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**Space Weather Technical Forecast**

Issued on Monday, 12 June 2023 at 01:27 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>**

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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 C3.3 at 11/0631 UTC from AR3321. This region is barely visible however, as it approaches the western solar horizon. There are eight sunspot regions visible in total, the majority of which are small, simple and stable at this time. AR3327 in the southwest is the main region of note, presented as a broad collection of smaller spots. Despite its diffuse nature, a small reverse polarity spot near its leader, along with a northeast-southwest orientated inversion line brings increased potential instability. AR3331 is a larger bipolar region in the southeast and was responsible for an M-flare on 09 Jun, but has been generally stable since. No Earth-directed CMEs were observed in the last 24 hours. A central southern disc filament eruption was observed at 11/0855 UTC, however no CME was in evidence in subsequent coronagraph imagery and appears to have been largely reabsorbed into the sun.

**Solar Wind / Geomagnetic Activity:** The solar wind at L1 was indicative of the connection to a fast wind environment, most likely from the HSS of CH11/+ or CH10/+, but with some increased IMF (interplanetary magnetic field) at first that likely occurred due to the arrival a weak CME from 08 Jun. Solar wind speeds as observed by DSCOVR were initially around 330km/s, then gradually increased from 11/0100 UTC to become slightly elevated from around 11/0715 UTC. Wind speeds have generally trended up to 420-450km/s by the end of the period, with a peak of 479km/s at 11/1950 UTC. Density peaked early in the period at 34ppcc at 11/0007 UTC before undergoing an erratic downward trend, with more persistently average values observed towards the end of the UTC day. Total IMF strength, Bt increased from being Weak to Moderate from 11/0100 UTC, briefly peaking at Strong levels, with 15nT observed at 11/0304 UTC. A similar erratic decline has been observed since, with the IMF now Weak. The north-south component was predominately positive (northward) early on in the period, peaking +15nT, but with occasional turbulent rotations to negative (southward) with minimums of around -10 nT. Bz has varied weakly since around 11/1600 UTC. Phi angle has been largely 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 12/0001 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.

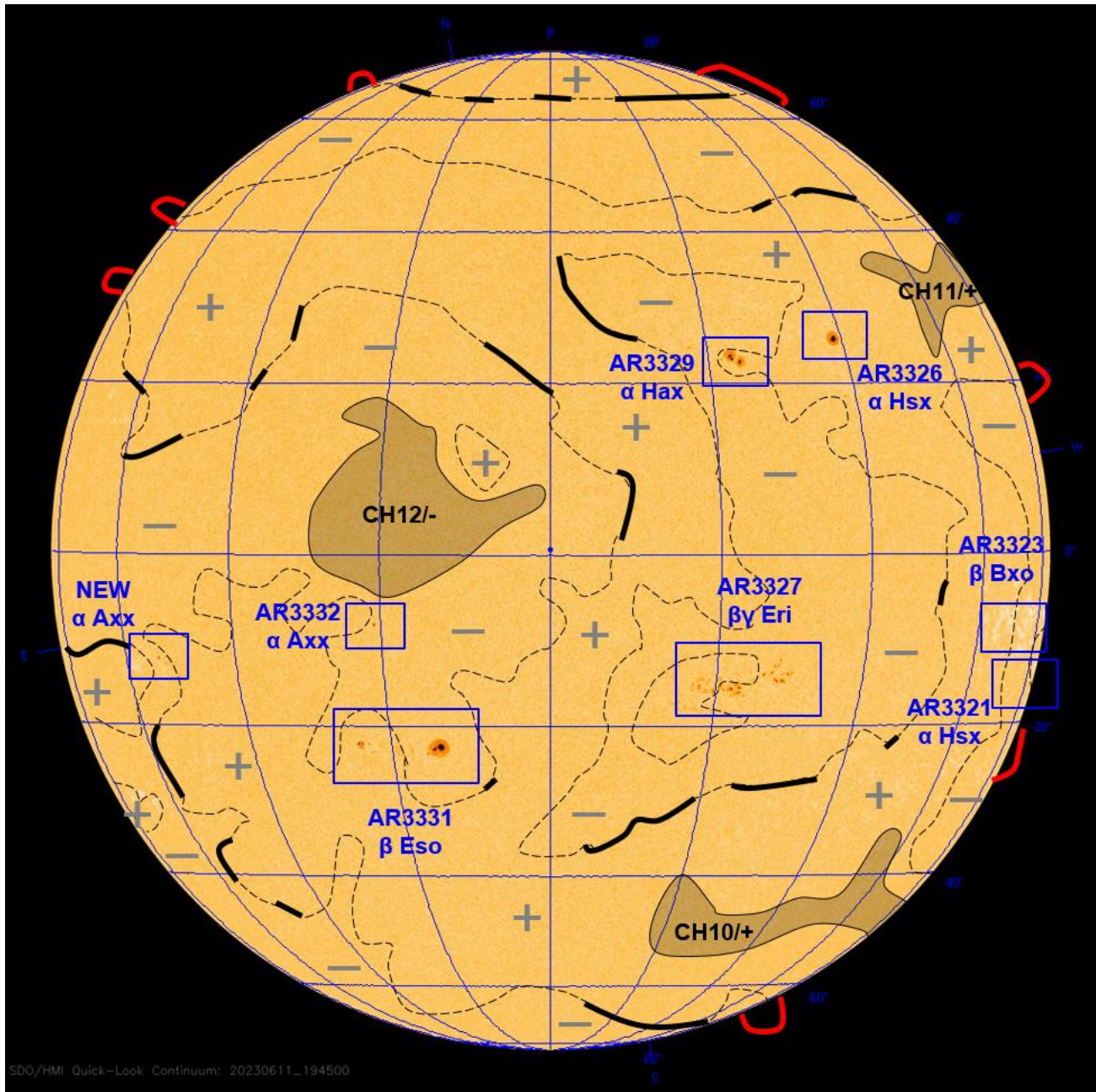
**Solar Wind / Geomagnetic Activity:** A CME associated with the M2.5 flare from AR3331 on 09 Jun, is directed mainly behind Earth but has the potential to give a glancing influence, most likely on day 2 (13 Jun). No other CMEs are currently expected. Ongoing slightly elevated solar winds are expected days 1-2 (12-13 Jun) due to CH11/+ or CH10/+ high speed stream (HSS)

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influence, before easing day 3 (14 Jun). Equatorial CH12/- near the Earth-Sun line is likely to become geo-effective on 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 Jun) with any CME glance that may occur, or interaction with the HSS of CH12/- on day 4 (15 Jun).

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

Figure 1. Solar Analysis Valid 11/1945 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:**

No CMEs are currently expected at Earth, however a glancing impact from a CME on 09 Jun, associated with the M2.5 flare from AR3331 is possible. This is most likely to occur on day 2 (13 Jun) with a small chance of an arrival late on day 1 (12 Jun).

Current slightly elevated solar winds are likely due to a connection to the fast wind associated with the high speed stream (HSS) of CH11/+ or CH10/+. These slightly elevated solar winds of around 400-450km/s are expected to continue day 1-2 (12-13 Jun), before likely easing day 3 (14 Jun). Equatorial CH12/- is approaching the Earth-Sun line with a fast wind enhancement expected to arrive at Earth on day 4 (15 Jun). This feature was apparent on the previous rotation, however, it appears larger than before and speeds of up to up to 500km/s could be observed as it becomes geo-effective.

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).

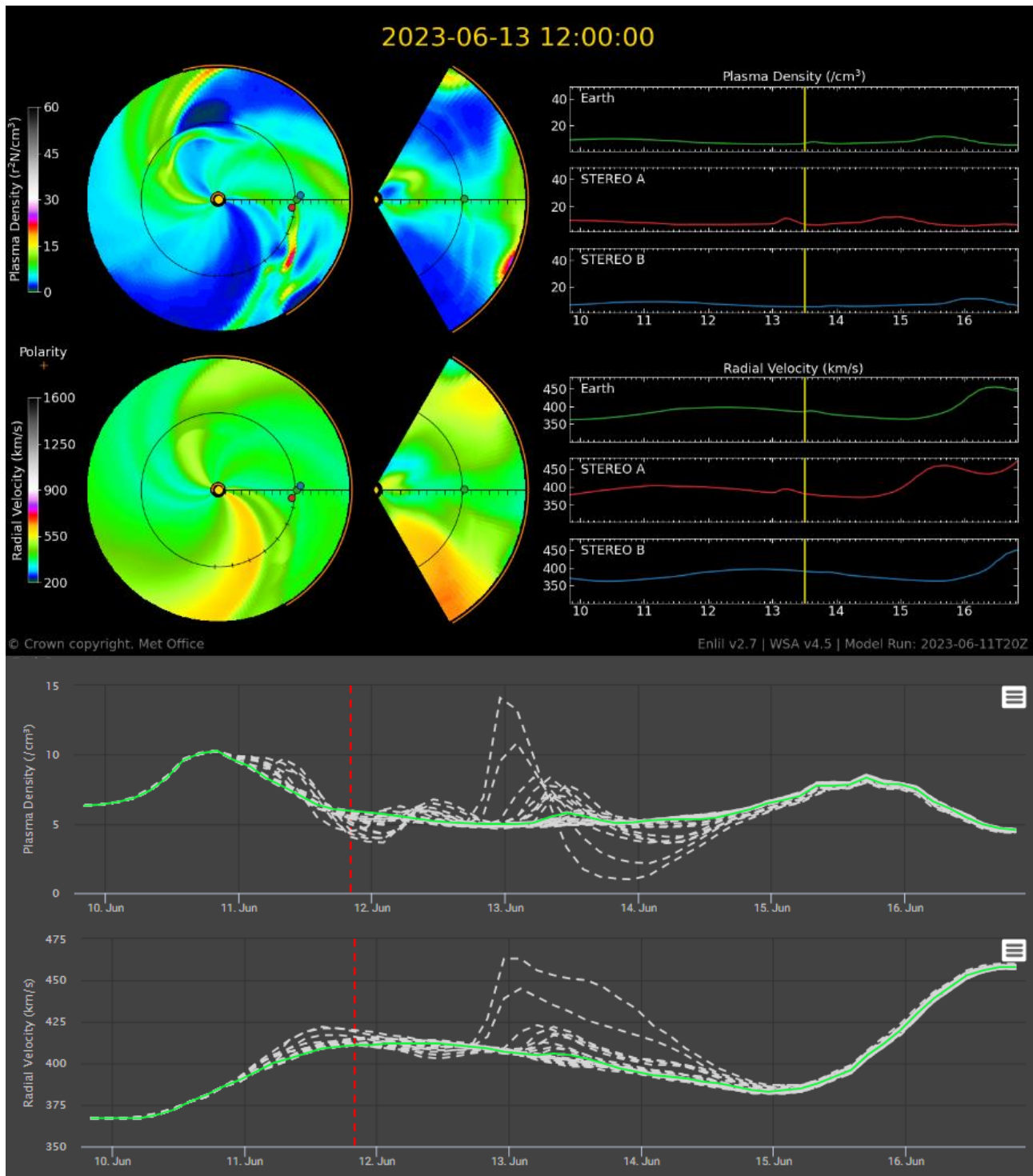
Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	10	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

**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	SW	700 km/s	Missing	Passes close behind Earth, late 12 or 13 Jun. Glancing impact possible



Figure 2: Latest Enlil and ensemble indicating weak CME glance, most likely on 13 Jun



## Radio Blackouts - X-Ray Flares:

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

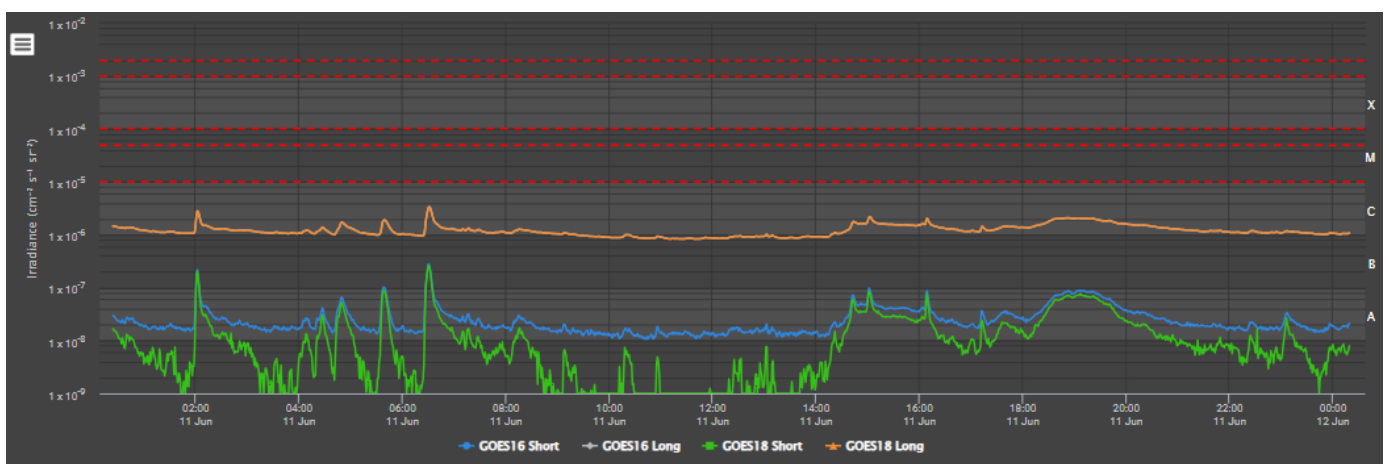
AR3327 is the most notable of the eight active regions on the disc, and remains the most likely source of flare activity. This is a broad collection of small spots, but with some apparent complexity with reverse polarity spots still evident near its main leader region and a magnetic polarity inversion line which is aligned more northwest-southeast, rather than orientated north-south. Despite a trend towards weakening penumbral extent, AR3327 remains bright in SDO aia-171, 94 and 304 imagery.

The majority of the other regions on the disc are smaller and simpler. The most active region in the last 24 hours is AR3221 (C3.3 flare at 11/0631 UTC) will soon rotate over the western limb and appears to be weakening. AR3331 is also of note as the source of the most recent M-flare on 09 Jun, but is now a simple bipolar and open group, and has been inactive since that flare.

STEREO A EUVI imagery suggests one or more bright regions are likely rotate over the eastern limb in the coming couple of days which could contain new sunspot groups.

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

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



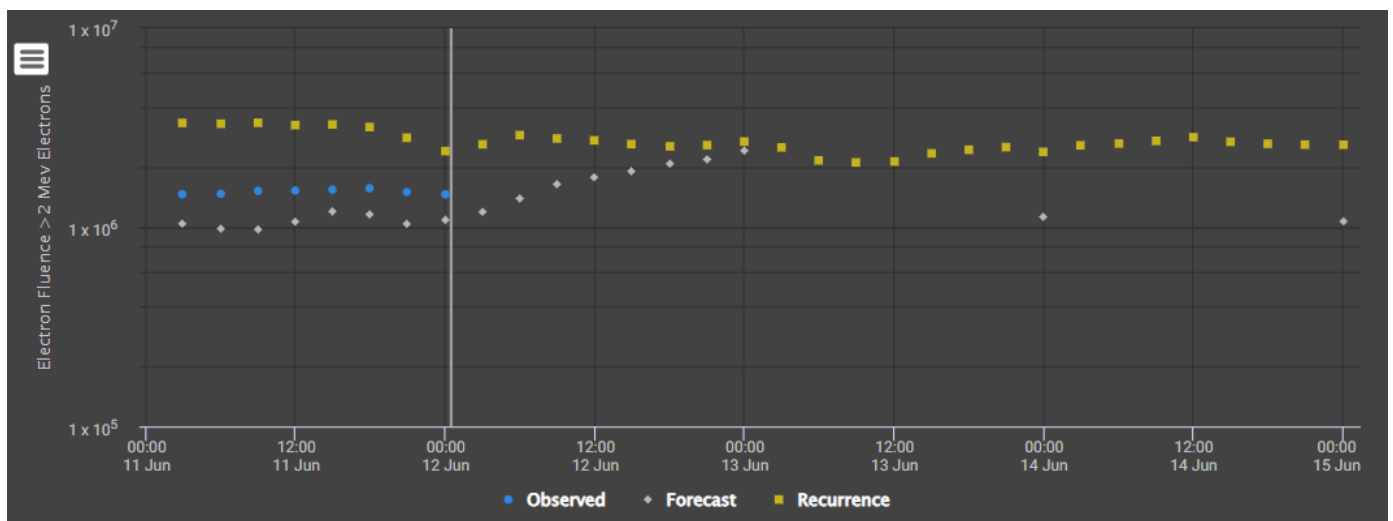
## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is at Background and expected to persist at this level. There is a very slight chance of S1/Minor Radiation Storms should any larger flares occur, with AR3327 the most likely source as it transits further across the western hemisphere.

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	5	5	5	5
Very Active	$\geq \text{S3}^*$	No	1	1	1	1

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

Figure 4: Latest MOSWOC REFM output



## 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. Geomagnetic activity resulting from the connection to the HSS from CH10/+ or CH11/+ has been relatively muted so far, therefore any electron response is expected to be small. 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	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	1	1
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5:

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