SOLAR INDICES BULLETIN

OCTOBER 1996

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

325 Broadway
Boulder, Colorado 80303 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} $J/m^2 Hz sec$.

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 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.

OCTOBER 1996 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit LEAR (15400)	LEAR (8800)	LEAR (4995)	Pentic (2800)	LEAR (2695)	LEAR (1415)	LEAR (610)	LEAR (410)	LEAR (245)
01	0	70	517	208	122	70	70	54	36	25	12
02	0	70	527	203	122	70	71	54	36	25	12
03	0	70	515	203	121	70	67	54	35	24	11
04	0	69	520	209	123	69	71	54	35	24	11
05	0	69	522	210	121	69	69	53	35	22	11
06	0	69	523	206	120	69	69	53	33	22	10
07	0	68	516	206	120	68	70	52	33	22	9
08	0	68	524	206	121	68	69	52	34	23	10
09	0	68	521	205	119	68	69	52	33	23	10
10	0	68	516	200	119	68	68	51	33	23	10
11	0	67	515	204	118	67	68	51	34	23	10
12	0	67	513	207	117	67	69	51	33	22	10
13	0	68	498	205	117	68	66	50	14	27	10
14	0	69	516	209	119	69	70	51	32	22	10
15	0	69	509	210	120	69	70	53	35	23	11
16	0	69	519	186	116	69	70	53	35	24	11
17	0	69	502	208	119	69	70	53	35	25	11
18	0	70	516	203	118	69	69	53	35	25	11
19	0	71	514	207	120	70	69	54	35	44	11
20	8	71	451	206	120	70	72	55	31	21	11
21	10	70	489	206	120	69	71	55	37	24	11
22	0	70	489	204	120	69	70	54	35	24	11
23	0	68	515	196	117	67	71	54	37	25	11
24	0	70	542	203	120	69	71	55	37	25	11
25	9	70	540	205	116	69	70	55	36	25	11
26	12	71	507	205	120	70	71	54	36	24	11
27	9	72	549	207	121	71	71	55	36	25	11
28	8	68	512	205	120	67	71	54	35	23	11
29	0	70	519	204	120	69	70	54	34	23	10
30	0	71	515	206	119	70	70	54	35	25	10
31	0	70	487	201	118	69	70	53	37	24	11
Mean	1.8	69	513	205	119	69	70	53	34	24	11

SEP 1996 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
73.5	74.8
72.3	73.6
71.2	72.4
70.8	72.0
70.3	71.4
69.7	70.8
69.5	70.5
68.2	69.2
67.9	68.8
68.0	68.9
67.6	68.5
67.8	68.6
67.3	68.1
67.1	67.9
66.4	67.1
68.0	68.7
69.0	69.6
68.9	69.6
69.2	69.8
69.2	69.7
69.8	70.3
68.6	69.1
69.9	70.4
70.0	70.4
70.8	71.2
70.0	70.4
69.8	70.1
71.0	71.2
70.1	70.3
69.5	69.7
69.4	70.1

♦ 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 September 1996 data combine observations from 42 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	8	7	7	7	6	6	6	8
					(2)	(3)	(4)	(5)	(6)	(7)	(7)	(7)	(3)
1997	6	7	7	8	9	10	11	12	12	13	15	16	10
	(7)	(8)	(8)	(9)	(10)	(12)	(13)	(15)	(16)	(18)	(20)	(22)	(13)

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 December 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 1997 prediction. There exists a 90% chance that in May 1997 the actual smoothed sunspot number will fall somewhere between 0 and 19.

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.