



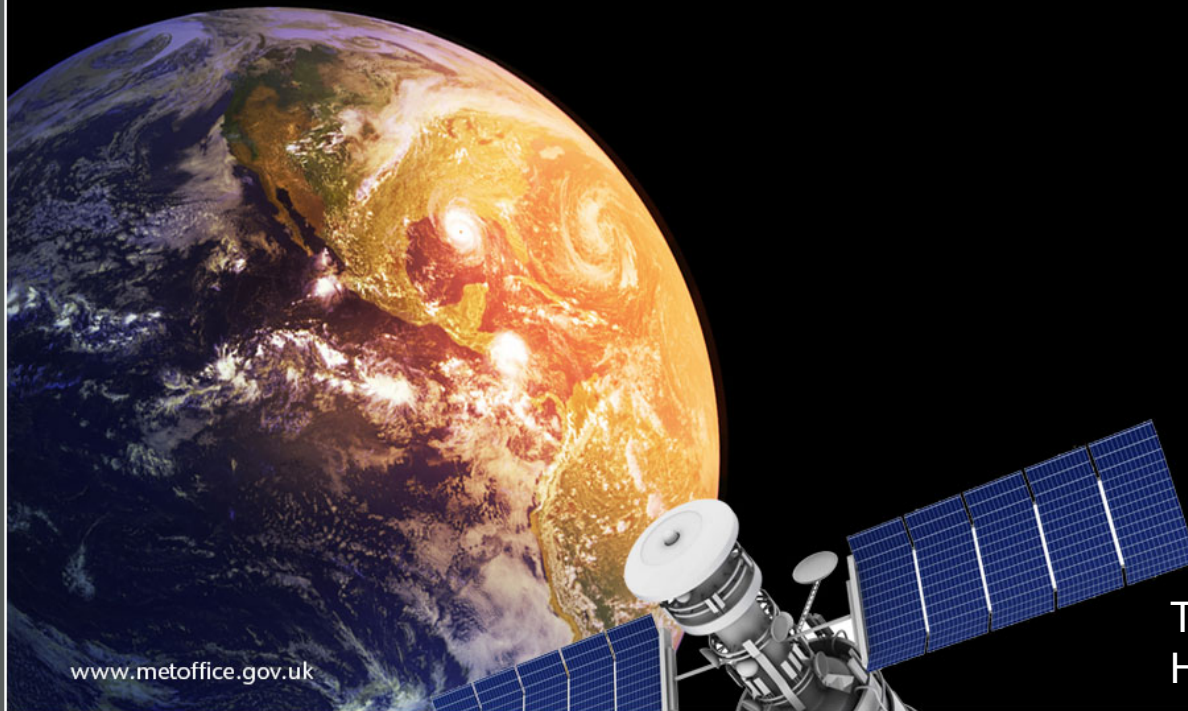
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# Met Office View of CCMC

Mike Marsh (for Mark Gibbs)

8<sup>th</sup> CCMC Workshop

15<sup>th</sup> April 2016



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Thanks to Sophie Murray, Edmund  
Henley & MO SWx Science team



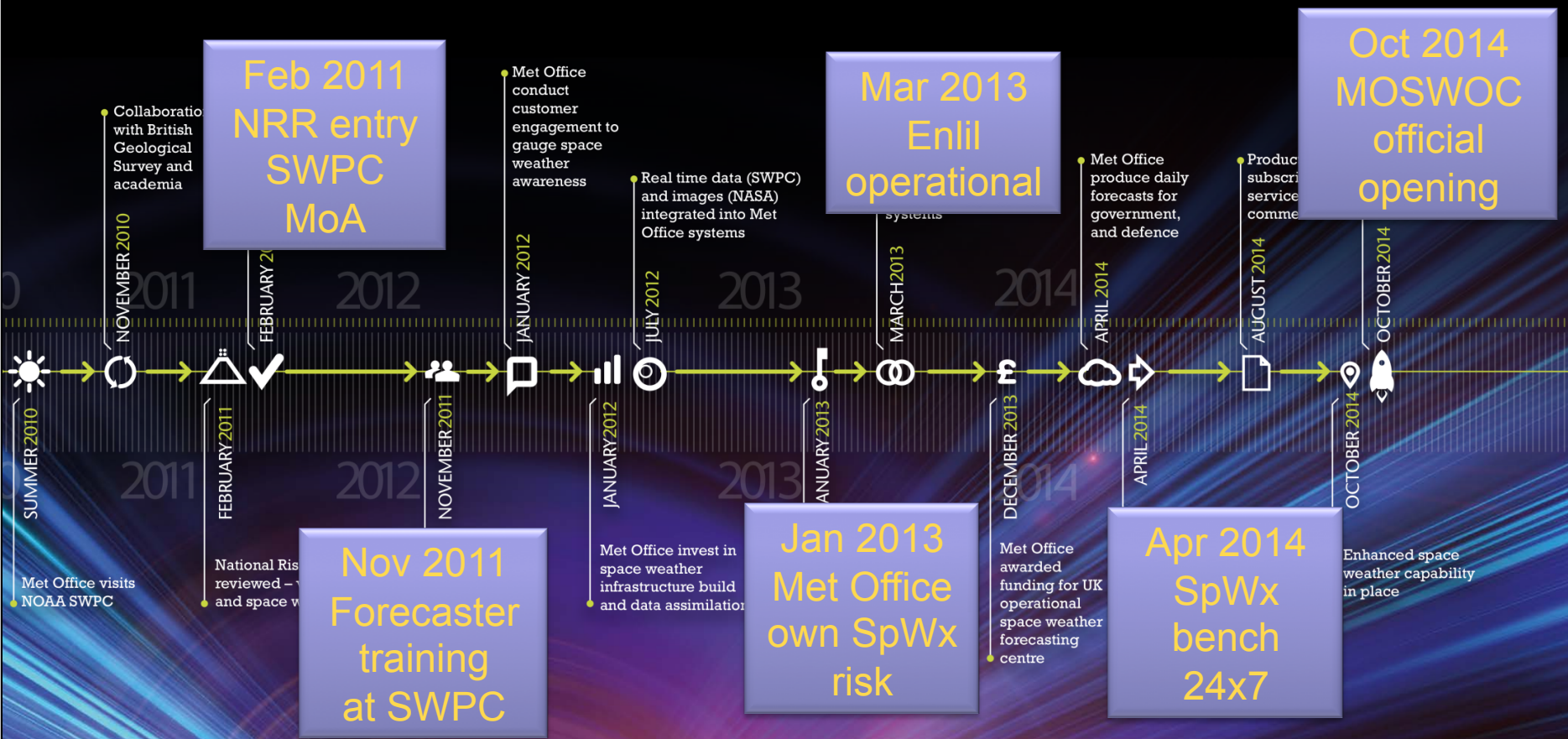
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# Background to SWx at the Met Office



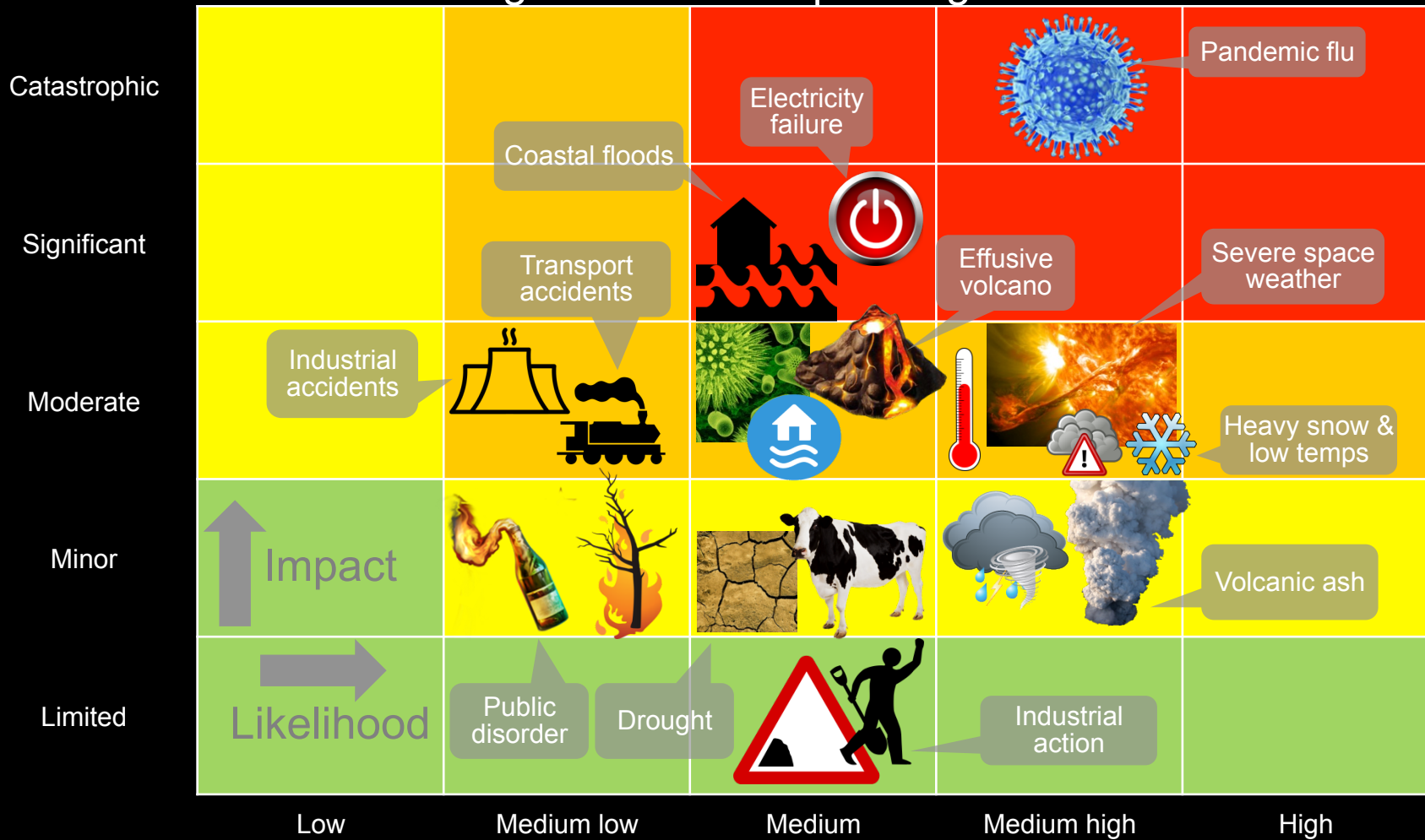
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# A space weather journey through time



# National risk register

## The UK government response guide





# Met Office Space Weather Operations Centre

- 24/7 Operations
- Fully integrated within Met Office Operations Centre
- National capability supporting government, military, and critical sectors
- Team includes
  - Space Weather Operational Meteorologists
  - Scientists
  - Programme managers
  - IT developers





Met Office

# Objectives and Services



**Met Office**

# Objectives and Services

## Objectives

Source of UK centric advice to support critical infrastructures, deliver socio-economic benefit, meet customer requirements

## Space Weather Services

- Subscription services (email) – forecasts, alerts, warnings, guidance documents (situational awareness)
- Customer sector specific tailored webpages
- Public awareness pages

## Forecast Products Tailored analysis

- Synoptic maps
- CMEs
- Geomag forecasts
- Flare/radio blackouts
- Proton storms
- Electron fluence

## Customer Sectors

Energy, Aviation, Marine, Satellite, Defence, and Rail



# Adapting to Customer Needs

Forecasts issued 2x daily to UK-based subscribers

Choice of two versions

- Technical forecast
- Plain-language forecast

**Technical forecast**  
Intended for use by experts

- Details such as Kp values, solar wind speeds, etc

**Plain-language forecast**  
Adapted for use by non-expert decision makers

## Met Office Space Weather Technical Forecast

Space Weather Technical Forecast (Ref: M043)

Issued on Thursday, 04 December 2014 at 00:26 local

This scientific guidance document 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 NOAA Space Weather Scales <http://www.swpc.noaa.gov/NOAAScales/index.html>

## Met Office Space Weather Forecast

Space Weather Forecast (Ref: TBC)

Issued on Thursday, 04 December 2014 at 00:17 UTC

This guidance document 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 NOAA Space Weather Scales <http://www.swpc.noaa.gov/NOAAScales/index.html>

Space Weather Forecast Headline: Low solar activity over the past 24 hours, but there remains a chance for minor or moderate radio blackout periods.

Space Weather Activity over the past 24 hours

Solar activity was low with a number of low common-class flares through the period. There are currently seven sunspot regions on the visible disc, some are complex and one is fairly large (named AR2222) which has been the one mainly responsible for the flares recently. No Earth directed Coronal Mass Ejections (CMEs) have been observed over the past 24 hours. The solar wind has been slightly elevated today, but geomagnetic activity was mostly quiet. Solar radiation levels remained below active levels.

Four Day Space Weather Forecast Summary

Solar activity is likely to remain at low levels over the next few days, with a chance (45%) of the odd moderate flare, especially from the largest sunspot (AR2222). Geomagnetic activity is expected to be mainly quiet with isolated unsettled periods, due to the slightly elevated solar wind. With no CMEs being observed to be heading to Earth, there is currently high confidence in this geomagnetic forecast. Solar radiation is also expected to remain at normal background levels.

Forecaster: Mark Soltzer Tel: 01392 886112 Email: moswoc@metoffice.gov.uk  
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## Met Office Space Weather Technical Forecast

Geomagnetic Storms:

Over the past 24 hours the solar wind has been slightly elevated due to effects from the southern coronal hole, and fairly iratic. However, geomagnetic activity was mostly quiet. The period started with just over 400km/s and rising recently to average around 475km/s, with a brief peak of 536km/s at 03:1832 UTC. Maximum IMF peaked around 11nT between 1600 and 1800 UTC. Bz was mainly positive but some brief dips to -5nT in recent hours. Phi angle has been mostly 360 degrees (towards the Sun).

Over the next four days geomagnetic activity is expected to remain mainly quiet with isolated unsettled periods, mainly due to potential changes in the solar wind due to occasional southern coronal hole activity.

## Met Office Space Weather Forecast

Geomagnetic Storms

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) (%)
Minor or Moderate	G1 to G2	No	10	10	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Radio Blackouts - X Ray 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) (%)
Active	R1-R2 M Class	No	45	45	45	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

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) (%)
Active	S1	No	10	10	10	10
Very Active	S3+	No	1	1	1	1

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

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# 'Expert' forecast

## Met Office Space Weather Technical Forecast

**Space Weather Technical Forecast (Ref: M041)**  
Issued on Sunday, 01 February 2016 at 17:44 local

This scientific guidance document provides a four-day assessment of space weather events. The probabilities listed below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Centre [http://www.metoffice.gov.uk/media/technical/space-weather/Space\\_WC\\_Brief.pdf](http://www.metoffice.gov.uk/media/technical/space-weather/Space_WC_Brief.pdf)

**1200 UPDATE:** No changes to the forecast. The anticipated high speed stream from CH20 is now underway, with a rapid increase to 540km/s at the time of writing. So far it has been mainly positive, often strongly, with an erratic Phi angle indicative of catching the edge of a coronal hole. The Phi appears to be mainly positive (away from the Earth at 180 degrees) during periods of enhanced solar wind. Geomagnetic activity is currently at the unsteady end of quiet (G0) with an increasing chance of unsteady to active periods looking likely today. Flare activity remains low with two C2 flares since midnight, one from AR2268 at 01:04:20 UTC and the other from AR2277 at 01:08:44 UTC. A filament eruption along the east limb just north of the equator occurred on 30:00:00 UTC this morning, most likely resulting in a small non-Earth directed CME (CME evidence directly leading to INTERMAGNET/CHROCHRO imagery at 01:10:00 UTC). A streamlet also came out of AR2275 at 01:08:30 UTC on the west limb, which may also have produced a small non-Earth directed CME.

**Space Weather Forecast Headline: No Significant Activity, Chance of Minor Storm Sunday 01 and Monday 02 February**

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

Solar activity has been low over the last 24 hours, with the largest flare of the period a C1.8 from sunspot region 2268 at 21:38 UTC. There are now six numbered sunspot regions on the earth-facing solar disc, with 2268 and 2277 still large and complex, while 2276 and 2278 have both decayed to spot.

Analysis of available Lasco imagery did not show any Coronal Mass Ejections (CMEs) released through Saturday, meaning that there are not thought to be any CMEs en route at present. Geomagnetic activity has ranged from quiet to active in the past day, with a peak of Kp 4 and Kp for Kp 5.5 peaked at 12:01, with Bz ranging between -8 to +8 mT. The solar wind has been relatively stable, peaking near 450km/s, while Phi changed from largely negative during the morning (towards the sun) to mainly positive (away from the sun), becoming more erratic into the evening.

There were no solar radiation storms on Saturday, with recent elevated >10MeV proton levels gradually declining. In the wake of the major in recent M-class flare activity. Finally, >2MeV electrons at geosynchronous orbit are enhanced at Background flux throughout.

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

Moderate solar activity is likely in the next four days, with a fair 60% chance of M-class flares on all days, and a slight chance (10%) of X-class flares. While there are no CMEs thought to be en route at present, coronal hole 31 will give a chance of minor storm on Sunday 01 and Monday 02 February, with Kp then falling towards moderate as the strength wanes. There is a slightly increasing chance of solar radiation storms in the four-day period: 20% chance on Sunday, rising to 25% or moderate, >10MeV electron flux is expected to rise in response to the anticipated coronal hole.

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## Met Office Space Weather Technical Forecast

Core high speed stream, with the chance of the Active Fluence threshold being surpassed rising from 1% on Sunday 01 February to 30% on Wednesday 04.



Figure 1: Coronal hole 30 - the main driver of space weather in the four-day period.

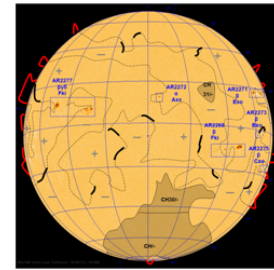


Figure 2: M03WOC Solar Synoptic Map, valid 18 UTC Saturday 31 January.

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## Met Office Space Weather Technical Forecast

### Geomagnetic Storms:

Analysis of available Lasco imagery shows no CMEs emitted through Saturday, meaning that there remains none en route. The dominant element of space weather in the coming four-day period is the predicted onset of the non-southward lobe of the southern polar coronal hole, labelled 'CH20' in the M03WOC Solar Synoptic Map. As stated in the midday update, this feature's latitude gives it a three-day repeat period, which means the chance of minor storm periods passes on Sunday 01 February and Monday 02 (days one and two). As well as CH20, there is a second much smaller coronal hole, CH21, which may become geoeffective in the period, with the same polarity and similar longitude, the only distinguishing feature is likely to be a slower stream. CH20 is thought to be near 500km/s, while CH21 is a newly-emerged, less-defined and presumably weaker feature. The coronal holes' influence is expected to wane towards midweek, leading to lower probabilities of high Kp indices.

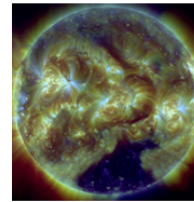


Figure 3: SDO/AIA 171/190/211 Angstrom composite image, showing the dominant dark lobe of the southern polar coronal hole. The non-southward lobe is progressively steering forward as it reaches lower latitudes with their faster rotation than the poles.

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## Met Office Space Weather Technical Forecast

Geo. Magneto Storm Level	Past 24 Hours (Y/N)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)	
Minor or Moderate	01 to 02	N	30	30	10	5
Strong	03	N	10	10	1	1
Severe	04	N	1	1	1	1
Extreme	05	N	1	1	1	1

### Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/Time (UTC)	Helio: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
N/A						

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## Met Office Space Weather Technical Forecast

### Radiation Storms - X-Ray Flares:

Solar activity has been low through Saturday, with the largest flare of the day a C1.8 from sunspot region 2268 at 21:38 UTC. Activity has shown a marked downturn in the past 24 hours, with the six-hour period in M-class flares of recent days replaced by a flat OGB-B15 X-ray trace near the 8.0 boundary today. This is despite 2277 appearing to still retain a C-class spot in its intermediate portion, with this and 2268 still still Zurich Phi groups. While both groups are spreading laterally (2277 is now 23 degrees across), there is some consolidation of active within each group, which may lead to explain part of the lack of activity. M03WOC also gives probabilities for flares remain near 60% for M-class and 20% for X based on the Figulus, however these are felt to be over-estimates, and have been amended downwards to 40 and 10 respectively based on sunspot age and lack of even O-class activity.

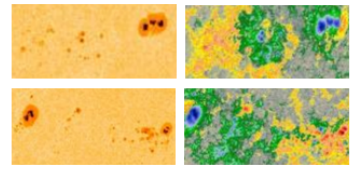


Figure 4: The two Zurich Phi groups on the disc: 2268 (top) and 2277 (bottom). Both retained identifiability (Phi) and HMI colorized magnetogram (right). All images: 22 UTC. The possible Mt Wilson Delta spot is the northeasternmost leading spot in 2277.

X-Ray Flares	Past 24 Hours (Y/N)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)	
Probability (Exceedance)	Level					
Active	R1-R5	N	60	60	60	60

## Met Office Space Weather Technical Forecast

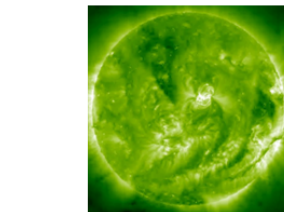


Figure 5: Stereo A EUVI 195 Angstrom image, with a notable bright region near the east limb revealing a large filament in relief. There is also a large equatorial coronal hole to the north of this, which may deliver further raised Kp indices in a week's time.

Using yesterday's status on the earth-facing disc, there are not thought to be any significant returning regions in the period: ex-2259 and ex-2261, which were both Mt Wilson Alpha groups. However, the southeast portion of Stereo A EUVI 195 is the brightest portion of the filament disc, implying that there has been some development in this area in the last tonight. The bright flux is also helping to pick out what appears to be a large filament bisecting this region and a possible coronal hole to its north - all nascent forecast elements that will need to be monitored in the next week or so.

X-Ray Flares	Past 24 Hours (Y/N)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)	
Probability (Exceedance)	Level					
Active	R1-R5	N	60	60	60	60

## Met Office Space Weather Technical Forecast

### Solar Radiation Storms - High Energy Protons:

No solar radiation storms were seen on Saturday, with >10MeV protons showing a slow decline from a peak of 1.6 pfu on Friday evening. The postulated cause of the enhancement was recent flare activity, most likely a trans-equatorial or eastern hemisphere event going to the slow rise and fall. The presence of two Zurich Figulus on the disc means that proton event probabilities are relatively high in the absence of significant flares. The westernmost group is around 40 degrees West, meaning that by day four it will be near West and a prime position to affect earth should it produce a flare. Probabilities therefore rise from 'Slight Chance to Chance through the period.'



Figure 6: OGB B-15 High-energy protons since 28 January. The blue line is >10MeV, showing recent enhancement.

Radiation Storms	Level (pfu/hr/deg <sup>2</sup> )	Past 24 Hours (Y/N)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	> 81	N	20	20	25	25
Very Active	> 83	N	1	1	1	1

\* 83 is 10 MeV at 1000 pfu and/or a 80 MeV at 10 pfu. (pfu = cm<sup>2</sup>s<sup>-1</sup>)

## Met Office Space Weather Technical Forecast

### High Energy Electron Event (>2MeV)

>2MeV electrons at geosynchronous orbit have been at Background flux through Saturday, ceasing at 01:00. After having reached moderate flux on Thursday 28 January, an active period that evening retroflected electrons in the earth's van Allen belts, and they have since failed to recover. With the solar wind speed peaking near 450km/s on Saturday, Active Fluence is a Slight Chance until the high speed stream from coronal hole 31 is well established, giving a rising risk through the period.

Radiation Storms	Level (cm <sup>-2</sup> /hr/deg <sup>2</sup> )	Past 24 Hours (Y/N)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	> 2 MeV	N	1	10	20	30
Very Active	> 2 MeV	N	1	1	5	10

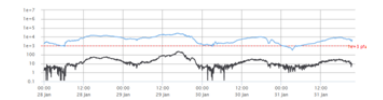


Figure 7: >2MeV high energy electrons since 23 January. Moderate flux has failed to be repeated since the raised geomagnetic activity late on 28 January.



# Sector Specific Nowcast/Forecast webpages

Sector forecasts
Met Office Space Weather
My account Log out

## Space Weather Energy

### FORECASTER OVERVIEW

**Moderate Radio Blackout**  
M-class flare likely over the ACE at 2130 UTC possible

Solar activity is expected to remain moderate over the coming days the large sunspot groups AR2055 and AR2056 rotate around the disc and become more geo-effective. Geomagnetic activity is expected to stay start ACTIVE but then become generally QUIET. There are a couple equatorial small coronal holes visible on the disc but their impact is thought to be minimal. With AR2051 now rotated completely out of view a proton event seems unlikely now and electrons should stay a background values.

Issued 8 May 2014 at 12:00

### WARNINGS AND ALERTS

	Active alerts	Warnings
Geomagnetic	-	-
Radio blackout	-	<b>R1</b> 21:00 20:05 03:00 21:05
Proton flux > 100 MeV	<b>S1</b> 11:23-now	-
Proton flux > 10 MeV	-	-
Kp	-	-
Kuk	-	-
Electrons	-	-

### GEOMAGNETIC STORM FORECAST

Probabilities of geomagnetic storms

Probability	Level	Past 24 h.	Day 1	Day 2	Day 3	Day 4
Minor or moderate	G1 to G2	No	65	05	05	05
Strong	G3	No	45	01	01	01
Severe	G4	No	01	01	01	01
Extreme	G5	No	01	01	01	01
		%	%	%	%	%

Geomagnetic commentary

The largest flare over the last 24 hours was M1.2 flare at 16:29 UTC from AR2051 which has revolved around the western limb. With one beta-gamma spot (AR2055) and one beta-gamma-delta spot (AR2056) there is still a risk of further M-class flare activity over the next few days.

Issued 8 May 2014 at 12:00

### ENLIL

No Earth directed CMEs have been observed. Maximum solar wind speed is 500 km/s

Issued 8 May 2014 at 12:00

### ACE MAGNETOMETER

### BGS 3-HOURLY KP INDEX

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# Operational Standards



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# Met Office operational standards

- 24/7/365 staffing of forecasting office.
- 99+% reliability of observing, processing & dissemination systems.
- Key web products  $\geq 99.5\%$  others  $\geq 97.5\%$ .
- All data and models mirrored across 2 computer halls (run models and systems in-house).
- Redundant power, cooling & networking at all facilities.
- Contingency plans for outages of all forecast-critical system elements: e.g., alternate processing sites, backup instruments for observations and backup computers for model runs, etc...



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# MOSWOC: Resilience

Run all models & systems in-house

- All data & models mirrored across 2 computer halls
- BC laptop, relocate within building or outside

Use data, products etc from SWPC, BGS

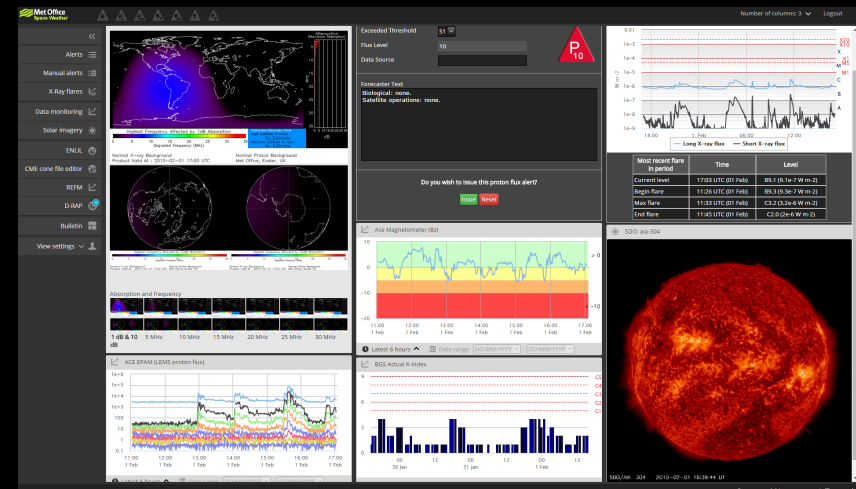
- Arrive via robust data transfer

Forecaster suite developed in-house

- Visualise models, monitor observations, issue alerts & warnings

Requirements

- Tried & tested models
- Models run on Met Office resilient infrastructure





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# CCMC – MO Partnership Opportunities

*Everything we do is based on world-leading science and enhanced by the close working relationships we have with partner organisations around the globe.*



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# Foundations of Operational Forecasting

*SWx at the Met Office*





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R20

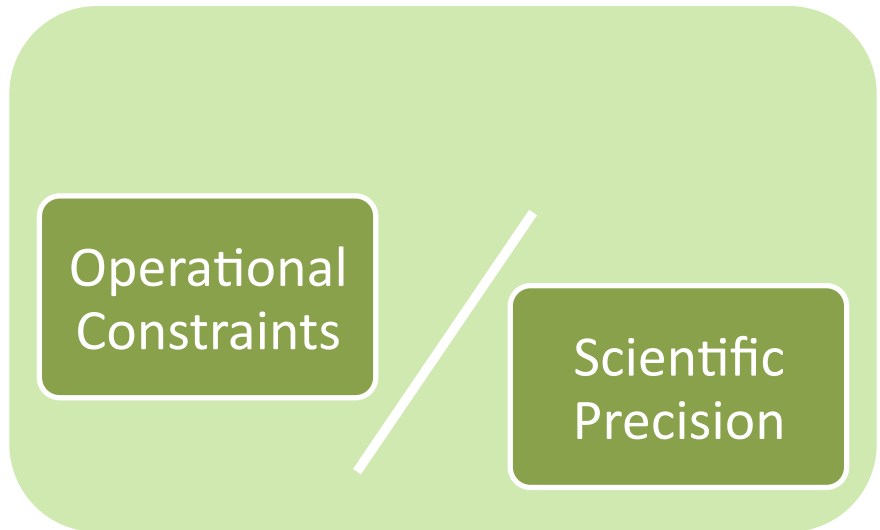
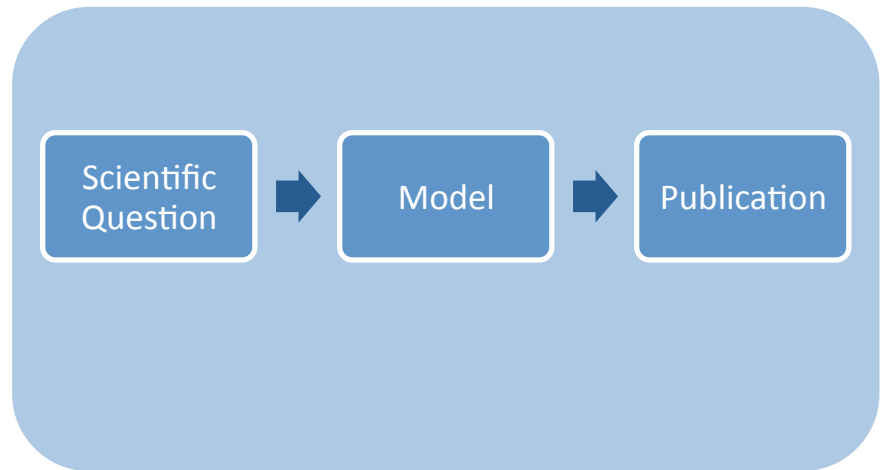
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# Operational Requirements

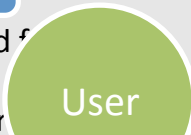




# User & System Requirements

## User Requirements

- **Timeliness:** Data assimilated (NRT) and forecast produced in a timely manner.
- **Data Model:** Models should be data driven



## System Requirements

- **Robustness:** models should run successively for a range of space weather conditions and handle errors appropriately and informatively, allowing operational service and IT support teams to understand and resolve problems.
- **Forecast Cycle:** The model should run fast enough to be used within a forecasting cycle excluding data latencies (varies by domain and conditions).
- **Quality Assurance:** High standard of code structure, documentation, error handling and version control allowing systematic model management i.e. perform acceptance tests, reviewing procedure for code changes and allow operational service and IT support teams to resolve problems.
- **Environment:** Deployed using appropriate operating system of operational centre (at Met Office this is Linux operating system).
- **Language:** Portable and model written in



Could these be adapted to go from general NASA ARL to define an agreed space weather Operational Readiness Level?

scores defined to inform forecaster interpretation. Skill scores available to benchmark impact of replacing standalone model with coupled model, or to benchmark model upgrades.

- **Ensembles:** Ensemble operation possible (unless deterministic models are shown to perform better).
- **Autonomy:** Models should have the potential to run automatically, without human intervention, producing output for forecaster assessment.

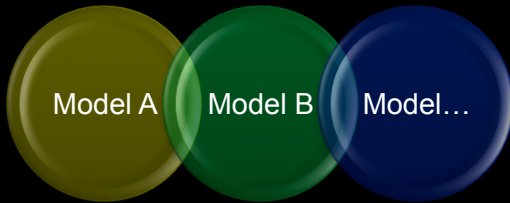
should be parallelised to ensure HPC operation (supported OpenMP and MPI protocols).

- **Resilience:** Fall back option of using a simpler configuration, other initialisation, repeat forecast, or alternative input data source to maintain continuous forecasting capability (e.g. solar or geomagnetic drivers as input) in case of technical issues (e.g. data availability).
- **Dependencies:** Models should not have dependencies on non-standard libraries not under the operational centre control (e.g. SolarSoft).
- **Coupling:** Model should be suitable for coupling to other appropriate models with compatible boundary conditions and input/output parameters.



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# Where does CCMC fit?



## Operational Readiness Level



Is this the role CCMC could / should take on?



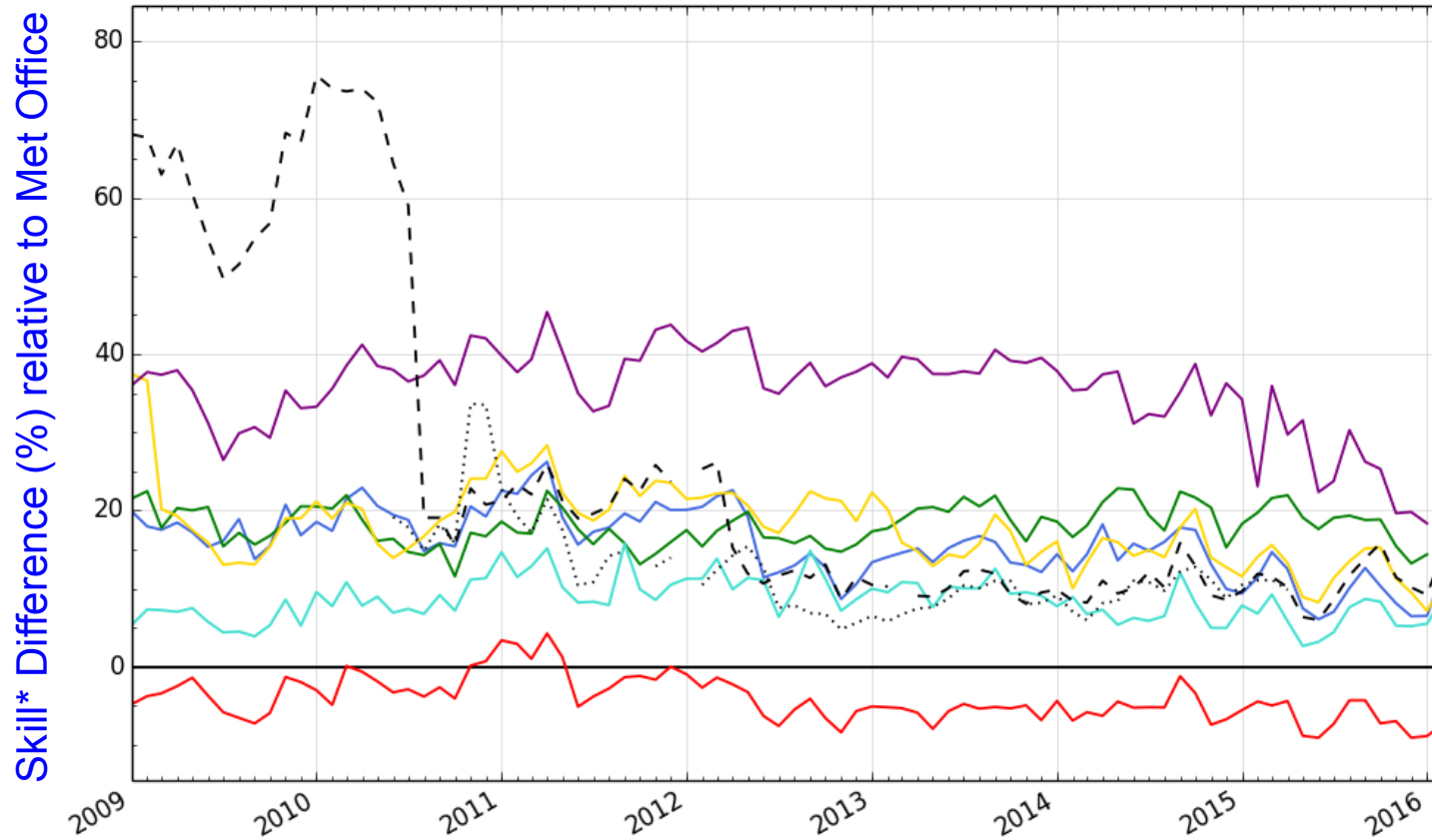
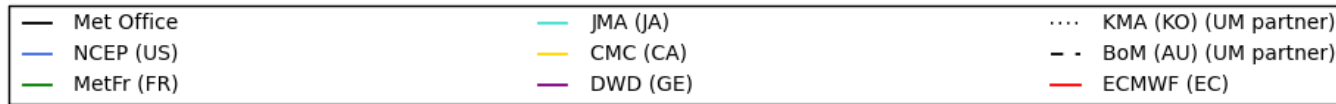
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# Model Verification



# Terrestrial NWP Model Science Indicator

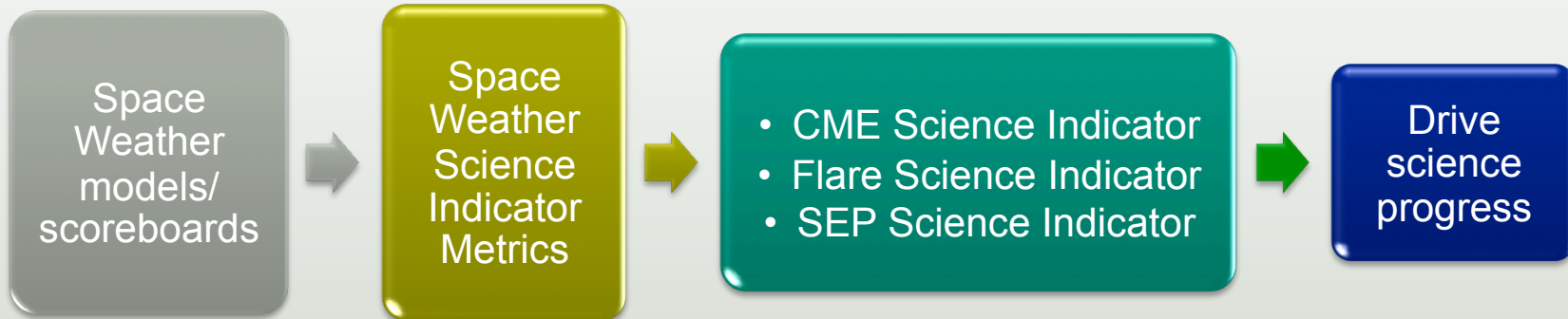
Global ranking of Met Office Global Model forecast accuracy based on the WMO weighted global index components used by the WMO/CBS



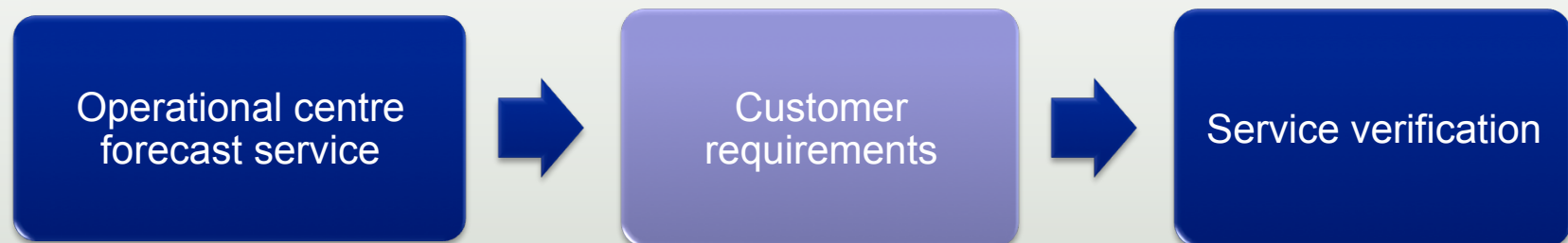
\* Parameters: Surface pressure, 500hPa geopotential height, 250hPa/850hPa Winds;  
Forecast ranges from T+24h to T+120h

# Space Weather Model Verification

**Space Weather needs equivalent internationally agreed science metrics**



**Forecast service verification is responsibility of Op centre**





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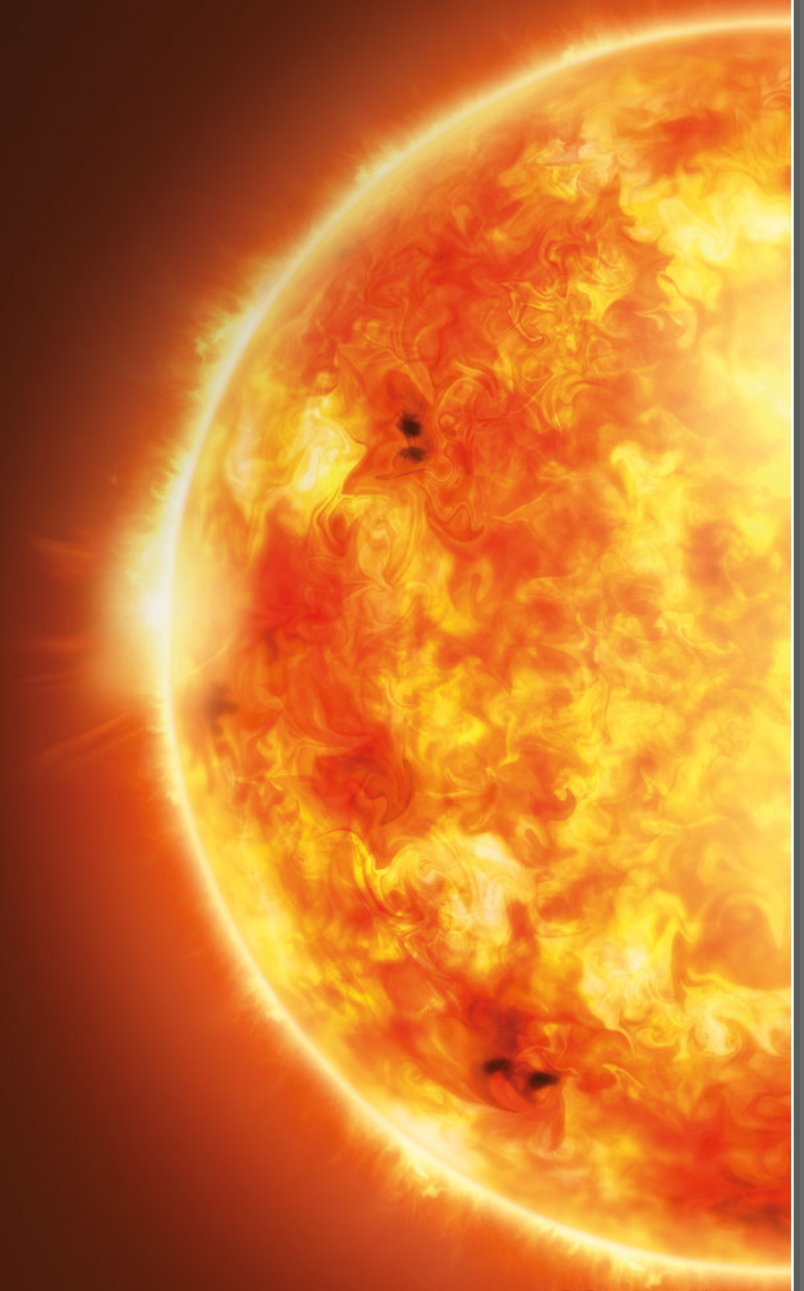
# Met Office View of CCMC

- Independent judge
- Science basis of models
- Science indicator model rank
- Targeted studies directed by Ops Centers
- Verify models & techniques
  - Not services – responsibility of Ops Centres



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Thank You







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# Extra slides



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# Research activities

## Research to operations (R2O) role

- Relevant research for improvements
- Implementing models
- Verification

## Collaborations are crucial

- Academic community best-placed to do fundamental research
- Work closely with other government research agencies and universities in UK and worldwide..

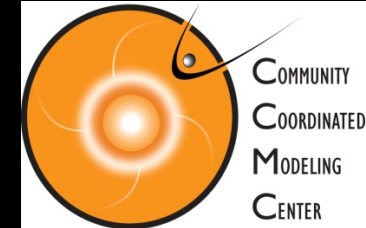


# UK Impacts

Category		UK Effect	US and Global Effect	Physical measure	Average Frequency (1 cycle = 11 years)
Scale	Descriptor	Duration of event will influence severity of effects		Kp values*	Number of storm events when Kp level was met; (number of storm days)
<b>Geomagnetic storms</b>					
<b>Geomagnetic storms</b>					
G 5	Extreme	<b>Power systems:</b> Localised voltage control and protective system problems may occur leading to potential for localised loss of power. Transformers may experience damage.	<b>Power systems:</b> widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage.		
		<b>Spacecraft operations:</b> may experience extensive surface charging, drag may increase on low-Earth-orbit satellites, problems with orientation, uplink/downlink and tracking satellites.	<b>Spacecraft operations:</b> may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites.		
		<b>Other systems:</b> HF (high frequency) radio communication may be impossible in many areas for one to two days, GNSS(GPS) satellite navigation may be degraded for days with possible effects on infrastructure reliant on GNSS (GPS) for positioning or timing, low-frequency radio navigation can be out for hours, and aurora may be seen across the whole of the UK.	<b>Other systems:</b> pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.)**.		
G 4	Severe	<b>Power systems:</b> No significant impact on UK power grid likely.	<b>Power systems:</b> possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.		
		<b>Spacecraft operations:</b> may experience surface charging and tracking problems, drag may increase on low-Earth-orbit satellites, corrections may be needed for orientation problems.	<b>Spacecraft operations:</b> may experience surface charging and tracking problems, corrections may be needed for orientation problems.		
		<b>Other systems:</b> HF radio propagation sporadic, GNSS(GPS) satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora may be seen across the whole of the UK.	<b>Other systems:</b> induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.)**.		
		<b>Spacecraft operations:</b> Corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions.	<b>Spacecraft operations:</b> corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions.		(300 days per cycle)
		<b>Other systems:</b> HF radio propagation can fade at higher latitudes, and aurora may be seen across Scotland.	<b>Other systems:</b> HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.)**.		
G 1	Minor	<b>Power systems:</b> No impact on UK power grid.	<b>Power systems:</b> weak power grid fluctuations can occur.	Kp = 5	1700 per cycle
		<b>Spacecraft operations:</b> Minor impact on satellite operations possible.	<b>Spacecraft operations:</b> minor impact on satellite operations possible.		(900 days per cycle)
		<b>Other systems:</b> Aurora may be seen as low as Northern Scotland.	<b>Other systems:</b> migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine)**.		

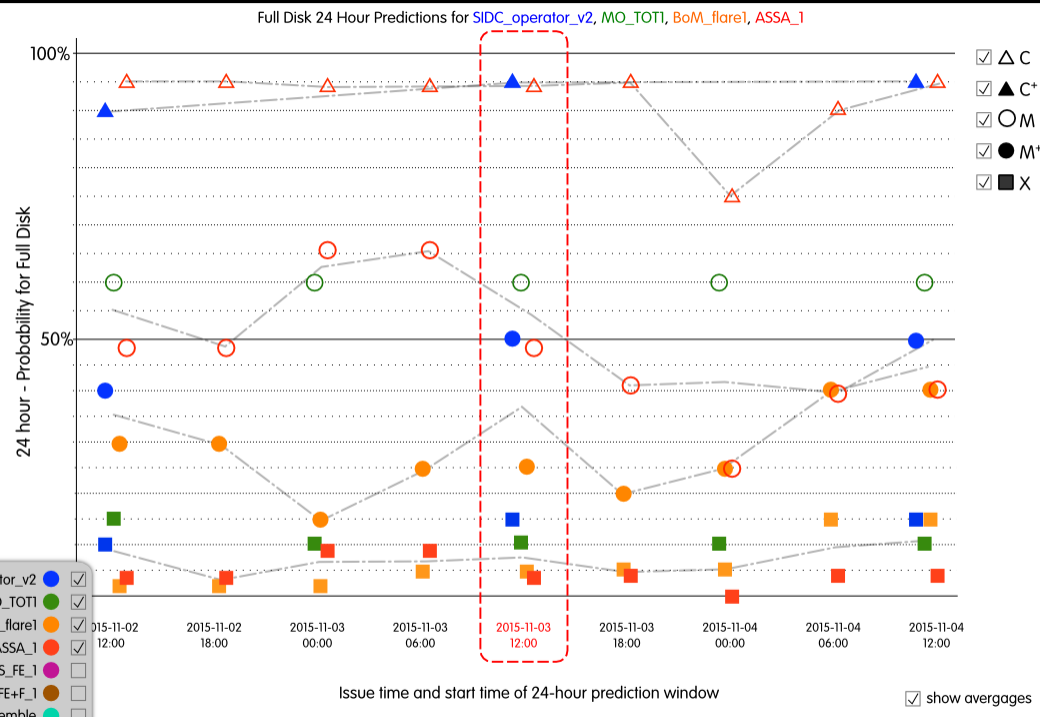
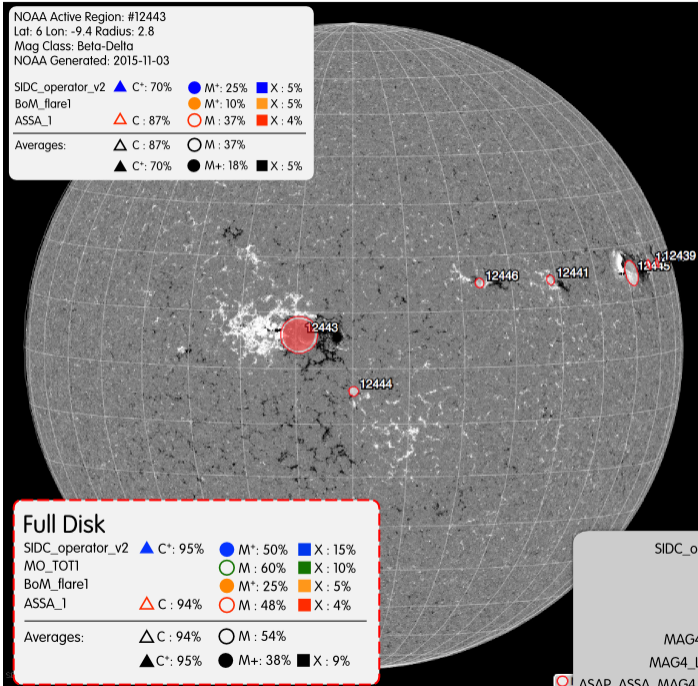


# Verification Flare Scoreboard



## Solar Flare Scoreboard

Snapshot for prediction window: 2015-11-03 12:00 - 2015-11-14 12:00 from issue time: 2015-11-03 12:00



issue time: 2015-11-03 12:00 prediction window: 2015-11-03 12:00 + 24 hours models settings Download Data



# CME forecasting

## Arrival time prediction

Technical guidance

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
12/1920Z	Partial	Filament eruption	20S35W	600	16/0200	nil

### NASA Community Coordinated Modeling Center CME Scoreboard

**CME: 2015-06-25T08:36:00-CME-001**  
 Actual Shock Arrival Time: 2015-06-27T03:30Z  
 Observed Geomagnetic Storm Parameters:  
 Max Kp: 3.0  
 CME Note: From AR12371. Associated with M7.9 flare.

Predicted Shock Arrival Time	Difference (hrs)	Confidence (%)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By
2015-06-26T16:00Z (-12.0h, +12.0h)	-11.50	----	2015-06-25T10:51Z	40.65	Max Kp Range: -- - 8.0	<a href="#">Other (SIDC)</a>	Leila Mays (GSFC) <a href="#">Detail</a>
2015-06-27T10:00Z (-7.0h, +7.0h)	6.50	----	2015-06-25T13:21Z	38.15	----	<a href="#">DBM</a>	Manuela Temmer (UNIGRAZ) <a href="#">Detail</a>
2015-06-27T05:00Z	1.50	----	2015-06-25T15:30Z	36.00	----	<a href="#">WSA-ENLIL + Cone (Met Office)</a>	Met Office (Met Office) <a href="#">Detail</a>
2015-06-28T02:00Z (-7.0h, +7.0h)	22.50	----	2015-06-25T16:45Z	34.75	Max Kp Range: 3.0 - 4.0	<a href="#">WSA-ENLIL + Cone (GSFC SWRC)</a>	Yaireska Collado (GSFC) <a href="#">Detail</a>
2015-06-27T15:18Z (-12.2h, +9.3h)	11.80	58.0	2015-06-25T21:33Z	29.95	Max Kp Range: 3.0 - 5.0	<a href="#">Ensemble WSA-ENLIL + Cone (GSFC SWRC)</a>	Karin Muglach (GSFC) <a href="#">Detail</a>
2015-06-27T15:00Z	11.50	----	2015-06-26T17:26Z	10.07	Max Kp Range: -- - 6.0	<a href="#">WSA-ENLIL + Cone (NOAA/SWPC)</a>	Leila Mays (GSFC) <a href="#">Detail</a>
2015-06-27T11:28Z	7.97	58.0	---	---	Max Kp Range: 3.0 - 5.75	Average of all Methods	Auto Generated (CCMC) <a href="#">Detail</a>
2015-06-27T17:00Z	13.50	----	2015-06-27T01:10Z	2.33	----	<a href="#">WSA-ENLIL + Cone (KSWC)</a>	RWC Jeju (KSWC) <a href="#">Detail</a>

