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.

SEPTEMBER 1998 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit LEAR (15400)	LEAR (8800)	LEAR (4995)	Pentic (2800)	LEAR (2695)	LEAR (1415)	LEAR (610)	LEAR (410)	LEAR (245)
01	100	177	599	303	223	180	168	116	64	54	55
02	85	163	595	311	230	166	164	111	61	48	44
03	79	163	596	303	221	166	163	114	64	60	117
04	68	155	589	287	214	158	159	109	66	51	26
05	80	154	585	280	212	156	156	110	63	46	21
06	112	165	572	276	204	168	154	108	---	---	---
07	116	151	577	266	194	153	151	111	58	42	16
08	125	154	561	259	190	156	155	109	56	42	14
09	119	145	565	262	188	147	157	113	56	39	18
10	112	142	558	259	183	144	148	111	58	40	14
11	96	139	571	255	174	141	143	110	58	40	17
12	92	135	570	255	168	137	142	109	57	39	14
13	95	131	567	249	166	133	134	104	57	38	14
14	78	122	562	244	158	124	126	98	54	37	14
15	60	117	566	241	153	118	117	93	53	37	14
16	56	119	566	245	154	120	115	91	52	37	20
17	74	117	564	247	154	118	115	92	53	37	14
18	70	123	568	243	156	124	116	92	53	36	13
19	93	127	569	251	164	128	122	95	53	36	13
20	114	132	564	250	172	133	126	98	50	35	12
21	125	138	565	247	169	139	133	101	54	36	14
22	138	141	566	247	172	142	134	101	54	37	23
23	135	143	572	252	173	144	137	103	57	45	30
24	117	135	568	255	177	136	135	103	50	37	29
25	105	139	561	256	171	140	130	99	42	35	54
26	82	136	564	255	168	137	130	100	40	34	32
27	76	127	566	251	168	128	127	100	42	35	---
28	85	123	561	248	160	123	122	96	---	---	17
29	60	116	566	249	156	116	118	95	42	---	14
30	41	122	555	244	152	122	113	93	43	31	12
31											
Mean	93	138	570	260	178	140	137	103	54	40	25

AUG 1998 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	112.1	115.4
02	109.6	112.9
03	108.5	111.7
04	115.8	119.2
05	126.8	130.5
06	138.3	142.2
07	145.0	149.1
08	146.8	150.9
09	154.1	158.3
10	149.2	153.3
11	150.1	154.1
12	147.0	150.9
13	136.8	140.4
14	137.0	140.6
15	133.4	136.8
16	139.7	143.3
17	136.3	139.7
18	132.6	135.8
19	134.6	137.9
20	138.6	141.9
21	132.1	135.2
22	132.9	135.9
23	126.4	129.3
24	121.2	123.9
25	122.1	124.8
26	126.9	129.6
27	135.0	137.8
28	139.2	142.0
29	146.5	149.4
30	163.3	166.4
31	178.5	181.8
Mean	136.0	139.4

♦ 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 40 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	54	59	64	70	77	84	91	98	103	108	75
				(3)	(6)	(8)	(10)	(13)	(15)	(18)	(21)	(24)	(10)
1999	112	116	120	126	131	136	140	142	144	148	151	153	135
	(26)	(27)	(27)	(27)	(26)	(27)	(30)	(32)	(34)	(38)	(40)	(42)	(31)
2000	153	153	154	154	152	150	149	148	147	145	142	140	149
	(45)	(48)	(49)	(51)	(51)	(50)	(48)	(49)	(49)	(49)	(49)	(49)	(49)

*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 March 1999 prediction. There exists a 90% chance that in March 1999 the actual smoothed sunspot number will fall somewhere between 93 and 147.

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.