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} $\mathrm{J/m^2 Hz\,sec}$.

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 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	136	232	572	342	250	224	220	147	71	51	29
02	135	231	559	352	267	223	225	150	70	50	16
03	136	220	571	334	248	212	200	147	66	52	26
04	142	218	577	349	264	210	206	155	73	47	18
05	118	212	555	339	238	205	180	137	65	42	---
06	98	197	552	316	222	190	171	131	62	45	35
07	90	189	559	321	222	182	171	130	62	43	27
08	100	199	565	346	251	192	183	131	65	50	24
09	121	229	691	348	260	221	187	145	67	48	22
10	115	225	579	361	273	217	200	138	66	49	22
11	129	229	587	349	260	221	189	162	67	53	23
12	129	233	573	355	261	225	198	146	73	55	23
13	124	241	588	363	277	233	231	152	72	56	28
14	122	229	558	362	267	221	206	147	67	53	27
15	104	218	546	348	255	210	206	142	67	51	26
16	87	216	548	339	244	209	182	141	70	44	26
17	74	212	548	344	241	205	181	138	67	56	---
18	86	211	547	342	243	204	197	143	70	45	20
19	93	214	526	317	241	207	192	145	66	44	30
20	109	222	523	308	237	214	206	160	67	44	31
21	118	225	545	346	254	217	192	155	69	45	30
22	120	229	527	346	253	221	196	180	70	44	21
23	140	227	513	339	250	219	199	159	72	44	22
24	109	231	516	337	249	223	193	158	70	44	27
25	103	235	540	367	272	227	205	150	71	43	23
26	106	240	497	372	292	232	217	156	69	44	37
27	118	248	537	352	278	240	211	162	69	46	---
28	121	260	557	364	285	252	227	167	72	47	27
29	116	261	479	289	230	253	239	147	68	41	93
30	119	243	576	258	206	235	223	149	67	43	---
31	112	243	538	349	280	235	221	154	73	49	28
Mean	113.9	226	553	340	254	219	202	149	68	47	28

DEC 2001 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
221.3	215.1
245.0	238.1
235.0	228.3
233.3	226.6
237.0	230.1
246.7	239.5
225.9	219.3
220.5	213.9
224.2	217.5
219.0	212.3
220.6	213.9
236.7	229.4
220.2	213.4
216.6#	209.9#
217.8	211.0
# 1800UT Reading	
209.1	202.5
205.5	199.0
211.8	205.0
208.2	201.6
221.1	214.0
234.3	226.7
242.8	234.9
254.6	246.3
274.5	265.5
258.8	250.3
267.8	259.0
274.6	265.6
263.3#	254.6#
264.4	255.7
246.6	238.5
245.6	237.5
235.6	228.2

◆ 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 January 2002 data combine observations from 46 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

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	111	110	109	107	107	108
								(5)	(9)	(10)	(11)	(12)	(4)
2002	105	104	102	99	97	95	92	89	87	84	81	78	93
	(13)	(15)	(17)	(19)	(19)	(19)	(18)	(18)	(18)	(18)	(18)	(15)	(17)
2003	75	73	71	68	65	63	61	59	57	55	53	52	62
	(13)	(12)	(12)	(13)	(14)	(15)	(16)	(16)	(17)	(18)	(19)	(21)	(14)

*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 June 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 July 2002 prediction. There exists a 90% chance that in July 2002 the actual smoothed sunspot number will fall somewhere between 74 and 110.

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.