Australian Government

Bureau of Meteorology

SPACE WEATHER SERVICES

SOLAR

AND

GEOPHYSICAL

SUMMARY

June 2023

Solar Activity

Solar activity was predominately at the R1 level during June 2023, with a single R3 event on 20-Jun. No R2 level flares were observed during the month. In total, 22 M-class flares and one X-class flare were observed. The largest flare was an X1.1 (R3) flare at 1709UT on 20-Jun, followed by an M4.8 (R1) flare at 2344UT on 22-Jun, both of which were produced by AR3341. Solar activity was at the R1 level on 2,7,9,16,18,19,20,21,22,24,26,27,28 and 29-Jun. Flares originated from several different active regions early in the month, whereas AR3340 and AR3341 were the main contributors to the flares observed in the second half of the month. AR3341 produced the solitary R3 level event on 20-Jun as well as five additional M-class flares at the R1 level. AR3340 and AR3341 both decayed significantly before rotating over the western limb late in the month. AR3354 appeared on the solar disk on 26-Jun and developed rapidly in area and magnetic complexity over the next two UT days. However, despite its high magnetic complexity the region remained relatively flare quiet, producing one M3.8 (R1) magnitude flare on 29-Jun and several other C-class flares. The region will rotate over the western limb in the first week of July. (Note that solar region AR3354 produced and X1 flare on 02-July).

The solar wind speed was mostly near to background levels during the first half of June. A rapid increase in the solar wind was observed late on 15-Jun, rising to approximately 700 km/s by 16-Jun due to the combined effects of a coronal hole high speed wind stream and a corotating interactive region. The solar wind speed then rapidly declined over UT day 17-Jun. A weak shock in the solar wind was observed at 1916UT on 24-Jun. This was possibly indicative of a glancing impact from a CME associated with the X1.1 flare observed on 20-Jun. No other significant shocks in the solar wind were observed this month. In general, solar wind speeds remained moderately elevated for the second half of June, mainly due to moderate sized patchy equatorial coronal holes.

The proton flux remained at background levels (S0) for the entirety of the month, with no enhancements over the 10 MeV threshold.

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

DATE	FLARES		FLARE MAX	FADEOUT POSSIBLE ON DAYLIGHT CIRCUIT
	CLASS M	CLASS X		
2 Jun 23	M1.5		0241UT	
7 Jun 23	M4.7		1146UT	1118-1159UT
9 Jun 23	M2.5		1711UT	
16 Jun 23	M1.0		0530UT	
16 Jun 23	M1.0		1038UT	
16 Jun 23	M1.0		1959UT	
18 Jun 23	M1.3		0031UT	
18 Jun 23	M2.5/2N		1353UT	
19 Jun 23	M1.4		0350UT	
19 Jun 23	M1.1/SF		1214UT	
20 Jun 23	M1.8		1126UT	
20 Jun 23	M1.0		1548UT	
20 Jun 23	M1.1/1N		1633UT	
20 Jun 23		X1.1	1709UT	1642-1726UT
21 Jun 23	M1.1/1N		1244UT	
21 Jun 23	M1.0/SF		1538UT	
22 Jun 23	M1.1/1N		1121UT	
22 Jun 23	M4.8		2344UT	2329-2357UT
24 Jun 23	M1.1/SN		1217UT	
26 Jun 23	M1.6/1N		1622UT	
27 Jun 23	M1.2/SF		1514UT	
28 Jun 23	M1.9/2N		0844UT	
29 Jun 23	M3.8/2B		1415UT	1400-1423UT
27 Jun 23	M1.2/SF		1514UT	
28 Jun 23	M1.9/2N		0844UT	
29 Jun 23	M3.8/2B		1415UT	1400-1423UT

Total Number of M-class flares 22, X-class flares 1
Total Number of flares for Jun was 23
The largest flare for the month was an X1.1 on Jun 20

FLARE ALERT	SWF ALERT
1 Jun 23	Flare Alert
2 Jun 23	Flare Alert
7 Jun 23	Flare Alert
9 Jun 23	Flare Alert
15 Jun 23	Flare Alert
16 Jun 23	Flare Alert
18 Jun 23	Flare Alert
19 Jun 23	Flare Alert
20 Jun 23	Flare Alert
21 Jun 23	Flare Alert
22 Jun 23	Flare Alert
23 Jun 23	Flare Alert
24 Jun 23	Flare Alert
26 Jun 23	Flare Alert
27 Jun 23	Flare Alert
28 Jun 23	Flare Alert
29 Jun 23	Flare Alert

PROTON ALERT

BEGIN DATE	BEGIN TIME	END DATE	END TIME	ENERGY THRESHOLD

None.

Ionospheric Activity

No significant ionospheric depressions were observed this month. Maximum usable frequencies were generally near predicted monthly values for June, with occasional enhancements of 15% observed. Mild depressions of 15% were briefly observed in Northern Australia on 07-Jun and in Southern Australia on 30-Jun. Spread F was frequently observed during local night hours in southern Australian regions. No significant shortwave fadeouts impacting the Australian region were observed during the month. The X1.1 flare on 20-Jun occurred during local night hours, thus not impacting local HF conditions. No significant ionospheric scintillation was observed during the month.

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

IONOSPHERIC DISTURBANCES (MUFs for the Australian region)

7 Jun 23	Northern region MUFs Depressed by 15%
30 Jun 23	Southern region MUFs Depressed by 15%

RADIO COMMUNICATIONS WARNINGS

DATE	Nº.	BEGIN	END
1 Jun 23	53	1 Jun 23	3 Jun 23
5 Jun 23	54	5 Jun 23	6 Jun 23
7 Jun 23	55	8 Jun 23	9 Jun 23
18 Jun 23	56	19 Jun 23	21 Jun 23
21 Jun 23	57	21 Jun 23	23 Jun 23
23 Jun 23	58	23 Jun 23	25 Jun 23
26 Jun 23	59	26 Jun 23	28 Jun 23
29 Jun 23	60	29 Jun 23	1 Jul 23

Geomagnetic Activity

The strongest regional disturbance for the month was observed on 16-Jun with a local A-index of 18. An isolated period of G2 geomagnetic conditions was observed at Hobart on this day. Overall, the Australian regional K-index (KAus) remained at G0 levels throughout the entirety of the month. The planetary K-index (Kp) reached G2 geomagnetic conditions on late 15-Jun and early 16-Jun due to the combined effects of a coronal hole high speed wind stream and a corotating interactive region. A weak shock in the solar wind was observed at 1916UT on 24-Jun. This was possibly indicative of a glancing impact from a CME associated with the X1.1 flare observed on 20-Jun. The planetary K-index then reached G1 geomagnetic conditions for a single period on 25-Jun. Patchy coronal hole features ensured the solar wind remained elevated for the second half of the month but did not induce any significant geomagnetic disturbances.

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

DATE	GEOMAGNETIC DISTURBANCES (for the Australian region)
16 Jun 23	G0 (isolated period of G2 at Hobart)

GEOMAGNETIC WARNINGS AND ALERTS

DATE	Nº.	BEGIN	END	ISSUED
15 Jun 23	32	16 Jun 23	16 Jun 23	Warning
23 Jun 23	33	26 Jun 23	26 Jun 23	Warning
24 Jun 23	34	25 Jun 23	26 Jun 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
1-Jun	164	7	96	16-Jun	157	17	120
2-Jun	162	2	94	17-Jun	158	6	102
3-Jun	165	1	89	18-Jun	164	6	100
4-Jun	168	5	91	19-Jun	169	7	99
5-Jun	169	3	92	20-Jun	180	5	99
6-Jun	172	2	91	21-Jun	176	3	103
7-Jun	167	1	77	22-Jun	173	7	109
8-Jun	169	2	81	23-Jun	170	6	109
9-Jun	164	1	83	24-Jun	161	11	113
10-Jun	161	1	93	25-Jun	155	12	122
11-Jun	154	4	92	26-Jun	158	7	110
12-Jun	146	2	94	27-Jun	151	5	104
13-Jun	146	2	94	28-Jun	155	4	93
14-Jun	144	1	88	29-Jun	162	14	103
15-Jun	153	14	92	30-Jun	159	7	92

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
Jul-22	125.8	6	63.9	91.4	84.9	7
Aug-22	118.1	6.9	52.5	75.4	92.2	29
Sep-22	135.1	7.9	74.6	96.3	96.2	13
Oct-22	133.5	7.9	82.1	95.4	99.1	19
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	107.1	42
Feb-23	173.5	10.3	115	110.9	109.5	51
Mar-23	157.2	9.3	131.5	122.6	111.9	21
Apr-23	145.8	8.3	119.3	96.4	113.5	9
May-23	156	6.5	97.7	137.9	115.7	60
Jun-23	161.7	5.5	97.5	163.4	117.0	23

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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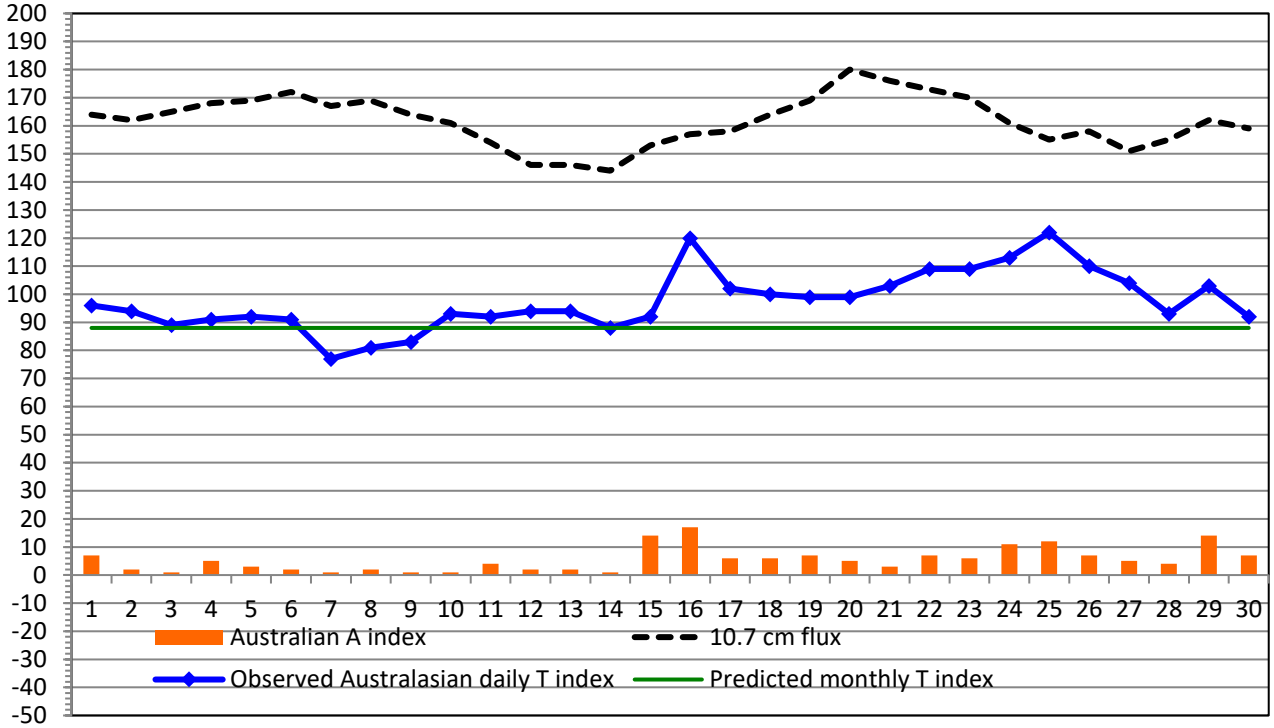
SWS WORLD T-INDICES

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*	88	87	83	79	75	72	70

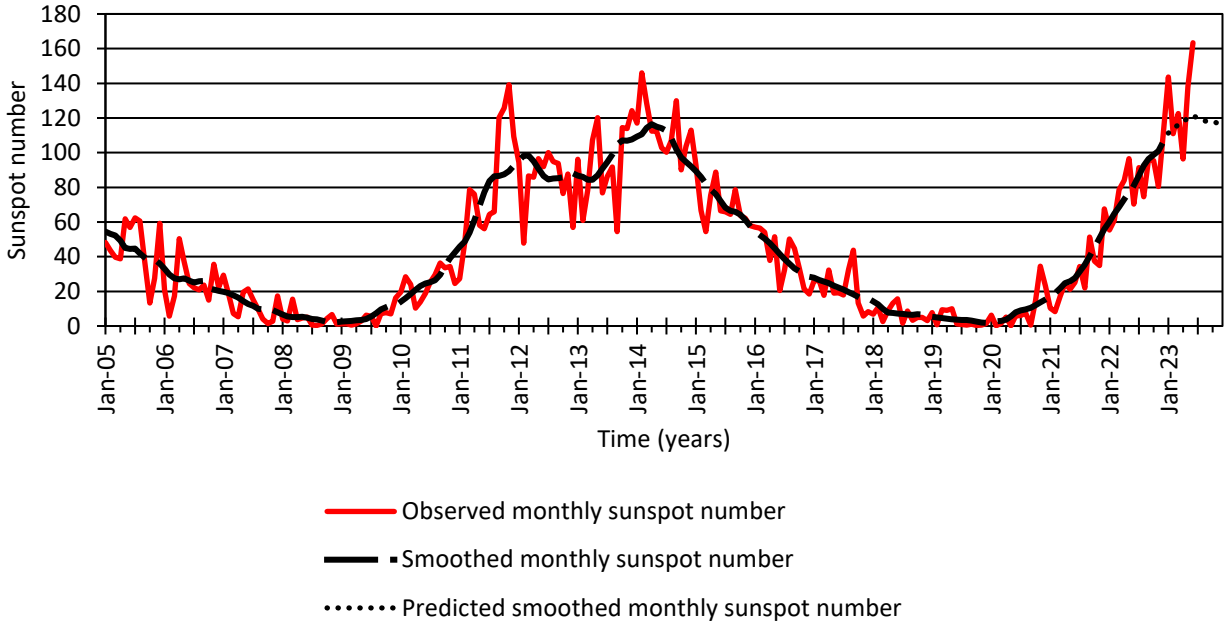
SWS predicted T-index

* New observed data. T-index value may have changed

Solar and Geophysical Indices - June 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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