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.

MAY 2001 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	115	210	590	327	221	213	181	157	76	54	18
02	118	176	585	320	207	178	171	151	76	57	37
03	115	172	477	327	215	174	166	153	74	45	26
04	132	176	586	327	207	178	156	147	74	54	33
05	118	161	569	294	184	163	151	139	73	48	---
06	92	155	576	308	185	157	133	136	71	46	18
07	79	138	568	300	170	140	119	124	66	44	15
08	55	129	538	273	163	131	124	115	63	38	14
09	63	129	570	295	169	131	125	120	64	42	15
10	60	130	566	296	173	132	125	121	62	40	16
11	80	137	471	261	166	139	121	108	64	44	20
12	84	138	569	290	173	140	128	120	64	47	26
13	85	139	573	297	176	141	136	123	66	47	27
14	102	138	573	302	174	141	133	116	63	86	17
15	96	142	578	302	178	145	134	128	62	41	16
16	99	138	518	293	172	141	135	125	62	42	20
17	95	147	573	314	206	150	162	132	66	44	21
18	100	138	---	---	---	141	---	---	---	---	---
19	85	141	574	303	180	144	149	120	66	43	16
20	82	142	572	305	180	145	138	133	68	43	18
21	95	150	577	312	187	153	147	133	71	46	18
22	121	152	567	316	192	155	155	135	74	51	28
23	134	159	563	301	192	163	141	135	72	49	52
24	118	170	583	307	190	174	141	141	73	51	32
25	112	162	580	317	193	166	145	136	68	53	32
26	118	147	576	311	187	150	154	138	71	50	57
27	124	147	573	315	182	150	125	136	66	42	20
28	103	143	571	307	181	146	141	130	70	54	22
29	92	139	567	298	175	142	137	127	65	43	18
30	75	132	---	---	---	135	---	---	---	---	---
31	69	133	574	299	171	136	132	121	64	41	37
Mean	97.3	149	564	304	184	151	142	131	68	48	25

APR 2001 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
257.5	257.2
228.0	227.9
223.1	223.1
204.8	205.0
207.5*	207.8*
* 2300UT Reading	
191.7#	192.0#
179.5	180.0
169.2	169.7
164.8	165.4
169.7	170.4
# 1700UT Reading	
159.6	160.3
149.0	149.8
137.0	137.8
138.7	139.6
134.2	135.1
123.4	124.3
126.1	127.1
131.8	133.0
144.5	145.8
180.4	182.2
191.1	193.0
192.5	194.6
196.4	198.6
193.5	195.8
193.9	196.3
196.2	198.7
190.8	193.3
187.8	190.4
191.7	194.5
187.8	190.7
178.1	179.3

♦ 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 May 2001 data combine observations from 37 stations. http://www.oma.be/KSB-ORB/SIDC/index.html.

♦ 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
1991	148	148	147	147	146	145	146	147	145	142	138	132	144
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
												(4)	0
2001	112	112	112	111	111	110	109	108	107	106	105	104	109
	(6)	(9)	(11)	(15)	(19)	(19)	(19)	(20)	(23)	(24)	(24)	(23)	(18)
2002	103	102	100	97	95	93	90	88	85	83	80	77	91
	(23)	(23)	(23)	(23)	(22)	(21)	(21)	(20)	(20)	(19)	(19)	(17)	(21)

*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 December 2000 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 November 2001 prediction. There exists a 90% chance that in November 2001 the actual smoothed sunspot number will fall somewhere between 81 and 129.

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.