SOLAR INDICES BULLETIN

JANUARY 2011

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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 $10^{-22}\ \mathrm{J/m^2 Hz\,sec}$. 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.

JANUARY 2011 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	37	91	552	231	135	87	84	74	45	34	15
02	33	91	548	234	135	87	81	76	47	33	16
03	32	92	553	235	134	88	84	75	43	31	11
04	33	91	552	230	132	87	80	75	46	31	11
05	25	88	544	228	132	85	80	72	46	32	8
06	19	87	544	230	131	84	78	72	46	32	11
07	24	86	551	228	128	83	77	71	46	32	12
08	17	85	552	228	129	82	77	70	45	31	12
09	22	83	556	227	127	80	73	67	44	34	14
10	18	83	544	232	129	80	76	68	44	31	20
11	17	83	565	224	127	80	73	66	44	32	12
12	15	80	500	206	116	77	75	64	42	31	13
13	9	80	371	175	108	77	71	63	41	32	12
14	0	79	485	224	125	76	71	65	44	21	28
15	8	80	543	223	124	77	73	65	43	33	16
16	14	80	551	226	127	77	75	65	43	32	13
17	19	82	552	224	126	79	75	67	43	31	13
18	22	81	546	228	126	78	75	68	42	31	14
19	18	81	558	229	128	78	73	68	43	32	---
20	20	82	544	223	127	79	76	68	45	31	13
21	23	88	562	243	127	85	83	70	44	35	21
22	22	88	572	251	124	85	81	69	44	36	40
23	23	84	567	251	124	81	79	67	43	34	16
24	20	83	566	---	122	80	78	64	43	35	18
25	21	81	522	245	119	78	76	64	42	34	30
26	17	80	554	246	116	77	76	64	40	34	---
27	14	81	564	242	125	78	75	63	42	33	17
28	9	81	536	229	125	78	73	63	40	32	12
29	10	81	539	226	128	78	73	66	41	32	16
30	13	83	491	179	106	80	73	63	42	31	13
31	14	81	537	228	124	78	76	66	39	31	12
Mean	19.0	84	539	228	125	81	76	68	43	32	16

DEC 2010 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	86.5	84.1
02	86.5	84.1
03	86.8	84.4
04	87.4	84.9
05	87.9	85.4
06	88.5	85.9
07	87.1	84.5
08	87.2	84.6
09	86.8	84.2
10	88.4	85.8
11	86.9	84.3
12	89.4	86.7
13	87.7	85.0
14	90.3	87.5
15	86.9	84.2
16	84.1	81.4
17	81.6	79.1
18	80.5	78.0
19	80.9	78.3
20	77.9	75.4
21	77.9	75.3
22	77.7	75.2
23	80.1	77.5
24	78.6	76.1
25	79.4	76.8
26	80.5	77.9
27	80.1	77.4
28	80.7	78.0
29	82.6	79.9
30	82.9	80.2
31	90.9	87.9
Mean	84.2	81.6

Radio data for 21-27 January are from Sagamore hill.

♦ 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 January 2011 observations were from 66 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	16	17	19	21	23	25	27	18
								(3)	(6)	(8)	(12)	(15)	(4)
2011	29	31	33	35	38	40	41	43	45	48	50	51	40
	(17)	(19)	(21)	(22)	(23)	(24)	(23)	(24)	(27)	(30)	(32)	(34)	(25)
2012	53	55	57	59	60	61	64	66	69	70	71	72	63
	(36)	(38)	(41)	(43)	(44)	(45)	(46)	(45)	(44)	(44)	(45)	(45)	(43)

*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 <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 June 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 July 2011 prediction. There exists a 90% chance that in July 2011, the actual smoothed sunspot number will fall somewhere between 18 and 64.

<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 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.