SOLAR INDICES BULLETIN

JANUARY 2004

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

JANUARY 2004 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	32	116	472	241	172	112	121	62	39	48	—
02	40	117	399	216	162	113	114	61	36	35	35
03	45	116	491	271	188	112	121	63	32	30	25
04	46	119	503	272	192	115	120	61	—	—	—
05	44	123	499	278	193	118	121	63	36	33	31
06	39	117	500	276	199	113	121	60	35	31	26
07	50	119	500	269	203	115	119	60	33	27	15
08	53	120	506	261	193	116	121	59	32	27	20
09	38	118	502	256	186	114	120	58	35	30	18
10	36	119	499	264	189	115	121	60	32	31	13
11	32	119	487	255	179	115	116	59	33	29	23
12	27	118	494	255	179	114	119	62	33	27	17
13	35	118	498	258	175	114	118	64	35	27	13
14	34	121	—	—	—	117	—	—	—	—	—
15	43	119	497	241	174	115	123	70	37	31	15
16	50	120	496	247	163	116	121	69	38	28	12
17	49	123	500	248	173	119	126	75	39	27	12
18	40	120	488	252	167	116	120	76	43	29	11
19	54	135	507	254	182	130	136	81	44	34	14
20	61	129	497	257	174	124	134	77	42	31	16
21	61	130	220	185	164	125	132	77	39	25	17
22	49	122	481	253	166	118	124	75	41	33	21
23	42	115	472	244	161	111	118	71	36	28	14
24	34	108	469	245	158	104	109	64	35	28	13
25	16	102	500	248	163	98	108	59	36	28	13
26	13	98	483	241	156	94	101	55	33	26	13
27	0	94	495	241	147	91	96	54	32	26	13
28	8	89	489	240	141	86	90	51	31	26	16
29	16	87	—	—	—	84	—	—	—	—	—
30	27	93	497	244	147	90	92	52	33	26	13
31	38	94	491	246	148	91	95	52	32	28	14
Mean	37.2	114	449	234	161	110	109	60	32	27	15

DEC 2003 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
143.3	139.3
139.3	135.4
123.8	120.3
115.8	112.5
111.7	108.5
108.9	105.7
92.0	89.3
93.7	90.9
92.2	89.4
89.2	86.5
86.1	83.4
87.2	84.5
87.8	85.0
92.4	89.5
100.8	97.7
106.3	103.0
117.5	113.8
123.0	119.1
122.5	118.6
130.1	125.9
133.4	129.1
137.6	133.2
142.0	137.4
138.9	134.4
139.1	134.6
* 1800UT Reading	
137.2	132.7
126.6*	122.4*
119.0	115.1
114.5	110.7
107.7	104.2
105.6	102.1
115.0	111.4

♦ 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 January 2004 data combine observations from 41 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
								(3)	(7)	(10)	(12)	(14)	(4)
2004	52	51	49	48	47	46	44	41	39	38	37	36	44
	(15)	(16)	(16)	(17)	(18)	(18)	(19)	(20)	(21)	(21)	(22)	(22)	(19)
2005	34	32	31	30	28	27	26	25	25	24	23	22	27
	(22)	(22)	(22)	(23)	(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 September 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 July 2004 prediction. There exists a 90% chance that in July 2004 the actual smoothed sunspot number will fall somewhere between 25 and 63.

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.