

# Space Weather Technical Forecast

Issued on Thursday, 08 June 2023 at 13:05 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>**

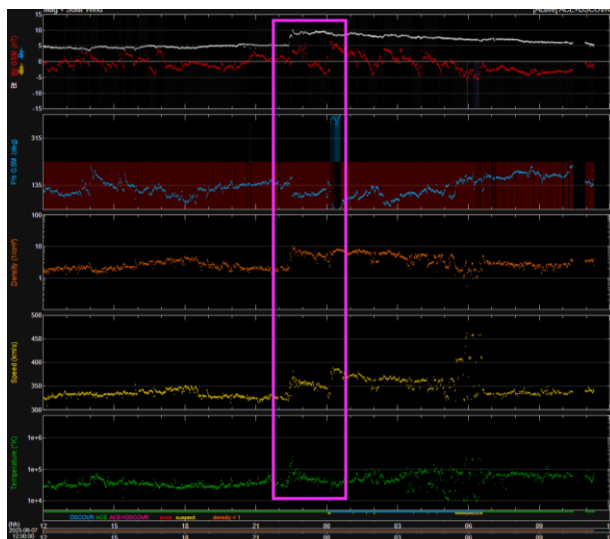
**Space Weather Forecast Headline: Chance of M-class flares (R1/Minor-R2/Moderate radio blackouts). Slight chance of G1/Minor Geomagnetic Storms.**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been Moderate over the last 24 hours, with GOES16 recording the falling limb of an M4.7 flare observed at 07/1146UTC, i.e. immediately prior to this reporting period. The sunspot region responsible for this event and other upper-end C-class flares was the largest and most dynamic on the disc in the period - AR3327 in the southeast quadrant, which now manifests as an Eac/Beta-Gamma-Delta. This group's potential Mt Wilson delta spot is showing in its trailing portion, while the spot group as a whole underwent areal growth, and also saw an emerging new large penumbral spot in its centre. This sunspot region was one of up to nine on the current solar disc, although activity and development in the remainder was more subtle, with minor movement seen in AR3323, 24 and 29.

A pair of prominences lifted off in the period - one from the vicinity of AR3331 at 07/2000UTC, and the second from high latitude in the northeastern quadrant at 08/0900UTC. Neither of these is expected to affect Earth. A filament disappeared from the northeastern central disc on (for example) Udaipur H-alpha imagery at 08/0900UTC (separately to the aforementioned prominence). There is not yet any evidence of any resulting interplanetary CME.

Coronagraph imagery for the period shows a slow eastward-heading CME of uncertain provenance in the current UTC morning. Modelling results are awaited, however a hit appears unlikely given the parameters submitted. All other CMEs noted appeared to have eastern limbward or else far-sided solutions in modelling, with no effects expected.



**Figure 0: L1 solar wind at ACE and DSCOVR, showing possible 04 June CME arrival.**

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: [moswoc@metoffice.gov.uk](mailto:moswoc@metoffice.gov.uk)

**Solar Wind / Geomagnetic Activity:** Solar wind parameters, as observed by ACE and DSCOVR at L1, showed a slow regime in the main, however a possible weak transient was observed around 07/2230UTC, which may be the shock from the awaited glance from the 04 June CME. The solar wind speed was accordingly at Background levels between 325 and 375km/s, with staged increases around 07/2230UTC and again around the turn of the UTC day to reach the 375km/s peak, with a slow waning trend then setting in. The solar wind density was within Background levels throughout, with a peak of around 10ppcc coincident with the purported CME passing L1. The IMF was steady at or below 6nT for the first half of the reporting period, rising to a peak of 10nT with the CME before also waning. The north-south component was small-scale and erratic between +6 and -5nT, with a gradual drift to become more reliably anti-aligned with Earth's field later in the current UTC morning. The phi angle was positive (away from the Sun) throughout.

The net effect of the above solar wind measures was for provisionally Quiet geomagnetic activity, with a peak of 2+ seen in the 00-03UTC interval.

**Energetic 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 largely Normal Background levels. Associated 24-hour fluence has been below the Active threshold (1e8 integrated pfu) on a generally steady trend, with 1.35e6 integrated pfu observed at 08/0001UTC.

### **Four-Day Space Weather Forecast Summary**

**Solar Activity:** There is a daily Chance of Moderate solar activity. Any significant flares are most likely to originate from AR3327. The risk of flares should fall very slightly from day two, Friday 09 June, as a front-sided group leaves the disc, with no major returning regions due to compensate.

**Solar Wind / Geomagnetic Activity:** The most likely CME to feature in geomagnetic activity may have already arrived, with the 04 June southwest quadrant filament perhaps showing as the 07/2230UTC L1 enhancement. Should this still be outstanding, there remains a Slight Chance of G1 within day one, however this now appears less likely, and the 04 June CME appears to have peaked. More marginal impacts from further CMEs are possible but not expected on days 3 and 4 (UTC weekend).

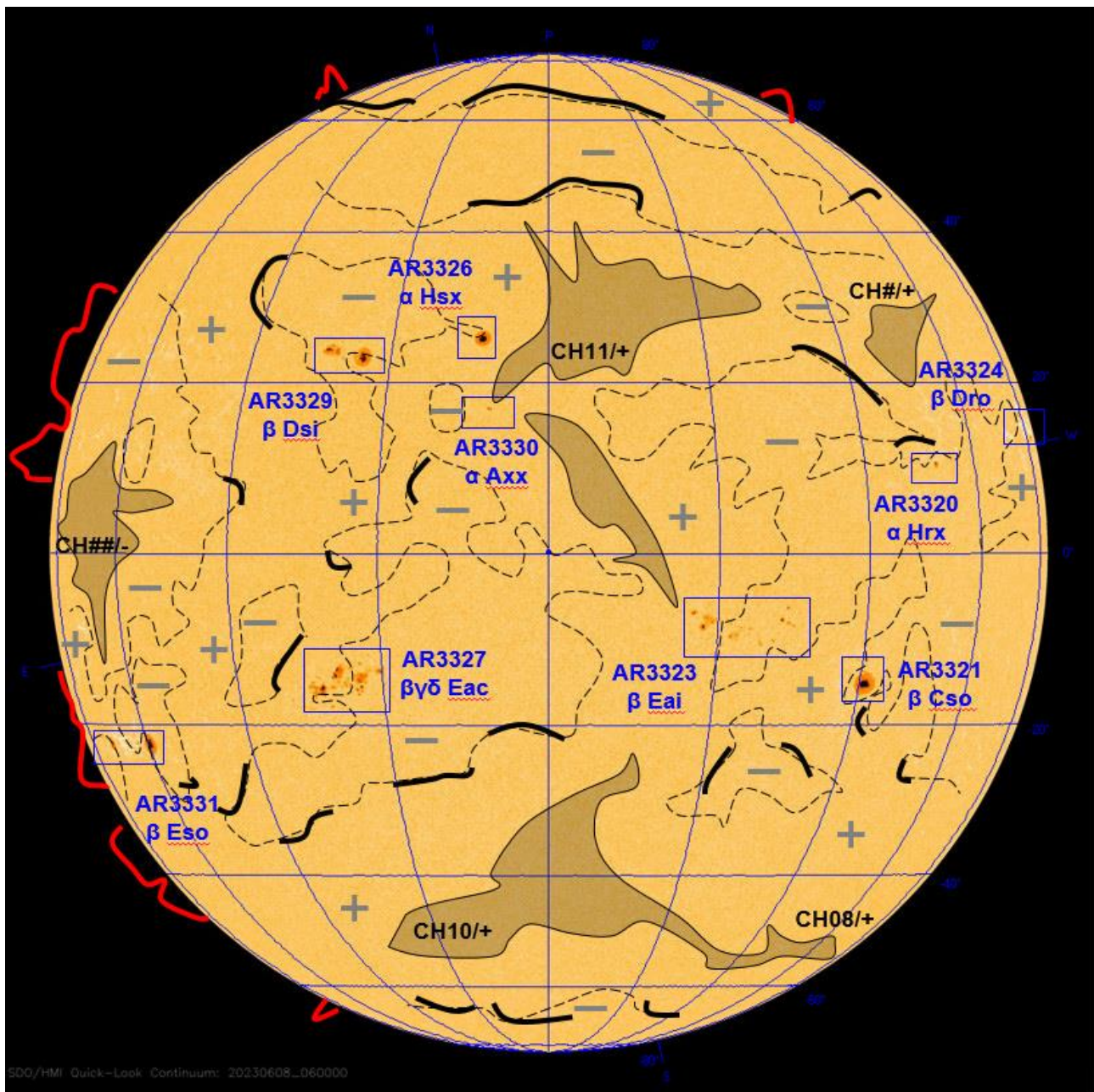
Otherwise, ambient solar winds are expected to become Slightly Elevated or Elevated on days 3 and 4 due to the arrival of positive coronal hole fast winds.

There is a Slight Chance of G1, peaking on day one should the CME from 04 June remain in transit, with a secondary peak then due on Saturday 11 June from a more reliable fast wind. Activity should be most reliably Quiet on Friday 09 June between these events.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, however there is a very slight chance of reaching the S1/Minor Storm threshold should any larger flares occur.

High energy electron flux (greater than 2MeV) is expected to be at mostly Normal Background levels, but may rise late in the period due to coronal hole high speed stream effects. Electron fluence is also expected to continue below the Active (1e8 integrated pfu) threshold, but with an eventual increasing trend.

Figure 1. Solar Analysis Valid 08/0600UTC.



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

**Geomagnetic Storms:**

The CME forecast initially comprises a possible glancing blow from the 04 June southwest quadrant filament eruption on day one, Thursday 08 June. This may have already passed L1 to minimal effect, but is retained in the forecast for now. The day one 20% chance of G1 assumes this 04 June CME arrival has yet to occur, rather than representing a resurgence in the very minor 07/2230UTC transient. In addition to this, some more tenuous CMEs are expected to pass largely behind Earth in the track of its orbit over the coming UTC weekend, with the most likely forecast being misses.

The fast wind forecast is expected to be more reliable in CH10/11/+ arriving on Saturday 10 June, with an according Slight Chance of G1, probably muted for being near the solstice. Earth crossed the solar equatorial plane northwards on 07 June, and for the coming half of the year it will lie above, with positive polarity features gradually becoming the more potent.

All considered, there are twin peaks in the Slight Chance of G1, the first imminent (or passed) with the 04 June CME, and the second on Saturday 10 June with the fast wind. The most likely Quiet day is expected to be Friday 09 June.

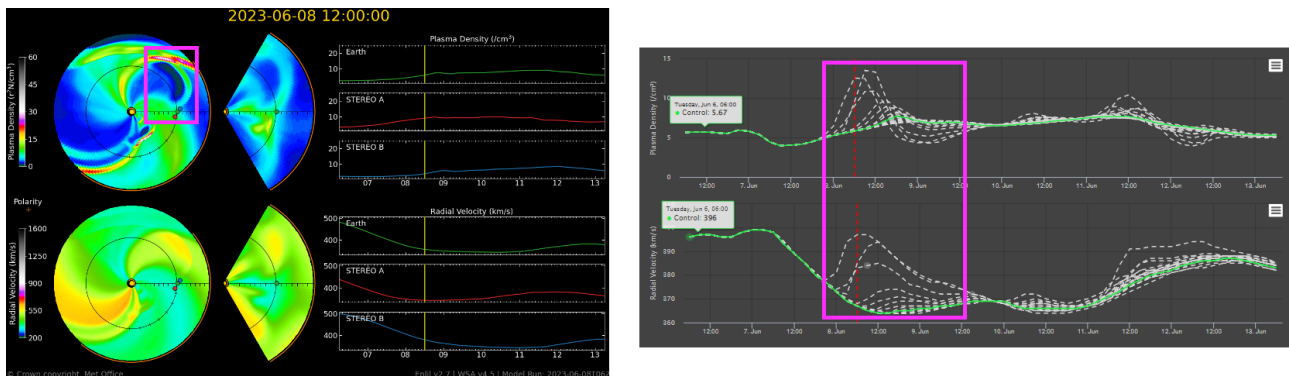
Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	5	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

**Geomagnetic Activity - Earthbound Coronal Mass Ejections**

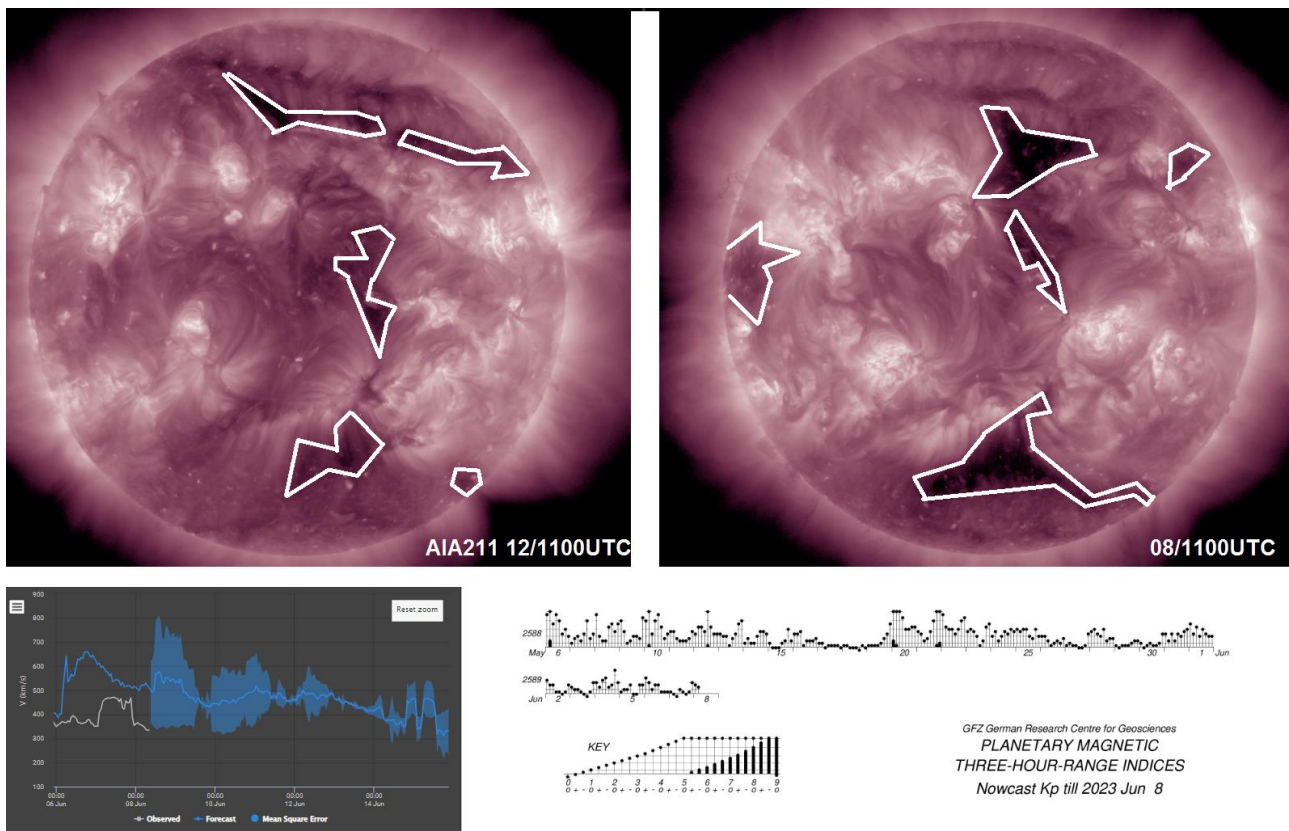
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1629	Partial	Filament eruption	SW	620km/s	Imminent or arrived L1 07/2230UTC	Now imminent and muted or else passed 1AU.



**Figure 2: Latest MOSWOC Enlil and ensemble, stopped at the most likely time of arrival of the awaited or arrived 04 June CME. Perturbations to the deterministic run over the UTC weekend are from other minor CMEs and not expected to feature at Earth.**



**Figure 3: AIA211 imagery from the previous and current rotations, showing some differences in upcoming coronal holes, although being near the solstice, the larger and more intense manifestations of CH10 and 11 on this pass should be muted. Also shown are solar winds and geomagnetic activity from the current and previous rotations.**



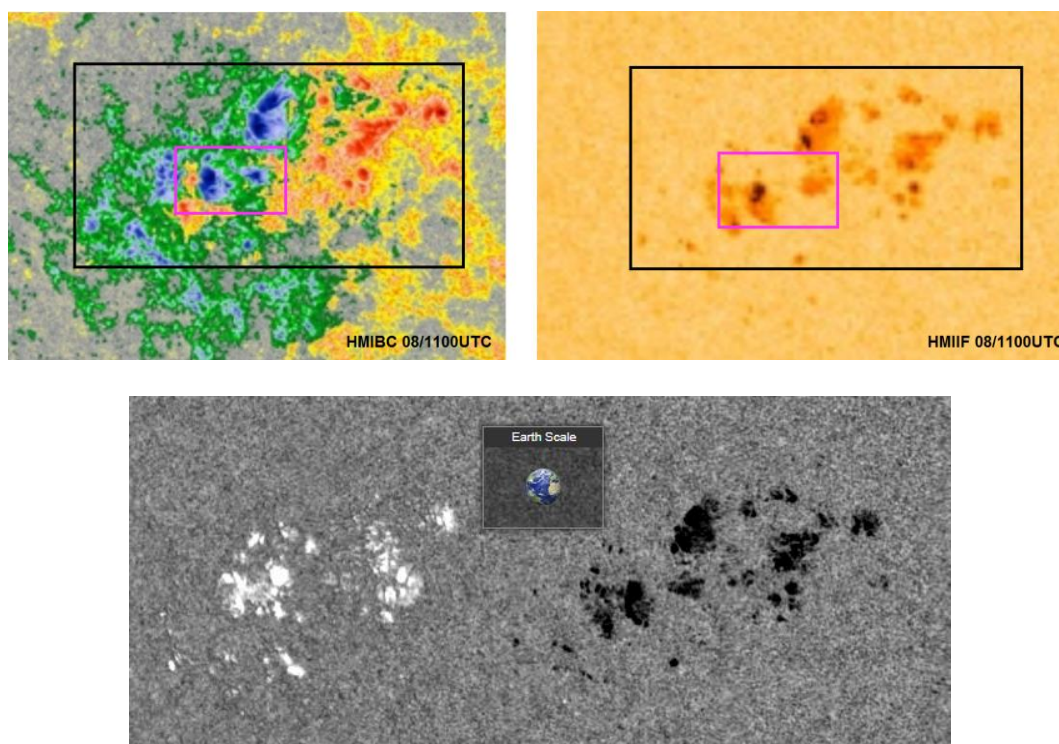
## Radio Blackouts - X-Ray Flares:

There are currently nine sunspot regions on the visible disc. The main changes in the period were largely within the largest and most complex group, AR3327, which shows a possible Mt Wilson delta spot in its trailing portion. This spot group also underwent areal growth, and also saw a emerging new large penumbral spot in its central portion. Trends in other sunspot groups were more subtle, with minor movement seen in AR3323, 24 and 29.

Solar activity carries a Chance of being Moderate, with further M-class flares and perhaps a Slight Chance of isolated X-class. The chance of significant flares reduces slightly from day 2 (Friday 09 June), with AR3324 (Cao/Beta) transiting to the far side. No new regions are anticipated to rotate round the east limb during the period to compensate.

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

**Figure 4:** HMIBC and HMIIF imagery of AR3327 in the southeastern quadrant, showing the now tenuous candidates for Mt Wilson delta spots. Also shown below is a 24-hour evolution in this group's footprint in HMIB, showing marked growth of a penumbral intermediate spot (compare white footprint from 07/100UTC with black from 08/1100UTC). Image processing courtesy of Helioviewer.org.



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

The high energy (greater than 10MeV) proton flux is at Background levels, where it is expected to remain. There is a very slight chance of S1/Minor Radiation Storms should any larger flares occur, with the most likely culprit being the moderately large and complex region AR3327, which will be moving across the central portion of the disc over the coming days.

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	10	10	10
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 = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$ )						

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

High energy electron flux (greater than 2MeV) is expected to remain at mainly Background levels through the period, with the current steady state not likely to be influenced until later in the UTC weekend after the arrival of the coronal hole fast wind(s).

Possible intervening CME effects serve to lower confidence in an eventual fluence rise slightly, but the magnitude of this is not expected to be sufficient to trouble the Active threshold in any case. The latest MOSWOC REFM appears realistic in its maintaining of the current fluence through the next 72 hours.

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	5	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1