SOLAR INDICES BULLETIN

NOVEMBER 2001

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

325 Broadway
Boulder, Colorado 80305-3328 USA
ISSN 1046-1914

♦ 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.

NOVEMBER 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	96	236	612	375	314	232	221	143	73	72	97
02	100	214	563	336	270	210	209	129	64	57	60
03	100	216	554	340	260	212	189	135	63	47	---
04	111	227	582	354	275	223	202	143	67	49	31
05	130	235	586	362	283	231	206	141	63	42	22
06	140	230	584	365	277	225	203	152	67	47	23
07	123	269	592	394	307	264	234	151	71	46	35
08	152	248	579	381	297	243	223	151	69	53	33
09	149	271	610	372	309	265	220	154	70	50	26
10	149	246	575	366	296	241	211	150	68	44	28
11	145	234	576	354	278	229	196	135	67	44	26
12	121	227	560	346	272	222	200	141	66	47	26
13	118	232	577	353	263	227	195	129	66	55	34
14	118	217	569	375	279	212	207	140	73	54	32
15	117	207	592	366	244	202	184	135	71	49	27
16	90	202	583	338	238	197	170	130	67	50	24
17	85	199	583	338	238	194	170	130	62	45	21
18	92	188	572	335	228	183	166	125	62	43	20
19	81	191	675	364	236	186	169	130	66	45	23
20	87	185	567	333	236	180	171	134	64	41	21
21	80	184	577	324	222	179	156	132	65	45	23
22	87	190	---	---	---	185	---	---	---	---	---
23	80	177	565	325	225	172	158	133	62	44	23
24	67	173	556	314	220	168	148	108	60	41	23
25	73	170	542	322	225	165	151	115	61	49	38
26	84	175	568	316	222	170	151	112	59	42	21
27	76	190	499	254	194	184	167	107	62	41	22
28	107	199	702	343	256	193	179	121	61	41	22
29	115	216	558	343	260	210	182	126	62	43	24
30	121	226	577	360	277	219	198	136	64	47	26
31											
Mean	106.5	212	581	346	259	207	187	133	65	47	30

OCT 2001 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	216.5	216.9
02	200.9	201.1
03	191.7	191.8
04	186.5	186.5
05	176.9	176.8
06	180.4	180.2
07	172.7	172.4
08	171.2	170.8
09	176.4	175.9
10	178.7	178.1
11	174.8	174.1
12	179.2	178.5
13	179.5	178.6
14	191.9	190.8
15	192.9	191.7
16	207.2	205.8
17	217.4	215.8
18	228.7	226.9
19	247.6	245.6
20	244.7	242.5
21	224.1	222.0
22	232.7	230.4
23	226.4	224.1
24	238.7	236.0
25	238.9	236.1
26	236.5	233.6
27	246.5	243.4
28	227.2	224.2
29	215.8	212.8
30	226.0	222.7
31	221.1	217.8
Mean	208.1	206.6

♦ 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 November 2001 data combine observations from 40 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	108 (3)	107 (7)	106 (11)	105 (14)	104 (15)	103 (16)	102 (16)	106 (7)
2002	101 (17)	100 (17)	98 (19)	96 (21)	94 (21)	91 (21)	89 (20)	86 (19)	84 (19)	81 (19)	79 (19)	76 (17)	90 (19)
2003	73 (14)	71 (13)	69 (13)	66 (14)	64 (15)	61 (16)	60 (17)	58 (17)	56 (18)	54 (18)	52 (19)	51 (21)	61 (16)

*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 May 2002 prediction. There exists a 90% chance that in May 2002 the actual smoothed sunspot number will fall somewhere between 73 and 115.

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.