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.

MARCH 2000 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	138	233	609	354	282	228	203	172	87	68	45
02	130	213	591	349	258	209	196	168	85	65	92
03	114	204	592	307	231	200	170	161	84	58	47
04	113	200	574	282	229	196	---	167	85	61	52
05	113	220	610	313	254	216	---	169	83	61	41
06	129	222	615	306	253	218	201	169	79	54	42
07	155	222	622	345	253	218	202	165	85	53	22
08	137	215	611	329	249	211	204	164	82	52	26
09	146	206	601	339	234	203	180	159	75	47	22
10	137	203	597	322	241	200	180	157	78	50	19
11	127	203	594	345	243	200	187	143	78	51	25
12	122	203	590	300	235	200	189	154	80	50	22
13	121	188	586	320	229	185	167	141	---	45	21
14	115	183	582	334	221	180	170	140	74	46	42
15	103	179	572	255	200	177	150	134	72	45	18
16	100	184	579	289	213	182	153	138	73	54	69
17	95	192	595	313	222	190	180	135	74	57	18
18	101	195	586	229	195	193	169	142	74	36	37
19	126	208	594	319	251	206	200	160	---	56	---
20	150	210	585	299	253	208	192	158	73	---	---
21	148	231	612	361	290	229	211	173	83	52	24
22	156	234	583	312	266	232	215	180	84	66	35
23	182	224	593	285	234	222	198	169	80	64	35
24	188	219	---	---	---	217	---	---	---	---	---
25	185	205	591	296	224	203	185	165	76	56	51
26	170	211	601	314	228	210	182	169	78	49	---
27	155	205	576	306	235	204	188	167	81	46	17
28	169	201	612	308	227	200	187	170	80	46	17
29	148	209	589	265	206	208	195	170	82	48	18
30	148	206	591	304	223	205	184	174	81	48	17
31	164	225	595	330	244	224	197	181	85	51	33
Mean	138.2	208	594	311	237	206	187	160	80	53	34

FEB 2000 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	138.1	134.1
02	144.4	140.2
03	154.1	149.7
04	167.4	162.7
05	167.8	163.1
06	177.7	172.8
07	181.9	177.0
08	173.6	169.0
09	175.5	170.8
10	175.7	171.1
11	170.2	165.8
12	163.2	159.1
13	159.9	155.9
14	158.7	154.7
15	156.0	152.2
16	160.2	156.3
17	168.4	164.4
18	141.1	137.8
19	144.8	141.5
20	153.3	149.9
21	152.1	148.7
22	172.3	168.6
23	185.1	181.2
24	192.2	188.3
25	210.4	206.2
26	214.8	210.6
27	227.3	222.9
28	218.8	214.7
29	219.0	215.1
Mean	173.2	169.1

♦ 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 March 2000 data combine observations from 38 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	86	91	93	94	98	102	105	108	110	95
										(4)	(7)	(9)	(2)
2000	111	111	113	113	113	113	114	114	114	113	112	112	113
	(12)	(15)	(16)	(18)	(21)	(22)	(23)	(26)	(28)	(30)	(33)	(34)	(23)
2001	112	112	111	111	110	110	109	108	107	106	105	104	109
	(35)	(36)	(37)	(39)	(41)	(41)	(39)	(39)	(39)	(39)	(38)	(37)	(38)

*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 December 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 September 2000 prediction. There exists a 90% chance that in September 2000 the actual smoothed sunspot number will fall somewhere between 86 and 142.

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.