

# SOLAR INDICES BULLETIN

NOVEMBER 1995

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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<sup>2</sup>Hzsec.

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  $\pm 7\%$  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 Learmonth, Australia (LEAR) data reflect equipment problems. Fluxes measured either at Palehua on the Hawaiian Islands, or at San Vito, Italy, will be substituted for frequencies at which many Learmonth values are missing.

NOVEMBER 1995 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

OCT 1995 FINAL FLUX

Day	Sunspot Obs Flux		Solar Flux Adjusted to 1 Astronomical Unit										Observed Adjusted	
	Number Intl	Pentic (2800)	LEAR (15400)	LEAR (8800)	LEAR (4995)	Pentic (2800)	LEAR (2695)	LEAR (1415)	LEAR (610)	LEAR (410)	LEAR (245)	Pentic (2800)	Pentic (2800)	
01	0	74	505	232	124	73	70	52	29	20	10	72.6	72.8	
02	8	73	522	225	123	72	68	51	30	20	11	72.5	72.7	
03	8	73	547	232	123	72	69	51	30	21	13	71.0	71.1	
04	0	73	516	229	123	72	66	52	30	19	11	70.8	70.8	
05	0	75	516	229	124	74	71	52	30	21	11	69.8	69.8	
06	8	75	519	229	126	74	71	53	31	21	10	71.0	70.9	
07	8	74	551	230	125	73	71	53	31	21	11	72.9	72.8	
08	8	76	540	235	125	75	71	54	32	21	10	74.3	74.1	
09	9	77	547	233	127	76	72	54	32	22	12	76.1	76.0	
10	12	78	534	244	136	76	78	56	32	22	10	82.3	82.1	
11	9	77	523	236	127	75	72	55	32	22	11	89.5	89.1	
12	8	76	541	228	126	74	72	55	33	22	11	92.2	91.8	
13	8	73	542	233	126	71	71	53	30	21	11	87.9	87.5	
14	8	75	544	231	125	73	70	52	30	21	10	87.2	86.7	
15	20	77	546	231	127	75	72	53	29	21	11	83.0	82.5	
16	25	76	542	229	125	74	72	53	31	21	11	85.6	85.0	
17	33	75	510	233	127	73	71	54	30	21	11	84.6	84.1	
18	23	75	---	---	---	73	---	---	---	---	---	81.5	80.9	
19	10	74	550	233	123	72	69	52	30	21	10	80.5	79.8	
20	10	73	552	234	124	71	70	53	28	20	11	82.5	81.8	
21	9	73	543	232	121	71	67	51	30	23	11	81.0	80.3	
22	9	73	543	---	---	71	---	---	27	23	12	80.5	79.7	
23	9	73	540	232	121	71	68	52	22	19	10	76.7	75.9	
24	0	72	538	231	122	70	68	52	28	23	11	74.3	73.5	
25	0	73	549	229	122	71	67	51	28	22	13	74.0	73.1	
26	0	73	546	232	121	71	67	50	28	22	11	73.9	73.0	
27	8	71	527	231	122	69	67	50	27	22	15	74.0	73.1	
28	9	73	539	263	122	71	68	51	28	22	10	73.8	72.9	
29	11	72	554	265	123	70	69	52	28	24	12	73.8	72.8	
30	12	74	566	251	121	72	68	51	27	23	10	73.3	72.3	
31												73.3	72.2	
Mean	9	74	538	235	124	73	70	52	29	21	11	77.9	77.5	

◆ 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 1995 data combine observations from 44 stations.

◆ 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 21, 22 AND 23

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1985	20	20	19	18	18	18	17	17	17	17	17	15	18
1986	14	13	13	14	14	14	14	13	12*	13	15	16	14
1987	18	20	22	24	27	28	31	35	39	44	47	51	32
1988	58	65	71	78	84	94	104	114	121	125	130	138	98
1989	142	145	150	154	157	158	159	158	157	157	158	154	154
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	18	17	17	16	16	15	19
						(2)	(3)	(5)	(5)	(5)	(6)	(6)	(3)
1996	14	13	12	11	11	10	10	9	9	8	8	8	10
	(7)	(8)	(9)	(9)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(9)
1997	8	8	9	9	10	10	11	12	13	14	14	16	11
	(10)	(10)	(10)	(10)	(11)	(12)	(13)	(15)	(16)	(17)	(19)	(22)	(14)

Sep 1986 marks Cycle 21's minimum and the onset of cycle 22, which reached a maximum in July 1989.

◆ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 21, and the beginning of Cycle 22, 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 March 1995 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 1996 prediction. There exists a 90% chance that in May 1996 the actual smoothed sunspot number will fall somewhere between 1 and 21.

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 minimum value of 12.3 that occurred in September 1986.

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 in US\$21.00. 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.