
Space Weather Technical Forecast

Issued on Tuesday, 20 June 2023 at 01:36 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. Active Fluence likely Day 1. Slight Chance of isolated G1/Minor Geomagnetic Storm intervals Days 2-4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with two M-class flares. Both flares emanated from the southeast limb and have been attributed to emerging region AR3341 (Hsx/Alpha) with a peak of M1.5 at 19/0351 UTC. There are currently eleven sunspot regions on the visible disc, the largest of which is AR3335 (Esi/Beta-Gamma) in the south central disc. This region has shown growth and decay of its trailing spots, but otherwise appears to be simplifying. AR3333 (Eai/Beta-Gamma), in the southwest and AR3338 in the northeast have shown some growth and decay but have remained relatively stable overall during the period. One region which has shown significant and rapid growth is AR3342 (Dsi/Beta-Gamma) in the southwest, its viewing angle will become increasingly restricted as it rotates westward with so future analyses of the sunspot less confident. Newly numbered AR3341 continues to emerge across the southeast limb, it is thought additional complexity will be revealed as the group rotates further onto the disc. All other regions remain small and magnetically simple, with little change during the period.

A slight dimming event was observed in coronagraph imagery in the northwest around 19/0200 UTC, however, this is not thought to have produced an Earth directed CME.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1, initially fluctuated between slow-ambient and slightly elevated levels, with speeds of 375-420 km/s. Around 19/1600 UTC winds saw a sudden, albeit slight, increase to around 450 km/s and since 19/2230 UTC has been approaching elevated levels. Density was below average (<5 ppcc). The IMF was weak throughout (5-8 nT) with its north-south component fluctuating between +/- 6nT. The phi angle was mostly negative (towards the Sun), but since 19/2230 UTC has been positive (away from the Sun). The net result of the above solar wind measures was Quiet to Unsettled geomagnetic activity (Kp 1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels. High energy electron flux (greater than 2MeV), as observed by GOES16, was initially at background levels but increased through the diurnal cycle to High 19/1225-1940 UTC with a peak of 2270 pfu observed at 19/1640 UTC. The associated 24-hour fluence peaked at 1.06e8 at 19/0000UTC, falling below the Active threshold (1e8 integrated pfu) at 19/0300 UTC where it has since remained. Observed fluence at 20/0000 UTC was 5.58e7.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Low to Moderate with a chance of further isolated M-flares and a slight chance of an X-flare. AR3341 and AR3342 will be monitored for further development, meanwhile AR3333 and AR3338 provide the largest contribution to flare risk through the period.

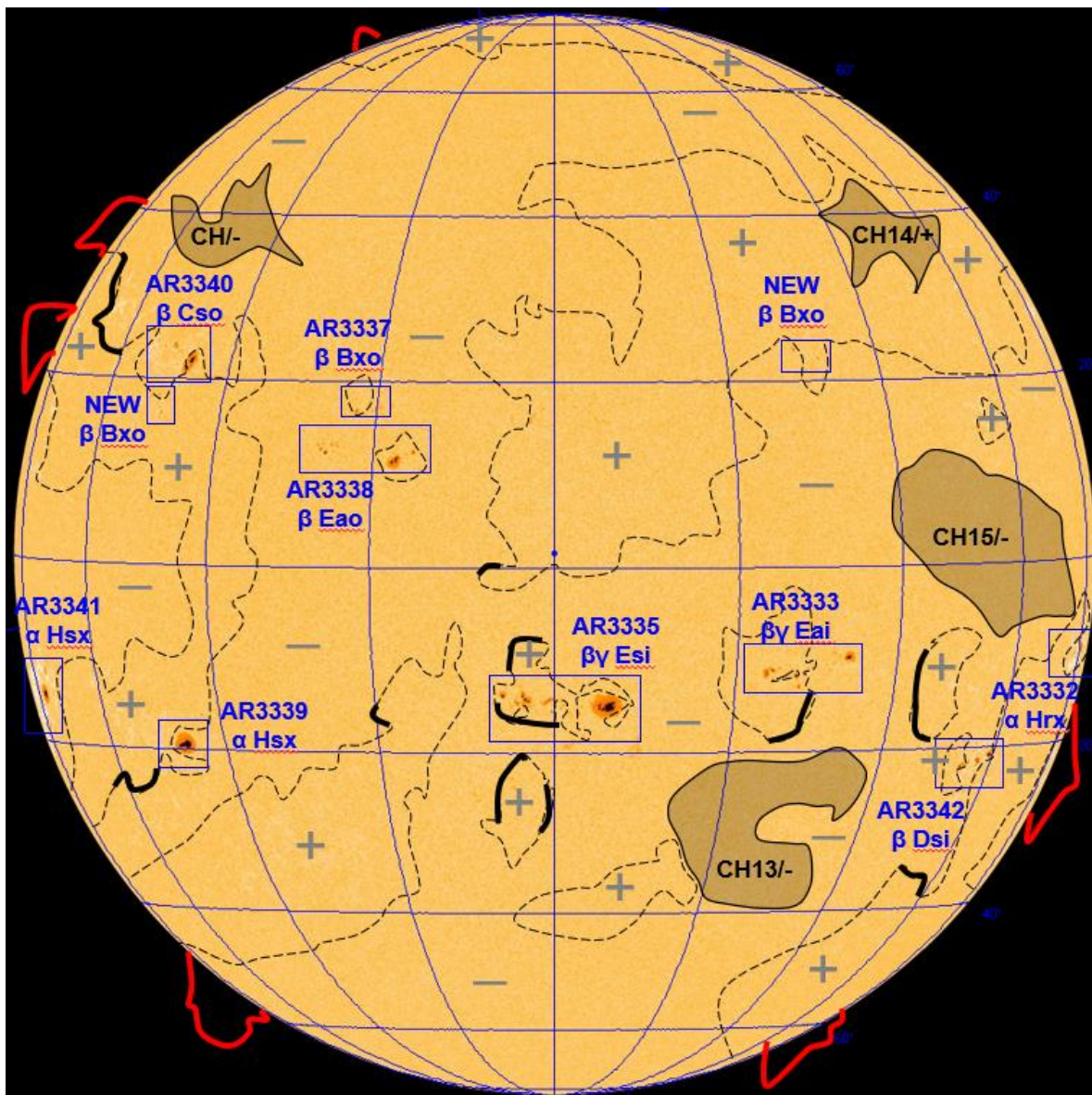
Solar Wind / Geomagnetic Activity: No Earth-directed CMEs currently feature in the forecast,

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although glancing blows are possible Days 2-4 (21-23 June). Slight enhancements to the solar wind are possible throughout should connection to an HSS occur from one of three regions that are geoeffective. Geomagnetic activity is expected to be mostly Quiet with a chance of Unsettled to Active intervals, and a slight chance of isolated G1/Minor Geomagnetic Storm intervals Days 2-4.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. High energy electron flux (greater than 2MeV) is likely to see diurnal peaks at Moderate to High levels. Electron fluence is anticipated to decline through the period, given the potential for geomagnetic activity. This is low confidence however.

Figure 1. Solar Analysis Valid 19/2000UTC.



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:

Several CMEs have been observed on coronagraph imagery over recent days, mainly around the periphery of the disc. A number of CMEs that left the Sun on 18-19 June may result in glancing blows at Earth on Days 2-3 (21-22 June) and Day 4 (23 June), producing some slight and transient enhancement. Much of the material is projected to pass behind the Earth however resulting in a miss. A small number of Enlil ensemble members support the possible arrivals, however, a miss is considered to be the more likely solution.

The solar wind is currently at slightly elevated levels and is anticipated to remain largely similar throughout in the absence of any glancing blow CME enhancement. Recent slight enhancement could be due to coronal hole influences, most likely from CH14/+. However, there remains the chance of some slight enhancement to the solar wind speed over the coming days, due to a possible connection with either CH13/- (southern hemisphere), or CH14/+ (northern hemisphere), or CH15/- near the solar equator.

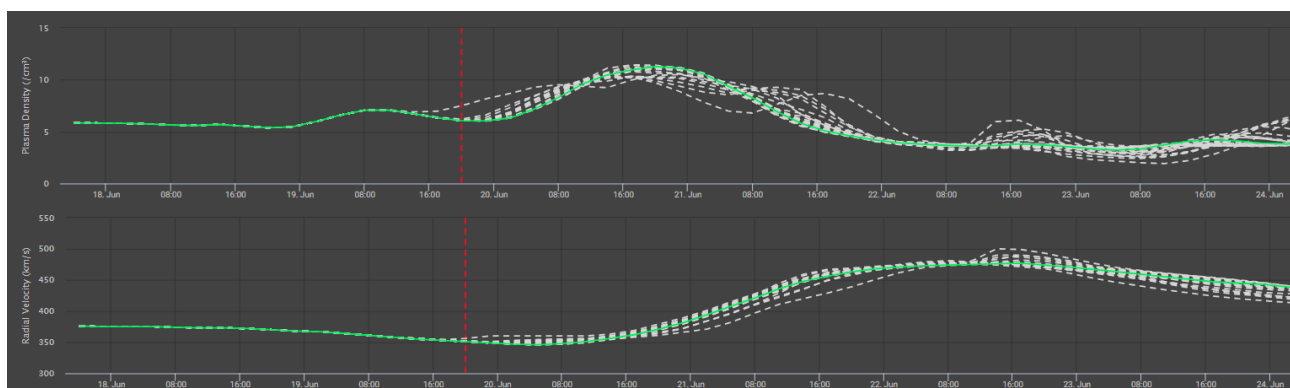
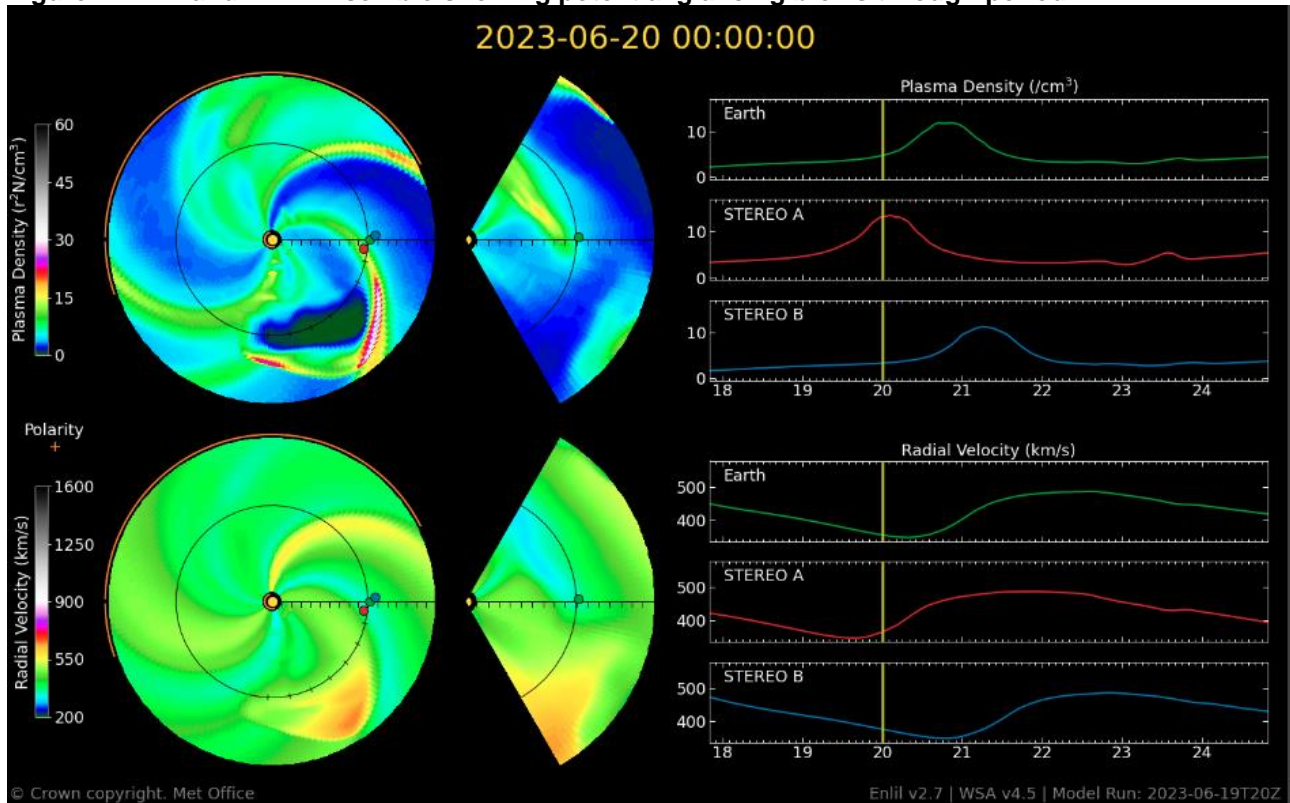
On the whole, geomagnetic activity is expected to be mostly Quiet, with a chance of Unsettled or Active intervals Days 2-4 (21-23 June). Geomagnetic activity should not exceed Active levels given the relatively small size of the sunspot regions, however, there is a very slight chance of an isolated G1/Minor Geomagnetic storm interval should glancing blow CME arrivals coincide with potential HSS enhancements.

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	15	10	15
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

Nil CME arrivals expected. See 'Geomagnetic Storms' section for more details

Figure 2: Enlil and Enlil Ensemble showing potential glancing blows through period.



Radio Blackouts - X-Ray Flares:

There are currently eleven sunspot regions on the visible disc, two of which are unnumbered. The largest region on the disc is AR3335 (Esi/Beta-Gamma) in the south central disc which previously produced a M2.5 flare but now appears to be stable and simplifying. Other complex regions AR3333 (Eai/Beta-Gamma), in the southwest and AR3338 in the northeast have shown some growth and decay but have remained relatively stable overall during the period. AR3342 (Dsi/Beta-Gamma), in the southwest, has developed quickly and as less stable region, will be monitored closely for potential flare activity. However, as it rotates further westwards, the viewing angle will become increasingly restricted, hindering accurate analyses. AR3341 close to the southeast limb is considered the source region for the M-flares on 19 June, with far-sided projections suggesting further spots emerging as part of this group through Day 1 (20 June). All other regions remain small and magnetically simple, with little change during the period.

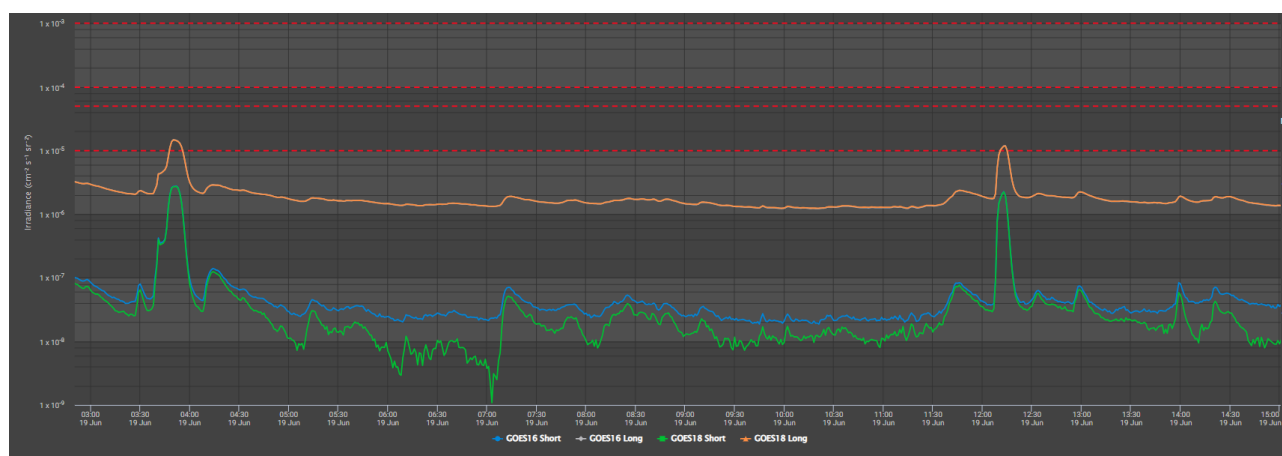
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No further significant regions are expected to depart or transit on to the disc over the coming days and thus solar activity is expected to remain Low to Moderate, with a chance of further M-class flares and slight chance of an X-class flare.

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

Figure 3: GOES16 & GOES18 X-Ray trace from past 24-hours



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is expected to remain at background levels. There is an ongoing slight chance of S1, with a number of sunspot groups in the southwest of the disc and further groups emerging and progressing westwards.

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	10	10	10	10
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 ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is expected to diurnally fluctuate between Background and Moderate/High levels. An overall decreasing trend is anticipated with shorter periods of diurnal high flux levels. Electron fluence fell below the Active ($1\text{e}8$) threshold around 19/0300 UTC and has been on a slow downward trend. There is significant spread in REFM between forecast and recurrence values, forecast values are currently thought to be giving good guidance. A decline in values is possible Days 2-4 (21-23 June) should geomagnetic activity increase as a result of either glancing blows from recent CMEs, or due to coronal hole high speed stream enhancements from CH13/-, CH14/+ and/or CH15/+.

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	70	40	30	30
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: REFM showing spread in potential fluence values. Low confidence Days 2-4.

