



# Space Weather - UK Activity

Peter Thorn,

European Relationships

Met Office



# Background



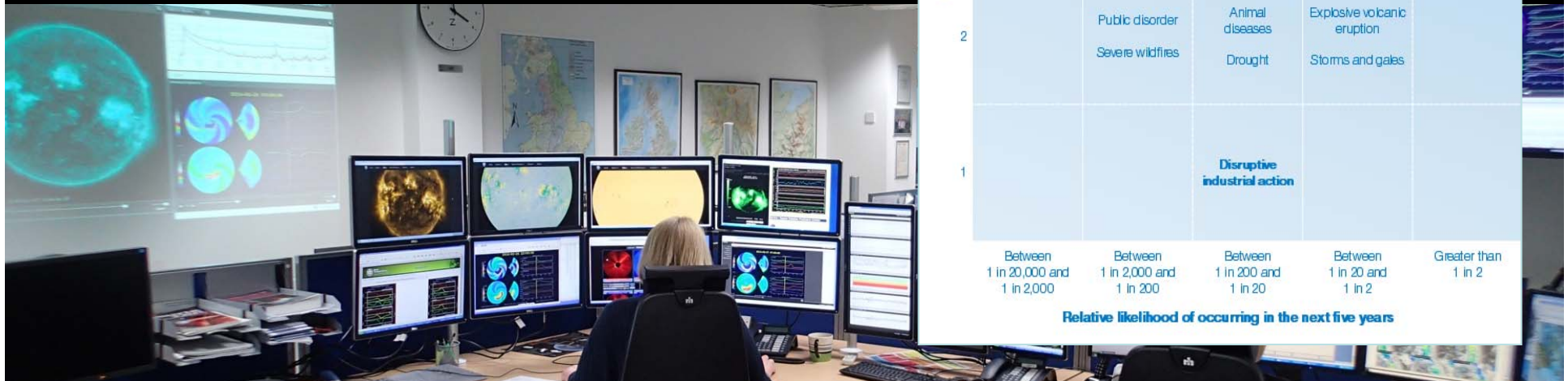
Cabinet Office

## National Risk Register of Civil Emergencies

2015 edition

Overall relative impact score	Between 1 in 20,000 and 1 in 2,000	Between 1 in 2,000 and 1 in 200	Between 1 in 200 and 1 in 20	Between 1 in 20 and 1 in 2	Greater than 1 in 2
5				Pandemic influenza	
4			Coastal flooding Widespread electricity failure		
3	Major transport accidents Major industrial accidents	Effusive volcanic eruption Emerging infectious diseases Inland flooding	Severe space weather Low temperatures and heavy snow Heatwaves Poor air quality events		
2	Public disorder Severe wildfires	Animal diseases Drought	Explosive volcanic eruption Storms and gales		
1		Disruptive industrial action			

Relative likelihood of occurring in the next five years





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## Space Weather

Space Weather describes disturbances in the Earth's upper atmosphere and magnetic field which have a variety of impacts on mankind and our technology. For more details on the space weather scales used in these forecasts see the [UK scales](#).

Note: This page does not automatically update, so if you have been viewing it for some time, please refresh to see the latest information.

### Forecaster Overview

**HEADLINE:** No significant activity observed. Still a chance of M-class flares.

**ANALYSIS OF SPACE WEATHER OVER PAST 24 HOURS:**

**Solar Activity:** Solar activity has been at low levels with occasional C-class X-ray flares, the largest being a C4 at 01:00:00 UTC. There are currently 9 numbered sunspot regions on the visible disk. Regions 2172, 2173 and 2175 have been among the most complex over recent days and are now nearing the west limb and have been allowing signs of decay. Of the remaining regions 2177 and 2178 are the most complex, both having beta-gamma magnetic classifications, with 2178 showing signs of growth within its intermediate spots. A coronal mass ejection (CME) was observed in solar coronagraph imagery at around 01:00:00 UTC. This CME appears to have come from just around the east limb and is not expected to have an earthbound component.

**Solar Wind / Geomagnetic Activity:** The solar wind was an ambient level with its speed measured at between 330 and 400 km/s by the ACE spacecraft. The total interplanetary magnetic field was steady at around 5 or 6 nT. The Bz component was occasionally negative/southward reaching -3 nT at 01:00. Phi data indicated a mainly positive (away from the sun) solar sector. Geomagnetic activity was mainly at quiet to unsettled levels but an active interval (Kp 4) was observed between 00:00 UTC due to a period of southward Bz in the solar wind.

**Energetic Particles:** High energy protons at geosynchronous orbit remained at background levels. The flux of high energy electrons was at normal to high levels with the flux measured by GOES-13 peaking at 1000 pfu at 01:17:00 UTC.

Issued on 2nd October 2014 00:10 UTC

### Notifications

There are currently no active notifications.

### Solar Imagery

SDO AIA-193 SDO AIA-304

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## Space Weather

'Space weather' describes changing environmental conditions in near-Earth space.

Magnetic fields, radiation, particles and matter which have been ejected from the Sun can interact with the Earth's upper atmosphere and surrounding magnetic field to produce a variety of effects. Major impacts include possible interruptions to radio communications and GPS, disruption of power grids and damage to spacecraft.

The new Met Office Space Weather Operations Centre will provide the critical information to help build the resilience of UK infrastructure and impacted industries in the face of space weather events, thereby supporting continued economic growth.

### Downloads

- [The Met Office and Space Weather](#)  
The Met Office and Space Weather
- [What is space weather](#)  
All you need to know about space weather and its impacts
- [Space Weather frequently asked questions](#)  
Got a question about Space Weather, take a look here first
- [Space Weather Impacts](#)  
Low level space weather events occur on a regular basis and whilst they can be of concern for specific industries, in the majority of instances they have little impact on our daily lives.
- [Measuring the Impact](#)  
Different aspects of space weather have a variety of impacts on mankind and our technology.

Last updated: 6 May 2014

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### Downloads

- [Space Weather \(PDF, 201 kB\)](#)  
Find out more about how we forecast space weather
- [Aviation Services \(PDF, 1 MB\)](#)  
aviation services

### Related pages

- [Met Office leading space weather forecasting capability](#)  
The Met Office welcomes the Royal Academy of Engineering report on Space Weather, the UK's first in-depth study of the impacts of space weather.
- [Met Office to see further space weather collaboration](#)  
The US National Oceanic and Atmospheric Administration (NOAA) and the United Kingdom Government Office for Science agree to strengthen collaboration on space weather.
- [Aviation services](#)  
A range of forecasting services designed to help reduce the impact of the weather on aviation operations.
- [Energy](#)  
Transmission and supply forecast services for the energy sector.
- [Space Weather](#)  
Developing a space weather forecasting system at the Met Office.

**Moderate Radio Blackout**  
M-class flare likely over 1  
ACE at 2130 UTC possibl

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.

SOLAR TIMELAPSE



SDO/AIA 193 2014-05-20 07:00

Space Weather Energy

FORECASTER OVERVIEW

**Moderate Radio Blackout observed this morning. Further M-class flare likely over the next few days. Sudden impulse at ACE at 2130 UTC possible CME from 3rd May.**

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	-	R1 21:00 20/05 03:00 21/05
Proton flux > 100 MeV	S1 11:23-now	-
Proton flux > 10 MeV	-	-
Kp	-	-
Kuk	-	-
Electrons	-	-

GEOMAGNETIC STORM FORECAST

Probabilities of geomagnetic storms

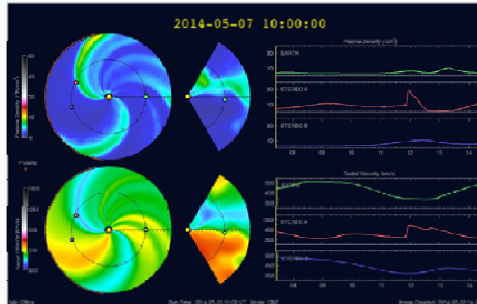
Probability	Level	Past 24 h.	Day 1	Day 2	Day 3	Day 4
Minor or moderate	G1 to G2	No	65	05	05	05
Strong	G3	No	45	01	01	01
Severe	G4	No	01	01	01	01
Extreme	G5	No	01	01	01	01
			96	96	96	96

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

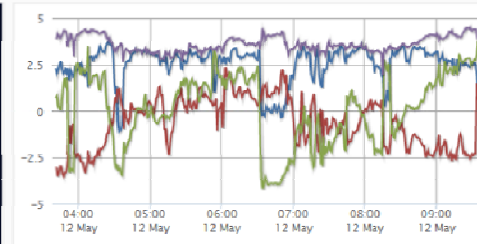
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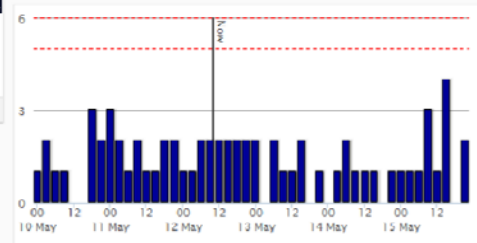
No Earth directed CMEs have been observed. Maximum solar wind speed is 500 km/s

Issued 8 May 2014 at 12:00

ACE MAGNETOMETER



BGS 3-HOURLY KP INDEX







# Impact scales

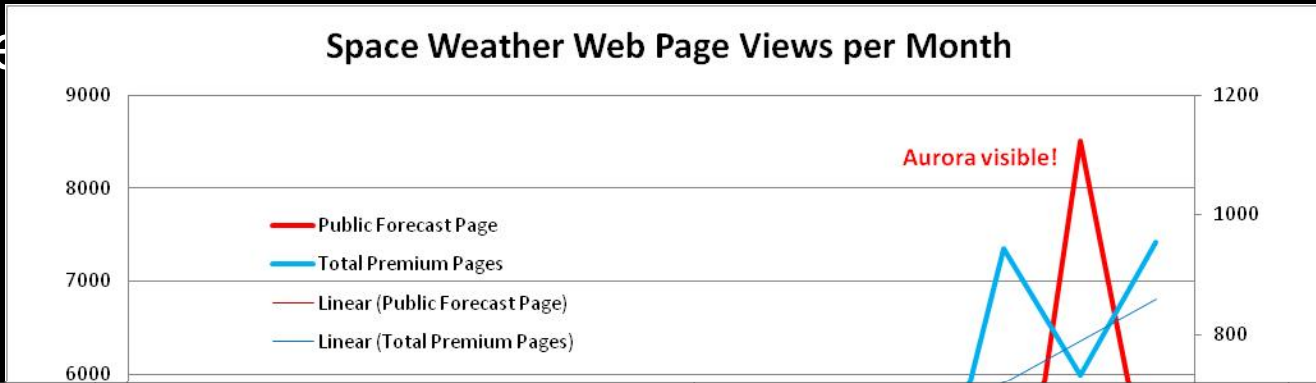
Category		Effect	Physical measure	Average Frequency (1 cycle = 11 years)
Category		UK Effect	US and Global Effect	
Scale	Descriptor	Duration of event will influence severity of effects		
<b>Geomagnetic Storms</b>				
<b>G5</b>	<b>Extreme</b>	<p><b>Power systems:</b> Localised voltage control and protective system problems may occur leading to potential for localised loss of power. Transformers may experience damage.</p> <p><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.</p> <p><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.</p>	<p><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.</p> <p><b>Spacecraft operations:</b> may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites.</p> <p><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.)**.</p>	
<b>G4</b>	<b>Severe</b>	<p><b>Power systems:</b> No significant impact on UK power grid likely.</p> <p><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.</p> <p><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.</p>	<p><b>Power systems:</b> possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.</p> <p><b>Spacecraft operations:</b> may experience surface charging and tracking problems, corrections may be needed for orientation problems.</p> <p><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.)**.</p>	
		<p><b>Spacecraft operations:</b> minor impact on satellite operations possible.</p> <p><b>Other systems:</b> migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine)**.</p>		



# User Communication

*Need to ensure forecasts are relevant to users*

- Re



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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>					
G 5	Extreme	<p><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.</p> <p><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.</p> <p><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.</p>	<p><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.</p> <p><b>Spacecraft operations:</b> may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites.</p> <p><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)**.</p>	Kp = 9	4 per cycle  (4 days per cycle)
G 4	Severe	<p><b>Power systems:</b> No significant impact on UK power grid likely.</p> <p><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.</p> <p><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.</p>	<p><b>Power systems:</b> possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.</p> <p><b>Spacecraft operations:</b> may experience surface charging and tracking problems, corrections may be needed for orientation problems.</p> <p><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)**.</p>	Kp = 8, including a 9-	100 per cycle  (60 days per cycle)



# Planning & Preparation for Space weather Events

- Vital to develop procedures to respond to space weather events
  - *Ensure everyone knows who is doing what!*
- Multiple exercises held to simulate space weather events and stress test response by all stakeholders
  - Scientific Advisory Group for Emergencies (SAGE)
    - Chaired by Government Chief Scientific Advisor, Sir Mark Walport
  - International rail workshop, London Sept 2015
  - National Grid; UK power transmission network operator
  - Satellite operators







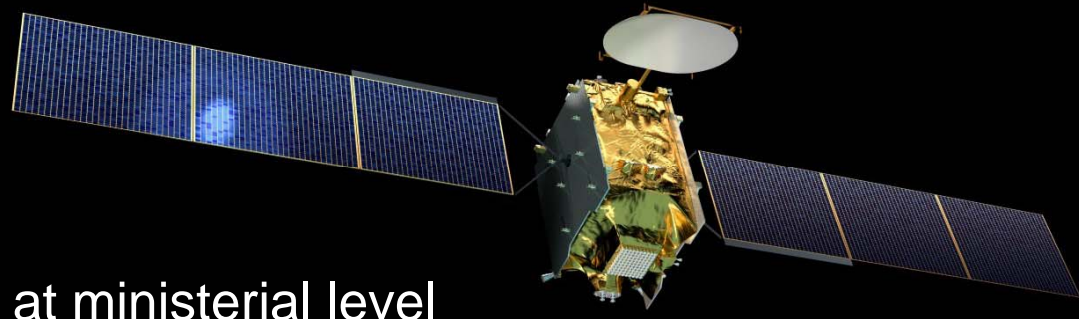
# UK Government Developments

- UK National Risk Register Review
  - Bi-annual review of national risk register underway
  - No change in severity or likelihood of space weather event anticipated
- Socio-economic Analyses
  - Multiple socio-economic exercises being undertaken:
    - International Partnership Space Programme (IPSP) led by Met Office
    - ESA tender issued Dec '15
    - UK University
    - USA - National Space Weather Action Plan
  - End of 2016, several analyses available; different scopes and approaches
- Strategic Defence and Security Review (SDSR)
  - High level policy document – review carried out every five years
  - First time that space weather included as threat to UK defence and security





# UK Government Developments



- L5 Mission

- Government support at ministerial level
- Needs socio-economic justification to progress further
- IPSP analysis includes business case for L5 mission
- Inclusion of space weather in SDSR provides further support

- Met Office Services Stakeholders Group

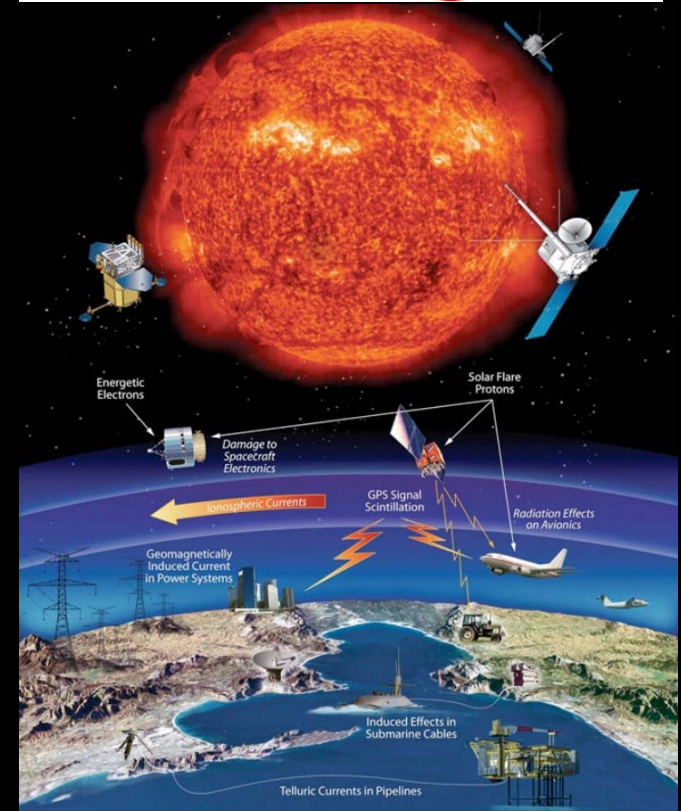
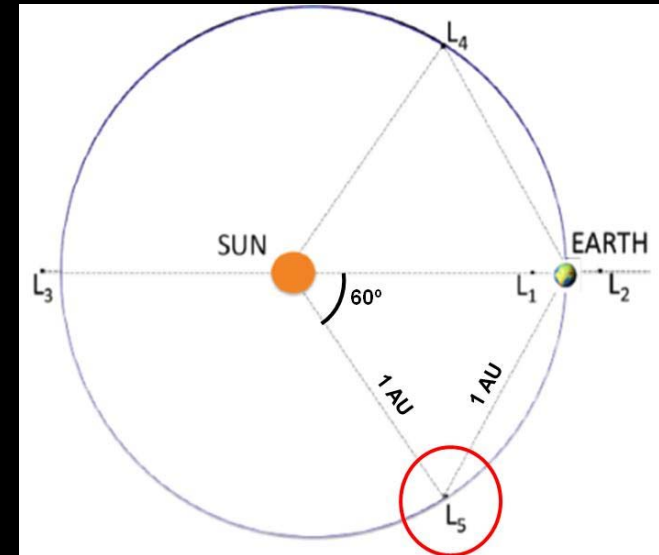
- Annual survey in progress
- Gathers feedback on Met Office services to all parts of UK government





# Themes

- Growing awareness
- Consistent messaging
- Event response planning
- Socio-economic underpinning
- Developing forecast capability





Thank you.

Any questions?

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# Services

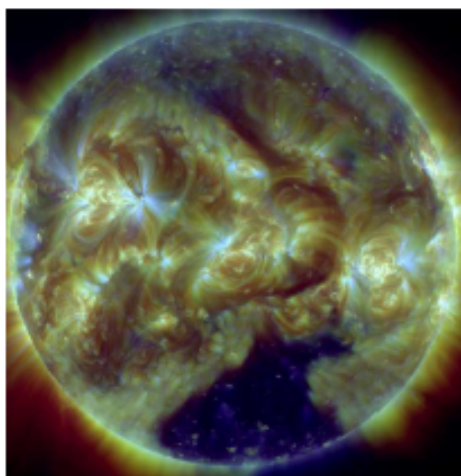


Figure 3: SDO/AIA 171/193/211 Angstrom composite image, showing the dominant dark blue of the southern polar coronal hole. The northernmost lobe is increasingly shearing forward as it reaches lower latitudes with their faster rotation than the poles.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1	Day 2	Day 3	Day 4
			(00-24 UTC)	(00-24 UTC)	(00-24 UTC)	(00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	N	30	30	10	5
Strong	G3	N	10	10	1	1
Severe	G4	N	1	1	1	1
Extreme	G5	N	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21.5R (UTC)						
Nil						

Radio Blackouts - 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 21:35 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 GOES-15 X-ray trace near the B/C boundary today. This is despite 2277 appearing to still retain a Delta spot in its intermediate portion, with this and 2268 still Zurich Fki groups. While both groups are spreading laterally (2277 is now 23 degrees across), there is some consolidation of spots within each group, which may help to explain part of the lack of activity. MOSWOC raw global probabilities for flares remain near 80% for M-class and 20% for X based on the F-groups, however these are felt to be over-estimates, and have been amended downwards to 60 and 10 respectively based on sunspot age and lack of even C-class activity.

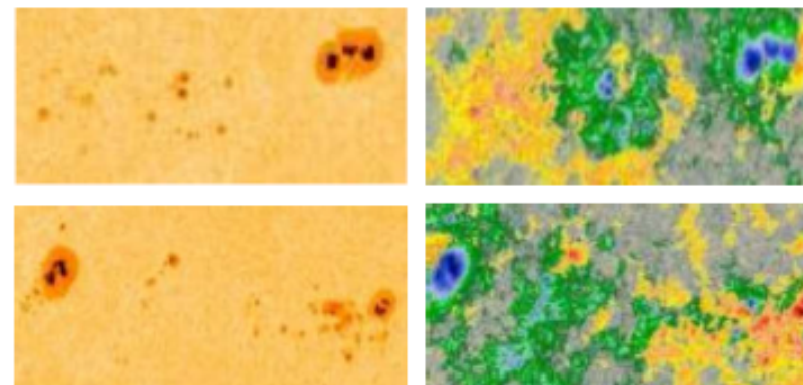


Figure 4: The two Zurich Fki groups on the disc: 2268 (top) and 2277 (bottom). HMI flattened intensitygram (left) and HMI colorized magnetogram (right). All images 22 UTC. The possible Mt Wilson Delta spot is the northeastmost-leading spot in 2277.