Australian Government

Bureau of Meteorology

SPACE WEATHER SERVICES

SOLAR

AND

GEOPHYSICAL

SUMMARY

November 2023

Solar Activity

Solar activity was predominately at R0-R1 levels this month with 16 R1 level flares observed and no X-class flares observed. An isolated R2 level event was observed on 28-Nov due to an M9.8 flare which was the largest flare for the month. No solar proton events were observed with S0 conditions observed all month. None of the flares caused significant shortwave fadeouts in the Australian region, however a minor fadeout was observed on 23-Nov associated with an M1.4 flare.

Two moderate CME shocks associated with solar filament eruptions were observed on 05-Nov at 0810UT and 1146UT, inducing G3 planetary geomagnetic conditions (G2 in Australia). A weak CME shock was observed on 12-Nov at 0531UT. A moderate CME shock was observed on 25-Nov at 0754UT, producing G2 planetary geomagnetic conditions (G1 in Australia). Elevated solar wind speeds were observed during the intervals 6-11-Nov, 22-23 Nov and 25-Nov.

Several significant CMEs were observed over 27-28 Nov. Two CMEs associated with filament eruptions were observed on 27-Nov and considered to be Earth-directed, with an arrival anticipated on 30-Nov. Halo CMEs were observed associated with the R2 flare on 28-Nov, also considered to be Earth-directed. The first of these CMEs arrived at 2333UT on 30-Nov.

M and X class flares for the month are listed below.
Please see our homepage https://www.sws.bom.gov.au for a link to an explanation of the Australian Space Weather Alert System (ASWAS) scales.

DATE	FLARES CLASS M	CLASS X	FLARE MAX	FADEOUT POSSIBLE ON DAYLIGHT CIRCUIT
1-Nov-23	M1.1		0626UT	
1-Nov-23	M1.4		1226UT	
2-Nov-23	M1.6/SB		1222UT	
2-Nov-23	M1.0		1921UT	
5-Nov-23	M1.8/1N		1143UT	
5-Nov-23	M1.6		1432UT	
11-Nov-23	M1.2/SF		1729UT	
14-Nov-23	M1.0/SN		2305UT	
18-Nov-23	M1.2		0542UT	
18-Nov-23	M1.1		1644UT	
18-Nov-23	M1.0		2233UT	
20-Nov-23	M1.2		0903UT	
23-Nov-23	M1.4		0338UT	
23-Nov-23	M1.0		1437UT	
24-Nov-23	M1.1/1F		0933UT	
28-Nov-23	M3.4		1932UT	1907-1935UT
28-Nov-23	M9.8		1950UT	1935-2009UT

FLARE ALERT	SWF ALERT
23 Nov 23	0304-0415UT

PROTON ALERT

BEGIN		END		ENERGY THRESHOLD
DATE	TIME	DATE	TIME	

None Issued.

Ionospheric Activity

Periods of maximum usable frequency (MUF) depressions were observed on 6, 7, 19, 15, 22-23 and 26 Nov following geomagnetic activity.

The deepest ionospheric depression for the month was observed on 06-Nov following coronal mass ejection induced geomagnetic activity. The Australian regional MUFs were depressed by 40% on this day. Another significant depression was observed on 26-Nov again following geomagnetic activity induced by a CME. Otherwise, MUFs were generally near predicted monthly values to 15-20% enhanced.

No significant shortwave fadeouts were observed in the Australian region during November. A minor shortwave fadeout was observed in the Australian region on 23-Nov, associated with an M1.4 flare.

Ionospheric scintillation was observed on 3-Nov at Weipa and on 5-Nov at both Darwin and Weipa.

Ionospheric depressions listed below are calculated using foF2 data from the SWS ionosonde network.

IONOSPHERIC DISTURBANCES (MUFs for the Australian region)

06 Nov 23: Australian regional MUFs Depressed by 40%
07 Nov 23: Northern region MUFs Depressed by 20%
10 Nov 23: Southern region MUFs Depressed by 15%
15 Nov 23: Southern region MUFs Depressed by 15%
22 Nov 23: Northern region MUFs Depressed by 20%
23 Nov 23: Southern region MUFs Depressed by 20%
26 Nov 23: Northern region MUFs Depressed by 45%
Southern region MUFs Depressed by 25%

RADIO COMMUNICATIONS WARNINGS

DATE	Nº.	BEGIN	END
02 Nov 23	108	03 Nov 23	05 Nov 23
04 Nov 23	109	05 Nov 23	07 Nov 23
05 Nov 23	110	05 Nov 23	07 Nov 23
06 Nov 23	111	06 Nov 23	07 Nov 23
11 Nov 23	112	12 Nov 23	13 Nov 23
14 Nov 23	113	15 Nov 23	16 Nov 23
18 Nov 23	114	19 Nov 23	20 Nov 23
21 Nov 23	115	21 Nov 23	21 Nov 23
21 Nov 23	116	22 Nov 23	22 Nov 23
22 Nov 23	117	23 Nov 23	24 Nov 23
22 Nov 23	118	23 Nov 23	23 Nov 23
23 Nov 23	119	23 Nov 23	23 Nov 23
25 Nov 23	120	26 Nov 23	26 Nov 23
28 Nov 23	121	28 Nov 23	30 Nov 23
29 Nov 23	122	30 Nov 23	01 Dec 23

Geomagnetic Activity

The strongest disturbance for the month was observed on 05-Nov with a local A index of 37 reached. The planetary Ap index reached 75 on this day. The planetary Kp reached G3 and the Australian regional KAus reached G2. This activity was associated with CME arrivals. A coronal hole wind stream induced mild geomagnetic activity over 22-23 Nov. Geomagnetic activity on 25-Nov was associated with a CME arrival, with the Australian regional field reaching G1 and planetary conditions reaching G2.

Disturbances with Australian A indices greater than or equal to 16 are reported below.

DATE	GEOMAGNETIC DISTURBANCES (for the Australian region)
05 Nov 23:	G2 (planetary G3)
06-Nov-23:	G0 (planetary G2)
22 Nov 23:	G0
23 Nov 23:	G0 (planetary G1)
25 Nov 23:	G1 (planetary G2)

GEOMAGNETIC WARNINGS AND ALERTS				
DATE	Nº.	BEGIN	END	ISSUED
02 Nov 23	65	04 Nov 23	05 Nov 23	Warning
04 Nov 23	66	05 Nov 23	06 Nov 23	Warning
06 Nov 23	67	07 Nov 23	08 Nov 23	Warning
09 Nov 23	68	11 Nov 23	13 Nov 23	Warning
16 Nov 23	69	19 Nov 23	20 Nov 23	Warning
22 Nov 23	70	22 Nov 23	22 Nov 23	Warning
24 Nov 23	71	26 Nov 23	26 Nov 23	Warning
27 Nov 23	72	30 Nov 23	01 Dec 23	Warning
29 Nov 23	73	30 Nov 23	01 Dec 23	Warning
29 Nov 23	74	30 Nov 23	01 Dec 23	Warning

Solar And Geophysical Indices

DATE	10cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX	DATE	10 cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX
01 Nov	159	6	137	16 Nov	118	6	109
02 Nov	158	5	140	17 Nov	120	2	95
03 Nov	156	2	150	18 Nov	127	2	118
04 Nov	155	9	140	19 Nov	140	2	114
05 Nov	155	37	96	20 Nov	157	5	132
06 Nov	146	21	27	21 Nov	172	13	88
07 Nov	145	13	83	22 Nov	190	20	56
08 Nov	146	9	134	23 Nov	194	2	82
09 Nov	139	8	131	24 Nov	178	6	127
10 Nov	144	6	128	25 Nov	176	28	114
11 Nov	142	1	131	26 Nov	180	7	57
12 Nov	137	9	132	27 Nov	187	4	140
13 Nov	134	10	115	28 Nov	182	6	143
14 Nov	124	7	125	29 Nov	171	3	138
15 Nov	119	9	108	30 Nov	167	2	128

DATE	10cm FLUX	AUSTRALIAN A-INDEX	AUSTRALIAN T-INDEX	SUNSPOT NUMBER		FLARES
	Monthly Average	Monthly Average	Monthly Average	Monthly Average	13-month smoothed	>M1.0
Dec-22	132.3	8.1	83.5	113.1	104.5	43
Jan-23	182.3	7.1	118.6	143.6	113.3	42
Feb-23	173.5	10.3	115	110.9	117.9	51
Mar-23	157.2	9.3	131.5	122.6	121.2	21
Apr-23	145.8	8.3	119.3	96.4	123.4	9
May-23	156	6.5	97.7	137.9	124.9	60
Jun-23	161.7	5.5	97.5	163.4	127.5	21
Jul-23	177.1	4.9	103.5	159.1	127.6	52
Aug-23	153.7	4.6	114.5	114.9	127.7	27
Sep-23	154.5	9.8	104.3	133.6	128.6	33
Oct-23	142.6	6.1	130.3	99.4	129.9	7
Nov-23	153.9	8.7	113.9	105.4	130.6	17
					Predicted sunspot numbers	

SPECIAL NOTE
In June 2015, WDC-SILSO, Royal Observatory of Belgium, Brussels, adjusted their original observed sunspot numbers (Version 1.0) to a Version 2.0 series in which the sunspot numbers are higher. In the Version 1.0 data series, some of the sunspot numbers were weighted. The new (Version 2.0) sunspot numbers are unweighted sunspot number counts (for more information see: www.sidc.be/silso/home). The Bureau of Meteorology SWS solar cycle prediction is now based on the Version 2.0 values. As a result of this recalibration, the observed monthly and observed and predicted smoothed sunspot numbers are higher in the monthly table and solar cycle graph.

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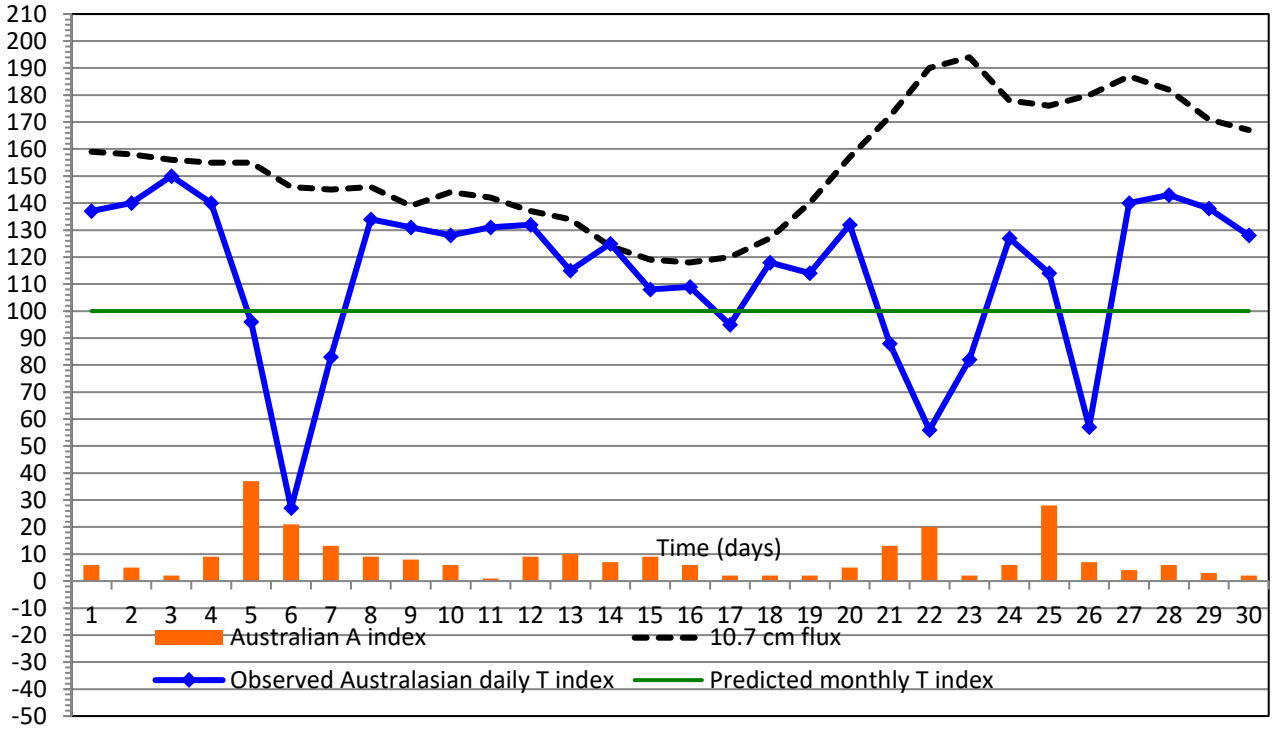
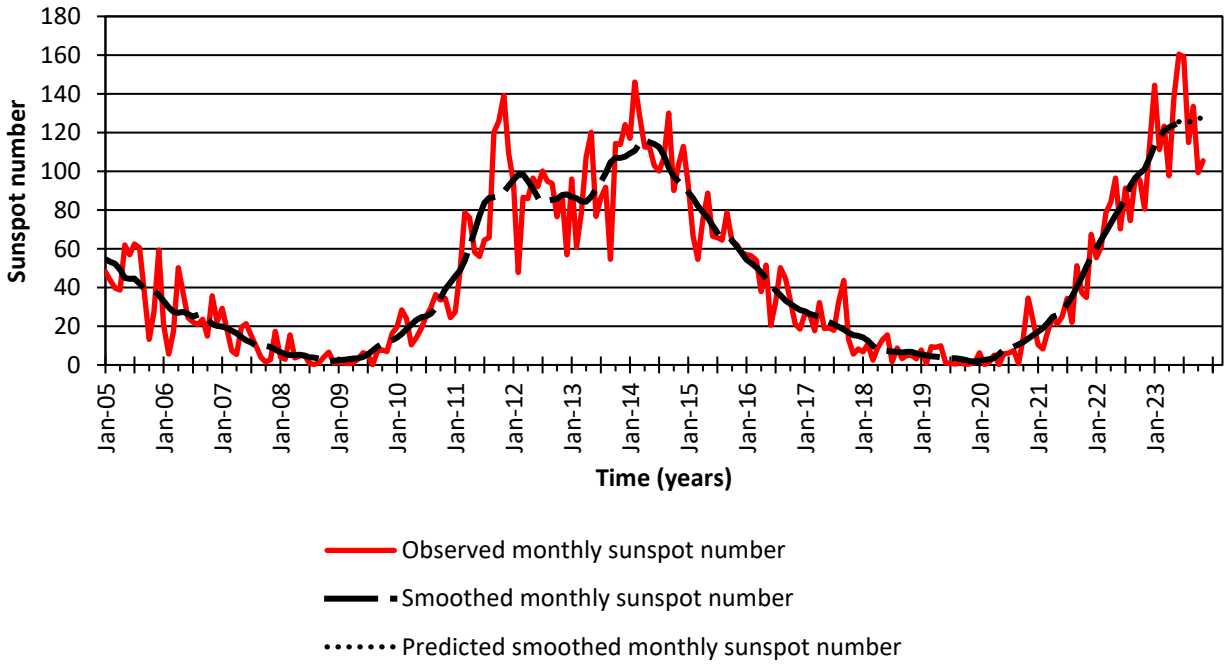
SWS WORLD T-INDICES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	8	2	3	-2	-6	-3	-3	-8	-6	-10	-15	-9
2019	-5	-3	-4	-4	-9	-14	-11	-14	-11	-14	-16	-12
2020	-2	-5	2	-1	-7	-7	-9	-2	-6	-6	7	12
2021	12	4	10	6	6	12	21	12	23	23	17	28
2022	41	52	63	71	81	65	67	56	72	75	65	71
2023	107	114	119	105	101	110	118	118	107	113*	100	98
2024	95	92	90	87	85	84	83	82	80	79	78	77
	SWS predicted T-index				* New observed data. T-index value may have changed							

Solar and Geophysical Indices - November 2023



Solar Cycle



Observed monthly sunspot numbers courtesy of WDC-SILSO, Royal Observatory of Belgium, Brussels (www.sidc.be/silso/home)

NOTES - notes - NOTES - notes - NOTES - notes

a. Times quoted in this publication are all Universal Time (UT).

b. The values of all indices are provisional. Final values are not available for several months.

c. M or X class flares refer to the X-ray classification system for solar flares. In this system, X class flares are more energetic than M class flares.

FLARE CLASS	X-RAY FLUX DENSITY	
	Ergs/cm^2/sec	W/m^2
M	0.01-0.1	10^{-5} to 10^{-4}
X	>0.1	> 10^{-4}

d. Class M flares, particularly the less energetic ones, are likely to cause a fadeout on only the lowest frequencies. Class X flares are likely to cause a fadeout over the entire HF spectrum. It should be noted that a fadeout will only occur on those circuits having a reflection point in the daylight hemisphere of the earth. Circuits having only night hemisphere reflection points will not be affected no matter the energy of the solar flares.

e. The 10cm flux is the radio power of the sun at a frequency of 2800 MHz (wavelength 10.7 cm). This flux is a good indicator of solar activity and is widely used in place of the sunspot number. The values are measured by the Penticton radio observatory, Canada. Unlike the sunspot number, the 10cm flux never drops to zero even during solar minimum. With no sunspots visible on the solar disk, the 10cm flux will still have a value of around 67. The table below gives a (statistical) comparison between 10cm flux and sunspot number. The 10cm flux is measured in solar flux units (10^{-22} W m^{-2} Hz^{-1}).

SUNSPOT No.	10 cm FLUX
0	67
20	78
40	93
60	110
100	147
150	195
200	243

f. Ionospheric disturbances refer to measurements made across Australia, but are generally applicable to mid-latitude Southern Hemisphere conditions. Spread F conditions indicate tilts in the ionosphere, which may result in multipath fading on some HF circuits.

g. The magnetic A-indices are for the Australian region. Large values for the A index correspond to disturbed conditions. Levels of magnetic disturbances are described in the following terms.

A INDEX VALUE	DESCRIPTION
0 up to 7	Quiet
8 up to 15	Unsettled
16 up to 24	Active
25 up to 35	Minor Storm
36 and above	Major Storm

h. The Australian daily T-index is a measure of the average of the ionospheric critical frequencies available on a particular day - the higher the value of the T-index, the higher the ionospheric critical frequencies (and Maximum Usable Frequencies on HF circuits) for that day. The T-index is based on data from Australian ionospheric stations and so is most applicable to HF circuits with reflection points in the Australian region.

i. The SWS monthly observed T-index is derived from the observed monthly median values of foF2 for each hour from ionospheric stations worldwide.

The predicted smoothed monthly T-indices are computed by using a statistical analysis of the observed monthly T-indices for all solar cycles since 1938.

The SWS T-indices may not be updated each month but only when sufficient new data becomes available.

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