SOLAR INDICES BULLETIN

JULY 2010

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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 $10^{-22}\ \mathrm{J/m^2 Hz\,sec}$. During periods of low 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 2010 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	8	73	529	228	126	75	83	64	44	30	13
02	8	73	520	225	125	75	81	63	44	33	13
03	8	72	459	200	118	74	82	62	43	31	13
04	9	72	---	---	---	74	---	---	---	---	---
05	17	73	523	226	126	75	81	63	43	33	14
06	16	73	527	227	126	75	83	63	43	33	14
07	8	74	512	215	126	76	83	63	42	33	13
08	8	76	516	218	126	78	87	64	43	32	15
09	11	80	533	240	132	82	90	68	43	33	14
10	14	80	549	233	133	82	90	68	43	32	15
11	23	83	529	230	134	85	97	71	44	32	13
12	22	80	526	230	130	82	90	71	44	33	14
13	19	79	528	230	130	81	89	69	44	33	14
14	11	78	513	233	132	80	90	73	45	34	15
15	16	76	523	228	130	78	86	68	45	33	13
16	10	77	524	211	127	79	86	70	45	33	13
17	9	79	515	233	128	81	87	69	46	32	15
18	9	77	511	220	128	79	89	68	42	32	16
19	9	80	517	227	130	82	90	70	46	33	13
20	19	87	534	240	143	89	98	75	46	32	16
21	22	89	519	234	145	91	99	74	45	33	17
22	23	88	533	236	145	90	100	74	45	33	15
23	28	86	531	231	137	88	98	72	45	33	14
24	30	85	527	231	132	87	95	72	45	32	20
25	25	85	524	230	133	87	96	74	44	33	14
26	21	84	530	232	131	86	96	73	45	32	15
27	12	83	517	235	134	85	92	73	44	32	14
28	22	85	528	233	139	87	97	74	45	32	14
29	24	85	527	231	135	87	94	72	46	32	14
30	20	83	532	226	133	85	91	70	46	36	16
31	17	82	529	227	133	84	89	71	46	38	16
Mean	16.1	80	523	228	132	82	90	69	44	33	15

JUNE 2010 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	72.7	74.8
02	74.0	76.1
03	74.6	76.8
04	71.9	74.0
05	70.3	72.4
06	68.0	70.0
07	68.5	70.6
08	71.9	74.0
09	71.5	73.7
10	72.9	75.2
11	74.6	76.9
12	76.2	78.6
13	76.3	78.7
14	72.8	75.1
15	70.1	72.3
16	71.6	73.9
17	70.4	72.7
18	70.5	72.8
19	68.9	71.2
20	70.0	72.3
21	72.0	74.3
22	73.3	75.7
23	74.0	76.5
24	74.4	76.9
25	74.5	76.9
26	74.5	76.9
27	72.9	75.3
28	73.9	76.4
29	73.6	76.0
30	73.8	76.3
31		
Mean	72.5	74.8

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolf 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 the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The July 2010 observations were from 67 stations. (http://sidc.oma.be)

♦ 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 23 AND 24

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
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	103	108	111	111	96
2000	113	117	120	120.7#	119	119	120	119	116	115	113	112	117
2001	109	104	105	108	109	110	112	114	114	114	115	115	111
2002	114	115	113	111	109	106	103	99	95	91	85	82	102
2003	81	79	74	70	68	65	62	60	60	58	57	55	66
2004	52	49	47	46	44	42	40	39	38	36	35	34	42
2005	35	34	34	32	29	29	29	27	26	26	25	23	29
2006	21	19	17	17	17	16	15	16	16	14	13	12	16
2007	12	12	11	10	9	8	7	6	6	6	6	5	8
2008	4	4	3	3	4	3	3	3	2	2	2	1.7###	3
2009	2	2	2	2	2	3	4	5	6	7	8	8	4
2010	9	11	12	14	16	18	21	23	26	28	31	34	20
		(2)	(4)	(6)	(8)	(11)	(14)	(16)	(19)	(22)	(26)	(30)	(13)
2011	37	40	42	44	47	49	50	53	55	57	59	61	49
	(33)	(36)	(38)	(39)	(39)	(40)	(41)	(42)	(44)	(45)	(46)	(49)	(41)
2012	63	64	66	68	70	71	74	76	78	80	81	82	73
	(50)	(52)	(54)	(55)	(56)	(57)	(58)	(57)	(55)	(56)	(56)	(56)	(55)

*May 1996 marks Cycle 23's mathematical minimum. **October 1996 marks the consensus Cycle 23 minimum which NGDC is now using.
April 2000 marks Cycle 23 maximun.

- Predicted values for Cycle 24 are based on DECEMBER 2008 being minimum.

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 23, and the beginning of Cycle 24, 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 2010 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 precisely. 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 2011 prediction. There exists a 90% chance that in January 2011, the actual smoothed sunspot number will fall somewhere between 4 and 70.

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 14 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.