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 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	133	221	580	368	283	214	226	135	62	43	21
02	137	245	---	---	---	238	---	---	---	---	---
03	150	235	566	320	253	228	199	153	68	46	18
04	145	233	580	354	274	226	206	148	67	45	17
05	158	237	590	363	286	230	207	149	67	48	26
06	142	247	596	347	275	239	208	151	70	53	24
07	138	226	564	348	263	219	199	138	100	106	95
08	140	221	572	345	262	214	192	133	67	48	26
09	141	224	584	351	265	217	195	130	64	288	25
10	115	219	573	364	288	212	217	140	66	51	27
11	106	221	545	317	251	214	203	135	64	48	---
12	117	237	598	367	289	229	216	137	67	51	33
13	119	220	---	---	---	213	---	---	---	---	---
14	101	245	536	363	284	237	217	139	63	43	26
15	108	218	648	344	260	211	196	129	65	53	25
16	120	209	556	311	233	202	193	127	62	63	39
17	119	206	549	324	235	199	178	124	63	74	28
18	115	212	568	337	249	205	180	136	69	59	28
19	99	208	574	339	246	201	189	132	66	56	29
20	101	221	578	340	259	213	209	132	65	53	31
21	120	234	580	344	267	226	207	145	67	53	26
22	135	243	583	356	285	235	210	145	65	59	26
23	133	255	553	350	300	246	220	147	68	51	61
24	157	275	588	376	336	265	248	154	74	54	33
25	143	259	561	386	329	250	238	151	71	61	62
26	167	268	---	---	---	259	---	---	---	---	---
27	164	275	561	367	305	265	243	154	73	50	29
28	156	263	643	443	372	254	282	164	73	53	27
29	137	264	604	378	313	255	243	154	71	53	31
30	134	247	567	324	261	238	223	152	69	48	28
31	135	246	582	346	256	237	211	157	68	53	32
Mean	113.8	237	578	353	278	229	213	143	68	63	32

NOV 2001 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
235.6	232.0
213.5	210.1
216.0	212.5
227.3	223.5
234.6	230.6
237.4	233.2
268.8	263.9
247.8	243.1
270.8	265.6
245.9	241.0
234.0	229.3
227.3	222.6
231.6	226.8
217.2	212.6
207.0	202.4
202.1	197.6
198.5	194.0
188.2	183.8
191.3	186.8
185.0	180.6
184.2	179.7
190.0#	185.3#
177.3	172.9
173.0	168.6
170.0	165.6
# 1800UT Reading	
174.8	170.3
190.4	185.3
198.5	193.1
216.4	210.5
225.8	219.6
212.7	208.1

♦ 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 2001 data combine observations from 34 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

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
2001	109	104	105	108	109	110	109	108	107	106	105	104	107
							(5)	(10)	(12)	(14)	(14)	(15)	(6)
2002	103	101	99	97	95	93	90	87	85	82	80	77	91
	(15)	(16)	(18)	(20)	(21)	(20)	(19)	(19)	(18)	(18)	(18)	(16)	(18)
2003	74	72	69	67	64	62	60	58	57	54	53	51	62
	(13)	(12)	(13)	(14)	(15)	(16)	(16)	(17)	(17)	(18)	(19)	(21)	(16)

*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 2001 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 2002 prediction. There exists a 90% chance that in June 2002 the actual smoothed sunspot number will fall somewhere between 73 and 113.

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.