SOLAR INDICES BULLETIN

NOVEMBER 2003

NATIONAL GEOPHYSICAL DATA CENTER
Solar-Terrestrial Physics Division (E/GC2)
Telephone (303) 497-6346

325 Broadway
Boulder, Colorado 80305-3328 USA
ISSN 1046-1914

♦ 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} $J/m^2Hz\,sec$. 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.

NOVEMBER 2003 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	PALE	PALE	PALE	Pentic	PALE	PALE	PALE	PALE	PALE
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	106	210	575	398	321	206	218	108	122	119	73
02	112	190	596	394	294	186	201	117	55	41	25
03	72	167	550	351	261	164	172	91	52	57	31
04	52	168	562	331	251	165	181	95	44	30	18
05	12	114	501	256	168	112	116	66	38	30	15
06	9	98	416	223	153	96	104	58	33	28	15
07	12	91	481	242	146	89	93	52	29	27	15
08	21	93	495	242	148	91	95	57	35	29	15
09	39	93	495	244	149	91	96	55	33	28	15
10	39	95	---	---	---	93	---	---	---	---	---
11	30	96	---	---	---	94	---	---	---	---	---
12	11	99	486	243	151	96	97	57	34	31	16
13	21	102	501	248	159	99	100	58	34	28	17
14	23	99	497	262	160	96	103	55	34	29	16
15	33	98	497	245	157	95	103	64	30	28	18
16	42	104	478	248	167	101	115	67	37	34	44
17	34	121	502	274	187	118	131	74	41	44	57
18	52	144	525	295	215	140	151	81	41	40	30
19	70	155	---	---	---	151	---	---	---	---	---
20	90	175	514	296	229	170	181	88	43	40	39
21	97	177	515	303	233	172	184	95	41	30	19
22	91	176	551	307	238	171	192	104	40	31	19
23	109	178	482	283	221	173	191	101	45	35	19
24	107	177	520	282	220	172	190	104	46	35	20
25	131	171	505	277	213	166	175	101	47	40	32
26	119	171	523	268	216	166	179	103	49	52	---
27	132	175	514	284	213	170	180	102	44	32	20
28	121	168	511	284	214	163	170	100	46	37	17
29	113	166	501	271	205	161	165	109	41	34	18
30	116	153	442	241	190	148	157	88	43	37	19
31											
Mean	67.2	141	509	281	203	137	150	83	44	38	25

OCT 2003 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	136.8	137.1
02	124.8	125.0
03	120.1	120.3
04	119.0	119.0
05	109.6	109.6
06	112.1	112.0
07	111.9	111.8
08	113.3	113.1
09	110.8	110.5
10	111.8	111.4
11	105.8	105.4
12	97.8	97.4
13	94.4	94.0
14	92.4	91.9
15	95.9	95.3
16	95.2	94.6
17	98.8	98.1
18	108.6	107.8
19	120.4	119.4
20	135.1	133.9
	#1700UT Reading	
21	151.5	150.2
22	153.5#	152.0#
23	183.2#	181.3#
24	190.6	188.5
25	221.5	219.0
	* 2300UT Reading	
26	243.4*	240.6*
27	257.2	254.0
28	274.4	270.9
29	279.1#	275.4#
30	271.4	267.6
31	248.9	245.2
Mean	151.3	150.1

♦ 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 November 2003 data combine observations from 39 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	66	64	62	60	57	55	54	66
						(3)	(5)	(8)	(10)	(13)	(15)	(17)	(6)
2004	53	52	51	50	48	47	45	42	40	39	38	37	45
	(18)	(19)	(19)	(20)	(20)	(20)	(20)	(21)	(22)	(23)	(23)	(23)	(21)
2005	35	33	32	30	29	28	27	26	25	24	23	22	28
	(23)	(23)	(23)	(23)	(23)	(22)	(22)	(22)	(21)	(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 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 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 May 2004 prediction. There exists a 90% chance that in May 2004 the actual smoothed sunspot number will fall somewhere between 28 and 68.

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.