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 $10^{-22}\ \mathrm{J/m^2 Hz\,sec}$. 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.

APRIL 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	93	153	515	288	204	152	156	91	46	33	18
02	103	158	517	294	216	157	160	95	36	29	19
03	90	156	508	287	256	156	161	91	48	37	22
04	72	153	534	310	225	153	163	93	47	34	36
05	60	137	516	288	197	137	140	86	43	33	16
06	52	126	507	281	183	126	127	75	45	33	18
07	48	116	488	258	180	116	121	69	41	34	20
08	34	112	505	276	173	112	115	67	41	33	25
09	42	109	506	263	168	109	111	66	40	32	31
10	38	104	492	269	165	104	107	63	38	29	--
11	25	103	515	262	163	103	105	61	39	29	17
12	37	102	470	257	166	102	106	62	36	30	17
13	38	102	510	260	168	102	107	72	37	26	13
14	35	102	507	262	161	102	106	62	37	27	14
15	29	101	488	255	154	101	102	61	34	26	14
16	16	99	543	250	164	99	104	75	38	27	12
17	19	101	513	262	164	101	110	65	39	27	14
18	27	108	505	265	169	108	114	69	38	28	14
19	34	112	501	267	173	113	116	67	41	27	14
20	45	119	519	273	183	120	126	87	43	38	20
21	58	126	501	280	196	127	135	75	41	15	--
22	75	132	516	276	191	133	136	83	40	30	--
23	73	133	528	285	192	134	138	82	46	33	18
24	73	128	520	279	193	129	139	84	46	36	35
25	89	144	513	296	206	145	146	87	48	36	28
26	86	144	528	293	205	145	151	88	48	37	28
27	103	154	518	293	213	156	158	95	51	45	75
28	100	152	481	290	217	154	158	90	46	41	25
29	109	155	523	310	227	157	160	86	49	40	25
30	98	154	514	289	239	156	161	89	46	41	25
31											
Mean	60.0	127	510	277	190	127	131	78	42	32	23

MAR 2003 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	138.1	135.6
02	147.3	144.7
03	149.1	146.5
04	146.0	143.6
05	148.5	146.2
06	150.3	147.9
07	149.9	147.6
08	148.3	146.2
09	152.7	150.6
10	143.7	141.7
11	141.5	139.7
12	138.0	136.2
13	134.2	132.5
14	138.9	137.3
15	130.7	129.3
16	128.6	127.2
17	124.4*	123.1*
18	118.4	117.3
19	108.2	107.2
20	97.4	96.6
21	91.0	90.3
22	89.0	88.3
23	93.0	92.4
24	97.8	97.3
25	108.8	108.2
26	127.2	126.6
27	141.1	140.5
28	146.9	146.4
29	155.1	154.6
30	154.5	154.2
31	160.1	159.8
Mean	132.2	130.8

*1700UT Reading

◆ 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 April 2003 data combine observations from 40 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	88	84	102
											(3)	(5)	(1)
2003	80	77	75	72	69	66	65	63	60	58	56	55	66
	(6)	(6)	(7)	(9)	(10)	(11)	(11)	(11)	(13)	(14)	(15)	(17)	(11)
2004	54	53	52	51	49	48	45	43	41	40	39	37	46
	(19)	(20)	(20)	(20)	(21)	(21)	(21)	(22)	(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 Oct 2003 prediction. There exists a 90% chance that in Oct 2003 the actual smoothed sunspot number will fall somewhere between 44 and 72.

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.