

Space Weather Technical Forecast

Issued on Friday, 30 June 2023 at 13:06 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Daily Chance of R1/R2 Radio Blackouts. Chance of G1 Geomagnetic Storm intervals, peaking 01 July.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray activity at GOES16 showing occasional C-class flares, but with a peak M3.8 at 29/1415UTC from AR3354. This sunspot group is by far the largest and most magnetically complex on the facing side of the Sun, and currently shows as an Fki/Beta-Gamma-Delta. The group has shown some spreading in the period, with a tendency for a slight overall decrease in penumbral area, although it retains several candidates for Mt Wilson delta spots. This was one of up to six sunspot regions on the Earth-facing side into the current UTC morning, with AR3340 now no longer discernible on the northwestern limb, while the remainder of groups were all stable and unipolar, including up to two new unnumbered regions.

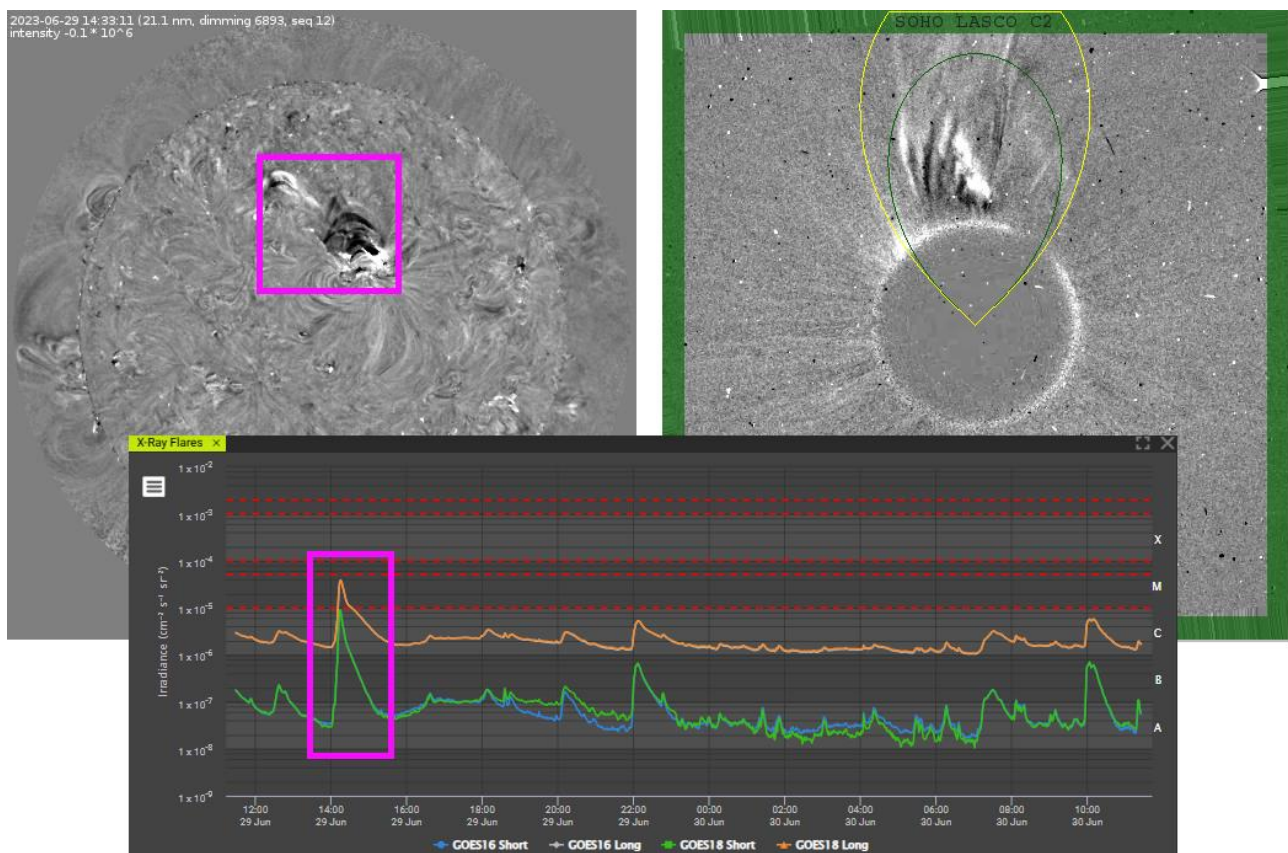


Figure 0: Top left: SIDC ROB-generated AIA 211 dimming, showing the M3.8 flare from AR3354 at 29/1415UTC. The subsequent CME is shown on Lasco C2, as at 29/1924UTC.

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The M-class flare from AR3354 had a coronal dimming associated with it, and ejecta was subsequently seen heading largely north of the Sun-Earth line through the UTC overnight period. This feature has been analysed and determined to carry a possible Earth-directed component - crossing 1AU within the UTC day of Tuesday 04 July as a marginal glancing blow. Also of note was a large but far-sided prominence eruption, with this seen heading north and east on coronagraph imagery, to no effect at Earth.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE and DSCOVR at L1, implies a possible weak CIR into a positive polarity fast wind, perhaps most likely that from coronal hole 18 in the southwest quadrant. The phi angle was consequently negative at first (towards the Sun), but transitioned to positive from 30/0130UTC.

The solar wind speed rose over the 24 hours from Slightly Elevated to Elevated levels, and figures of around 450km/s to peak near 550kms. There were several discontinuities observed in this trace, firstly within the negative phi sector at 29/1430UTC, but especially with the SSBC into the fast wind from 30/0130UTC. The solar wind density showed a gradual ramping to peak near 10ppcc with the CIR, falling away as the fast wind ensued. The IMF was modest throughout, with an early peak of 8nT but falling with time, while the north-south component varied between mainly anti-aligned (with Earth's field) to a maximum of -5nT, to a more variable behaviour into the current UTC day and with a maximum co-aligned +4nT.

The net effect of the above solar wind measures was for provisionally Active geomagnetic activity, peaking with Kp '4-' in the 15-18 and 21-24UTC intervals.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels, despite the mid-ranking centre-disc M-class flare.

High energy electron flux (greater than 2MeV), peaked within High flux, registering 2430pfu at 29/1710UTC, before a sharp decline at GEO due to UTC evening geomagnetic activity, falling to Normal Background before a subsequent hesitant (and partial) recovery. the 24-hour integrated fluence was 6.2e7 at 30/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a daily Chance of returning to Moderate, with a Slight Chance of X-class flares. This risk is almost entirely from AR3354 at first, but may be bolstered by returning regions into the new week.

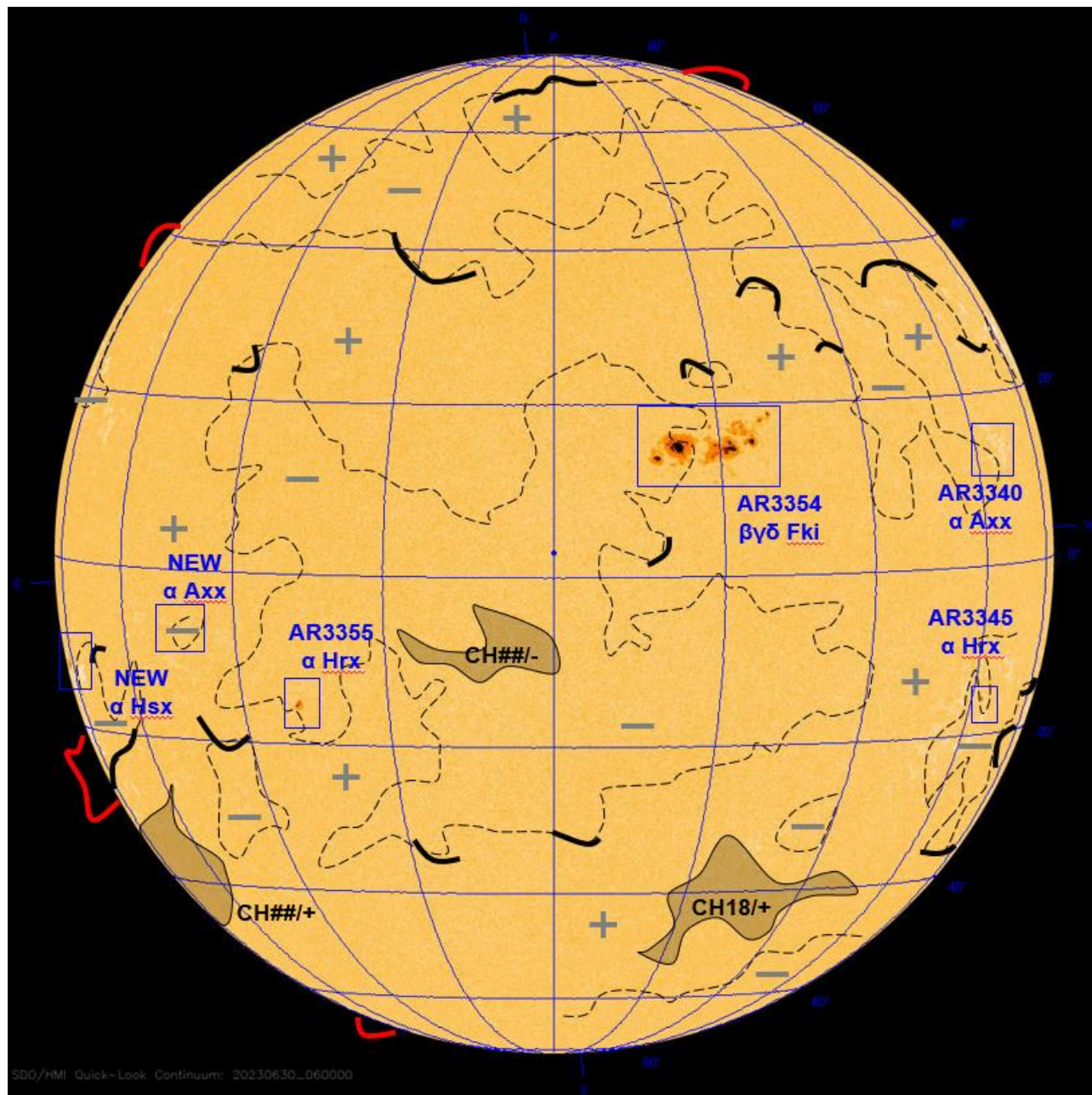
Solar Wind / Geomagnetic Activity: A CME which left the northeast quadrant of the Sun on 27 June may glance the Earth early on 01 July, but this is low confidence. A newly-analysed 29/1415UTC M3.8 flare-related CME from AR3354 may affect Earth as a glancing blow on Tuesday 04 July, i.e. outside the scope of the current forecast but with a suggested Slight Chance of G1 arising.

In the absence of CME activity, the current fast wind from CH18/+ is likely to be the only one in the forecast, with Active intervals most likely on days one and two, before a gradual easing later in the UTC weekend and new working week, with predominantly Quiet activity by this time.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to remain at Background levels, but with a daily Slight Chance of reaching the S1/Minor Storm level, mainly due to AR3354. This risk very slightly increases with time with AR3354's westward progression on the disc.

High energy electron flux (greater than 2MeV) should show a similar magnitude diurnal oscillation at first, with a possible day-on-day ebb later in the four days as the prospect of any CME resetting Van Allen belt electron counts increases.

Figure 1. Solar Analysis Valid 30/0600UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A CME which left the northeast quadrant of the Sun on 27 June may glance the Earth early on 01 July, but this is low confidence, with a range of potential arrivals between today (30th June) and 02 July possible. The risk of G1 is therefore largely concentrated within Saturday 01 July, with the current UTC day carrying a much lower chance of any impacts. The tail end of the UTC weekend is probably too long a transit time (i.e. too low a CME speed) to have any notable geomagnetic effect.

In addition to the above CME, the M3.8 flare from AR3354 at 29/1415UTC appears to have produced a CME with a marginal Earth-directed component, with flanking incidence possible outside the current four-day forecast period, but with a nominal lead-in of 5% G1 risk shown for day four, Monday 03 July. Just two of the 24-member MOSWOC Enlil ensemble suggest any CME arrival before Tuesday 04 July, and on balance, were there to be any arrival it would probably fall entirely within the UTC day of the fourth, perhaps suggesting a Slight Chance of G1.

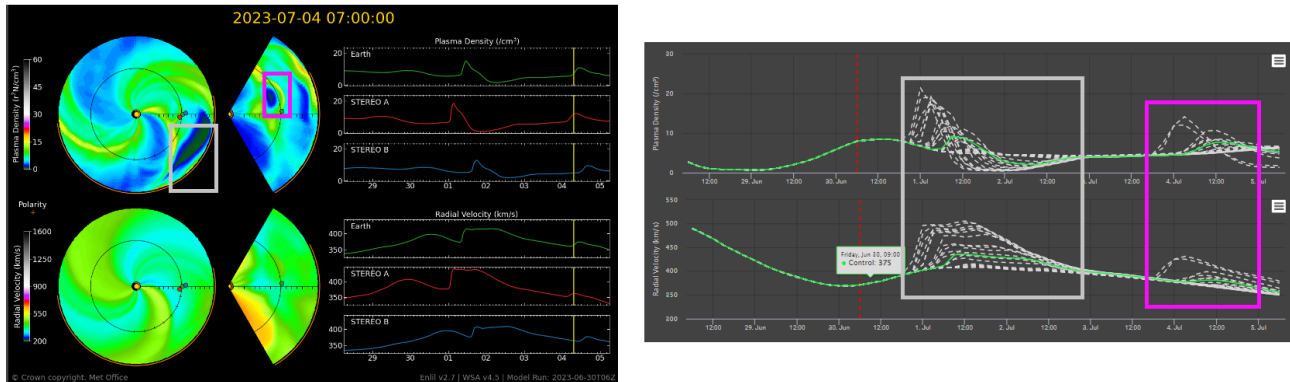
It is therefore very possible given the glancing nature of the above CMEs that the unperturbed fast wind from CH18 continues in this period, probably waning to leave largely Quiet conditions by the start of the UTC working week.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	25	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/0336	Partial	Filament Eruption	NE quadrant, near AR3354 at that time	600km/s	01/0600UTC	Glancing impact possible, but low confidence
29/1415	Partial	Flare	N Centre-disc	762km/s	04/0600UTC	Extreme glance, hence late arrival despite speed.

Figure 2: Latest (06Z) MOSWOC Enlil run and ensemble, showing boxed in grey the 27 June CME's suggested crossing of 1AU, and also the 29 June CME in magenta. The former is the more likely to affect Earth, although confidence is not high in both cases, in part given the very limited triangulation STEREO A now offers versus the Sun-Earth line viewpoint.



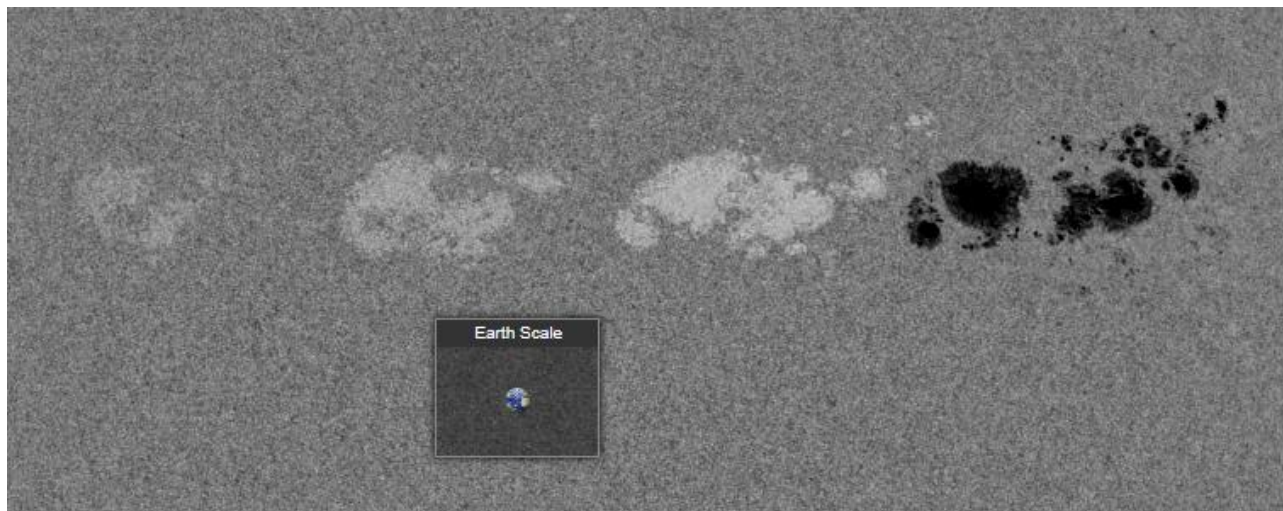
Radio Blackouts - X-Ray Flares:

Activity on the Earth-facing side of the Sun is now almost entirely associated with AR3354 - by far the largest and magnetically most complex group, and the daily raw probabilities of significant flares for the disc as a whole are essentially those for this Fki/BGD group.

This has become the case with the crossing of the western solar horizon of Ex-AR3340, and before the arrival of a possible series of returning regions from the far side into the coming UTC weekend (as suggested in far-side soundings). The first of these arriving regions is expected in the southeast, and may now be showing as raised flux loops in various SDO channels, especially AIA094 and 171. Because of the very narrow viewing angle, assessment as to its Zurich class is not yet possible (beyond perhaps the leading unipolar spot), and the outlook for flare activity is therefore likely to rise in the next 24 hours or so, but with the degree uncertain at the time of writing.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: The HMIIF running difference footprint of AR3354 at 24-hour intervals over the last three days. The rightmost image is the footprint in black at 30/1130UTC, and the leftmost 27/1130UTC in grey. Note the significant increase in area, the latitudinal spread and the emergence of new central spots through this period. Image processing courtesy of Helioviewer.org.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at background levels and is most likely to remain so throughout the period.

The 29/1415UTC M3.8 flare showed no response in the proton spectrum at GOES16, nor in fact at ACE EPAM LEMS. While it may be the case that similar such events repeat this behaviour, on balance, because of the potent Zurich class and the propensity of AR3354 to these occasional sizable flares, a slightly increasing daily Slight Chance of S1 or above is posited.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	10	15	15
Very Active	$\geq \text{S3}^*$	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) had followed a diurnal trend between Moderate and High until the advent of overnight UTC Active geomagnetic activity, which helped see a decline into the current UTC day.

The currently observed fast wind is likely to emanate from CH18/+, and is perhaps characterised by the 500km/s or so seen at ACE and also STEREO A in recent hours. This is probably the only fast wind to contribute to the forecast in the next four days, so while there is a question mark over intervening CME activity that will serve to lower confidence, overall, a continuation of flux and fluence levels near those seen at present is the most likely scenario, perhaps with a day-on-day ebb as the chances of any transient resetting GEO electron counts increases.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	Yes	50	40	30	20
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1