SOLAR INDICES BULLETIN

MARCH 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 $10^{-22}\ \mathrm{J/m^2 Hz sec}$. 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.

MARCH 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	44	102	524	231	154	100	106	57	31	25	15
02	31	99	491	243	152	97	101	57	33	28	15
03	26	90	484	243	150	88	99	56	33	28	22
04	23	98	490	242	157	96	106	59	31	28	20
05	35	107	506	249	160	105	106	60	36	29	19
06	39	105	506	254	161	103	111	60	36	32	15
07	40	106	484	255	160	104	108	62	35	29	17
08	35	108	496	247	167	106	115	63	38	32	25
09	38	109	494	254	162	107	113	67	39	32	27
10	38	113	—	—	—	111	—	—	—	—	—
11	38	113	—	—	—	111	—	—	—	—	—
12	48	108	492	259	166	106	120	68	37	30	25
13	40	104	—	—	—	102	—	—	—	—	—
14	38	103	467	235	160	101	114	64	43	29	15
15	32	101	492	248	151	99	106	62	38	48	14
16	37	110	503	254	163	108	113	67	38	12	18
17	48	110	513	250	163	108	113	65	36	31	23
18	49	115	513	258	173	113	124	68	36	32	17
19	58	112	503	256	165	111	117	65	36	30	17
20	50	114	492	250	162	113	118	65	34	27	20
21	48	111	505	253	162	110	115	65	37	30	15
22	57	116	498	256	165	115	121	67	37	29	14
23	61	118	507	249	168	117	124	69	30	27	18
24	57	120	508	265	174	119	130	71	32	38	20
25	83	127	516	261	177	126	130	73	25	26	15
26	84	124	515	255	184	123	135	72	36	29	16
27	88	128	516	273	188	127	133	76	36	30	17
28	76	129	512	270	182	128	133	77	37	30	15
29	66	129	510	263	183	128	137	69	38	32	20
30	54	127	501	266	177	126	131	71	48	58	
31	56	121	477	256	171	120	128	71	39	34	37
Mean	48.9	112	501	253	166	111	118	66	36	31	19

FEB 2004 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	97.3	94.5
02	101.5	98.5
03	99.4	96.6
04	101.4	98.6
05	105.5	102.5
06	106.7	103.7
07	111.1	108.1
08	116.2	113.1
09	117.8	114.7
10	116.5	113.5
11	114.2	111.2
12	112.2	109.3
13	107.8	105.1
14	103.7	101.1
15	102.1	99.6
16	98.7	96.3
17	101.9	99.5
18	97.7	95.4
19	96.4	94.2
20	95.4	93.2
21	98.2	96.0
22	103.9	101.7
23	104.3	102.1
24	105.5	103.4
25	118.5	116.1
26	120.8	118.4
27	122.2	119.8
28	115.8	113.6
29	110.0	108.0
30		
31		
Mean	107.0	104.4

♦ 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 March 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	58	56	54	53	65
									(4)	(8)	(10)	(12)	(3)
2004	52	51	49	48	47	46	44	41	39	38	37	36	44
	(13)	(14)	(15)	(16)	(16)	(17)	(18)	(19)	(20)	(21)	(21)	(22)	(18)
2005	34	32	31	30	28	27	26	25	25	24	22	22	27
	(22)	(22)	(22)	(22)	(22)	(22)	(21)	(21)	(21)	(20)	(19)	(18)	(21)

*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 September 2004 prediction. There exists a 90% chance that in September 2004, the actual smoothed sunspot number will fall somewhere between 22 and 60.

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.