SOLAR INDICES BULLETIN

APRIL 2011

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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 $10^{-22}\ J/m^2 Hz\,sec$. 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 Radio Solar Telescope Network (RSTN) preliminary observed and adjusted 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 data are replaced by fluxes measured either at Sagamore Hill, Massachusetts, San Vito, Italy, or Learmonth, Australia.

APRIL 2011 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit: RSTN (15400)	RSTN (8800)	RSTN (4995)	Pentic (2800)	RSTN (2695)	RSTN (1415)	RSTN (610)	RSTN (410)	RSTN (245)
01	48	109	531	249	142	109	106	104	58	43	31
02	45	108	501	233	150	108	111	112	59	40	20
03	43	114	505	240	157	114	116	114	64	41	28
04	48	113	499	234	151	113	113	110	59	40	21
05	40	109	505	239	157	109	112	108	58	39	22
06	41	117	534	267	153	117	112	106	59	38	13
07	58	112	526	263	151	112	112	102	58	38	20
08	60	109	552	266	149	109	109	101	56	36	19
09	56	105	545	266	146	105	106	99	55	36	16
10	40	105	547	260	136	105	105	97	55	35	16
11	48	106	556	270	149	106	113	100	56	36	16
12	66	110	562	286	145	110	116	101	54	38	21
13	79	118	563	266	156	118	121	103	54	38	25
14	88	119	557	277	165	119	119	104	54	37	26
15	91	129	564	290	176	129	128	108	51	35	29
16	66	119	560	276	158	119	120	105	56	46	52
17	51	114	567	264	157	114	117	102	57	46	69
18	51	111	562	271	155	111	113	97	54	40	22
19	51	111	571	266	153	111	115	94	54	39	26
20	52	117	576	269	155	117	118	97	57	43	27
21	57	113	567	283	160	113	122	101	55	40	20
22	62	115	807	266	166	115	122	103	52	37	21
23	56	119	558	267	160	119	120	102	54	36	15
24	46	117	556	269	162	117	119	105	56	35	16
25	40	112	561	267	157	112	117	104	56	35	15
26	53	109	563	268	146	109	112	103	57	35	17
27	52	108	557	266	153	108	112	103	58	37	21
28	44	110	567	273	158	110	114	104	56	37	20
29	44	110	1009	195	130	110	106	95	56	37	28
30	57	110	561	277	154	110	113	102	58	39	18
Mean	41.5	113	573	263	154	113	115	103	56	38	24

MAR 2011 FINAL FLUX

Observed Pentic (2800)	Adjusted Pentic (2800)
110.5	108.5
113.4	111.4
120.9	118.8
126.8	124.7
134.6	132.5
142.5	140.3
151.9	149.6
166.7	164.3
143.1	141.1
131.3	129.5
123.1	121.5
120.7	119.2
112.9	111.5
107.4	106.1
101.5	100.3
104.9	103.8
90.1	89.2
87.6	86.8
88.8	88.0
92.0	91.2
101.0	100.2
99.8	99.1
104.6	104.0
107.6	106.9
112.6	112.0
114.5	113.9
115.6	115.1
118.5	118.1
116.2	115.9
117.6	117.3
113.3	113.1
115.8	114.6

♦ 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 SOLAR INFLUENCE DATA CENTER, RINGLAAN 3, 1180 BRUSSELS, BELGIUM. (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	95
1999	83	85	84	86	91	93	94	98	102	108	111	111	117
2000	113	117	120	121	119	119	120	119	116	115	113	112	111
2001	109	104	105	108	109	110	112	114	114	114	116	115	102
2002	114	115	113	111	109	106	103	99	95	91	85	82	66
2003	81	79	74	70	68	65	62	60	60	58	57	55	42
2004	52	49	47	46	44	42	40	39	38	36	35	35	29
2005	35	34	34	32	29	29	29	27	26	26	25	23	16
2006	21	19	17	17	17	16	15	16	16	14	13	12	8
2007	12	12	11	10	9	8	7	6	6	6	6	5	3
2008	4	4	3	3	4	3	3	3	2	2	2	2	4
2009	2	2	2	2	2	3	4	5	6	7	8	8	18
2010	9	11	12	14	16	16	17	17	20	23	25	27	45
											(3)	(7)	(11)
2011	29	31	33	35	38	40	41	43	45	48	50	52	65
	(10)	(12)	(14)	(15)	(16)	(16)	(16)	(18)	(22)	(26)	(29)	(32)	(37)
2012	54	56	58	59	60	62	64	67	69	70	71	72	77
	(34)	(36)	(39)	(41)	(42)	(43)	(43)	(42)	(41)	(41)	(42)	(42)	(42)

♦ 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 August 2011 prediction. There exists a 90% chance that in August 2011, the actual smoothed sunspot number will fall somewhere between 18 and 62.

<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.