SOLAR INDICES BULLETIN

APRIL 2004

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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.

APRIL 2004 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	55	113	483	253	164	112	121	68	37	27	19
02	51	108	390	228	145	107	111	65	32	28	19
03	47	107	483	252	162	107	116	65	34	29	16
04	55	109	485	245	157	109	114	65	34	29	16
05	57	109	487	262	165	109	115	66	35	31	16
06	40	101	479	251	160	101	109	61	33	27	16
07	39	98	486	252	154	98	104	60	36	29	17
08	27	94	478	248	149	94	98	59	37	0	16
09	15	90	487	241	143	90	94	55	35	31	18
10	13	88	474	237	144	88	93	54	35	27	18
11	13	90	490	244	146	90	94	55	35	28	16
12	25	91	489	243	149	91	99	55	32	26	14
13	35	93	485	255	153	93	101	58	33	27	16
14	42	95	495	261	161	95	106	60	36	29	13
15	34	97	487	241	154	97	103	59	36	29	17
16	31	97	499	247	155	97	105	58	36	28	16
17	50	98	503	254	157	98	107	60	36	28	15
18	58	109	500	263	169	109	117	67	37	29	15
19	63	113	503	257	161	114	120	68	33	29	11
20	59	111	139	167	112	112	52	40	32	26	12
21	59	113	361	256	166	114	120	70	35	30	22
22	57	117	501	264	169	118	124	72	38	31	21
23	43	115	501	266	171	116	125	70	39	31	23
24	38	112	490	261	169	113	116	67	36	30	16
25	31	107	493	255	165	108	114	64	35	32	15
26	34	100	502	258	160	101	109	60	36	29	15
27	26	95	496	253	154	96	102	58	34	29	15
28	23	90	491	249	150	91	95	55	32	27	14
29	24	89	505	248	146	90	97	55	34	28	14
30	34	89	505	248	147	90	95	55	34	28	15
31											
Mean	39.3	101	472	249	155	102	106	61	35	28	16

MAR 2004 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
101.8	100.0
98.8	97.1
90.4	88.9
97.5	95.9
106.7	105.0
104.5	102.9
106.1	104.6
107.8	106.3
108.7	107.2
112.6	111.1
113.2	111.7
107.5	106.2
103.8	102.6
102.5	101.3
101.4	100.3
109.6	108.5
109.8	108.8
115.4	114.4
112.2	111.3
113.6	112.7
111.2	110.4
116.4	115.6
118.3	117.6
119.7	119.0
127.0	126.4
123.8	123.2
127.6	127.2
129.0	128.6
128.6	128.3
126.7	126.4
121.2	121.0
112.0	111.0

◆ 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 2004 data combine observations from 45 stations. (http://sidc.oma.be)

◆ 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
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	120.7#	119	119	120	119	116	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	115	115	111
2002	114	115	113	111	109	106	103	99	95	91	85	82	102
2003	81	79	74	70	68	65	62	60	60	58	56 (3)	55 (6)	66 (1)
2004	54 (8)	53 (10)	52 (11)	51 (12)	50 (13)	48 (13)	46 (15)	43 (16)	41 (18)	40 (19)	39 (19)	38 (20)	46 (15)
2005	36 (21)	34 (21)	32 (21)	31 (21)	30 (21)	28 (21)	27 (20)	26 (20)	26 (21)	25 (20)	23 (19)	22 (18)	28 (20)

*May 1996 marks Cycle 22's mathematical minimum. **October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

◆ 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 December 2003 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 2004 prediction. There exists a 90% chance that in October 2004, the actual smoothed sunspot number will fall somewhere between 21 and 59.

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.