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 2001 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	52	131	567	281	161	128	115	114	61	42	10
02	53	130	563	282	162	127	113	116	---	---	---
03	75	140	573	293	174	137	130	114	64	42	14
04	92	141	566	290	174	138	136	116	65	42	---
05	104	156	577	295	183	153	136	122	---	---	---
06	91	158	585	302	192	155	155	120	65	36	18
07	85	177	578	315	206	174	163	139	71	53	21
08	63	167	591	313	202	164	146	132	73	62	65
09	79	161	579	309	200	158	158	121	67	44	16
10	97	160	575	296	189	157	165	119	65	42	16
11	90	158	546	295	188	155	158	128	66	45	16
12	95	158	577	296	184	156	142	122	63	43	15
13	80	147	569	291	173	145	140	128	61	42	16
14	80	142	565	284	166	140	140	127	63	43	17
15	75	136	571	295	175	134	140	128	64	45	23
16	75	140	558	272	158	138	112	115	66	42	15
17	51	134	---	---	---	132	---	---	---	---	---
18	65	140	576	283	170	138	120	---	64	44	---
19	66	147	567	299	180	145	128	117	67	44	16
20	80	153	585	301	188	151	132	119	71	49	19
21	88	159	592	315	204	157	144	126	65	46	18
22	85	183	594	332	215	181	148	138	68	46	18
23	113	180	586	329	214	178	156	140	71	56	39
24	149	219	611	376	260	217	186	165	79	71	141
25	186	217	574	367	268	215	188	182	83	79	118
26	218	264	604	405	306	262	194	204	86	79	123
27	241	273	647	479	355	271	286	214	88	128	543
28	258	274	624	448	334	273	243	218	93	206	560
29	218	262	642	432	324	261	235	215	83	79	108
30	231	257	590	379	297	256	259	204	88	124	281
31	205	246	592	388	298	245	251	194	75	60	152
Mean	114.2	178	584	328	217	176	164	145	71	62	92

FEB 2001 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
160.9	156.2
166.3	161.6
163.6	159.0
148.1	144.0
165.3	160.7
170.0	165.3
164.0	159.6
156.5	152.3
162.4	158.1
160.7	156.5
151.3	147.4
144.6	140.9
141.3	137.8
137.9	134.6
135.1	131.8
129.6	126.5
129.8	126.8
132.0	129.0
137.0	134.0
145.5	142.3
143.6	140.5
145.8	142.7
145.2	142.2
137.3	134.6
134.9	132.2
135.4	132.8
130.6	128.1
131.8	129.4
146.7	143.1

♦ 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 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 2001 data combine observations from 30 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
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	103	108	111	111	96
2000	113	117	120	121	119	119	120	119	116	116	115	114	117
										(5)	(11)	(14)	(3)
2001	114	114	114	113	113	112	111	110	109	108	107	106	111
	(16)	(18)	(20)	(23)	(26)	(26)	(25)	(26)	(28)	(29)	(28)	(28)	(24)
2002	105	103	101	99	97	94	91	89	86	84	81	78	92
	(27)	(27)	(27)	(26)	(25)	(24)	(24)	(23)	(22)	(21)	(20)	(19)	(24)

*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 Septeptember 2000 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 2001 prediction. There exists a 90% chance that in September 2001 the actual smoothed sunspot number will fall somewhere between 81 and 137.

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.