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 2000 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	124	185	570	298	191	179	220	152	85	99	100
02	109	167	563	299	192	162	144	147	85	85	120
03	128	164	580	293	186	159	154	136	74	46	18
04	66	152	556	287	179	147	148	126	69	45	17
05	65	147	571	261	171	142	121	123	69	47	21
06	63	141	581	293	183	136	129	112	59	45	23
07	68	144	556	286	193	139	160	118	65	44	19
08	61	138	553	284	174	133	122	108	65	43	16
09	58	135	559	278	170	130	118	107	65	44	17
10	62	147	575	279	182	142	---	114	68	45	17
11	72	144	562	276	169	139	129	122	68	---	17
12	89	150	570	279	178	145	131	124	68	45	13
13	114	165	569	296	197	159	151	137	---	42	16
14	135	182	565	291	190	176	157	146	73	49	24
15	153	188	574	298	195	182	149	147	76	47	19
16	145	191	589	306	207	184	159	162	78	48	19
17	151	197	590	330	221	190	154	---	79	---	21
18	138	198	585	308	217	191	171	159	83	---	22
19	118	199	586	319	223	192	161	164	81	53	23
20	120	201	589	297	211	194	153	172	82	52	23
21	116	195	589	309	221	188	160	163	80	51	23
22	107	190	589	317	219	183	190	166	68	45	21
23	102	191	597	319	228	184	160	163	80	50	22
24	115	193	---	---	---	186	---	---	---	---	---
25	108	187	582	303	216	180	155	163	84	51	20
26	121	189	585	305	214	182	153	154	80	51	23
27	118	188	587	334	228	181	145	156	84	52	18
28	118	185	579	297	206	178	151	152	79	51	27
29	99	182	---	---	---	175	---	---	---	---	---
30	111	182	577	290	213	175	147	142	77	51	19
31	87	170	---	---	---	164	---	---	---	---	---
Mean	104.5	174	576	298	199	168	152	142	75	51	26

NOV 2000 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
204.4	201.2
196.3	193.2
198.8	195.5
194.7	191.4
186.4	183.1
178.1	174.9
179.9	176.6
172.8	169.5
166.2	163.0
153.4	150.4
149.6	146.6
146.6	143.6
143.7	140.6
148.6	145.4
146.5	143.2
154.2	150.7
163.3	159.6
177.1	172.9
174.9	170.7
173.7	169.6
185.4	180.9
194.9	190.1
205.3	200.1
197.1	192.1
202.3*	197.0*
* 18UT Observation	
202.4	197.0
191.7	186.6
195.5	190.3
188.4	183.2
192.3	187.0
178.8	174.9

♦ 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 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 2000 data combine observations from 32 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
1990	151	153	152	149	147	144	141	141	142	142	142	144	146
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	113	117	120	121	119	119	119	119	119	118	117	116	118
							(6)	(12)	(16)	(19)	(23)	(26)	(9)
2000	116	116	115	115	114	114	113	111	111	109	108	107	112
	(27)	(29)	(30)	(33)	(36)	(35)	(33)	(32)	(33)	(34)	(33)	(32)	(32)
2001	106	105	102	100	98	95	93	90	87	85	82	79	93
	(32)	(32)	(31)	(30)	(28)	(10)	(27)	(26)	(26)	(25)	(23)	(22)	(23)

*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 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 June 2001 prediction. There exists a 90% chance that in June 2001 the actual smoothed sunspot number will fall somewhere between 79 and 149.

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.