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**Space Weather Technical Forecast**

Issued on Monday, 12 June 2023 at 13:18 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>**

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**Space Weather Forecast Headline: Chance of M-class flares (R1-R2/Minor-Moderate radio blackouts).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity** Low with a number of low level C-flares, peaking at C5.2 at 12/0658 UTC from ex-AR3330, which has subsequently decayed. The six sunspot regions on the visible disc have generally been declining, with AR3327 in the southwest and AR3331 in the southeast losing penumbral extent, although the latter did observe some slight flux emergence with its intermediate spots and is now the most likely visible group for notable flares. AR3329 and AR3326 both in the northwest are the other two numbered groups and these persist as mature unipolar regions. The other two unnumbered regions are associated with small flux emergences in the southeast disc. No Earth-directed CMEs were observed in the last 24 hours, however a large polar crown filament (PCF) eruption was observed from the northern disc. There are also a number of other large filaments on the Earth-facing Sun.

**Solar Wind / Geomagnetic Activity:** The solar wind at L1 showed the ongoing fast wind environment, likely due to CH11/+ or CH10/+. Solar wind speeds as observed by DSCOVR were slightly elevated at around 400-470km/s, whilst the density has gradually declined from around average to below average levels. Total IMF strength, Bt decreased from Moderate at 12 nT to be weak from around 11/2030 UTC at 5-8nT. The north-south component was initially turbulent between +7 nT and -9nT, but became predominately positive (northward) from 11/2030 UTC. Phi angle has been mainly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

**Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as observed by GOES16, has remained at background levels. High energy electron flux (greater than 2MeV), as observed by GOES16 has been at background. The associated 24-hour fluence remained below the Active threshold (1e8 integrated pfu), with 1.46e6 integrated pfu observed at 12/0000 UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is expected to be mainly Low with a chance of rising to Moderate with isolated M-flares.

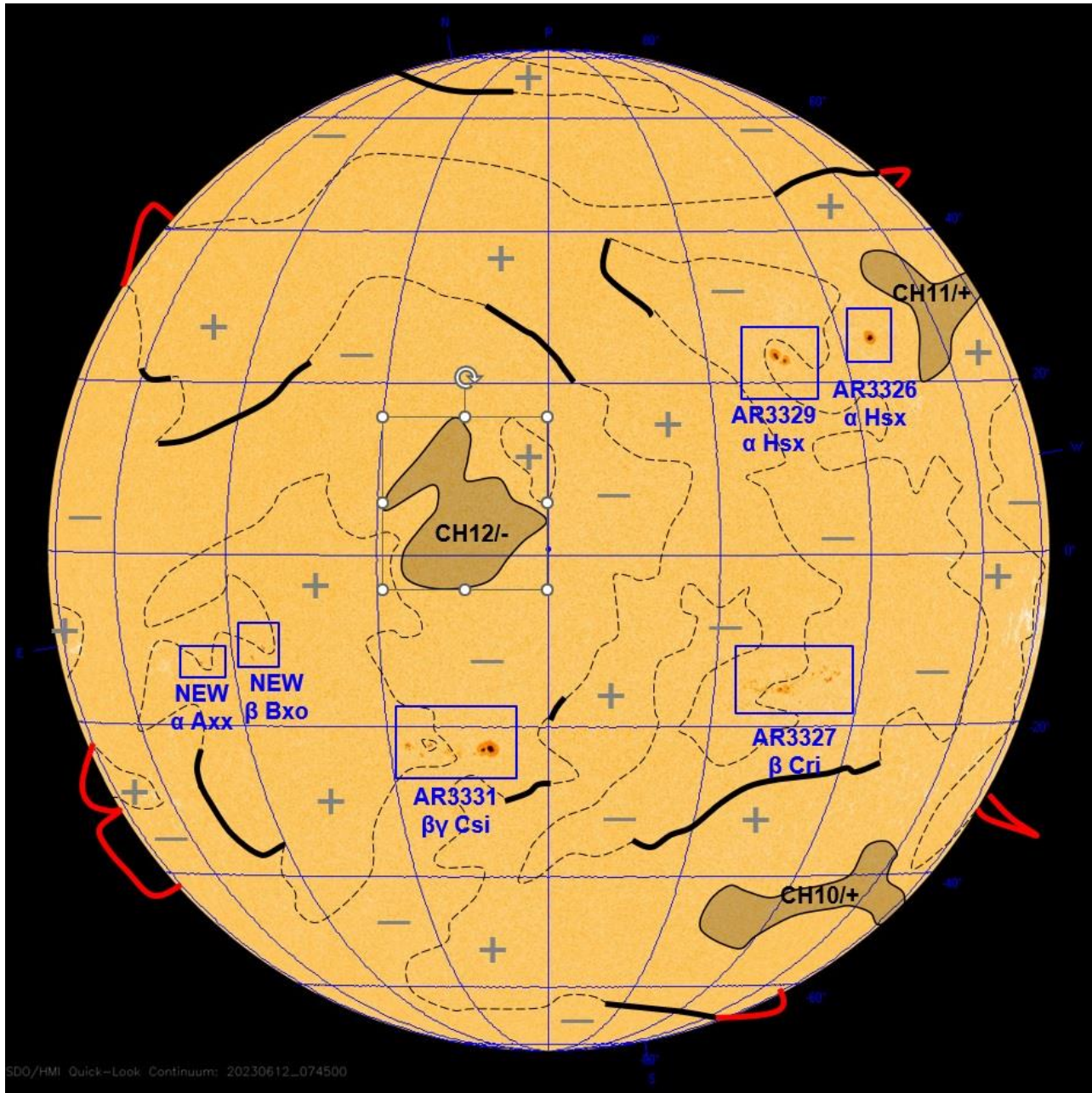
**Solar Wind / Geomagnetic Activity:** A CME associated with the M2.5 flare from AR3331 on 09 Jun is directed mainly behind Earth but has the potential to give a glancing influence, most likely on day 2 (13 Jun). There are no other Earth-directed CMEs. Ongoing slightly elevated solar winds are expected days 1-2 (12-13 Jun) due to CH11/+ or CH10/+ high speed stream (HSS) influence, before easing day 3 (14 Jun). The next fast wind enhancement is expected to be from the arrival of the HSS of Equatorial CH12/- during day 4 (15 Jun). Mainly Quiet geomagnetic conditions are expected with Unsettled spells. There is a slight chance of Active to G1 Minor Storm intervals, mainly late day 1 or day 2 (12 or 13 June) due to CME glance or on day 4 (15 June) due to fast wind enhancement.

**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

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expected to remain mainly background. Electron fluence is expected to persist below the Active (1e8 integrated pfu) threshold.

**Figure 1. Solar Analysis Valid 12/0800 UTC.**



**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 from the 09 June, associated with the M2.5 flare from AR3331 is forecast to miss, passing just behind Earth later on day 1, or more likely day 2 (12-13 Jun). However this will bring the chance of a glancing impact. No other Earth-directed CMEs have been observed.

Solar winds are currently slightly elevated, likely due to a connection to the fast wind associated with the high speed stream (HSS) of CH11/+ or CH10/+. Solar winds are expected to continue at around 450km/s day 1-2 (12-13 Jun), before likely easing from day 3 (14 Jun). Equatorial CH12/- is also approaching the Earth-Sun line, with the fast wind enhancement from the arrival of its HSS expected on day 4 (15 Jun). This feature was apparent on the previous rotation, but is a larger and more distinct region on this occasion. A G2 Moderate Storm was observed on 20 May, however this was likely due to a CME which was embedded into the HSS arrival, reducing the value of persistence.

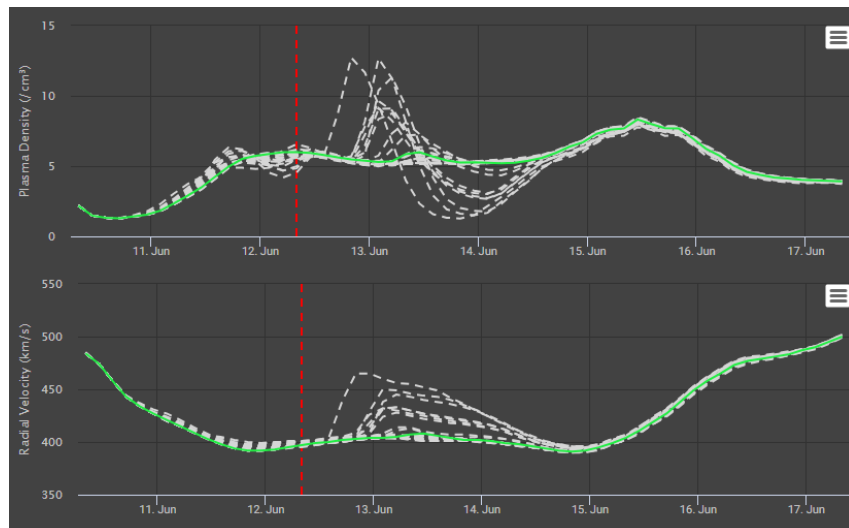
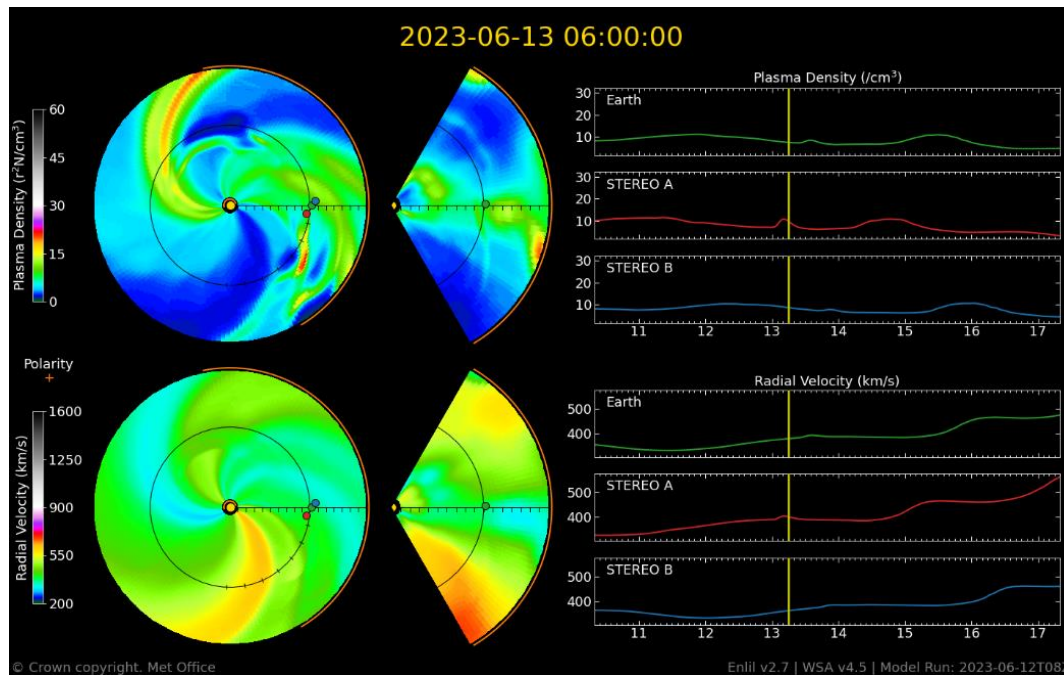
Geomagnetic conditions are forecast to be mainly Quiet with Unsettled spells through the period. There is a slight chance of Active to G1 Minor Storm intervals, mainly late day 1 or day 2 (12 or 13 Jun) with any CME glance that may occur, or from the interaction with the CIR from the HSS of CH12/- on day 4 (15 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	No	5	10	1	20
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
09/2227	Partial	M2.5 of AR3331	SE	693	Missing	Small chance of glancing impact late 12 Jun or 13 Jun

Figure 2: Enlil and ensemble showing slight glance of CME possible





## Radio Blackouts - X-Ray Flares:

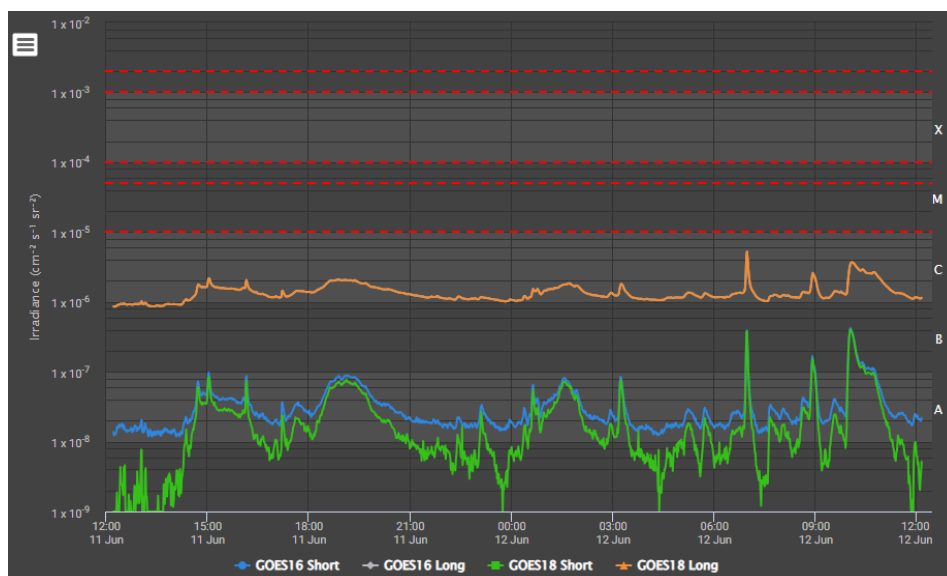
Low activity is expected to continue through the period, although with a chance rising to Moderate.

Sunspot activity on the Earth-facing disc has been in a declining trend with most spots decreasing in areal extent and complexity, including AR3326 and AR3329 in the north east which are now mature unipolar regions. AR3327 has also continued to fade, with penumbra dispersing from its component small spots. AR3331 has also seen the penumbra on its trailer spot fade, although this has had some small development of a reverse polarity spot within its intermediate region, and is now perhaps the most likely source of any notable flares.

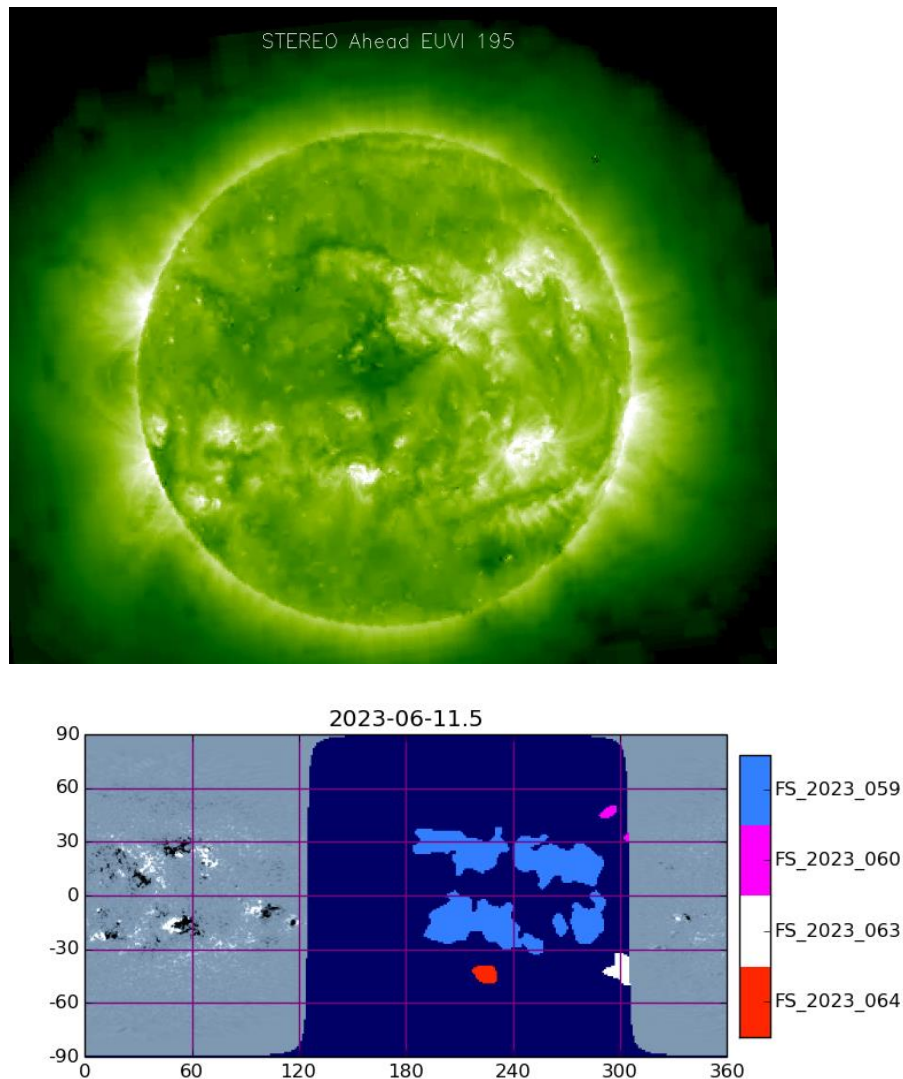
There are also potential far-sided sunspots rotating onto the disc during the coming days, as indicated by far-sided products, perhaps ex-AR3314 and ex-AR3310 from the last rotation. This is supported by C-flare activity that has been observed over the NE and SE limbs, with along with looping visible on SDO aia-94, STEREO A-euvi and other similar imagery.

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	No	20	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

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



**Figure 4: STEREO A euvi showing far side regions expected to rotate onto disc. This is supported by far-side imagery from [jsoc.stanford.edu/data/farside](https://jsoc.stanford.edu/data/farside) below.**



## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is at Background and expected to persist at this level.

Radiation Storms	Level (cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> )	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	1	1	1	1
Very Active	≥ S3 <sup>*</sup>	No	1	1	1	1

<sup>\*</sup> S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm<sup>-2</sup>sr<sup>-1</sup>s<sup>-1</sup>)

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

High energy electron flux (greater than 2MeV) is expected to be at mainly background levels through the period. Furthermore, any glancing CME arrival late day 1 or day 2 (12 or 13 Jun) is likely to drop out any increase in electron flux that occurs, as will the onset of the HSS from CH12/- on day 4 (15 Jun).

Electron fluence is not expected to exceed the Active ( $1\text{e}8$  integrated pfu) threshold with REFM currently providing good guidance.

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	$\geq 2 \text{ MeV}$ $\geq 1\text{e}8$	No	1	1	1	1
Very Active	$\geq 2 \text{ MeV}$ $\geq 1\text{e}9$	No	1	1	1	1

Figure 5: GOES-16  $>2\text{MeV}$  electron Fluence with REFM and Recurrence

