SOLAR INDICES BULLETIN

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

325 Broadway
Boulder, Colorado 80305-3328 USA
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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 <u>observed</u> noon value dropped to 62.6 units; the highest <u>observed</u> value of 457.0 occurred on April 7, 1947.

The preliminary <u>observed</u> and <u>adjusted</u> Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. <u>Observed</u> numbers are less refined, since they contain fluctuations as large as ±7% from the continuously changing sun-earth distance. <u>Adjusted</u> 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.

APRIL 2002 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	116	207	544	356	259	206	186	131	68	48	23
02	130	206	526	340	252	205	186	134	61	46	21
03	126	209	552	349	255	209	197	131	63	50	27
04	127	216	608	358	278	216	211	196	64	51	16
05	127	217	525	344	255	217	188	131	54	46	20
06	136	206	534	340	246	206	187	155	59	43	31
07	138	208	492	335	244	208	179	138	63	43	28
08	134	206	534	341	253	206	187	179	63	42	24
09	139	205	531	387	247	205	187	143	65	42	21
10	142	194	545	349	250	194	187	146	69	57	109
11	152	197	561	350	247	197	177	122	62	41	19
12	162	212	525	394	282	213	189	150	67	51	57
13	144	226	538	368	284	227	198	143	64	40	20
14	150	210	596	357	291	211	206	190	71	60	69
15	138	203	539	347	249	204	178	138	65	55	123
16	113	196	578	354	254	197	194	137	65	47	116
17	94	194	535	334	233	195	171	134	62	42	97
18	106	188	539	335	231	189	167	140	60	41	35
19	104	180	533	343	232	181	166	126	60	41	26
20	102	177	589	331	240	178	158	129	59	40	24
21	95	173	527	339	230	174	162	121	58	40	20
22	93	170	540	330	220	171	158	126	59	45	33
23	114	175	491	327	221	176	160	138	59	45	32
24	150	177	539	313	211	179	155	124	58	42	29
25	147	167	539	319	206	169	149	123	58	49	43
26	101	163	538	323	214	164	160	122	58	45	49
27	88	157	501	315	239	159	154	119	58	50	44
28	71	147	530	312	196	149	149	128	55	41	39
29	87	153	499	308	199	155	137	113	55	41	36
30	85	153	532	323	209	155	141	139	56	48	27
31											
Mean	120.4	190	539	341	241	191	174	138	61	46	42

MAR 2002 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	187.7	184.3
02	191.0	187.6
03	182.7	179.6
04	174.9	172.0
05	172.2	169.4
06	177.8	175.0
07	179.7	177.0
08	176.8	174.2
09	207.7#	204.8#
10	179.3	176.9
	# Burst IP	
11	182.3	180.0
12	178.4	176.2
13	184.3	182.1
14	180.7	178.6
15	175.9	174.0
16	184.6	182.7
17	184.4	182.7
18	178.1	176.5
19	174.8	173.3
20	187.8	186.3
21	174.1	172.8
22	171.6	170.4
23	170.4	169.4
24	175.3	174.3
25	170.0	169.1
26	165.7	164.9
27	169.1	168.4
28	176.2	175.6
29	181.3	180.8
30	188.7	188.2
31	204.4	204.0
Mean	180.3	178.4

♦ 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
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 April 2002 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
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	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	113	112	110
											(3)	(7)	(1)
2002	110	109	106	104	101	98	96	93	90	87	85	81	97
	(11)	(14)	(16)	(18)	(19)	(19)	(19)	(19)	(20)	(21)	(20)	(17)	(18)
2003	78	75	73	70	67	65	63	61	59	56	54	53	65
	(14)	(12)	(12)	(13)	(14)	(14)	(15)	(15)	(17)	(18)	(19)	(21)	(15)

*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 2001 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 October 2002 prediction. There exists a 90% chance that in October 2002 the actual smoothed sunspot number will fall somewhere between 66 and 108.

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.