SOLAR INDICES BULLETIN

OCTOBER 2003

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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.

OCTOBER 2003 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	76	137	521	291	194	137	141	81	38	34	17
02	68	125	--	--	--	125	PALE	--	--	--	--
03	62	120	496	277	178	120	127	76	41	33	19
04	49	119	479	258	169	119	123	75	37	30	16
05	57	110	503	273	167	110	119	73	40	31	17
06	41	112	487	274	171	111	120	71	37	29	15
07	41	112	503	296	178	111	124	75	40	34	16
08	43	113	501	271	173	112	121	69	38	31	15
09	47	111	490	268	175	110	119	66	41	31	16
10	45	112	504	269	168	111	118	66	39	31	15
11	41	106	497	261	159	105	110	66	29	28	15
12	25	98	420	246	154	97	101	62	34	28	15
13	13	94	435	247	157	93	102	61	37	22	16
14	13	92	433	220	143	91	96	59	38	31	16
15	13	96	454	240	160	95	108	80	33	29	15
16	19	95	441	246	158	94	103	58	38	29	17
17	30	99	452	245	155	98	105	61	36	31	17
18	41	109	462	261	176	108	115	68	38	48	93
19	41	120	484	288	198	119	127	72	37	35	33
20	47	135	536	312	242	133	142	102	45	52	139
21	59	152	536	360	276	150	166	80	43	65	165
22	58	154	--	--	--	152	--	--	--	--	--
23	61	183	611	475	368	181	213	102	44	48	76
24	75	191	437	398	307	188	191	100	48	48	77
25	88	222	457	434	367	219	229	107	65	99	188
26	89	298	539	435	364	294	249	127	57	58	72
27	133	257	543	485	399	253	268	121	56	315	188
28	165	274	607	530	443	270	285	134	71	189	188
29	167	279	--	--	--	275	--	--	--	--	--
30	167	271	527	455	406	267	272	123	--	--	--
31	160	249	567	444	384	245	256	117	53	54	47
Mean	65.6	153	497	324	235	151	155	84	43	55	56

SEPT 2003 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	108.1	110.1
02	105.7	107.6
03	110.5	112.4
04	112.2	114.1
05	108.0	109.8
06	104.9	106.6
07	107.8	109.4
08	98.8	100.3
09	95.9	97.3
10	99.3	100.6
11	96.7	98.0
12	94.4	95.6
13	96.1	97.3
14	94.7	95.8
15	97.3	98.4
16	99.3	100.4
17	105.9	107.0
18	109.2	110.2
19	111.1	112.1
20	111.9	112.9
21	119.9	120.9
22	122.6	123.5
23	124.9	125.7
24	133.5	134.3
25	132.6	133.4
26	131.1	131.8
27	129.7	130.3
28	137.0	137.6
29	135.1	135.6
30	133.0	133.3
31		
Mean	112.2	113.4

♦ 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 October 2003 data combine observations from 40 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	67 (3)	65 (5)	63 (7)	61 (9)	59 (11)	57 (13)	55 (15)	54 (17)	65 (7)
2004	53 (19)	51 (19)	50 (20)	49 (20)	48 (21)	46 (21)	44 (21)	42 (22)	40 (22)	39 (23)	38 (23)	36 (24)	45 (21)
2005	34 (24)	33 (23)	31 (23)	30 (23)	29 (23)	27 (22)	26 (22)	26 (22)	25 (22)	24 (21)	23 (20)	22 (19)	27 (22)

*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 <u>smoothed</u> 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 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 April 2004 prediction. There exists a 90% chance that in April 2004 the actual smoothed sunspot number will fall somewhere between 29 and 69.

<u>The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead.</u> 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.