
Space Weather Technical Forecast

Issued on Friday, 16 June 2023 at 13:12 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. Further G1/Minor geomagnetic storm conditions likely today, slowly easing. Chance of Active fluence by Day 4 (19 June).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with two M1 flares from AR3337 and AR3338. There are currently nine sunspot regions on the visible disc. AR3333 and AR3335 are both in the southeast quadrant and are the two largest regions on the disc, but neither are significantly complex. AR3335 is also close to another group, AR3336, which has produced a high level C-flare. The close proximity of these two groups could enhance magnetic shear across the two regions. AR3338 near the northeast limb has also started to reveal penumbra on its trailing spot and again this is in close proximity to simple region AR3337 so these two regions are also interacting magnetically. The two largest flares of the last 24 hours have originated from these regions. The remaining regions currently appear small, weak and simple. There are also a number of large filaments on the Earth-facing disc, with the potential to produce Earth-directed CMEs if they were to erupt. Currently no Earth-directed CMEs have been observed using available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE and DSCOVR and L1, showed the onset of a strong High Speed Stream (HSS) from CH12. Wind speeds started the period at ambient levels, steadily increasing from around 16/1400 UTC to reach strong levels, currently varying between 630-740 km/s. Density was initially above average (peak 50ppcc at 15/1335 UTC) but has since dropped back to average levels or slightly below. The total IMF, Bt, was moderate to strong at first, peaking around 20 nT, but dropped back to weak levels around 16/0300 UTC. The north-south component, Bz, was moderately negative at times until around 16/0300 UTC when it became mostly weakly negative. The phi angle was mostly negative (towards the Sun) throughout. Geomagnetic activity was Quiet at first, soon becoming Active to G1/Minor Storm (Kp 4-5), with a G2/Moderate Storm interval 16/0300-0600 UTC.

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 at mostly background levels. The associated 24-hour fluence remained well below the Active threshold (1e8 integrated pfu), with a gradually decreasing trend, and 1.95e6 integrated pfu observed at 16/0000UTC.

Four-Day Space Weather Forecast Summary

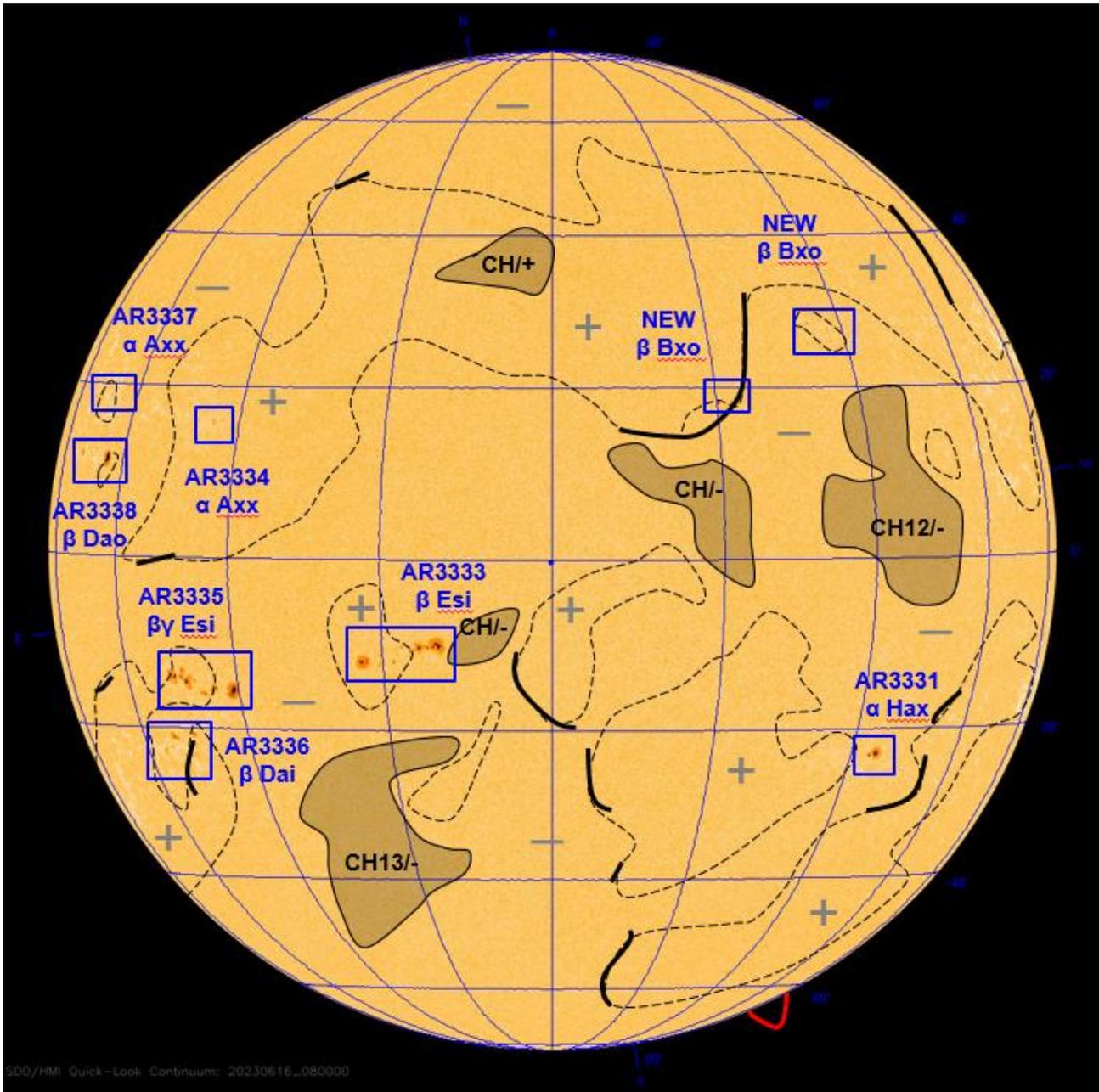
Solar Activity: Solar activity is expected to be Low to Moderate, with a chance of further M-flares. Further M-flares could occur from the regions near the northeast limb, but also from the larger regions in the southeast.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs currently expected. Earth is currently under the influence of a HSS from CH12, which is followed by an as yet unnumbered coronal hole. The influence of their HSS is likely to persist for much of this forecast

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period, although likely gradually declining in strength and activity. Initially strong solar wind speeds should gradually decrease to elevated levels through Day 2 (17 June), and perhaps to slightly elevated levels during Days 3 and 4 (18-19 June). Geomagnetic activity is forecast to be Active to G1/Minor Storm (Kp 5) at first, gradually decreasing to become Unsettled to Active (Kp 3-4) through tomorrow. Geomagnetic activity is expected to further decline thereafter, likely becoming Quiet to Unsettled (Kp 1-3) during Days 3 and 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 show a rise later in the period as the current HSS eases. Electron fluence is also likely to rise later in the period, with a chance of reaching above Active ($1e8$ integrated pfu) by Day 4 (19 June).

Figure 1. Solar Analysis Valid 16/0800 UTC.


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:

There are no Earth-directed CMEs currently expected.

The HSS associated with CH12/- has arrived and Enlil is providing reasonable guidance, although it is underestimating the peak wind speeds by around 100 km/s. CH12 is followed by an as yet unnumbered coronal hole, and the two of these extend quite a way across the western hemisphere. Therefore the influence of the HSS is likely to persist for much of this forecast period, although gradually declining in strength and activity. Initially strong solar wind speeds should gradually decrease to elevated levels through Day 2 (17 June), and perhaps to slightly elevated levels during Days 3 and 4 (18-19 June).

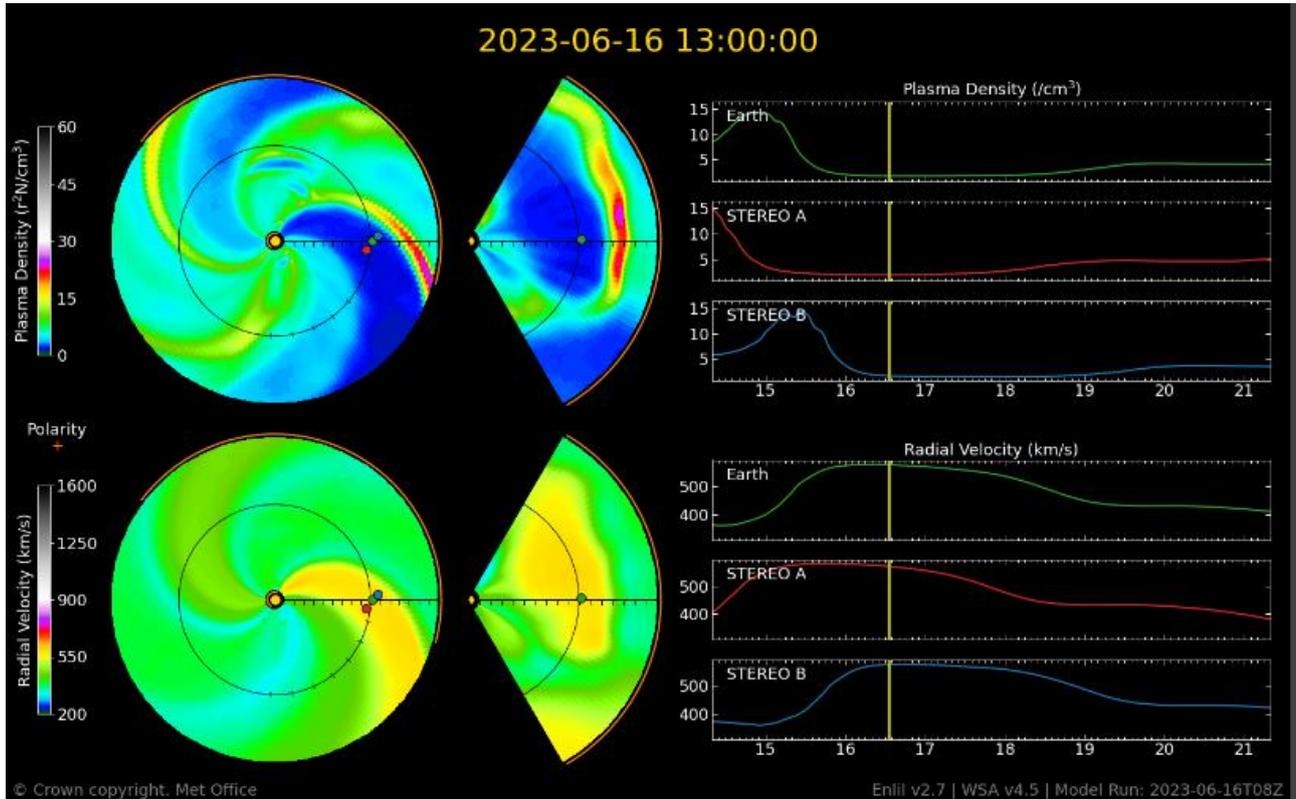
Geomagnetic activity is forecast to be Active to G1/Minor Storm (Kp 5) at first, gradually decreasing to become Unsettled to Active (Kp 3-4) through tomorrow. Geomagnetic activity is expected to further decline thereafter, likely becoming Quiet to Unsettled (Kp 1-3) during Days 3 and 4.

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	Yes	70	30	5	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

No Earth directed CMEs are currently expected.

Figure 2: MOSWOC Enlil. Whilst recent Enlil runs have been underforecasting a little the strength of the current HSS, this latest run appears to have moved in the right direction.



Radio Blackouts - X-Ray Flares:

There are currently nine sunspot regions on the visible disc. AR3333 and AR3335 are both in the southeast quadrant and are the two largest regions on the disc, with a little more complexity in AR3335, but neither are significantly complex. AR3335 is also close to another group, AR3336, which has produced a high level C-flare. The close proximity of these two groups could enhance latitudinal magnetic shear across the two regions, greater than would be expected than if both sunspot regions were more remote to each other. AR3338 near the northeast limb has also started to reveal penumbra on its trailing spot and again this is in close proximity to simple region AR3337 so these two regions are also interacting magnetically. The two largest flares of the last 24 hours (both M1) have originated from these regions. The remaining regions currently appear small, weak and simple.

No significant regions are due to leave the disc in the coming four days, however further regions are potentially approaching the east limb as inferred by brighter flux regions in STEREO A and SDO imagery. As there is not yet significant activity from over the east limb, flare probabilities are kept flat until these regions become visible and can be analysed.

Solar activity has been Moderate in the last 24 hours with two M1 flares from AR3337 and AR3338. There was also a C9.7 flare peaking at 15/1255 UTC from AR3336. Solar activity is likely to be Low to Moderate with a chance of further M-flares, and a slight chance of X-flares.

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	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: X-ray flare trace for the last 24 hours. Two recent M-flares from AR3337 and AR3338.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is at background levels and is expected to continue at this level. Most of the larger sunspot regions are in the east of the disc at present, and not in a favoured position for proton storming. The risk increases very slightly through the period, however, as these larger regions rotate towards centre disc.

Radiation Storms	Level (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	3	3	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 = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

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

High energy electron flux (greater than 2MeV) is expected to largely be at background levels at first. The current HSS enhancement from CH12/- has had a fairly strong geomagnetic effect, unusually so given Earth's proximity to the Solstice. As such it seems likely that electron counts through the Van Allen Belts will be increasing, currently below GEO due to the strength of the solar wind speed. As the wind speed eases, it seems probable that this will result in increasing electron flux at GEO, perhaps becoming High at diurnal max later in the period.

The associated 24 hr electron fluence is expected to remain below the Active ($1\text{e}8$ integrated pfu) threshold during Days 1 and 2 (16 and 17 June), with a rise becoming likely thereafter. There is a chance of reaching Active fluence by Day 4. The REFM model is showing an increase below Active through the next 3 days, which seems like reasonable guidance, although confidence is only moderate in the level of increase by this time.

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	5	20	30
Very Active	$\geq 2\text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing a gradual increase in fluence, which seems like a good trend.

