SOLAR INDICES BULLETIN
MAY

♦ **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 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.

MAY 2000 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	91	158	577	300	198	160	143	121	72	52	34
02	80	153	577	297	189	155	142	128	72	47	17
03	76	137	568	---	---	139	---	---	67	45	17
04	66	135	558	287	169	137	124	119	64	43	16
05	71	130	568	266	160	132	117	116	66	43	16
06	50	127	558	258	159	129	116	117	68	45	24
07	52	131	---	270	163	133	126	110	68	43	16
08	64	137	---	283	171	139	---	118	65	43	15
09	99	150	585	299	---	152	144	130	71	45	16
10	120	179	573	311	207	182	158	138	65	73	112
11	133	178	580	317	236	181	173	146	74	53	25
12	133	190	630	335	254	193	186	154	74	50	26
13	161	217	614	318	258	221	213	150	77	51	35
14	180	233	621	352	285	238	209	161	78	---	25
15	205	244	630	372	306	249	224	174	80	52	24
16	189	259	599	332	280	264	176	176	64	44	27
17	170	262	630	330	288	268	236	193	90	78	215
18	161	253	620	366	303	259	242	188	90	95	229
19	158	254	627	376	317	260	250	175	87	65	6
20	180	246	605	351	285	251	227	174	84	67	101
21	163	232	600	339	273	237	225	177	80	58	---
22	143	215	569	303	245	220	210	174	76	54	27
23	132	204	606	317	244	209	200	165	78	49	37
24	134	189	609	339	238	193	192	156	78	55	25
25	109	173	581	318	214	177	160	132	72	52	27
26	117	168	516	280	200	172	161	136	69	43	17
27	106	162	575	297	196	166	146	136	69	45	20
28	124	156	579	247	173	160	140	126	61	41	19
29	117	149	570	265	174	153	134	125	63	45	21
30	93	146	572	281	184	150	149	130	70	45	24
31	67	154	---	---	---	158	---	---	---	---	---
Mean	120.8	185	588	311	227	188	176	146	73	52	42

APR 2000 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
222.9	222.7
219.3	219.3
215.4	215.5
206.7	206.9
194.4	194.7
177.7	178.1
174.9	175.4
182.0	182.5
176.3	176.9
177.8	178.6
181.5	182.4
173.0	173.9
164.0	165.0
165.2	166.3
163.7	164.9
159.0	160.2
157.9	159.2
160.4	161.8
167.7	169.2
180.6	182.4
187.3	189.2
201.8	204.1
206.1	208.4
205.6	208.1
202.5	205.1
189.9	192.4
183.5	186.0
183.4	186.0
174.9	177.5
169.5	172.0
184.2	185.5

◆ 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 May 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	113	96
												(3)	(0)
2000	114	115	116	116	116	116	117	117	116	116	115	114	116
	(7)	(11)	(13)	(16)	(19)	(20)	(21)	(24)	(27)	(29)	(33)	(34)	(21)
2001	114	114	113	113	112	112	111	110	109	108	107	106	111
	(35)	(36)	(37)	(40)	(41)	(41)	(40)	(39)	(40)	(40)	(39)	(37)	(39)

*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 December 1999 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 2000 prediction. There exists a 90% chance that in November 2000 the actual smoothed sunspot number will fall somewhere between 82 and 148.

<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.