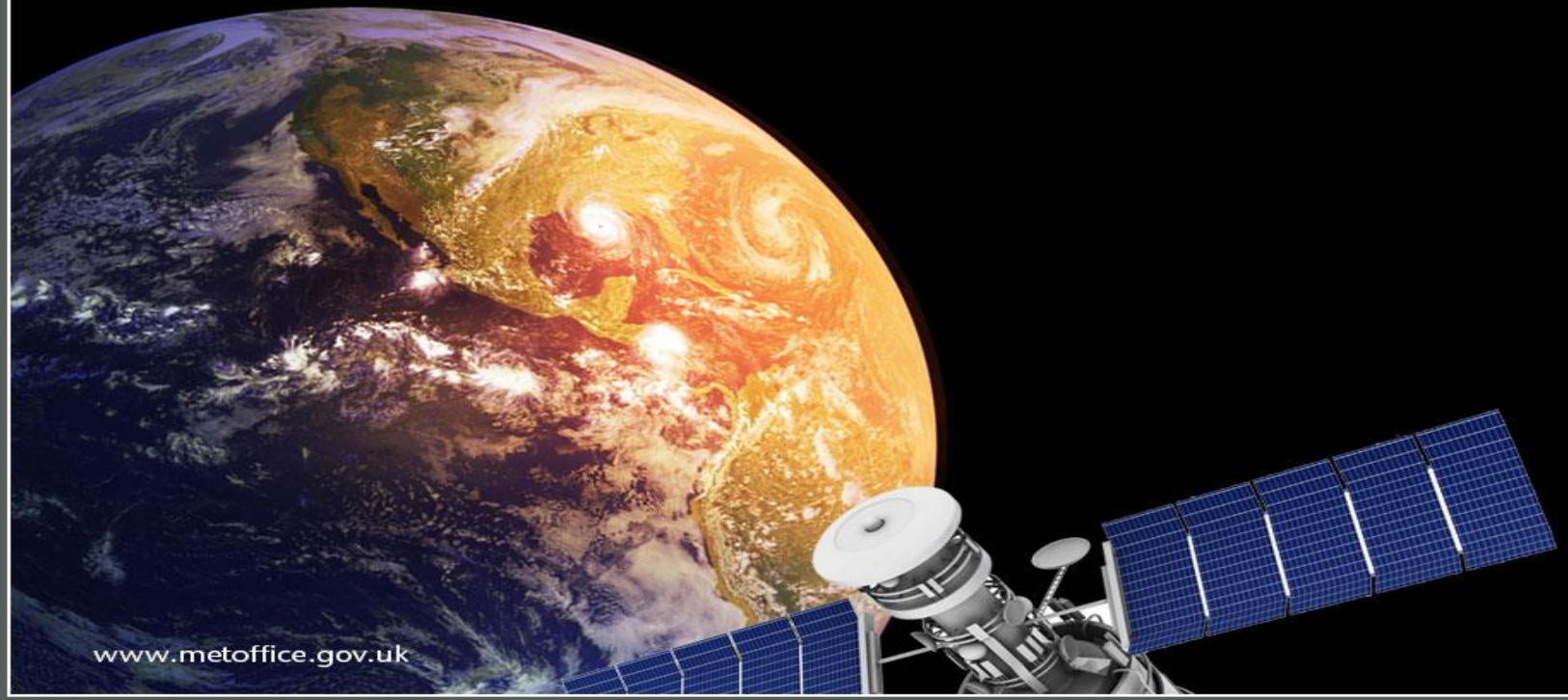
The UK Met Office Space Weather Operations Centre (MOSWOC)

Gareth Powell, UK Met Office, 8th January 2019



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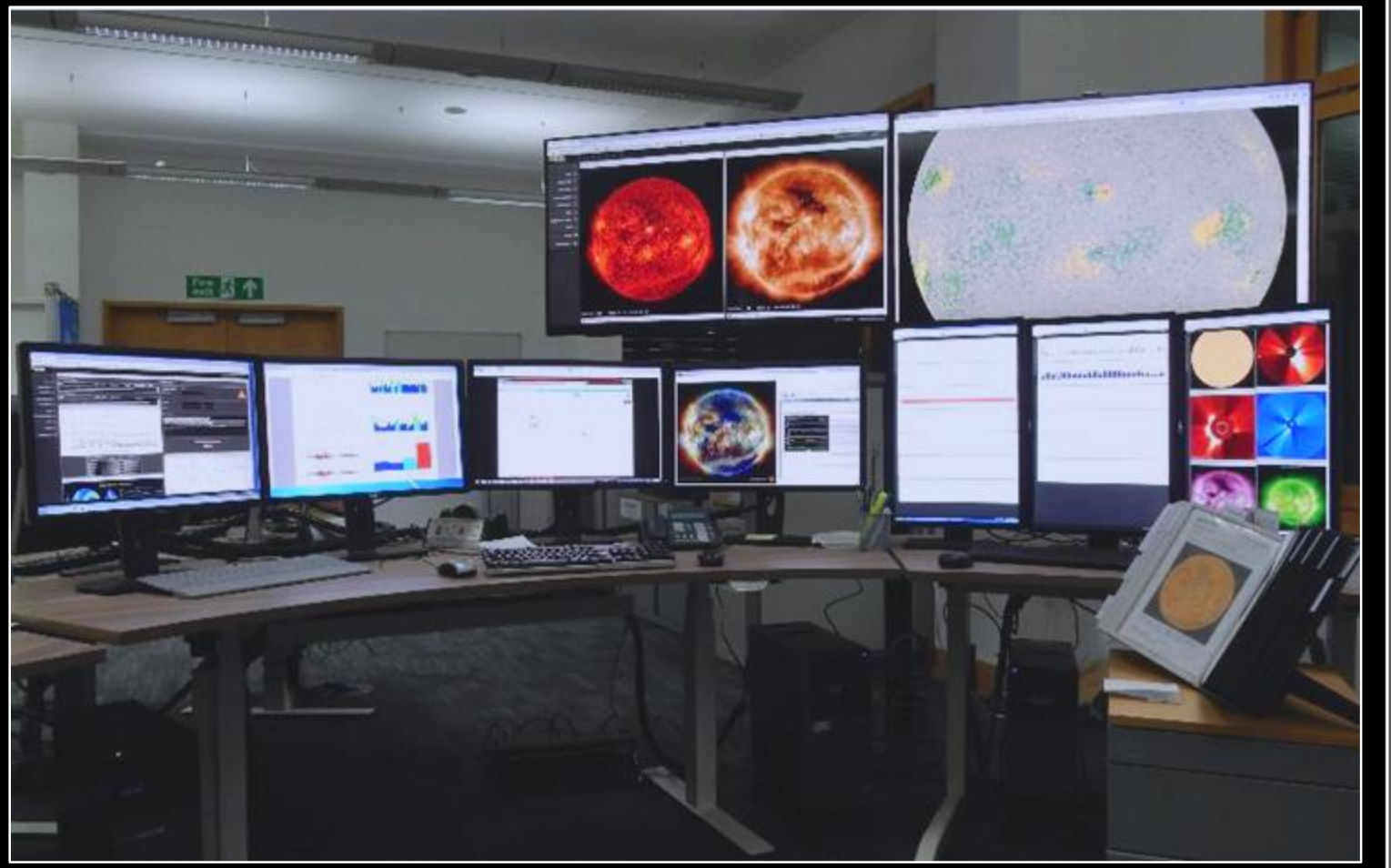
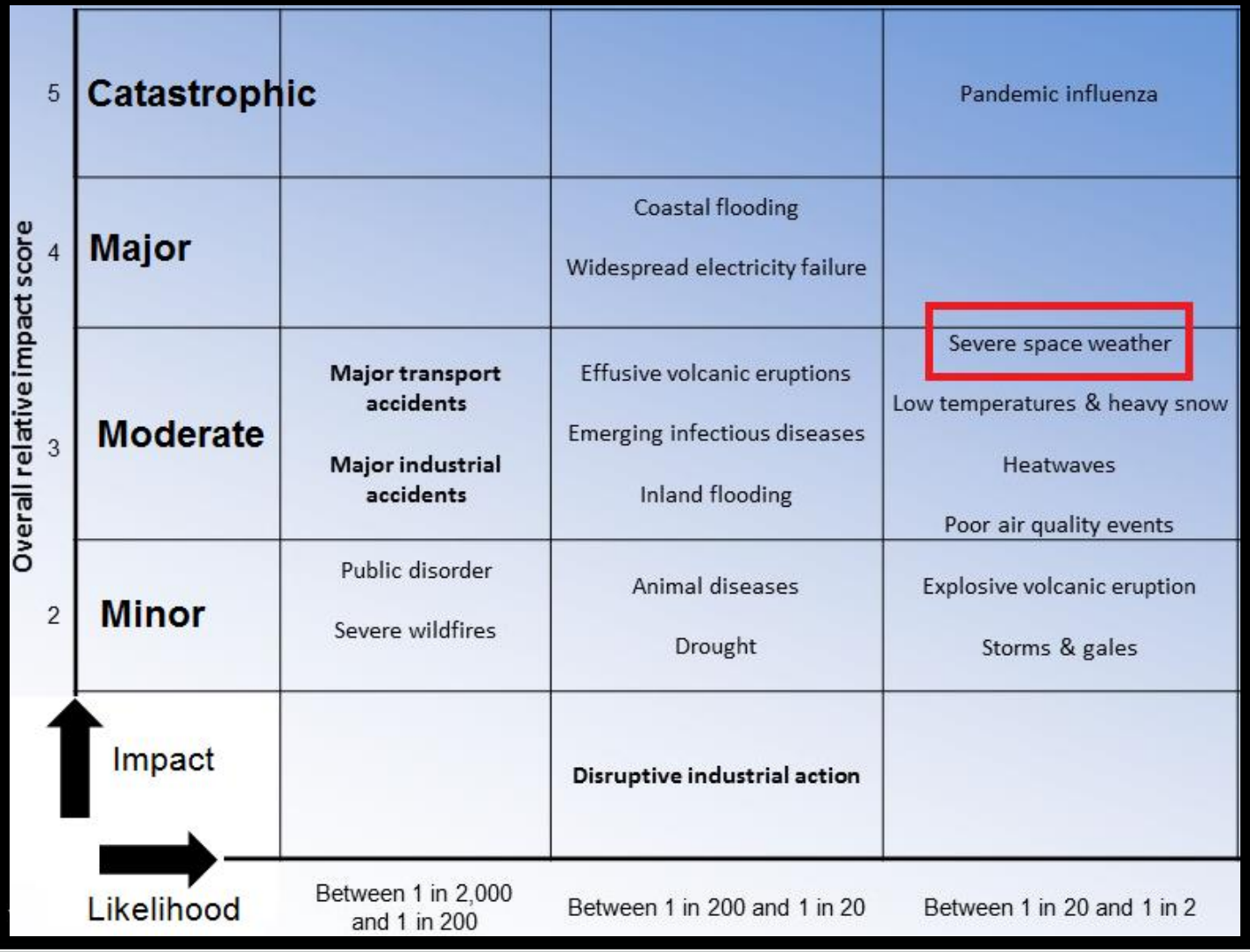
MOSWOC - Introduction

- Based at Met Office HQ Exeter
- One of only three 24x7 centres:
  - MOSWOC, SWPC & 557th
- Only one outside USA
- In-house science & models



MOSWOC - Origins

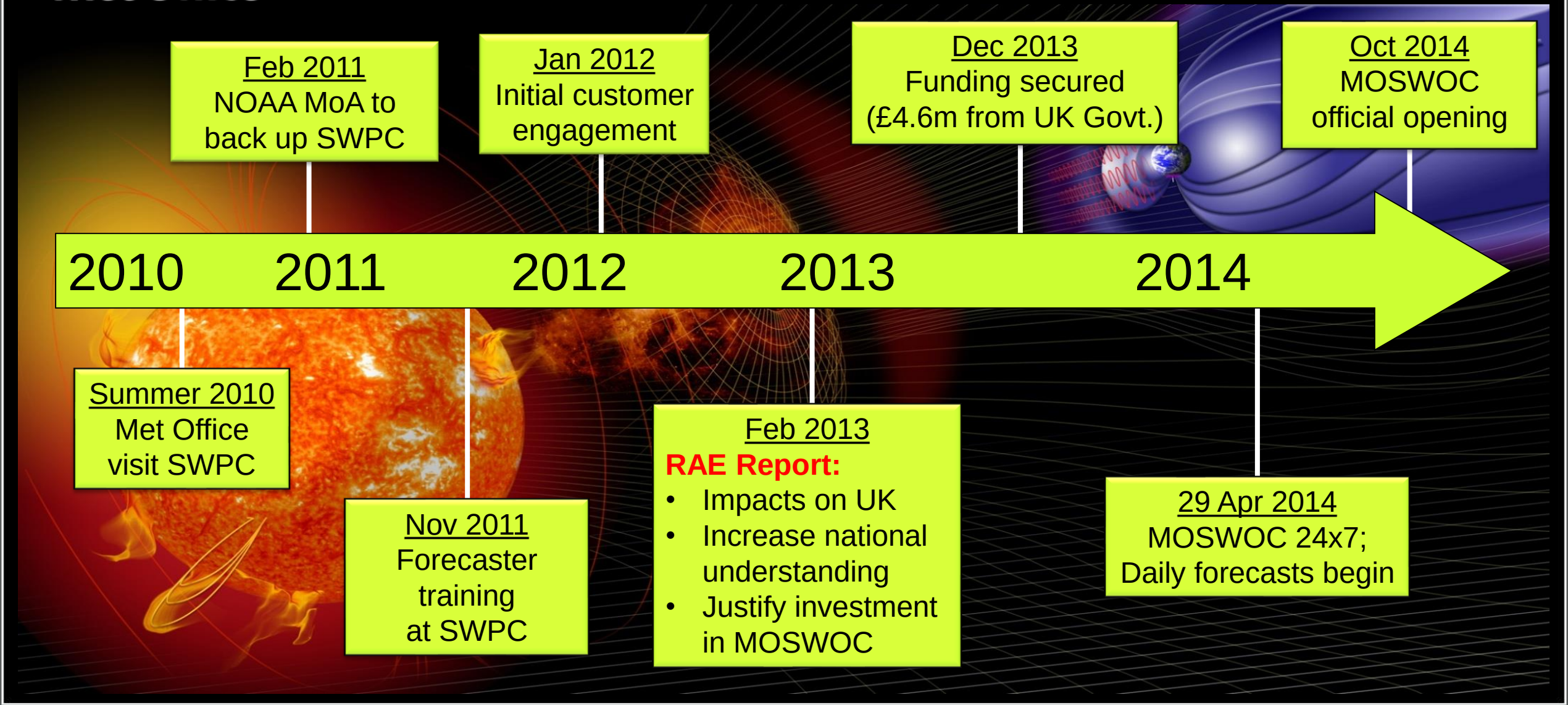
The UK National Risk Register (NRR)



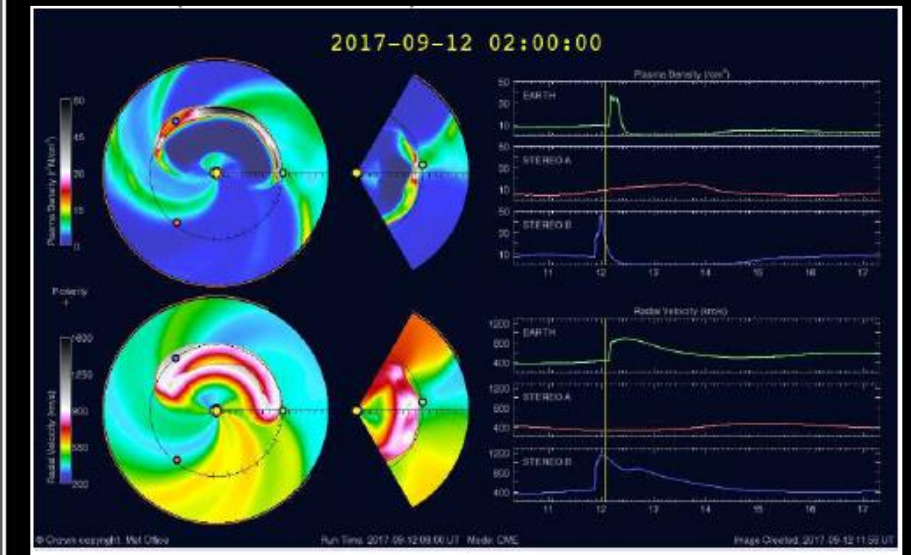
- Eyja volcanic eruption 2010
- Review of UK natural hazards
- Space Weather added 2011
- 4th highest risk!
- Forecast capability needed

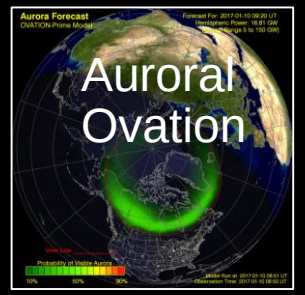
- Met Office made risk owner:
  - 24 x 7 operations
  - IT infrastructure
  - Partnerships

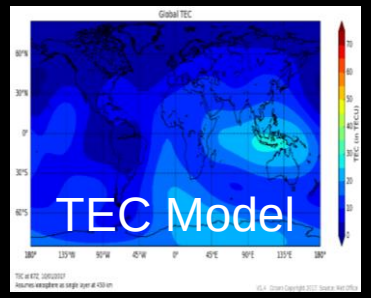
MOSWOC - Evolution

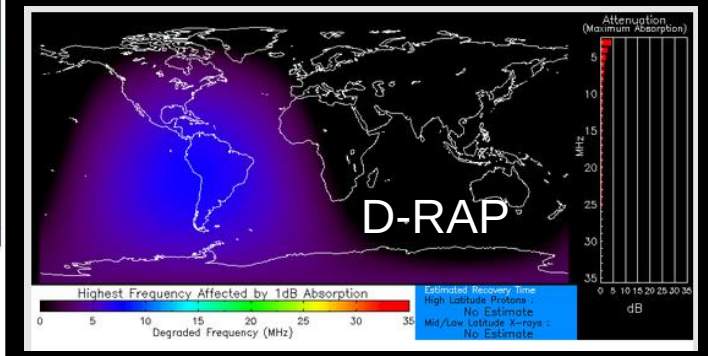


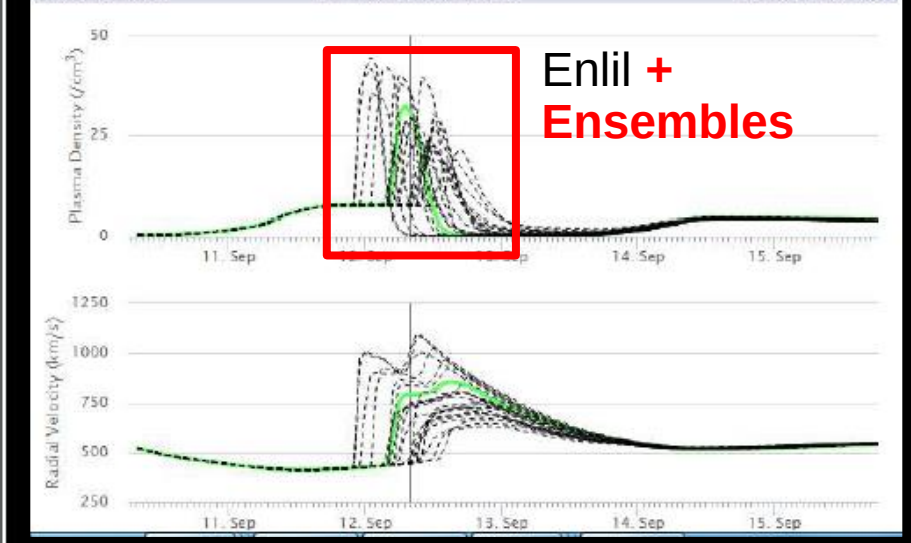
MOSWOC - Capabilities

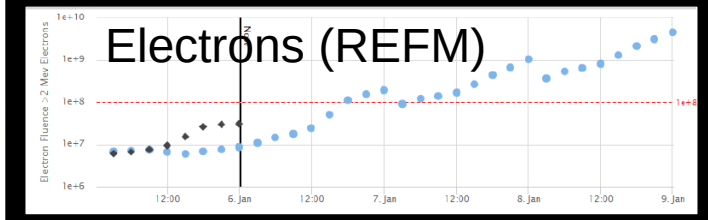


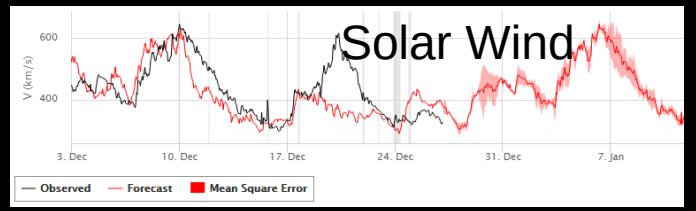


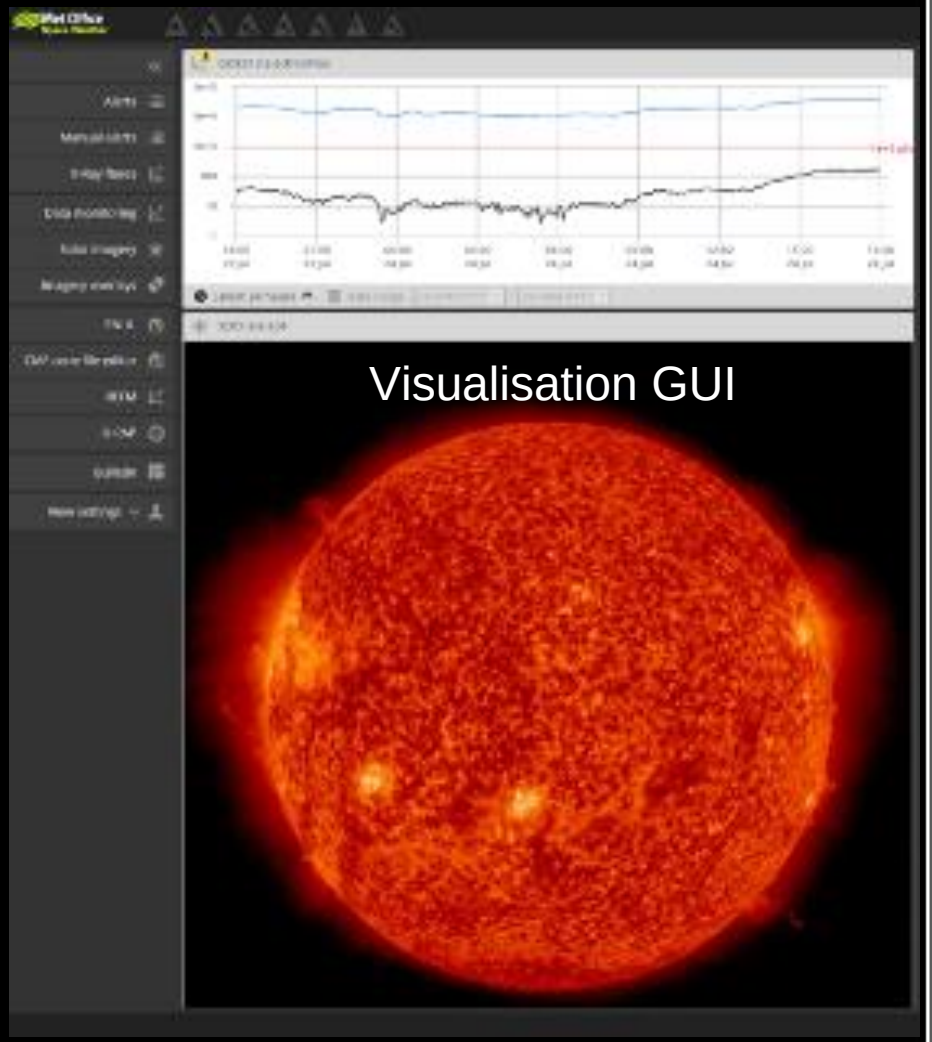












MOSWOC – Services – Key Product

Met Office

Key Product:

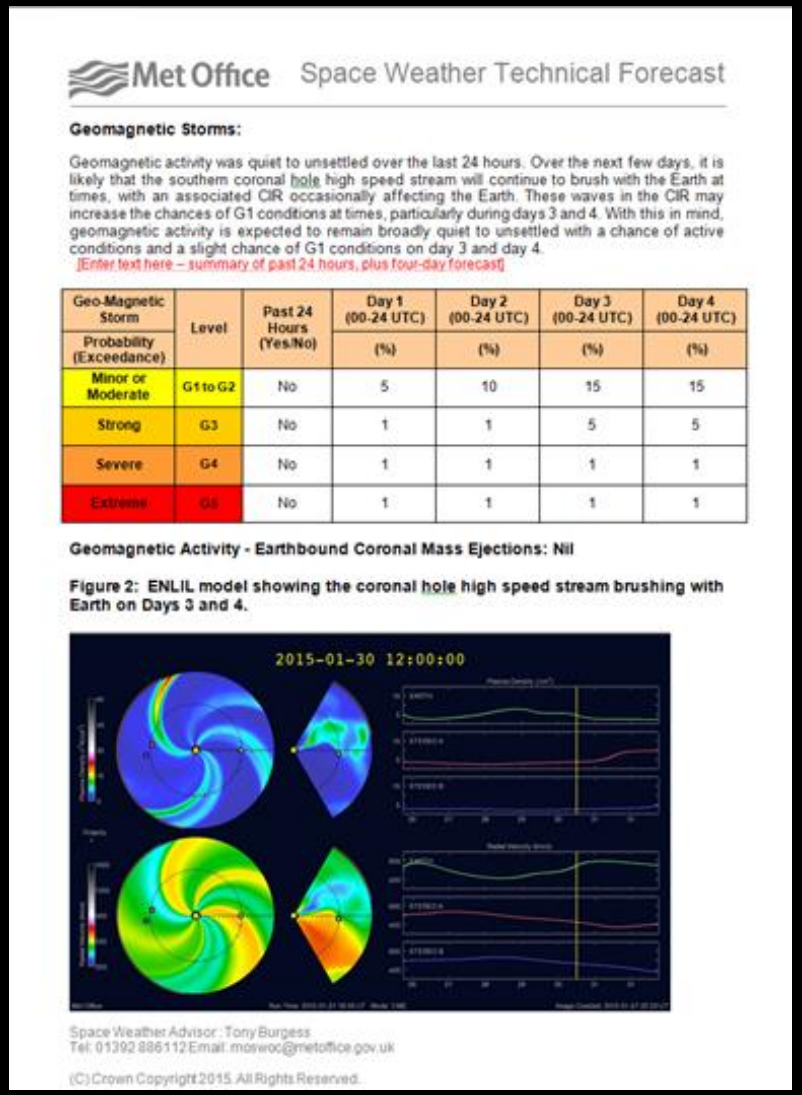
Twice-daily 4-day forecast

Midday and midnight UTC

Flares, geomagnetism, radiation storms, electrons

‘Technical’ and Plain Language versions

Online or PDF by email



Met Office Space Weather Technical Forecast

Geomagnetic Storms:

Geomagnetic activity was quiet to unsettled over the last 24 hours. Over the next few days, it is likely that the southern coronal hole high speed stream will continue to brush with the Earth at times, with an associated CIR occasionally affecting the Earth. These waves in the CIR may increase the chances of G1 conditions at times, particularly during days 3 and 4. With this in mind, geomagnetic activity is expected to remain broadly quiet to unsettled with a chance of active conditions and a slight chance of G1 conditions on day 3 and day 4.

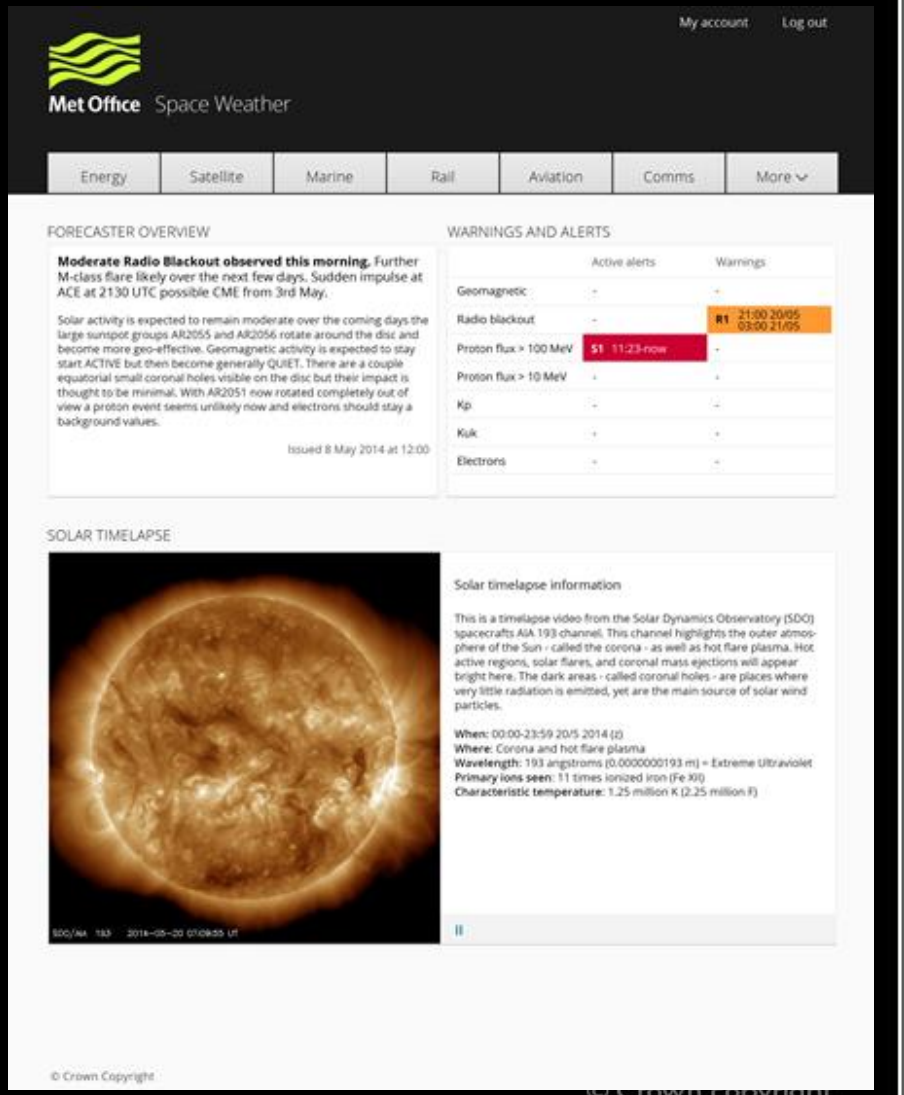
[Enter text here – summary of past 24 hours, plus four-day forecast]

Geo-Magnetic Storm Probability (Exceedance)	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	5	10	15	15
Strong	G3	No	1	1	5	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections: Nil

Figure 2: ENLIL model showing the coronal hole high speed stream brushing with Earth on Days 3 and 4.

Space Weather Advisor: Tony Burgess
Tel: 01392 886112 Email: moswoc@metoffice.gov.uk



MOSWOC – Services – Impact Matrix

Satellite systems impact matrices:

- SATCOM (VHF to EHF)
- Terrestrial comms (VLF to EHF)
- GNSS/GPS
- Regional products

Met Office Space Weather Operations Centre (MOSWOC) **EXERCISE** **EXERCISE**

Space Weather Impact on SATCOM Assessment

Issued: 30 October 2015

30 October 2015	0001 Z to 0600 Z			0600 Z to 1200 Z			1200 Z to 1800 Z			1800 Z to 2400 Z		
	VHF	UHF	SHF	VHF	UHF	SHF	VHF	UHF	SHF	VHF	UHF	SHF
High Latitude	U	U	M	U	U	M	U	U	M	U	U	M
Mid latitude	M	M	S	M	M	S	M	M	S	U	U	M
Equatorial	S	M	S	S	M	S	S	M	S	S	M	S

Comments: High risk of further R3 blackouts continues, S4 storm in progress (affecting high lats) and minor-moderate geomagnetic storms possible.

Comments: As morning but with a risk of strong/severe (G3-G4) geomagnetic storms.

31 October 2015	0001 Z to 1200 Z			1200 Z to 2400 Z		
	VHF	UHF	SHF	VHF	UHF	SHF
High Latitude	U	U	M	U	U	M
Mid latitude	U	U	M	U	U	M
Equatorial	S	M	S	S	M	S

Comments: High risk of further R3 blackouts continues, S4 storm in progress (affecting high lats) and strong/severe (G3-G4) geomagnetic storms possible during the morning.

01 November 2015	0001 Z to 1200 Z			1200 Z to 2400 Z		
	VHF	UHF	SHF	VHF	UHF	SHF
High Latitude	M	M	S	M	M	S
Mid latitude	M	M	S	M	M	S
Equatorial	S	M	S	S	M	S

Comments: R3 strong radio blackouts and G1-G2 minor storms a continuing risk resulting in slight to moderate signal degredation. S4 radiation storm should decrease to S3.

U	Unfavourable	Frequent or general signal loss, signal fade and/or interference are likely.
M	Moderate impacts	Occasional or Intermittent periods of signal loss, signal fade and/or interference are likely.
S	Slight degradation	Isolated or periods of slight signal loss, signal fade and/or interference are likely.
F	Favourable	The environment is unlikely to contribute to communications problems.

This forecast provides guidance on anticipated communications effectiveness for the stated geographic area and period.

For further space weather advice contact SpOCC Tel: 01494 494068/95221 X4068
This product is issued daily from MOSWOC and is non amendable.

Feedback on this product would be welcomed and should be directed to SpOCC at Air-1GP-BMSpaceOpsCCGroup@mod.uk

MOSWOC – Enlil for other planets!

Forecasts for Mercury, Venus and Mars also

Enlil output direct to ESA

Assessment of accuracy

Jupiter next..?

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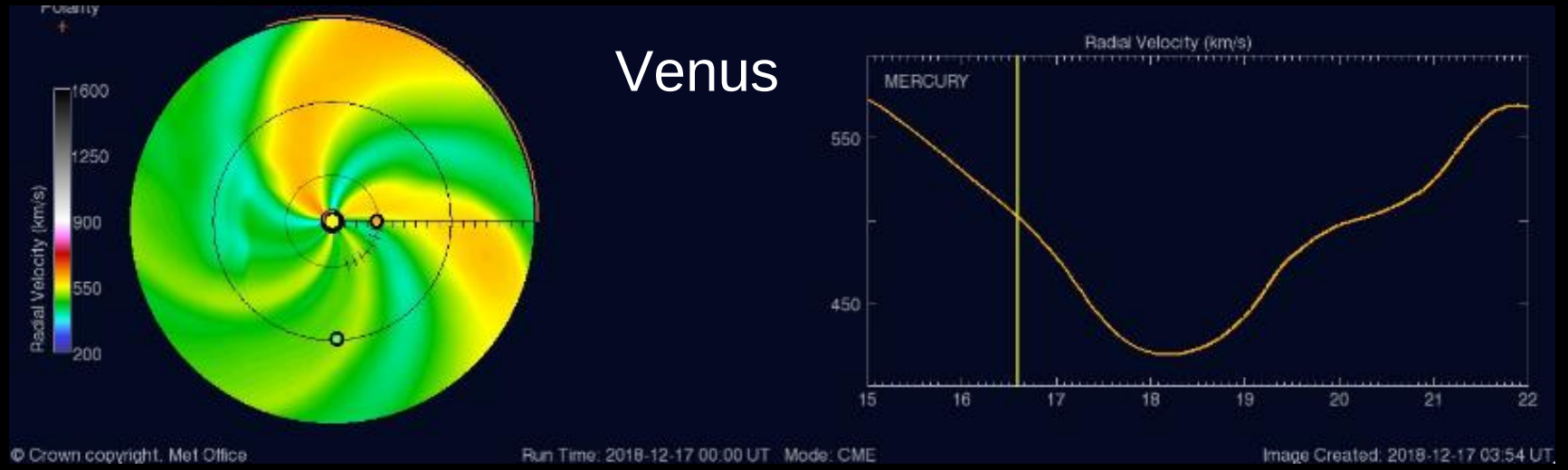

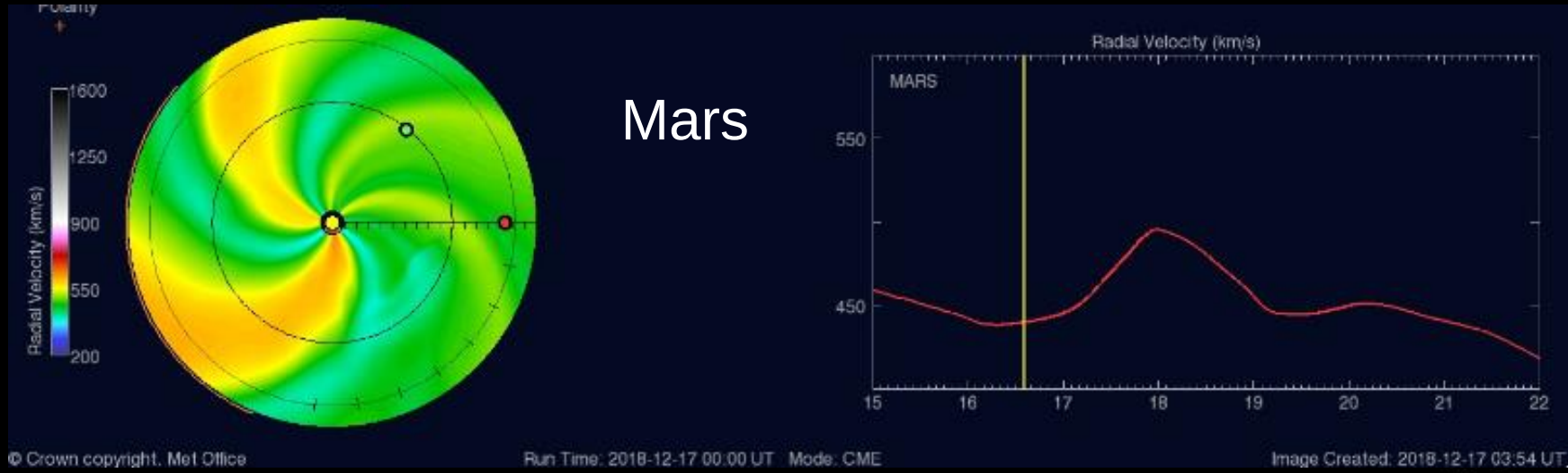

MOSWOC – Watches, Warnings and Alerts

Watches – hours to days

Geomagnetic Storm ≥ G3

Warnings – minutes to hours

Geomagnetic Storm ≥ G3

Proton storms ≥ S1

Integrated electron counts

Alerts - occurring

Geomagnetic Alerts ≥ G1

Radio Blackout Alerts ≥ R2

Proton Storms ≥ S1

Alert issued by the Met Office at 16/05/2013 08:50:00Z

Notification Type: **Radio Blackout Alert**

Exceeded Threshold: **R4**

Threshold Class: X15

Start Date & Time: 16/05/2013 08:45:00Z

Data Source: GOES15

Forecaster Text:
Solar Activity - An extreme radio flare has been detected impacting the UK.
Potential impacts:
HF Radio: HF radio communication blackout is likely on most of the sunlit side of Earth for up to a few hours. HF radio contact lost during this time.
Navigation: Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of GNSS (GPS) satellite navigation possible on the sunlit side of Earth.

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Alert Example

MOSWOC – Other Services

Routine:

- Sunspot Region Summary and Flare probability forecast
- Kp forecasts: Daily 3-day, and rolling 24-hour
- Teleconferences

Ad hoc:

- Significant Event Briefings
- Exercise Support
- 24 x 7 telephone support
- Space Weather Training

Met Office — Sunspot Region Summary

Observed Sunspot Regions:

Report issued four times a day (0300, 0900, 1500, 2100 UTC) from analysis of NASA SDO imagery and data from NOAA SWPC.

No.	Loc	Lo	Area	Z	LL	NN	Mag Type	Growth	M	X	P
2529	N11W52	342	900	Eki	13.0	10	Beta	Decrease	34	1	5
2532	N06E53	237	60	Cai	6.0	5	Beta	Increase	12	0	1
Total Raw %									42	1	5
Total Issued %									30	1	5

Comments: Region 2529 continues to show signs of decay, with almost all intermediate and trailer spots now very tenuous with only rudimentary penumbra at best. However this region recently (18/0029UTC) produced an M6.7 flare, the largest observed since 25th June 2015, so still has flare potential. Issued probabilities of M-class flares increased to 30% in light of this. Region 2532 has developed some intermediate spots since previous analysis, so is now classed Cai (from Cao).

Carrington 0-deg Longitude: at 18/0200 UTC = 290°

Space Weather Advisor: Gareth Powell
Transmitted by the Met Office on 18 April 2016 at 12:00 UTC

Met Office — Kp / Kuk 24 hour Forecast

Forecast Issued on Friday, 12 September 2014 Time of Issue 02:34 Local

Kp/Kuk Level for next 24 hours:

0000	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-00
Kp	4	6	6	5	5	4	4	5
Kuk	4	6	6	5	5	4	4	5

MOSWOC - Customers

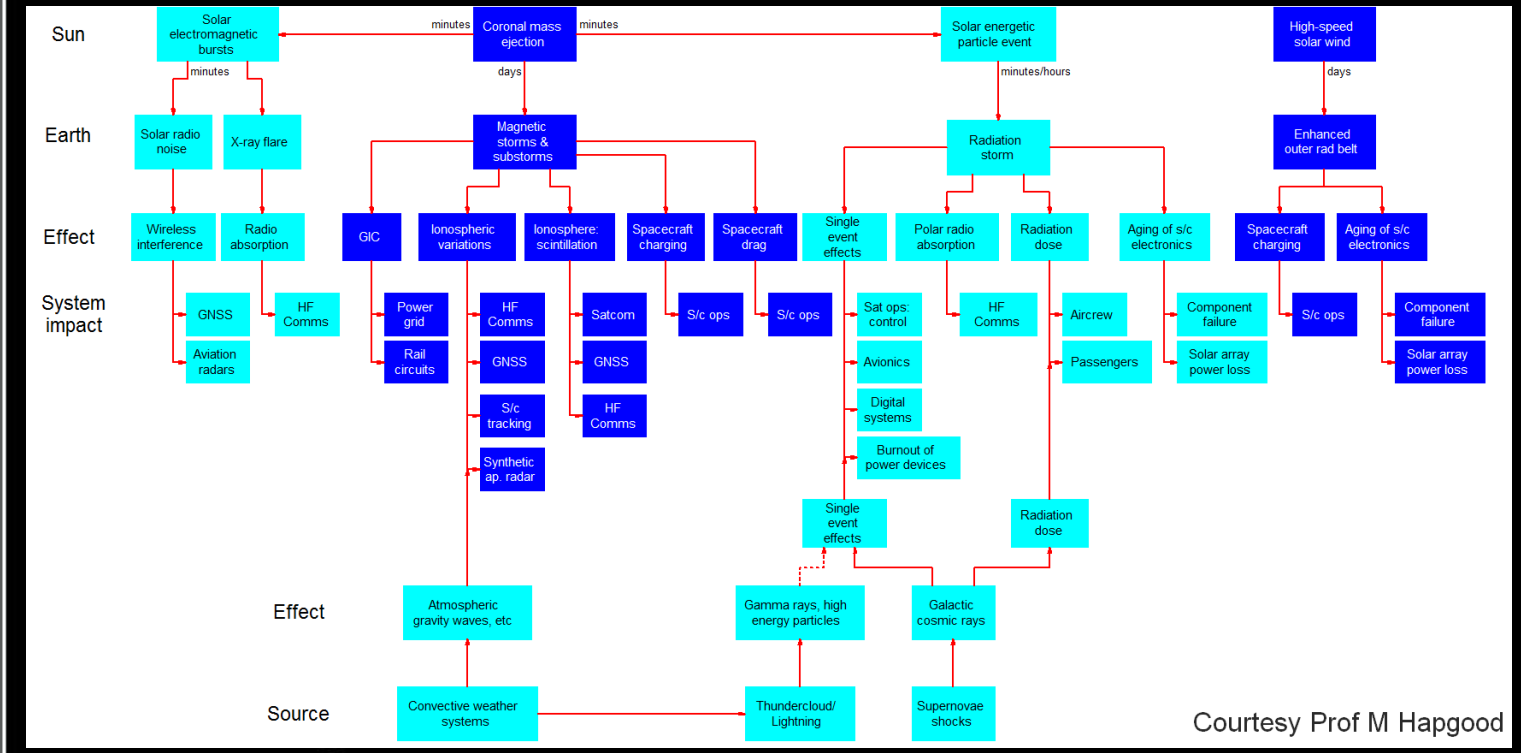
Power	Government Partners	Scientific Institutes
National Grid	Business Energy and Industrial Strategy	British Geological Survey (BGS)
EDF Energy	Cabinet Office	British Antarctic Survey (BAS)
Scottish Power	UK Space Agency	Swedish Meteorological and Hydrographical Institute (SMHI)
Northern Powergrid	Department for Transport	Finnish Meteorological Institute (FMI)
	Ministry of Defence	South Africa National Space Agency (SANSA)
	Public Health England	European Space Agency (ESA)
	Regional and devolved governments	
Satellites	**Transport**	**Telecommunications**
Airbus	National Air Traffic Services (NATS)	British Telecom (BT)
SES	Civil Aviation Authority (CAA)	Telefonica
Avanti	Maritime and Coastguard Agency	OFCOM
Finance	**Military**	**Emergency Services**
Bank of England	UK and Overseas	

Potential Impacts on UK

- Greatest concern: **Widespread loss of electricity supply**
  - Urban areas – hours to days
  - Remote areas – weeks to months / rolling cuts
- Loss of satellite comms and GNSS services:
  - Transport – aviation, shipping, rail
  - Financial transactions
  - Emergency services / military
  - Public reaction?
- **Loss of GNSS alone would cost UK approx. £1bn per day**

UK Space Weather Strategy

PREDICT → UNDERSTAND → PREPARE → RESPOND



- Common understanding
- Proportionate risk mitigation
- Collective response
- 5-year outlook
- Apply internationally

MOSWOC - Partnerships

Met Office

UCL
MULLARD SPACE SCIENCE LABORATORY

NOAA
NATIONAL WEATHER SERVICE
SPACE WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

BGS 1835
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

UNIVERSITY OF BATH

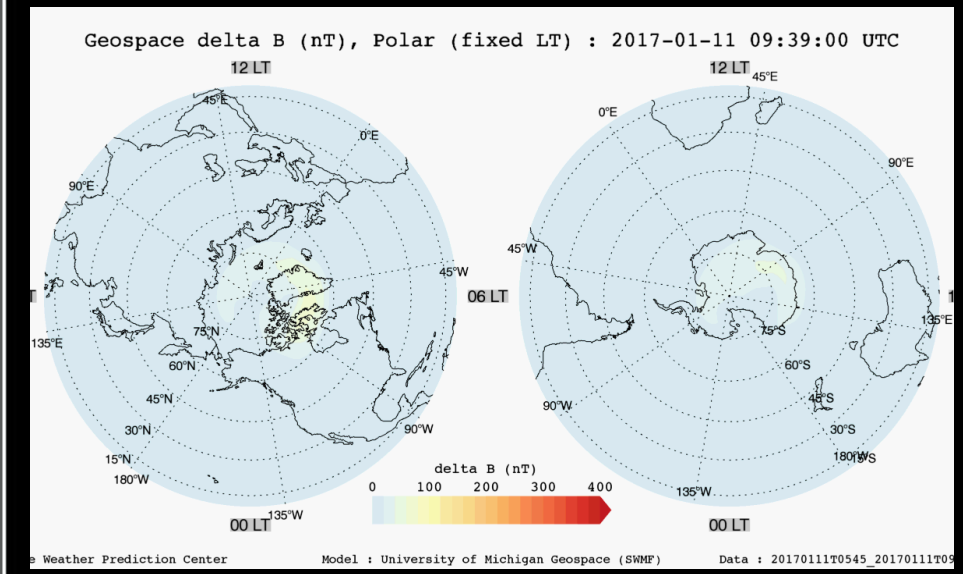
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

RAL Space

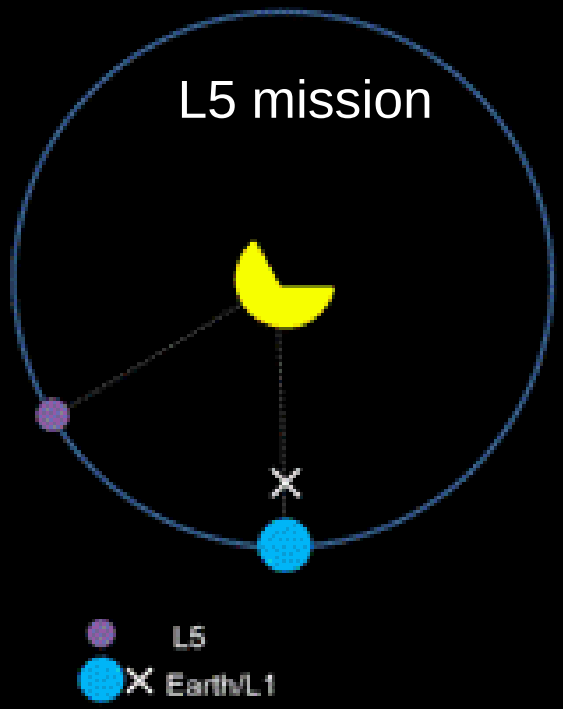
Science & Technology Facilities Council

Government Office for Science

MOSWOC – The Future



Magnetosphere Model



Training

PREDICT → UNDERSTAND → PREPARE → RESPOND

UK Space Weather Strategy

MOSWOC - Summary

- Only 24x7 operational space weather forecasting outside of USA
- One of only 3 in the world
- From concept to full operations in 4 years
- Much capability in-house
- Utilise partnerships in UK and Internationally to develop science and operations
- Developing UK Space Weather Strategy
- Contribution towards UK, European and global preparedness for space weather

Met Office

Any Questions?

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http:/www.metoffice.gov.uk/space-weather

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