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

JULY 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	17	81	490	237	141	83	90	52	26	24	12
02	20	81	462	223	135	83	90	49	23	24	11
03	20	80	490	232	135	82	85	49	31	25	11
04	19	79	492	236	138	81	87	50	31	26	12
05	16	78	494	227	137	80	85	51	31	26	11
06	17	79	498	235	137	81	87	49	31	27	11
07	9	79	497	229	137	81	86	50	36	27	11
08	11	82	479	236	140	84	91	50	36	27	11
09	27	87	488	239	143	89	96	53	38	29	12
10	38	93	500	245	153	96	101	56	37	26	12
11	47	104	506	242	159	107	113	61	39	28	12
12	50	125	502	262	182	129	136	70	32	30	12
13	88	127	523	280	203	131	151	74	41	28	12
14	90	138	522	274	199	142	152	77	37	30	20
15	82	146	525	277	206	150	159	83	41	33	18
16	65	147	527	284	214	151	157	84	46	34	18
17	79	149	546	307	230	153	167	86	51	40	19
18	93	155	512	303	239	160	179	87	50	40	48
19	100	170	529	326	265	175	196	98	53	46	47
20	91	175	538	325	278	180	202	91	58	67	—
21	88	172	532	310	271	177	194	92	58	73	—
22	84	173	533	313	276	178	194	93	54	46	41
23	74	165	535	301	264	170	189	92	47	49	—
24	69	147	516	282	236	151	161	78	47	41	34
25	57	145	528	285	226	149	158	79	51	53	—
26	64	128	509	266	207	132	141	71	40	29	13
27	55	118	521	263	191	121	129	63	34	28	13
28	39	101	500	252	167	104	112	58	36	29	12
29	24	100	505	240	161	103	110	58	39	28	11
30	24	89	510	239	147	91	—	54	34	30	20
31	23	86	495	241	142	88	93	53	35	28	16
Mean	51.0	119	510	265	189	122	133	68	40	35	18

JUN 2004 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
90.0	92.5
90.4	93.0
90.0	92.6
89.4	92.0
84.5	87.0
88.4	91.0
88.5	91.2
86.0	88.6
85.2	87.9
82.5	85.0
83.9	86.5
88.0	90.7
95.2	98.2
99.9	103.1
109.4	112.9
111.5	115.1
111.3	114.9
107.8	111.3
112.7	116.4
119.1	123.0
115.8	119.6
116.7	120.5
112.5	116.2
108.3	111.9
102.9	106.3
98.9	102.2
97.2	100.4
89.4	92.4
85.1	87.9
81.8	84.5
97.4	100.5

♦ 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 July 2004 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	68	65	62	60	60	58	57	55	66
2004	52	51 (2)	50 (4)	49 (5)	47 (6)	46 (7)	44 (9)	42 (12)	40 (14)	39 (15)	38 (16)	36 (17)	44 (9)
2005	34 (18)	33 (19)	31 (19)	30 (19)	29 (20)	27 (19)	26 (19)	26 (19)	25 (19)	24 (19)	23 (18)	22 (17)	27 (19)

*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 March 2004 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 January 2005 prediction. There exists a 90% chance that in January 2005, the actual smoothed sunspot number will fall somewhere between 16 and 52.

<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.