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 Learmonth, Australia (LEAR) data reflect equipment problems. Fluxes measured either at Palehua on the Hawaiian Islands, or at San Vito, Italy, will be substituted for frequencies at which many Learmonth values are missing.

DECEMBER 1998 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	LEAR	LEAR	LEAR	Pentic	LEAR	LEAR	LEAR	LEAR	LEAR
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	127	163	542	265	185	158	158	125	80	53	26
02	87	152	549	265	183	148	158	124	81	53	23
03	91	153	548	268	179	149	146	124	80	51	23
04	86	148	544	262	174	144	154	118	72	46	23
05	68	142	535	252	172	138	140	116	---	---	24
06	89	142	---	---	166	138	138	108	---	---	13
07	95	153	553	261	175	148	141	109	74	50	23
08	119	162	546	258	183	157	145	107	74	51	24
09	103	154	542	232	181	149	153	112	74	55	25
10	108	134	548	261	182	130	143	107	72	48	21
11	105	143	544	255	173	139	137	101	71	50	23
12	102	143	546	257	174	139	137	102	72	48	24
13	84	144	531	243	168	140	133	101	73	52	-1
14	83	144	562	235	167	140	132	102	71	56	72
15	72	142	538	256	167	138	132	103	73	51	29
16	60	141	547	261	168	136	134	103	71	48	22
17	49	146	574	262	168	141	135	103	72	49	24
18	60	155	575	269	171	150	136	106	72	47	24
19	50	138	---	268	170	134	134	103	73	49	25
20	50	135	553	271	166	131	132	102	75	50	24
21	43	135	510	252	158	131	124	102	65	42	20
22	39	129	536	271	160	125	129	104	72	48	23
23	47	140	576	276	165	135	130	110	81	53	26
24	58	139	560	266	167	134	136	111	78	50	23
25	66	144	558	262	170	139	138	111	74	50	24
26	81	145	---	287	180	140	146	117	---	53	24
27	100	167	550	293	193	161	144	117	77	51	23
28	121	184	568	306	217	178	171	130	79	49	19
29	96	183	560	319	225	177	170	125	83	53	23
30	99	179	553	325	235	173	171	124	83	54	22
31	92	175	584	284	209	169	164	120	75	51	22
Mean	82	150	551	268	179	145	143	111	75	50	24

NOV 1998 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
121.4	119.5
126.1	124.1
151.8	149.3
141.4	139.0
152.7	150.1
140.9	138.4
148.5	145.8
152.7	149.9
162.4	159.3
153.8	150.8
147.1	144.1
141.6	138.7
135.4	132.6
126.5	123.8
126.4	123.7
124.6	121.8
120.8	118.0
114.8	112.2
116.5	113.7
121.5	118.6
121.2	118.3
126.1	123.0
129.9	126.7
140.2	136.7
149.5	145.6
156.4	152.3
158.9	154.7
164.8	160.4
167.8	163.2
163.4	158.9
140.2	137.1

♦ 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 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 August 1998 data combine observations from 31 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
1988	58	65	71	78	84	94	104	114	121	125	130	138	98
1989	142	145	150	154	157	158	159	158	157	157	158	154	154
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	69	75	82	88	92	97	66
							(2)	(5)	(7)	(9)	(12)	(15)	(3)
1999	101	105	109	114	118	123	126	129	131	134	137	139	121
	(17)	(18)	(17)	(16)	(15)	(16)	(20)	(23)	(26)	(29)	(32)	(34)	(21)
2000	140	140	141	141	140	139	138	138	137	135	133	132	138
	(37)	(39)	(41)	(43)	(43)	(42)	(41)	(41)	(42)	(42)	(43)	(43)	(41)

*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 1998 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 1999 prediction. There exists a 90% chance that in June 1999 the actual smoothed sunspot number will fall somewhere between 107 and 139.

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.