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 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.

SEPTEMBER 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	46	108	502	272	166	109	119	75	42	31	15
02	43	106	512	274	167	107	114	73	42	31	15
03	47	111	510	276	169	112	122	79	41	37	19
04	50	112	513	283	178	113	122	78	40	32	16
05	39	108	507	270	167	109	117	73	39	31	16
06	37	105	493	268	164	106	115	71	39	30	15
07	30	108	511	269	162	109	114	73	38	29	--
08	25	99	503	265	156	100	107	69	36	29	8
09	17	96	499	260	159	97	105	66	39	31	21
10	28	99	495	266	158	100	105	65	35	29	11
11	34	97	495	266	159	98	107	64	40	32	8
12	29	94	493	251	152	95	102	60	38	29	--
13	30	96	497	263	159	97	102	60	34	28	--
14	36	95	527	268	168	96	106	98	21	22	11
15	42	97	508	265	160	98	107	60	31	26	--
16	46	99	502	267	164	100	--	63	38	30	--
17	58	106	496	266	167	107	115	67	38	32	--
18	58	109	501	274	171	109	121	69	41	31	17
19	52	111	505	274	171	111	121	71	--	--	--
20	46	112	513	281	180	112	126	72	41	34	16
21	50	120	511	284	185	120	130	76	39	22	16
22	57	123	467	272	176	123	130	74	42	34	30
23	65	125	381	270	179	125	133	78	42	33	16
24	64	134	389	294	194	134	143	84	46	36	18
25	67	133	395	261	183	133	143	82	36	32	16
26	77	131	399	277	186	131	142	85	42	34	18
27	79	130	430	272	181	130	138	78	44	32	27
28	71	137	466	288	199	137	146	83	40	37	30
29	74	135	488	297	206	135	150	83	42	36	21
30	66	133	508	287	193	133	141	82	41	35	22
31											
Mean	48.8	112	484	273	173	113	122	74	39	31	17

AUGUST 2003 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	107.3	110.6
02	111.4	114.7
03	120.0	123.6
04	122.5	126.0
05	130.6	134.4
06	128.7	132.4
07	137.0	140.9
08	132.9	136.6
09	130.0	133.6
10	131.1	134.7
11	129.2	132.7
12	123.3	126.6
13	130.8	134.3
14	129.7	133.1
15	131.4	134.7
16	126.9	130.1
17	119.3	122.3
18	115.9	118.7
19	116.7	119.5
20	111.8	114.5
21	119.2	122.0
22	120.9	123.7
23	120.2	122.9
24	116.4	119.0
25	116.5	119.0
26	120.8	123.4
27	125.7	128.3
28	118.7	121.1
29	116.3	118.7
30	114.0	116.2
31	109.7	111.8
Mean	122.1	125.2

♦ 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 September 2003 data combine observations from 37 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	72	69	66	64	62	60	58	56	54	66
				(3)	(5)	(7)	(8)	(10)	(12)	(14)	(16)	(18)	(8)
2004	53	52	51	50	49	47	45	42	41	40	38	37	45
	(19)	(20)	(20)	(21)	(21)	(21)	(21)	(22)	(23)	(24)	(24)	(24)	(22)
2005	35	33	32	30	29	28	27	26	25	24	23	22	28
	(24)	(24)	(24)	(23)	(23)	(23)	(22)	(22)	(22)	(21)	(20)	(19)	(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 March 2004 prediction. There exists a 90% chance that in March 2004 the actual smoothed sunspot number will fall somewhere between 31 and 71.

<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.