Australian Government

Bureau of Meteorology

SPACE WEATHER SERVICES

SOLAR

AND

GEOPHYSICAL

SUMMARY

October 2023

Solar Activity

Solar activity was predominately at the R0 level for the month, with only seven low-level M class flares observed and no X class flares observed. The largest flare for the month was an M2.5 flare on 01 October.
None of the R1 events this month caused significant shortwave fadeouts in the Australian region, however minor shortwave fadeouts may have been observed on 01 and 10 Oct.

The sunspot number in October was significant below from what has been observed in previous months. The Sun had several active sunspot regions on the visible disk at the start of the month, but by the middle of the month most sunspots were simple and not flare productive. This behaviour continued until the end of the month, and by 30-Oct sunspot numbers began to increase noticeably. AR3474 grew the most significantly at the end of the month into a beta-gamma magnetic configuration, but did not produce any significant flares in October.

Solar radiation storm conditions were S0 for the entire month.

Many CMEs were observed during October, although only a few of these had an Earth-directed component. Most CME impacts in October were glancing impacts only, not head-on impacts. Many of the CMEs observed were fast halo events, mostly originating from the far side of the Sun and therefore not Earth-directed.

A notable event was when a CME first observed on 16-Oct did have an Earth-directed component which arrived on 20-Oct and G1 geomagnetic storming was observed on 21-Oct.
A second impact may have been observed on 28 or 29 Oct, although the Earth may have been influenced by a co-rotating interaction region (CIR) from a fairly large coronal hole wind stream at this time, masking the impact.

Fast solar wind speeds were observed on 14, 26 and 29 Oct.

M and X class flares for the month are listed below.

DATE	FLARES		FLARE MAX	FADEOUT POSSIBLE ON DAYLIGHT CIRCUIT
	CLASS M	CLASS X		
01 Oct 23	M2.5		0132UT	0121-0156 UT
02 Oct 23	M1.9/1N		1246UT	
07 Oct 23	M1.7/SB		1806UT	
10 Oct 23	M1.6		0209UT	0202-0224 UT
10 Oct 23	M2.3/SF		1217UT	
12 Oct 23	M1.1		0458UT	
27 Oct 23	M1.4		2324UT	

FLARE ALERT	SWF ALERT
01 Oct 23:	0121-0156 UT
02 Oct 23:	
07 Oct 23:	
09 Oct 23:	
10 Oct 23:	0202-0224 UT
12 Oct 23:	
14 Oct 23:	
16 Oct 23:	
27 Oct 23:	

PROTON ALERT

BEGIN		END		ENERGY THRESHOLD
DATE	TIME	DATE	TIME	

None issued

Ionospheric Activity

Periods of maximum usable frequency (MUF) depressions were observed in the Australian region on 7, 14, 20 28, and 29 Oct following geomagnetic activity.
MUF depressions in October were generally mild, with maximum depressions being around 15-20% for all of these events.

Otherwise, MUFs were either near predicted monthly values or 15-20% enhanced throughout October. Daily T-indices were either enhanced or at the expected monthly T-index for October. The highest recorded daily T-index was 153 on 16-Oct and the lowest recorded daily T-index of October was 85 on 22-Oct.

No significant shortwave fadeouts were observed in the Australian region during the month of October. Minor shortwave fadeouts may have been observed in the Australian region on 01 and 10-Oct for a short time. No polar cap absorption or auroral absorption events were observed in October.

Spread-F was observed at mid and low latitude sites over 04-05, 13-16, 18-21,
23-25 and 28-30 Oct. Sporadic-E was frequently seen at low latitude sites during local night hours. Otherwise, HF communication conditions were generally good.

Ionospheric scintillation was observed on 07, 12, 13, 17 and 28 Oct.

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

IONOSPHERIC DISTURBANCES (MUFs for the Australian region)

01 Aug 21: Northern region MUFs Depressed by 15%
07 Aug 21: Southern region MUFs Depressed by 15%
08 Aug 21: Southern region MUFs Depressed by 15%
28 Aug 21: Southern region MUFs Depressed by 25%
29 Aug 21: Southern region MUFs Depressed by 15%
30 Aug 21: Southern region MUFs Depressed by 15%

RADIO COMMUNICATIONS WARNINGS

DATE	Nº.	BEGIN	END

02 Oct 23	103	02 Oct 23	04 Oct 23
10 Oct 23	104	11 Oct 23	12 Oct 23
26 Oct 23	105	27 Oct 23	28 Oct 23
29 Oct 23	106	29 Oct 23	31 Oct 23
31 Oct 23	107	31 Oct 23	01 Nov 23

Geomagnetic Activity

Planetary geomagnetic conditions reached the G1 level on 5, 21, 26, 27 and 29 Oct.
Australian region geomagnetic conditions remained at G0 on all days in October.
All of these events were due to weak glancing CME blows. The G1 on 29-Oct was coupled with a co-rotating interaction region (CIR) that was moving ahead of a fairly large coronal hole wind stream. The maximum Australian A-index of the month was 16 on 26-Oct and the maximum planetary A-index was 23 on 26-Oct.

A notable event was when a CME that was first observed on 16-Oct had an Earth-directed component that arrived on 20-Oct and G1 geomagnetic storming was observed on 21-Oct. While the actual impact was minimal, the event had the solar wind parameter Bz oriented southward for over 24 hours. The prolonged southward oriented Bz parameter was the main driver of the geomagnetic storm.

Enhanced geomagnetic activity below the G1 threshold was observed in the Australian region on 31-Oct at around 1000-1200 UT. The Learmonth magnetometer observed a 3-hourly K-index of 5 (G1), while the other Australian magnetometers observed a K-index of 4 (G0, just under the G1 threshold). This event was accompanied by a small increase in GIC and a small disturbance to the Australian DST index. The solar wind parameter Bz was oriented only slightly southward (near -4 nT) for the two hours leading up to the event, which may have induced a substorm responsible for this event.
It is uncertain what the cause of this was as space weather was overall quiet at this time.

G0 geomagnetic conditions were observed on all other days.

DATE	GEOMAGNETIC DISTURBANCES (for the Australian region)
None observed.	

GEOMAGNETIC WARNINGS AND ALERTS				
DATE	Nº.	BEGIN	END	ISSUED
05 Oct 23	60	06 Oct 23	07 Oct 23	Warning
21 Oct 23	61	21 Oct 23	21 Oct 23	Warning
26 Oct 23	62	26 Oct 23	27 Oct 23	Warning
28 Oct 23	63	30 Oct 23	31 Oct 23	Warning
29 Oct 23	64	29 Oct 23	31 Oct 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 Oct	161	4	109	17 Oct	137	3	147
02 Oct	158	5	122	18 Oct	135	9	144
03 Oct	154	4	137	19 Oct	129	6	132
04 Oct	155	6	136	20 Oct	126	6	106
05 Oct	156	8	137	21 Oct	123	8	138
06 Oct	155	8	152	22 Oct	119	5	107
07 Oct	157	3	140	23 Oct	122	1	112
08 Oct	157	6	142	24 Oct	121	4	126
09 Oct	166	6	139	25 Oct	126	3	128
10 Oct	164	2	129	26 Oct	126	16	133
11 Oct	158	2	141	27 Oct	128	6	118
12 Oct	157	3	138	28 Oct	128	14	133
13 Oct	149	13	144	29 Oct	129	14	100
14 Oct	148	6	124	30 Oct	140	8	113
15 Oct	145	1	134	31 Oct	147	10	135
16 Oct	144	2	149				

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
Nov-22	123.4	7.3	76.1	77.6	101	6
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	125.4	60
Jun-23	161.7	5.5	97.5	163.4	126.5	21
Jul-23	177.1	4.9	103.5	159.1	124.8	52
Aug-23	153.7	4.6	114.5	114.9	123.1	27
Sep-23	154.5	9.8	104.3	133.6	122.2	33
Oct-23	142.6	6.1	130.3	99.4	121.7	7
					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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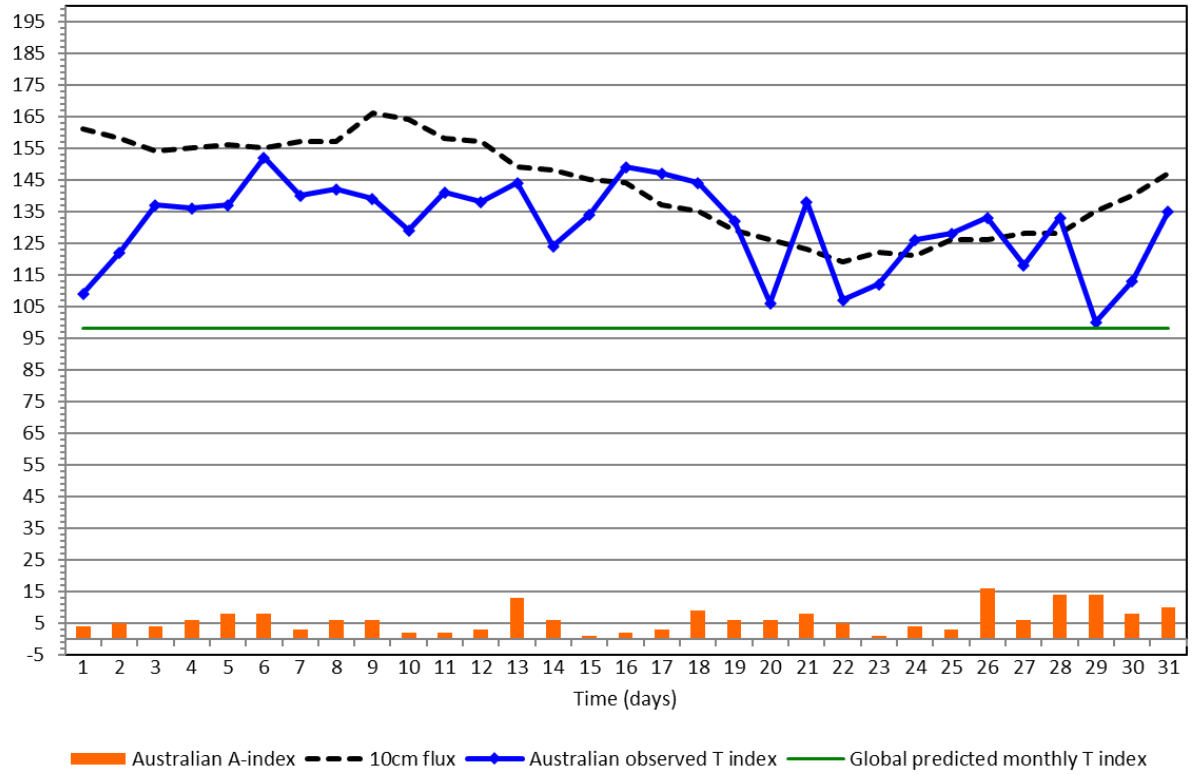
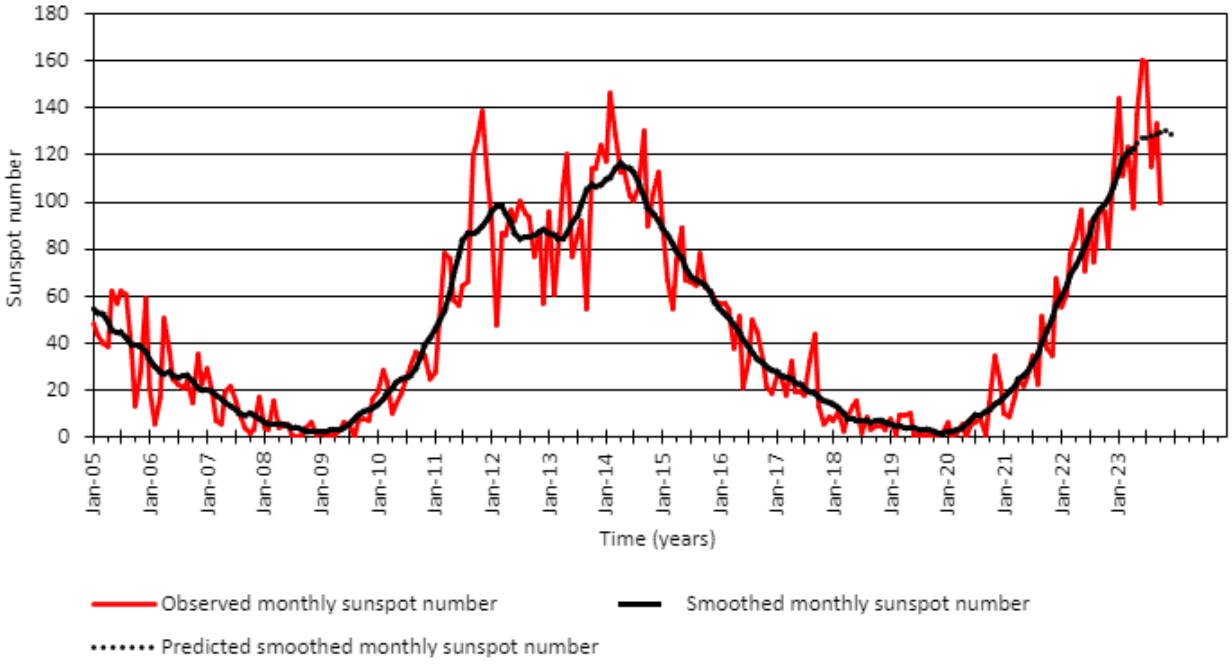
SWS WORLD T-INDICES

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*	98	96	94
2024	91	88	85	82	81	80	79	78	77	76	75	74
	SWS predicted T-index				* New observed data. T-index value may have changed							

Solar and Geophysical Indices - October 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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