

Space Weather Technical Forecast

Issued on Sunday, 25 June 2023 at 13:27 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: Chance of R1/R2 Radio Blackouts throughout. Slight chance of G1/Minor Geomagnetic Storm conditions on day 3 (27 Jun).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with an M1.1 flare from AR3337 at 24/1217 UTC. There are currently fourteen sunspot regions on the visible disc, however almost all are small and magnetically simple. The largest and most complex group is AR3340 in the northwest which has undergone notable growth of its intermediate spots with a number of mature penumbra emerging. AR3337, which is the source of the largest flare remains a very small region, but with a magnetic alignment that is conducive to instability due to an east-west orientated neutral line. Nearby AR3335, while another very small sunspot region, has also been showing some slight growth, and has been the source of the largest of the observed C-flares. No new Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: The solar wind as measured by DSCOVR at L1, showed the signature of a CME arrival, likely a glance from the CME from the X1.1 flare on 20 Jun. This likely arrived around 24/1915 UTC, with speed rising from slightly elevated levels of 460 km/s to around 540 km/s. The speed remained variable thereafter. Density also rose from average levels, to just above average at 14ppcc with this arrival, before rising further to peak 20 ppcc. The total IMF strength, Bt, rose from background 5-6 nT to peak at Moderate 10-12nT 24/1915-2100 UTC, then declined to 8-10nT thereafter. The north-south component Bz was initially variable between +5 and -5nT, but became predominately negative (southward) with the CME arrival, with minimum -10nT. A rotation to northward (positive) values followed around 25/0100 UTC and persisted with maximum observed 7nT. Geomagnetic activity was Quiet to Unsettled (Kp2-3), with 1 Active (Kp4) interval 24/2100-2400 UTC and 1 G1/Minor Storm (Kp5) 25/0000-0300 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background. High energy electron flux (greater than 2MeV), as observed by GOES16 ranged between Background and very briefly High, with a peak value of 1080pfu at 24/1445UTC. The associated 24-hour fluence showed a steady then largely declining trend through the day, reaching 2.26e7 integrated pfu at 25/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with isolated M-class flares possible.

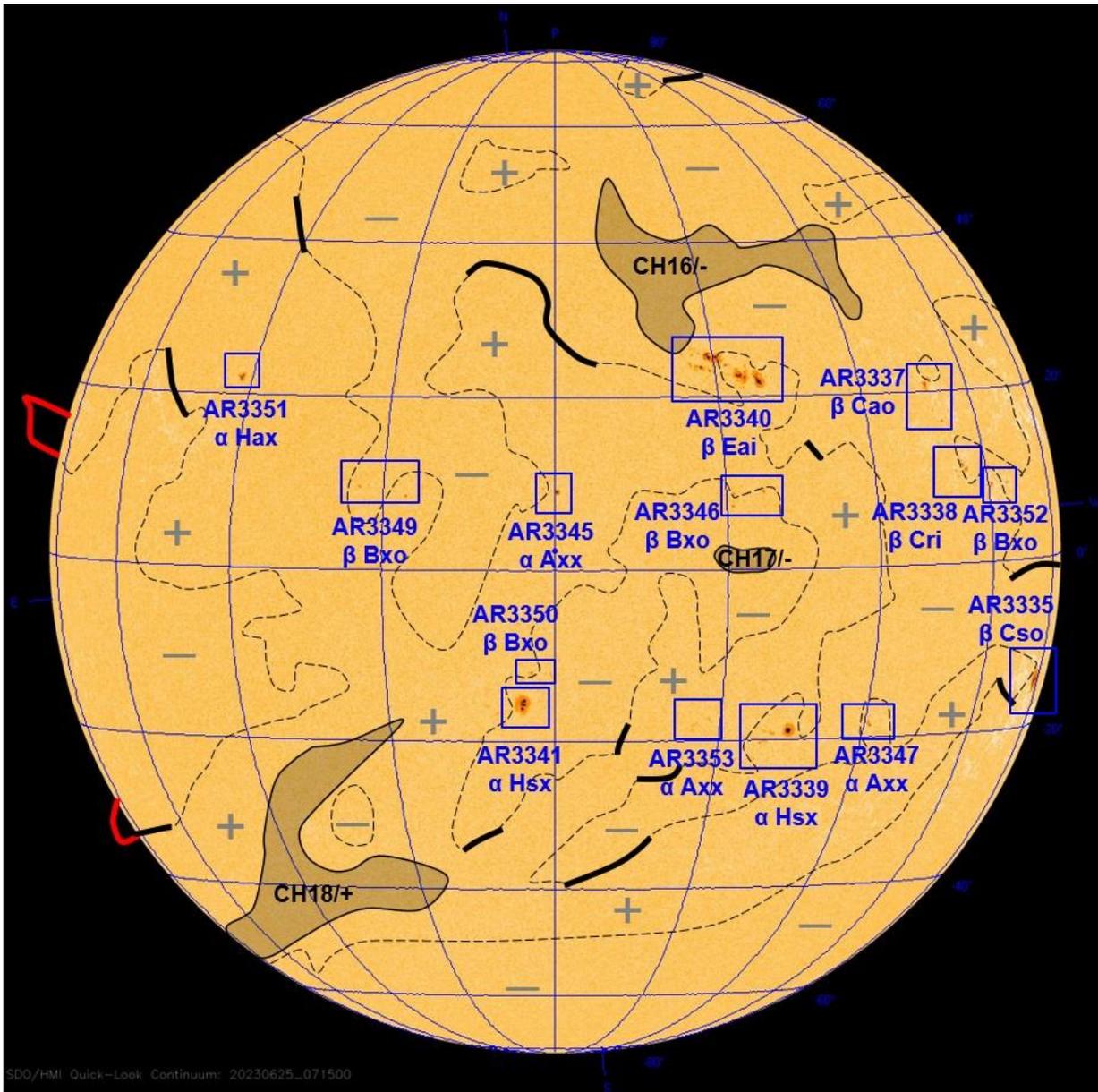
Solar Wind / Geomagnetic Activity: There is a CME that may glance Earth on day 3 (27 Jun), from the M4.8 flare and associated filament eruption from AR3341 on the 22 Jun. Otherwise currently elevated solar winds are expected to ease to slightly elevated levels. Further coronal hole sourced enhancements are then possible from day 3 (27 Jun) onward however these are low confidence. Geomagnetic activity is expected to be Quiet with isolated Unsettled to Active intervals possible day 1 (25 Jun) and just a slight chance of a G1/Minor storm interval as the magnetic cloud of the recent CME arrival recedes. This becoming mostly Quiet day 2 (26 Jun). Potentially rising to Unsettled to Active, with a slight chance of G1 Minor Storms day 3 or 4 (27 Jun)

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or 28 Jun).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels with a slight chance of rising if any notable flare activity occurs, primarily from AR3340. High energy electron flux (greater than 2MeV) is expected to see current Background to Moderate levels continue. The corresponding 24-hour integrated fluence expected to remain under the Active threshold throughout.

Figure 1. Solar Analysis Valid 25/0800 UTC.



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

Geomagnetic Storms:

There is one potentially glancing CME in the forecast, albeit with low confidence. This was produced by the M4.8 flare from AR3341 in the southeast disc on 22/2344 UTC and the associated filament eruption. The majority of the CME is missing behind and below Earth, likely reaching 1AU early on day 3 (27 Jun) however a glancing interaction is likely as this passes.

Solar winds are currently slightly elevated to elevated at 450-550km/ due to the influence of the CME arrival on the 24 Jun, These winds are expected to ease, likely falling to around 400km/s day 2 (26 Jun). The forecast is then low confidence due to uncertain coronal hole analysis. This is due to sunspots in the northwest disc obscuring the view of CH16/-, and also the presence of a very small coronal hole, CH17/-, in the centre disc. Enlil suggests that Earth either doesn't encounter the HSS of either region or that any enhancement is very limited. This is also supported by 27-day persistence. However, given the location of these holes, a potential connection is possible on day 3, alongside any CME arrival.

Geomagnetic activity is expected to be Quiet with isolated Unsettled to Active intervals possible day 1 (25 Jun) and just a slight chance of a G1/Minor storm interval as the magnetic cloud of the recent CME arrival recedes. This becoming mostly Quiet day 2 (26 Jun) before activity potentially increases to Unsettled to Active, with a slight chance of G1 Minor Storms with any slight coronal hole enhancement or CME arrival day 3 or 4 (27 or 28 Jun).

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	Yes	5	5	10	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
23/0714	Partial	M4.8 flare and filament	SE	493	27/0000 +/- 12 hrs	Low confidence. Glancing impact

Figure 2a: L1 Solar wind observations, showing CME glance

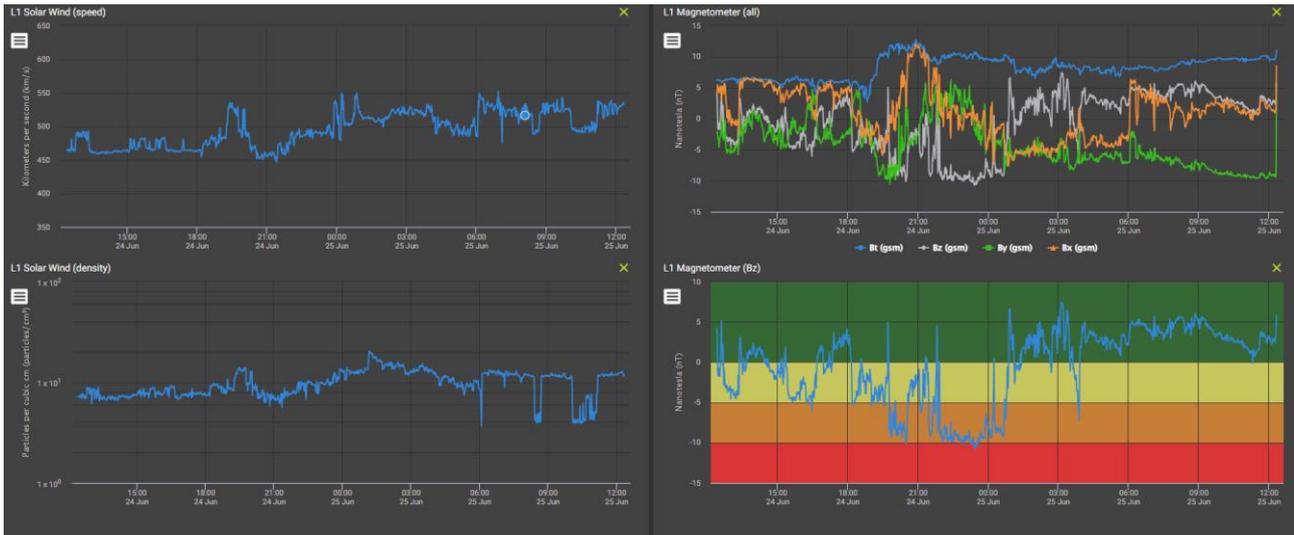
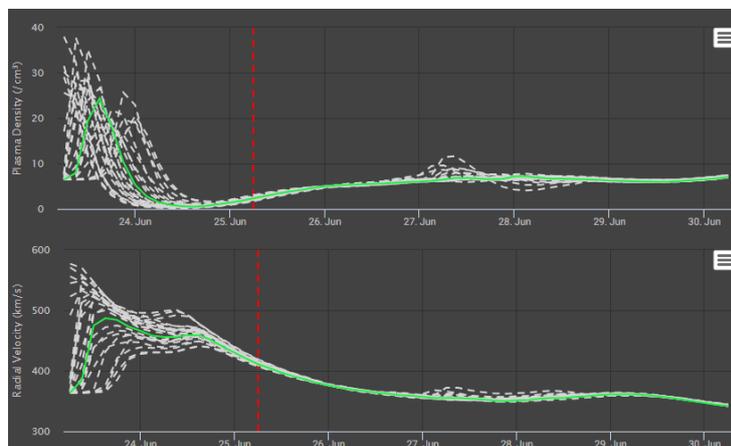
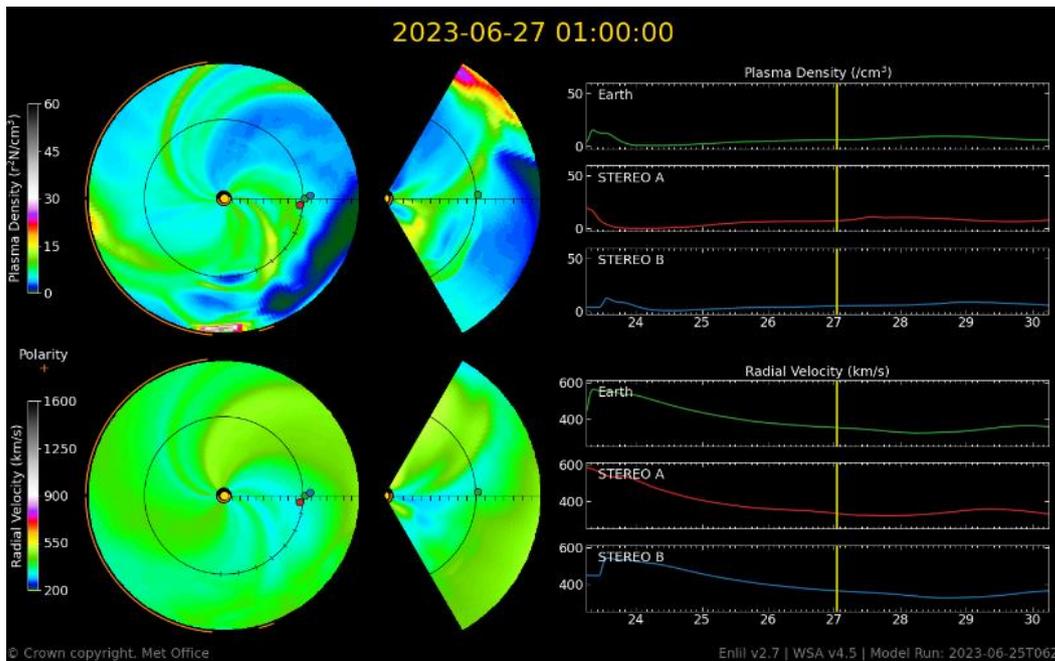


Figure 2b: Enlil showing potential glancing arrival of CME



Radio Blackouts - X-Ray Flares:

There are fourteen sunspot regions on the disc with isolated M-flares likely, resulting in Low to Moderate Activity.

The main region of interest is AR3340 in the northwest, with ongoing flux emergence within its intermediate area. The subsequent spots are maturing with penumbra development, and there are some signs of complexification of the region with the looping observed in SDO aia imagery. However this currently remains a simple bipolar group (Mt. Wilson Beta class). This has been the source of a number a C-class flares, and the most likely source of further significant flare activity.

The majority of the other sunspots are smaller, simpler and stable, with a couple of exceptions. AR3337 in the northwest produced the largest flare of the last 24 hours, an M1.1 peaking at 25/1217 UTC. This remains a small and indistinct region, however its east-west aligned magnetic neutral line is typical of unstable regions with an ongoing chance of similar small flares. AR3335, developing near to AR3337 is also a small region but produced the largest observed C-flares in the last 24 hours, and ongoing growth may lead to further flaring.

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	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at Background levels and expected to remain so throughout the period. This is despite the number of sunspots in the western disc, as they remain small and relatively simple and unlikely to produce significant flares. The possible exception is developing AR3340, which currently provides the main risk of producing any proton events.

Radiation Storms	Level (cm ⁻² sr ⁻¹ 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	≥ S1	No	5	5	5	5
Very Active	≥ S3*	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux is expected to follow its recent trend Background to Moderate, This perhaps rising a little day 2 (Jun 26) as solar winds ease after the recent CME arrival, with a slight chance of briefly reaching High at diurnal max. A further suppression of observed flux is then likely day 3 and into day 4, (Jun 27-28) from any glancing CME or weak HSS arrival, before perhaps rising again towards the end of the period although this is very low confidence by this stage.

The associated fluence is expected to remain below the Active level at least until day 4 (28 Jun), This is supported by REFM, which gives a good indication of expected fluence in the absence of any further solar wind enhancements.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹ 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	≥ 2 MeV ≥ 1x10 ⁸	No	1	1	1	5
Very Active	≥ 2 MeV ≥ 1x10 ⁹	No	1	1	1	1

Figure 4: GOES 16-Electron Flux and associated fluence with REFM

