SOLAR INDICES BULLETIN

NOVEMBER 2000

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

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.

NOVEMBER 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	135	204	548	310	213	200	196	176	88	52	21
02	147	196	---	---	---	192	---	---	---	---	---
03	141	199	581	310	213	195	185	185	93	53	20
04	130	195	570	293	197	191	168	178	78	48	17
05	133	186	577	308	202	182	168	166	84	51	18
06	108	178	579	306	198	174	177	156	---	---	---
07	122	180	592	304	203	176	173	148	76	49	17
08	127	173	596	311	204	169	159	144	75	50	19
09	95	166	578	324	192	162	145	133	71	46	17
10	101	153	582	272	179	149	141	124	64	45	17
11	90	150	569	269	168	147	125	120	65	44	17
12	72	147	561	284	175	143	148	117	62	44	18
13	70	144	565	283	179	140	130	117	67	---	---
14	84	149	572	281	180	145	135	122	68	48	19
15	98	147	571	285	178	143	132	119	68	46	19
16	95	154	302	197	130	150	71	93	69	48	18
17	94	163	571	294	191	159	144	136	64	46	24
18	116	177	573	289	212	172	182	146	74	50	23
19	125	175	563	298	202	170	163	141	74	50	---
20	110	174	569	291	202	169	164	151	75	50	27
21	120	185	582	324	205	180	160	156	79	61	49
22	113	195	589	318	218	190	174	169	90	73	72
23	91	205	602	323	229	199	172	175	88	66	32
24	98	197	567	330	231	191	221	172	114	196	---
25	74	202	594	321	230	196	201	176	99	63	35
26	59	202	587	332	222	196	181	177	---	59	24
27	79	192	586	321	218	186	187	166	90	---	---
28	106	196	589	323	215	190	239	173	82	56	26
29	123	188	589	309	209	182	173	172	88	58	20
30	138	192	593	314	212	186	193	167	87	54	23
31											
Mean	106.5	179	569	301	200	174	166	151	79	58	25

OCT 2000 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	201.6	201.9
02	202.6	202.9
03	192.0	192.1
04	184.1	184.1
05	173.8	173.7
06	158.1	157.9
07	155.6	155.3
08	148.9	148.6
09	140.8	140.4
10	139.6	139.1
11	151.4	150.8
12	162.7	161.9
13	168.1	167.2
14	163.3	162.3
15	161.1	160.1
16	160.9	159.8
17	154.1	153.0
18	151.1	149.9
19	157.8	156.5
20	160.7	159.3
21	158.0	156.5
22	160.2	158.6
23	166.5	164.8
24	159.2	157.5
25	164.0	162.0
26	171.0	168.9
27	175.9	173.7
28	182.2	179.7
29	187.1	184.5
30	193.7	191.0
31	193.4	190.5
Mean	167.7	166.6

♦ 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 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 November 2000 data combine observations from 36 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	108	111	111	95
2000	113	117	120	121	119	119 (4)	119 (9)	119 (15)	119 (19)	118 (22)	117 (26)	116 (28)	118 (10)
2001	116 (30)	116 (31)	115 (33)	115 (35)	114 (38)	114 (37)	113 (35)	112 (34)	111 (35)	109 (36)	108 (35)	107 (34)	112 (34)

*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 <u>smoothed</u> 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 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 May 2001 prediction. There exists a 90% chance that in May 2001 the actual smoothed sunspot number will fall somewhere between 76 and 152.

<u>The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead.</u> 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.

Although every effort has been made to ensure that these data are correct, we can assume no liability for any damages their inaccuracies might cause. The charge for a 1-year subscription to this monthly bulletin is US$17.00. To become a subscriber, you may either call (303) 497-6346 or write the NATIONAL GEOPHYSICAL DATA CENTER, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80303 USA. Please include with your written order a cheque or money order payable in U.S. currency to the "Department of Commerce, NOAA/NGDC". Payment may also be made through VISA, MasterCard or American Express credit cards.