24
02	72	139	483	255	186	135	140	79	40	38	33
03	78	124	476	260	170	120	126	73	---	---	---
04	66	116	476	249	171	112	119	67	37	29	27
05	59	112	440	255	167	108	114	66	36	32	28
06	45	109	485	242	157	105	106	61	33	27	15
07	32	92	450	222	144	89	94	53	29	26	15
08	26	94	464	237	148	91	95	53	32	26	15
09	16	92	463	239	147	89	94	51	31	26	15
10	25	89	458	239	142	86	89	49	27	29	17
11	25	86	470	233	144	83	89	48	23	24	15
12	23	87	473	241	147	84	91	50	30	26	15
13	28	88	481	240	177	85	94	74	31	28	16
14	31	92	476	240	147	89	93	52	32	27	15
15	30	101	467	241	158	97	101	57	33	29	17
16	39	106	479	252	162	102	110	61	36	30	17
17	68	118	488	254	168	114	118	68	38	32	19
18	71	123	501	258	174	119	126	75	40	32	25
19	71	123	484	248	177	119	129	78	41	35	22
20	74	130	499	257	186	125	132	80	45	36	21
21	60	133	499	259	180	128	136	84	43	35	22
22	74	138	508	263	184	133	138	88	45	39	28
23	76	142	497	268	193	137	146	89	43	39	55
24	59	139	493	277	198	134	145	89	48	38	30
25	44	139	507	276	191	134	140	88	46	38	27
26	40	137	505	275	188	132	134	85	41	33	18
27	31	127	502	259	179	122	128	81	39	30	16
28	34	119	489	252	170	115	120	71	39	32	17
29	28	115	502	251	169	111	115	68	38	30	18
30	17	108	500	252	165	104	109	65	38	34	32
31	16	106	496	269	185	102	127	70	40	44	---
Mean	47.0	115	474	250	169	111	117	70	37	32	22

NOV 2003 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
210.4	207.2
190.4	187.4
166.9	164.2
168.4#	165.6#
114.0	112.1
97.8	96.1
91.0	89.4
92.7	91.0
93.0	91.2
94.6	92.8
95.6	93.7
98.7	96.7
102.1	100.0
98.9	96.8
97.8	95.6
# 1800UT Reading	
104.4	102.0
121.0	118.2
144.3	141.0
155.1	151.5
175.2	171.0
177.0	172.8
176.2	171.9
178.2	173.8
177.3	172.8
170.7	166.3
170.9	166.5
174.7	170.1
167.7	163.2
165.9	161.4
152.8	148.6
140.8	137.7

♦ 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 December 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
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
2003	81	79	74	70	68	65	63	61	59	57	55	54	65
							(3)	(6)	(9)	(12)	(14)	(16)	(5)
2004	53	52	50	49	48	46	44	42	40	39	38	36	45
	(17)	(17)	(18)	(19)	(19)	(19)	(20)	(21)	(21)	(22)	(22)	(23)	(20)
2005	35	33	31	30	29	27	26	26	25	24	23	22	28
	(23)	(23)	(23)	(23)	(23)	(22)	(21)	(21)	(21)	(20)	(19)	(19)	(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 September 2003 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 May 2004 prediction. There exists a 90% chance that in June 2004 the actual smoothed sunspot number will fall somewhere between 27 and 65.

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.