SOLAR INDICES BULLETIN

◆ 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.

JANUARY 2000 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	48	130	557	248	167	125	122	107	64	43	17
02	48	133	555	252	168	128	129	112	66	42	17
03	54	133	551	263	163	128	122	114	67	43	14
04	64	135	---	---	---	130	---	---	---	---	---
05	73	137	564	270	168	132	124	114	67	43	13
06	85	145	573	258	174	140	137	115	69	45	16
07	85	150	---	---	---	145	---	---	---	---	---
08	75	155	570	266	183	149	140	129	73	67	---
09	76	161	569	285	192	155	145	128	49	19	19
10	65	163	572	276	191	157	153	128	77	51	19
11	90	178	579	285	201	172	161	136	77	48	17
12	134	196	586	292	226	189	175	153	79	50	19
13	153	202	588	287	222	195	181	153	76	45	15
14	164	201	588	293	231	194	189	162	80	49	16
15	166	211	572	290	236	204	201	160	81	47	18
16	163	208	587	297	210	201	179	158	44	17	17
17	123	196	591	307	208	189	182	151	78	48	---
18	120	195	582	272	175	188	157	147	64	45	22
19	114	179	566	276	195	173	157	136	70	49	23
20	95	171	582	291	199	165	152	132	75	62	42
21	88	159	512	278	178	153	141	122	70	53	30
22	84	151	596	275	178	146	137	114	66	48	19
23	82	141	560	245	166	136	123	110	---	43	16
24	80	141	574	283	168	136	124	107	65	46	22
25	85	137	573	269	167	132	125	106	66	45	22
26	77	141	552	228	149	136	121	101	64	46	34
27	70	132	578	246	164	128	117	100	63	41	17
28	60	126	574	272	164	122	120	102	64	42	18
29	61	128	549	254	166	124	118	105	61	40	15
30	55	133	566	267	151	129	111	107	65	44	17
31	58	139	572	249	164	134	120	118	69	43	16
Mean	90.2	158	570	272	184	153	144	125	70	47	34

DEC 1999 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
165.0	160.4
165.5	160.9
151.8	147.5
147.5	143.3
142.7	138.6
142.8	138.6
153.3	148.8
150.1	145.6
156.2	151.5
164.4	159.5
159.1	154.3
159.2	154.4
166.1	161.0
168.4	163.1
178.7	173.1
194.0	187.9
200.7	194.4
205.5	198.9
206.9	200.3
209.2	202.4
217.2	210.1
201.7	195.1
198.4	191.9
182.4	176.5
178.4	172.5
177.0	171.2
161.7	156.4
150.4	145.4
143.7	139.0
135.6	131.2
130.1	125.8
169.8	164.5

♦ 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 November 1999 data combine observations from 44 stations. http://www.oma.be/KSB-ORB/SIDC/index.html.

♦ 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
1990	151	153	152	149	147	144	141	141	142	142	142	144	146
1991	148	148	147	147	146	145	146	147	145	142	138	132	144
1992	124	115	108	103	100	97	91	84	80	76	74	73	94
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	85	90	93	94	97	99	102	104	106	94
								(5)	(10)	(13)	(15)	(18)	(5)
2000	107	108	109	110	110	110	111	111	111	110	110	110	110
	(20)	(23)	(24)	(26)	(27)	(28)	(28)	(29)	(31)	(32)	(34)	(35)	(28)
2001	110	110	109	109	108	108	107	106	105	104	103	102	107
	(35)	(36)	(37)	(40)	(41)	(41)	(40)	(39)	(40)	(40)	(39)	(38)	(39)

*May 1996 marks Cycle 22's mathematical minimum.
**October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.

♦ 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 1999 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 2000 prediction. There exists a 90% chance that in July 2000 the actual smoothed sunspot number will fall somewhere between 83 and 139.

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.