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.

NOVEMBER 2002 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	124	162	525	294	206	159	143	104	52	38	19
02	115	165	508	307	216	162	146	101	51	35	20
03	123	169	500	302	216	166	151	103	51	65	96
04	101	177	513	310	228	173	151	107	58	47	76
05	122	183	631	332	267	179	180	159	60	45	38
06	137	185	539	312	237	181	168	166	55	37	28
07	145	190	526	300	218	186	162	113	52	35	20
08	115	189	522	304	225	185	167	121	56	35	19
09	129	191	522	317	238	187	170	129	55	37	20
10	126	191	547	313	242	187	168	126	54	38	20
11	114	185	507	272	226	181	181	104	54	36	23
12	100	178	520	315	224	174	167	125	50	35	20
13	94	182	518	301	222	178	154	101	52	38	19
14	104	184	516	308	235	180	159	109	51	39	24
15	96	198	511	285	223	193	177	111	54	44	40
16	89	199	530	313	238	194	167	113	55	59	53
17	91	185	548	330	246	180	176	126	54	50	45
18	90	179	523	312	228	174	162	112	57	50	42
19	74	168	505	303	216	163	150	109	53	2	21
20	94	159	517	291	199	155	135	100	54	37	19
21	82	151	508	297	196	147	130	99	54	41	21
22	79	149	--	--	--	145	--	--	--	--	--
23	77	148	524	294	198	144	133	105	57	48	27
24	67	146	528	301	205	142	146	125	54	45	22
25	52	137	491	281	180	133	114	88	44	39	26
26	49	142	509	293	190	138	125	88	56	49	--
27	68	143	509	300	187	139	129	88	54	43	26
28	70	140	499	288	197	136	127	88	51	34	27
29	61	141	544	279	187	137	126	90	52	40	24
30	61	146	578	278	190	141	141	118	52	40	21
31											
Mean	95.0	169	525	301	217	165	152	111	54	41	31

OCT 2002 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	139.8	140.1
02	135.8	136.0
03	145.9	146.1
04	157.5	157.6
05	155.1	155.1
06	161.7	161.6
07	163.8	163.5
08	165.4	165.1
09	167.2	166.8
10	171.9	171.4
11	179.4	178.7
12	180.4	179.7
13	179.2	178.3
14	181.2	180.2
15	176.8	175.7
16	182.5	181.4
17	178.9	177.7
18	172.6	171.3
19	179.5	178.1
20	180.3	178.7
21	182.5	180.8
22	169.4	167.7
23	163.6	161.9
24	160.3	158.5
25	172.9	170.9
26	158.0	156.1
27	157.1	155.2
28	158.3	156.3
29	161.6	159.4
30	167.7	165.3
31	170.2	167.7
Mean	167.0	165.9

♦ 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 November 2002 data combine observations from 37 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 (3)	103 (5)	100 (6)	97 (9)	94 (11)	91 (11)	87 (10)	103 (5)
2003	83 (9)	79 (8)	77 (8)	74 (10)	71 (10)	69 (10)	67 (11)	65 (11)	62 (12)	60 (13)	58 (15)	57 (17)	68 (11)
2004	56 (19)	55 (20)	54 (21)	52 (21)	51 (21)	49 (22)	47 (22)	44 (23)	42 (24)	41 (25)	40 (25)	38 (25)	47 (22)

*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 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 June 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 May 2003 prediction. There exists a 90% chance that in May 2003 the actual smoothed sunspot number will fall somewhere between 61 and 81.

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.