SOLAR INDICES BULLETIN

JULY

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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 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.

JULY 2000 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

	Sunspot	Obs Flux	Solar Flux Adjusted to 1 Astronomical Unit								
	Number	Pentic	PALE	PALE	PALE	Pentic	PALE	PALE	PALE	PALE	PALE
Day	Intl	(2800)	(15400)	(8800)	(4995)	(2800)	(2695)	(1415)	(610)	(410)	(245)
01	145	164	261	223	158	169	154	126	64	40	15
02	132	162	573	300	201	167	159	145	67	45	19
03	124	156	576	273	180	161	141	139	66	41	16
04	114	158	577	307	197	163	159	144	69	48	19
05	127	169	588	304	206	174	167	147	74	51	35
06	154	174	587	323	222	179	172	154	78	54	39
07	177	187	594	322	227	193	179	165	81	61	58
08	177	210	603	343	241	217	194	172	79	64	---
09	179	211	596	372	261	218	203	167	81	56	---
10	201	215	658	---	302	222	---	188	---	---	---
11	202	225	629	400	299	232	239	185	89	95	---
12	186	230	650	405	315	237	264	206	89	63	87
13	194	232	583	366	267	239	215	181	87	58	47
14	164	204	---	---	---	210	---	---	---	---	---
15	148	213	609	335	256	220	202	182	82	57	27
16	197	219	618	338	259	226	226	181	62	51	---
17	224	228	607	344	255	235	228	201	87	---	---
18	228	249	628	349	275	257	256	209	98	75	53
19	246	250	---	---	---	258	---	---	---	---	---
20	241	253	359	254	222	261	228	202	95	61	38
21	231	251	628	338	279	259	268	209	92	65	31
22	216	251	620	365	292	259	258	208	94	59	28
23	199	217	605	350	262	223	228	183	84	56	---
24	171	225	603	358	273	232	214	180	86	56	---
25	167	202	531	342	245	208	193	167	87	66	30
26	133	175	595	319	214	180	167	147	77	50	17
27	126	162	586	307	199	167	159	142	71	47	19
28	120	158	594	310	202	162	167	148	75	49	21
29	113	153	566	285	186	157	155	143	77	57	23
30	112	150	582	292	184	154	156	140	70	51	19
31	93	148	569	295	180	152	138	140	71	45	16
Mean	169.1	200	578	326	237	206	196	169	80	56	31

JUNE 2000 FINAL FLUX

Observed	Adjusted
Pentic	Pentic
(2800)	(2800)
148.0	152.3
187.2+	192.7+
165.9	170.7
169.7	174.7
171.0	176.1
+ burst ip	
186.4	192.0
180.3	185.8
174.6	179.9
168.9	174.1
179.6	185.1
186.8	192.6
192.7	198.7
199.2	205.5
200.6	206.9
202.4	208.9
197.5	203.8
193.1	199.4
187.6	193.7
178.4	184.2
183.7	189.7
188.0	194.2
179.7	185.6
175.2	181.0
168.3	173.9
175.1	180.9
177.4	183.4
178.6	184.6
175.3	181.2
163.3	168.8
159.6	165.0
179.8	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 July 2000 data combine observations from 30 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	114	115	115	115	116	116	116	116	115	114	113	115
		(4)	(8)	(11)	(15)	(17)	(18)	(22)	(25)	(28)	(31)	(33)	(18)
2001	113	113	113	112	112	111	110	109	108	107	106	105	110
	(34)	36	(37)	(39)	(41)	(40)	(39)	(39)	(39)	(39)	(38)	(37)	(38)

*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 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 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 January 2001 prediction. There exists a 90% chance that in January 2001 the actual smoothed sunspot number will fall somewhere between 79 and 147.

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 consensus minimum value of 8.8 that occurred in October 1996. For solar maximum discussions, visit http://www.sec.noaa.gov.