
Space Weather Technical Forecast

Issued on Sunday, 11 June 2023 at 13:17 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 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 C5.7 at 10/2116 UTC from AR3323 in the southwest quadrant, although this region is now barely visible as it approaches the western solar horizon. There are nine sunspot regions visible in total, however the majority of these are small, simple and stable. AR3327 is the main region of note, as a broad collection of smaller spots. Despite its diffuse nature, a small reverse polarity spot near its leader, along with an increased east-west component to its inversion line, brings increased potential instability. AR3331 and AR3327 are the larger of the bipolar regions. The former was the source of an M-flare on 09 Jun, but generally stable since, while the latter has produced a couple of small C-class flares in the last 24 hours. No Earth-directed CMEs were observed in the last 24 hours, however a central southern disc filament eruption was observed at 11/0855 UTC, however no coronagraph imagery is currently available to assess the likelihood of an associated CME.

Solar Wind / Geomagnetic Activity: The solar wind at L1 showed the connection to a fast wind environment, most likely from the HSS of CH11/+ or CH10/+, but with some increased IMF (interplanetary magnetic field) that likely occurred due to the arrival of either of the weak CMEs from 08 Jun. Solar wind speeds as observed by ACE were initially around 300km/s then gradually increased from 11/0100 UTC to be slightly elevated at near 400 km/s. Density initially trended upward, peaking 27ppcc at 10/2250 UTC, before erratically easing. Total IMF strength, Bt increased from being weak to peak at 15nT around 11/0100 UTC. The north-south component became predominately positive (northward) peaking 15nT, but with occasional turbulent rotations to negative (southward) with minimums of around -10 nT. As the total IMF eased slightly to 8-12nT, the north-south component trended to be more predominately negative. Phi angle was initially negative (towards the Sun), but rotated to be positive (away from the Sun) from 11/0200 UTC. 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 11/0000 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.

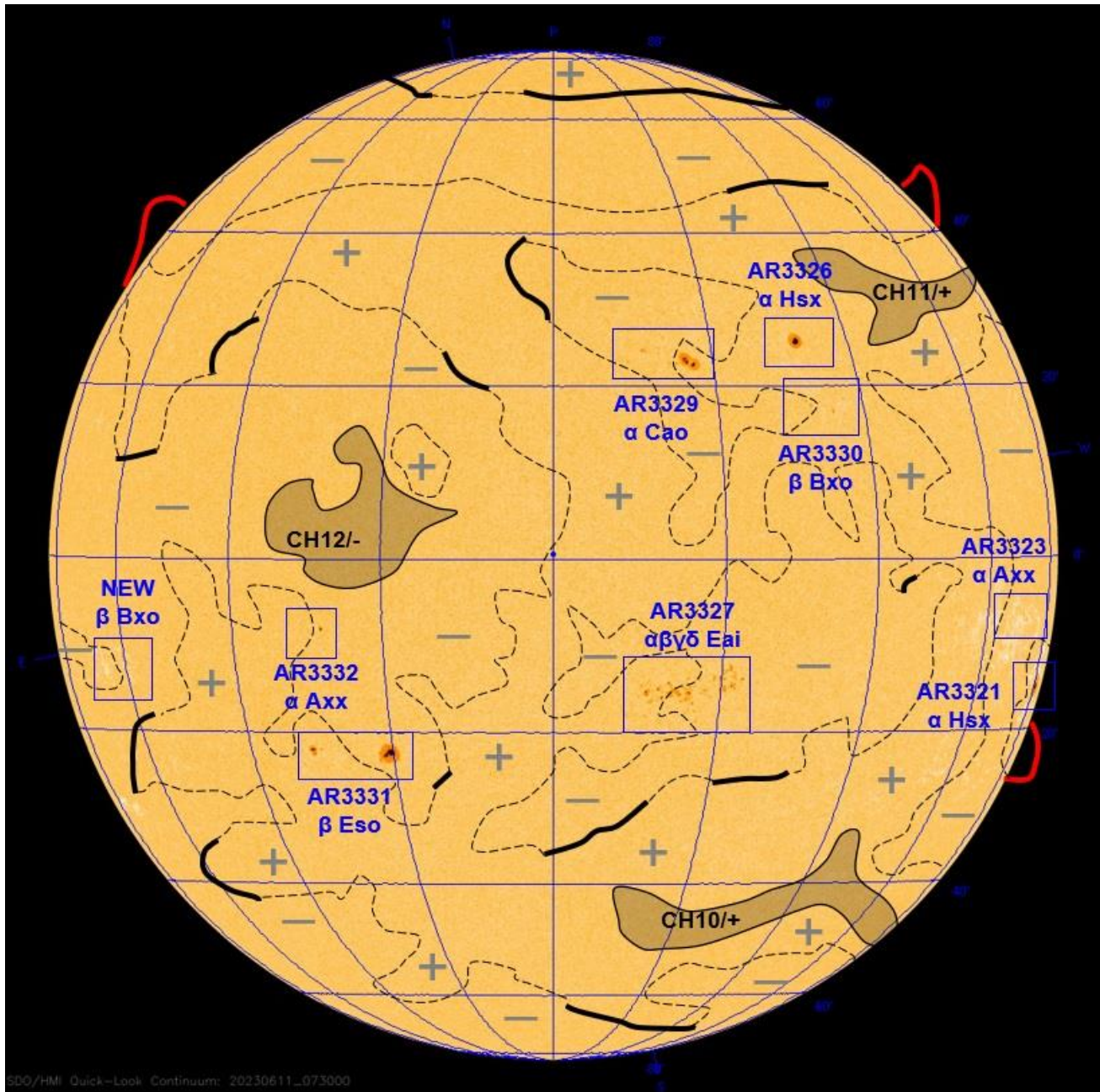
Solar Wind / Geomagnetic Activity: A CME associated with the M2.5 flare from AR3331 on 09 Jun, is directed mainly behind Earth but has the potential to give a glancing influence, most likely on day 3 (13 Jun). No other CMEs are currently expected. Ongoing slightly elevated solar winds are expected days 1-3 (11-13 Jun) due to CH11/+ and CH10/+ high speed stream (HSS) influence, before easing day 4 (14 Jun). Quite geomagnetic conditions expected with Unsettled spells. There is a slight chance of Active to G1 Minor Storm intervals, mainly late day 1 (11 Jun) due to ongoing HSS enhancement, or late day 2 or day 3 (12 or 13 Jun) with any CME glance

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that may occur.

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 at background, perhaps rising to Moderate day 1 or 2 (11 or 12 Jun). Electron fluence is expected to persist below the Active (1e8 integrated pfu) threshold.

Figure 1. Solar Analysis Valid 11/0800 UTC.



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

Geomagnetic Storms:

No CMEs are currently expected to impact at Earth, however 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. This is most likely on day 3 (13 Jun) with a small chance of arriving late on day 2 (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/+. This potentially including some enhancement from weak CMEs from 08 Jun that also had the slight chance of a glancing impact. These slightly elevated solar winds of around 400-450km/s are expected to continue day 1-3 (11-13 Jun), before potentially easing day 4 (14 Jun).

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 (11 Jun) due to ongoing HSS enhancement, or late day 2 or day 3 (12 or 13 Jun) with any CME glance that may occur.

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	5	10	1
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 early hours of 13 June Glancing impact possible

Figure 2a: ACE Solar winds in the last 24 hours (Speed and Phi top, Density, Bz bottom)

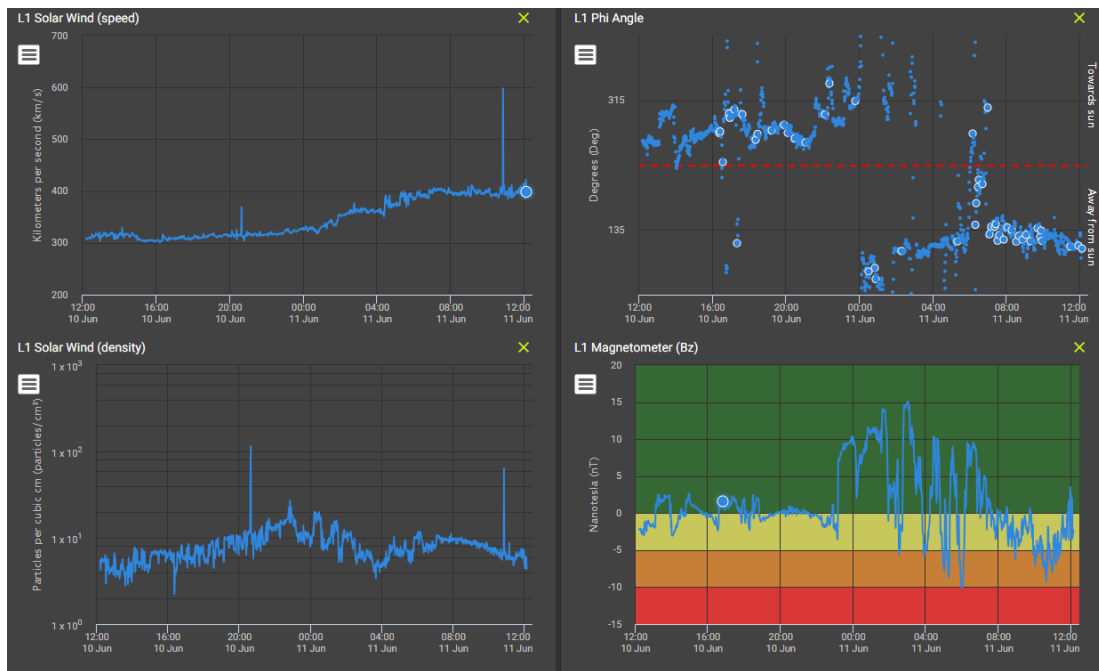
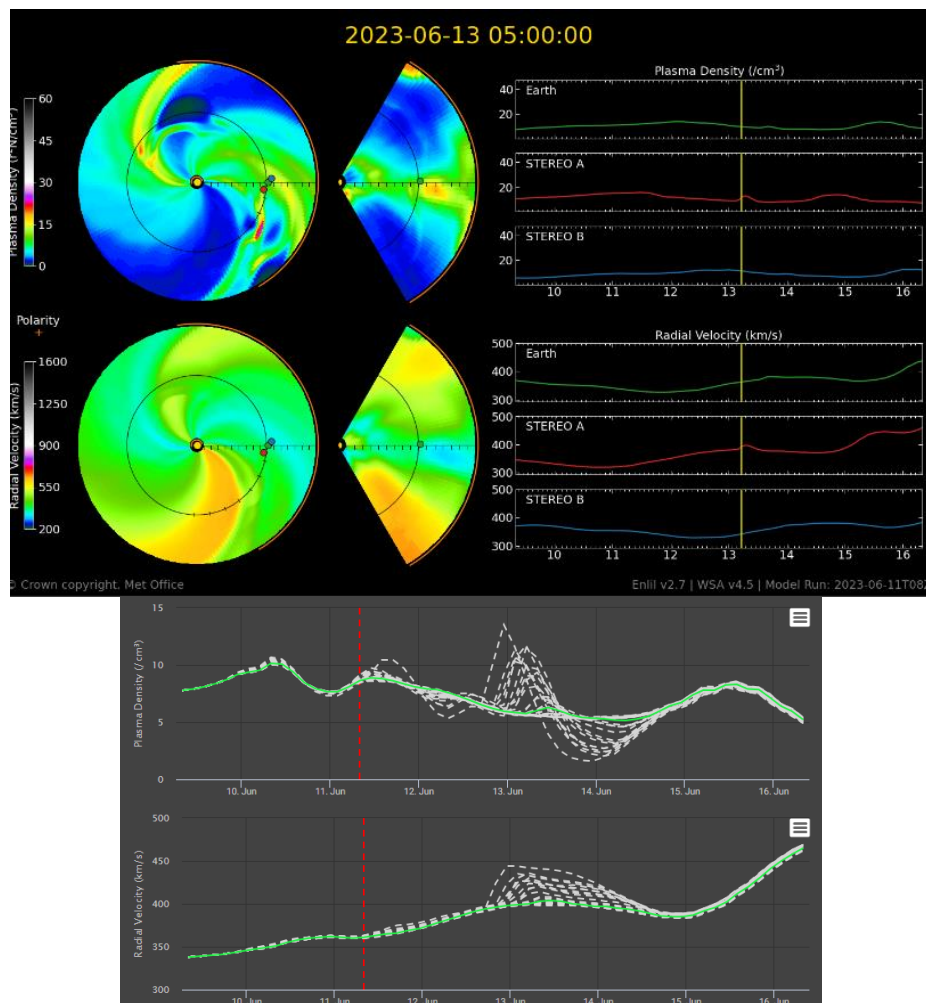


Figure 2b: Enlil and ensemble showing weak CME glance, most likely early on 13th



Radio Blackouts - X-Ray Flares:

Low activity is expected, perhaps rising to Moderate with a slight chance of isolated M-flares.

AR3327 is the most notable of the nine active regions on the disc, and the most likely source of flare activity. This is a broad collection of small spots, but with some apparent complexity with reverse polarity spots near its main leader region and a magnetic polarity inversion line which is more east-west, rather than orientated north-south. Despite a trend towards weakening penumbral extent, AR3327 also 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 AR3223 which is now rotating off the disc, and weakening since its recent C5.7 flare. AR3331 is also of note as the most recent M-flare source, on 09 Jun, but is now a simple bipolar and open group, and has been inactive since that 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	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

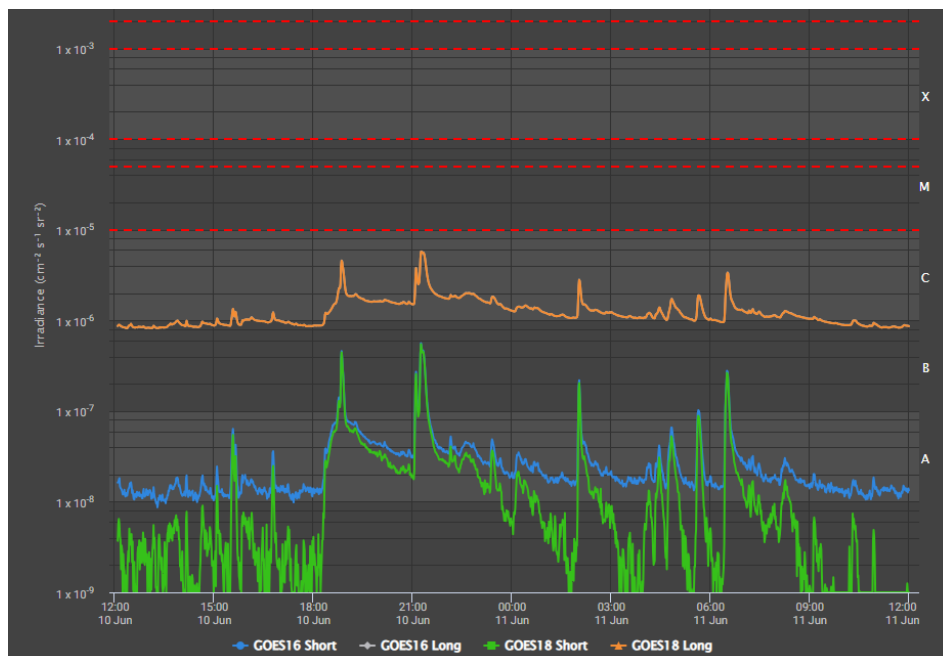
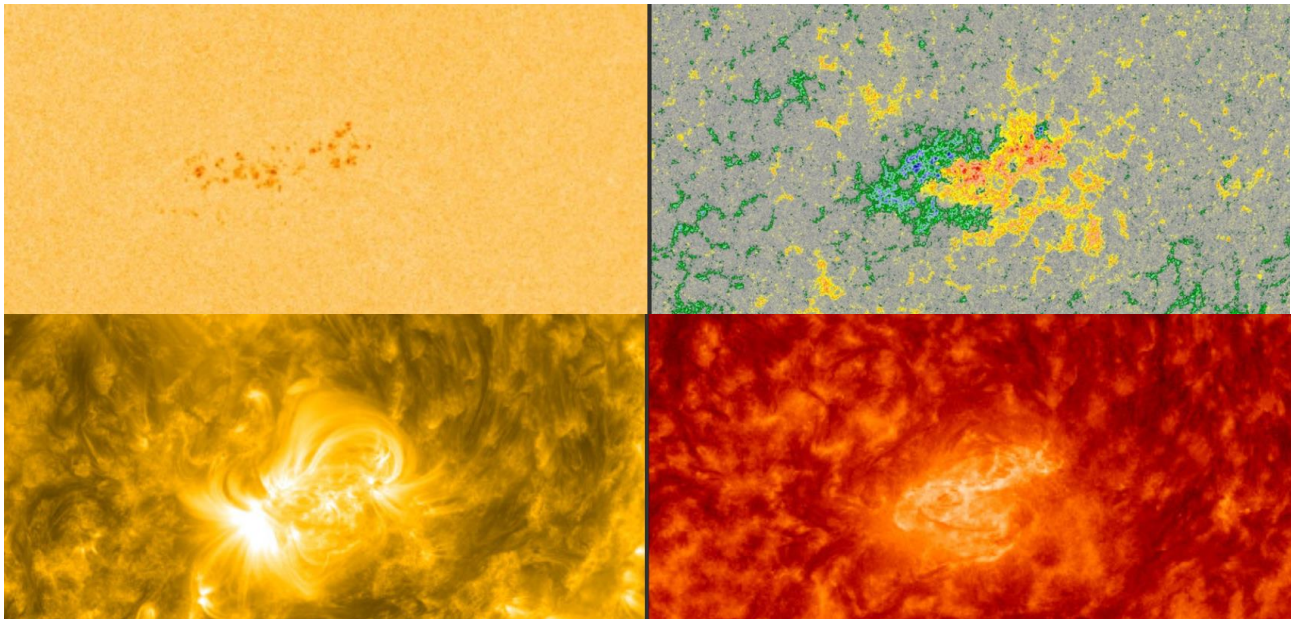


Figure 4: SDO hmi intensitygram and magnetogram of AR3327 (top). Aia-171 and aia 304 imagery of AR3327 below. Notable looping visible, along with potential shear on magnetic field lines, despite relatively weak flux apparent in SDO intensity gram.



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 moves across the western hemisphere.

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)

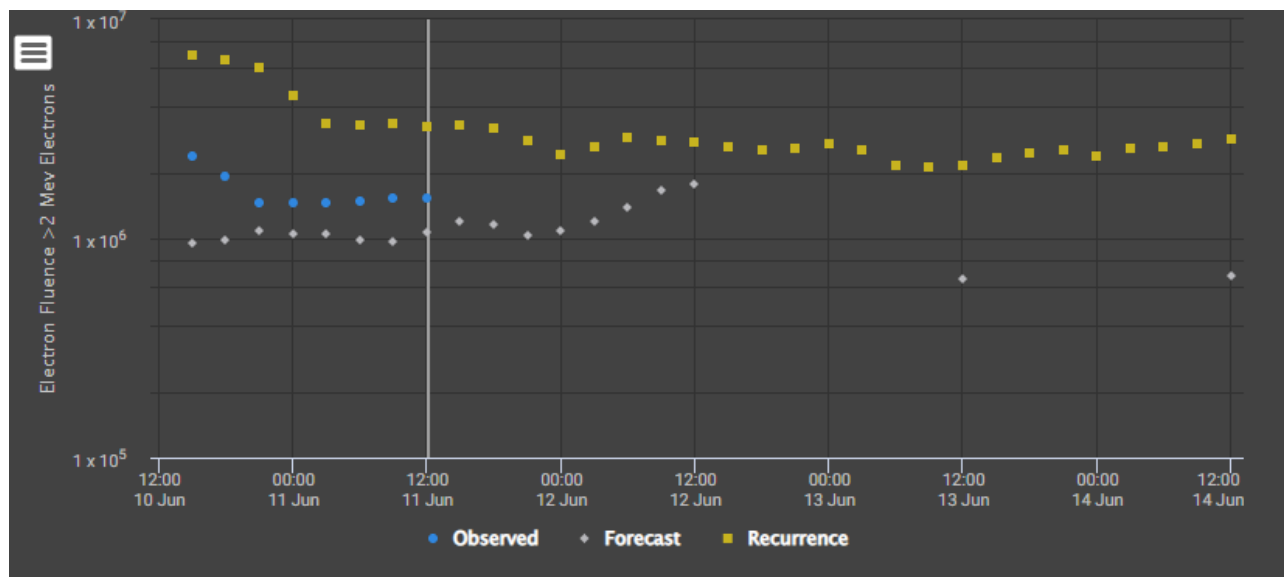
High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is expected to be at mainly background through the period. Should connection to high speed streams from either CH10/+ or CH11/+ occur, then flux may increase to moderate perhaps briefly high (1000 pfu) later day 1 or day 2 (11-12 Jun), however this is low confidence. Furthermore, any glancing CME arrival late day 2 or day 3 is likely to drop out any increase flux that occurs.

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	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^8$	No	1	1	1	1
Very Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^9$	No	1	1	1	1

Figure 5: GOES-16 24 hr $>2\text{MeV}$ electron Fluence and REFM with Recurrence



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