

SOLAR INDICES BULLETIN

MAY 1997

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

325 Broadway
Boulder, Colorado 80303 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 $10^{-22} \text{ J/m}^2\text{Hzsec}$.

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.

MAY 1997 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

APR 1997 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	72	507	201	127	73	70	51	37	26	12	76.3	76.2	
02	0	72	502	203	128	73	70	50	37	25	12	80.5	80.4	
03	0	71	499	200	125	72	68	50	36	25	11	78.8	78.8	
04	8	71	487	199	125	72	68	49	37	26	12	78.5	78.6	
05	9	72	471	194	126	73	69	50	34	24	26	80.2	80.3	
06	8	72	513	201	126	73	69	50	38	27	14	78.1	78.3	
07	8	72	516	204	129	73	70	51	39	27	12	76.8	77.0	
08	10	72	514	202	128	73	69	51	38	26	11	76.1	76.3	
09	9	72	507	200	125	73	69	49	37	25	11	78.1	78.3	
10	17	72	506	200	127	73	68	50	37	25	11	77.6	78.0	
11	16	72	507	200	127	73	71	50	37	26	12	77.1	77.4	
12	10	72	495	200	127	74	70	49	36	24	11	76.4	76.9	
13	12	74	509	202	129	76	70	49	36	25	11	78.8	79.3	
14	13	74	514	200	129	76	71	50	35	24	10	77.4	77.9	
15	11	73	511	202	127	75	71	50	36	25	11	78.7	79.2	
16	17	80	489	194	126	82	69	50	30	21	9	75.0	75.6	
17	20	73	---	197	127	75	70	49	30	21	10	71.7	72.3	
18	21	74	---	198	126	76	70	50	31	21	10	70.1	70.7	
19	27	74	331	198	128	76	73	51	34	23	12	69.9	70.6	
20	39	79	331	198	128	81	73	51	34	23	12	69.7	70.4	
21	52	85	538	209	137	87	78	54	38	30	15	70.1	70.9	
22	48	81	526	210	138	83	79	55	37	30	22	70.7	71.5	
23	40	76	522	205	133	78	77	55	37	28	12	68.9	69.7	
24	30	77	524	206	132	79	74	55	36	26	12	69.8	70.7	
25	29	78	522	206	131	80	75	54	36	26	11	68.7	69.6	
26	35	80	532	208	134	82	78	55	37	26	11	70.9	71.8	
27	23	78	530	210	136	80	78	55	38	26	12	73.1	74.1	
28	17	77	534	210	125	79	77	54	38	25	11	72.4	73.4	
29	14	76	529	206	122	78	74	55	39	26	12	71.9	72.9	
30	12	75	513	198	120	77	74	54	38	26	11	72.6	73.7	
31	19	73	458	196	119	75	73	53	36	25	11			
Mean	18.5	75	498	202	128	76	72	52	36	25	12	74.5	75.0	

◆ 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 Cugnion of the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The May 1997 data combine observations from 40 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	17	15	13	12	11	11	17
1996	11	10	10	9	8	9	9	8	9	9	10	10	9
												(1)	(0)
1997	10	10	10	10	10	11	12	12	13	14	15	16	12
	(3)	(4)	(5)	(6)	(8)	(10)	(12)	(14)	(15)	(17)	(19)	(22)	(11)

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 June 1996 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 November 1997 prediction. There exists a 90% chance that in November 1997 the actual smoothed sunspot number will fall somewhere between 0 and 34.

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 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.