SOLAR INDICES BULLETIN

APRIL 1998

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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.

APRIL 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	56	106	546	225	149	106	105	76	40	30	14
02	59	103	---	223	140	103	98	71	---	---	---
03	57	104	545	224	143	104	99	75	35	27	24
04	51	110	554	228	148	110	103	79	38	29	17
05	59	126	560	238	158	126	114	83	44	34	23
06	63	133	---	---	---	133	---	---	49	39	23
07	93	135	551	236	165	135	130	91	49	38	25
08	106	141	555	233	173	141	138	99	43	39	27
09	125	140	471	---	---	140	---	---	48	36	18
10	108	130	299	184	139	131	127	96	39	35	38
11	96	128	472	228	157	129	125	90	---	---	---
12	75	117	474	213	152	118	120	96	49	35	18
13	59	115	477	228	153	116	114	93	48	33	13
14	70	112	469	219	149	113	112	91	48	34	20
15	63	113	462	214	149	114	106	89	48	34	14
16	54	106	480	207	149	107	110	88	48	36	17
17	46	101	492	200	144	102	102	84	49	36	15
18	23	99	482	190	141	100	101	80	48	36	16
19	31	96	482	190	140	97	98	75	47	35	15
20	30	98	485	184	136	99	93	71	44	33	16
21	34	92	630	196	134	93	89	69	41	31	16
22	32	88	619	191	132	89	86	68	41	31	13
23	26	90	610	191	129	91	82	64	41	32	22
24	16	91	619	191	134	92	87	66	42	32	12
25	23	92	616	191	133	93	88	65	42	32	15
26	13	91	620	188	130	92	90	67	41	32	16
27	12	91	615	193	131	92	90	68	42	34	23
28	32	98	617	191	135	99	90	68	41	30	16
29	42	101	616	198	140	103	96	70	44	38	25
30	46	103	616	237	138	105	97	70	47	34	22
31											
Mean	53.3	108	537	208	144	109	103	79	44	34	19

MAR 1998 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
98.3	96.5
91.5*	89.9*
96.6	95.0
101.7	100.0
96.7	95.1
*Snow on antenna	
91.7	90.3
91.9	90.5
91.2	89.9
90.0	88.7
96.3	95.0
100.7	99.4
101.6	100.3
104.9	103.7
119.6	118.2
133.0	131.6
123.9	122.6
125.5	124.3
127.0	125.9
124.6	123.5
126.5	125.5
125.8	124.9
127.6	126.8
122.0	121.3
120.6	119.9
115.0	114.4
110.0	109.5
108.1	107.7
103.9	103.6
100.3	100.0
107.5	107.2
108.1	107.9
109.1	108.0

♦ 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 April 1998 data combine observations from 42 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
1987	18	20	22	24	27	28	31	35	39	44	47	51	32
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	29	32	36	40	23
											(2)	(4)	(1)
1998	46	51	57	62	67	73	80	88	95	102	107	111	78
	(6)	(8)	(11)	(14)	(17)	(19)	(22)	(25)	(28)	(31)	(34)	(37)	(21)
1999	116	120	125	131	136	142	146	149	151	154	158	160	141
	(40)	(40)	(39)	(40)	(40)	(41)	(43)	(43)	(45)	(49)	(51)	(52)	(44)

*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 1997 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 October 1998 prediction. There exists a 90% chance that in October 1998 the actual smoothed sunspot number will fall somewhere between 71 and 133.

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.

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