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 2002 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	72	150	508	286	193	145	136	98	53	22	21
02	73	146	519	282	185	141	125	97	52	34	21
03	69	146	520	277	190	141	128	97	53	38	19
04	86	149	508	271	187	144	128	96	53	35	19
05	82	149	535	279	185	144	140	123	53	38	24
06	82	148	508	279	185	143	132	101	49	34	21
07	79	151	522	279	187	146	136	100	50	36	21
08	104	154	509	285	194	149	140	101	51	35	21
09	107	156	518	289	195	151	135	100	52	36	22
10	94	161	528	290	200	156	145	107	54	36	21
11	74	152	519	290	195	147	136	104	52	36	23
12	65	153	524	284	198	148	150	109	49	36	34
13	75	167	528	298	204	161	144	106	51	36	24
14	124	186	520	301	221	180	157	114	55	37	24
15	119	203	526	298	226	196	168	121	57	42	25
16	129	203	559	357	273	196	195	125	64	53	47
17	140	213	558	304	239	206	193	129	58	58	--
18	134	197	532	301	226	190	176	126	59	50	42
19	134	193	534	328	248	186	184	129	61	--	--
20	124	197	517	311	225	190	169	123	51	38	--
21	112	184	521	298	216	178	160	126	55	45	40
22	104	172	542	306	222	166	154	130	51	38	24
23	75	159	515	312	196	153	137	95	49	36	23
24	61	147	515	289	188	142	129	89	49	36	22
25	35	132	517	273	178	127	120	83	44	34	--
26	32	127	258	200	118	122	46	54	42	31	--
27	29	117	507	267	160	113	103	78	46	34	--
28	27	117	493	263	155	113	102	77	48	34	19
29	31	115	493	265	159	111	104	79	47	32	21
30	25	114	500	265	156	110	99	79	49	35	19
31	33	115	--	--	--	111	--	--	--	--	--
Mean	81.6	157	512	288	197	152	139	103	52	37	25

NOV 2002 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
162.2	159.7
164.6	162.1
169.2	166.5
177.4	174.4
183.1	180.0
184.5	181.2
189.8	186.4
189.0	185.5
190.6	187.0
191.4	187.7
184.7	181.0
178.2	174.6
182.4	178.6
184.1	180.2
197.5	193.2
199.2	194.8
184.7	180.5
178.9	174.8
168.2	164.3
159.1	155.3
150.9	147.2
149.1	145.5
147.5	143.8
146.2	142.5
136.8	133.2
142.3	138.5
142.6	138.8
139.7	136.0
141.3	137.5
146.2	142.1
168.7	165.1

♦ 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 December 2002 data combine observations from 35 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	97	94	91	87	103
							(2)	(5)	(8)	(11)	(11)	(10)	(4)
2003	83	79	77	74	71	69	67	65	63	60	58	57	68
	(9)	(8)	(8)	(9)	(10)	(10)	(11)	(11)	(12)	(13)	(15)	(17)	(11)
2004	56	55	54	53	51	49	47	44	42	41	40	38	47
	(18)	(20)	(20)	(20)	(21)	(21)	(21)	(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.

♦ 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 May 2003 prediction. There exists a 90% chance that in June 2003 the actual smoothed sunspot number will fall somewhere between 59 and 79.

<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.