SWIMMR

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Met Office

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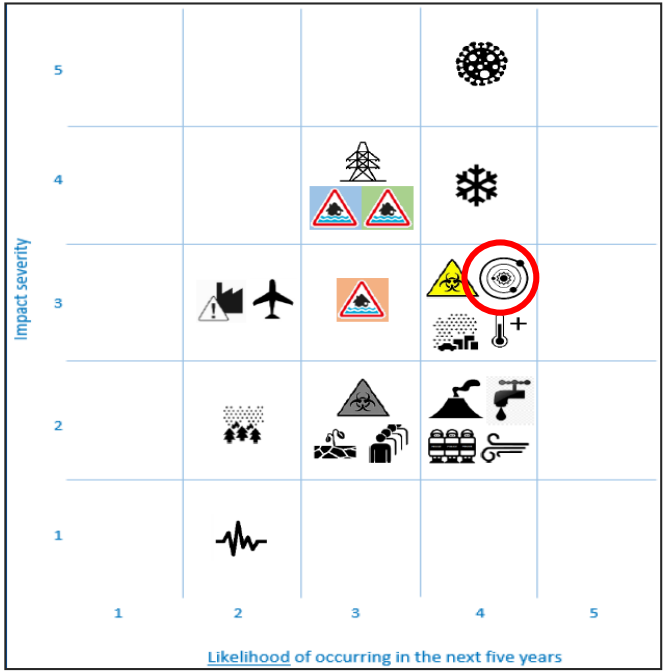
1. Overview of Met Office activities
2. More information on each project



Met Office Space Weather Operations Centre (MOSWOC)

- Fully integrated within Met Office Operations Centre
- National capability supporting;
  - Government, military & critical sectors
- 1 dedicated forecaster on duty 24/7
  - Mutual back-up with Volcanic Ash Advisory Centre position
- One of only 3 24/7 manned centres globally

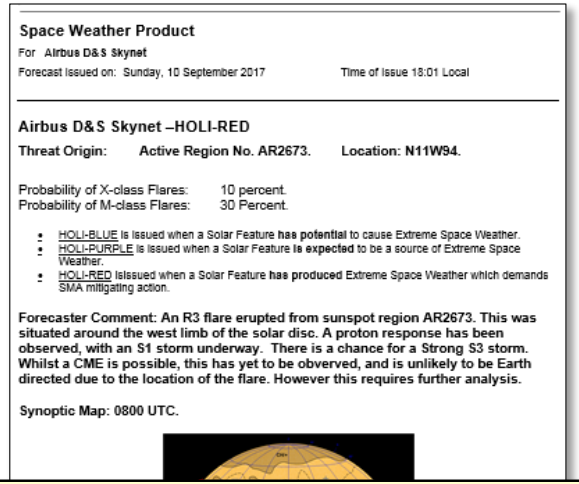
Growing user base
(number & criticality)

Existing users

- Government & CNI operators
  - E.g. National Grid, satellite operators, CAA, etc
- UK military Skynet secure communications satellites

New /developing users

- UK Space Operation Centre (SpOC / NSpOC)
- ICAO Global Space Weather Centre
- UK spaceport
- UK satellite constellations



Space Weather Product

For Airbus D&S Skynet

Forecast Issued on: Sunday, 10 September 2017 Time of Issue 18:01 Local

Airbus D&S Skynet –HOLI-RED

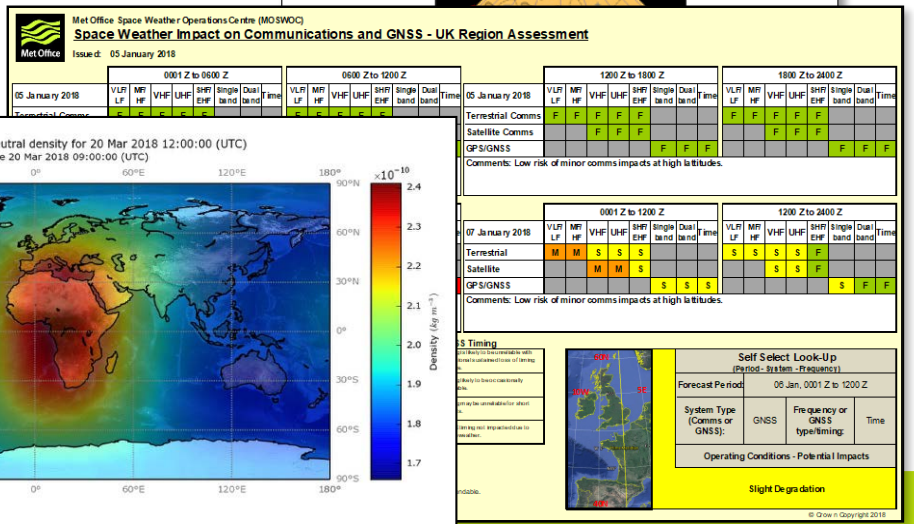
Threat Origin: Active Region No. AR2673. Location: N11W94.

Probability of X-class Flares: 10 percent.
Probability of M-class Flares: 30 Percent.

- HOLI-BLUE is issued when a Solar Feature has potential to cause Extreme Space Weather.
- HOLI-PURPLE is issued when a Solar Feature is expected to be a source of Extreme Space Weather.
- HOLI-RED isissued when a Solar Feature has produced Extreme Space Weather which demands SMA mitigating action.

Forecaster Comment: An R3 flare erupted from sunspot region AR2673. This was situated around the west limb of the solar disc. A proton response has been observed, with an S1 storm underway. There is a chance for a Strong S3 storm. Whilst a CME is possible, this has yet to be obverved, and is unlikely to be Earth directed due to the location of the flare. However this requires further analysis.

Synoptic Map: 0800 UTC.



Met Office Space Weather Operations Centre (MOSWOC)

Space Weather Impact on Communications and GNSS - UK Region Assessment

Issued: 05 January 2018

Met Office

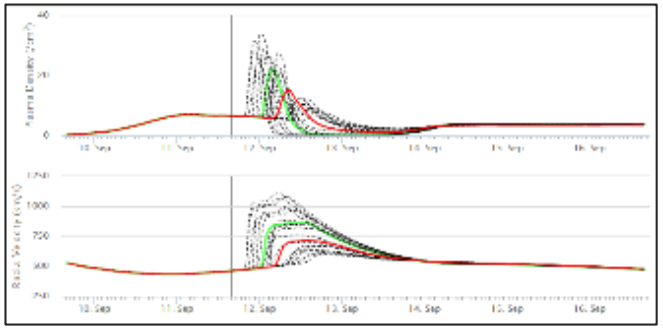
200 km Atmospheric neutral density for 20 Mar 2018 12:00:00 (UTC)
at reference date 20 Mar 2018 09:00:00 (UTC)

Motivation for SWIMMR

Motivation

- MOSWOC created by importing SWPC capability
- No UK space weather research programme results in continued dependence on US
- Lack of diversity in models
- Cost if transitioning research into operations is expensive

CME / Geomagnetic focus



Why SWIMMR?

1. Fill capability gaps (now & future)
    - Radiation effects
    - Ionospheric impacts – navigation & communications
    - Atmospheric density (orbit determination & collision risk)
    - Electric-field modelling
2. Utilise UK knowledge & capability
    - Showcase UK science
    - Create diversity in forecast solutions
3. Reduce the research-to-operations gap

The projects

The opportunities – STFC led

- S1: Improved in-situ radiation measurements for space and aviation
- S2: Support for technology testing and modelling
- S3: Support for the transition from research to operations
- S4: Forecasting from the Sun to L1
- S5: Support for a ground radiation monitoring network
- S6: Production of an updated space weather impact study

The opportunities – NERC led

- N1: Improvement of satellite risk forecasts
- N2: Improvement of aviation risk forecasts
- N3: Improved forecasting of effects on GNSS and HF communications
- N4: Improved forecasting of ground level current effects
- N5: Improved forecasts of space weather effects on satellite drag

Radiation effects

- S1: In-situ radiation measurements for space and aviation
- S5: Support for a ground radiation monitoring network
- S2: Support for technology testing and modelling
- N1: Improvement of satellite risk forecasts
- N2: Improvement of aviation risk forecasts

S1: Improved in-situ radiation measurements for space and aviation

Why

- Radiation risk to spacecraft & aircraft is a key issue
- Need data to support modelling, verification & nowcasts
- Re-invigorate the capability to build indigenous UK state-of-the-art monitors

What

- Define measurement requirements
- Develop & build 12 monitors (utilising existing heritage)
  - 2 satellite, 10 aircraft
- Fly the monitors to provide new data into MOSWOC
- Begin development & testing of miniaturised radiation monitor

S5: Support for development of a ground radiation monitoring network

Why

- Radiation risk to aircraft is key issue and risk to autonomous vehicles is unknown
- Need data to support modelling, verification & nowcasts
- No monitoring in the UK
- Existing neutron monitors are large & expensive

What

- Define measurement requirements
- Explore potential for smaller & more affordable monitors (c.f. neutron monitors)
- Establish a prototype network

S2: Support for technology testing and modelling

Why

- Limited understanding of the performance of electronics in an ‘severe’ radiation environment
- Grow userbase for ChipIR and hence increase testing & knowledge

What

- Contribute to upgrade of ChipIR to increase independence from main beam
- Offset the cost of testing electronic components / systems
- If suitable, test detectors developed in S1

N1: Improvement of satellite (radiation) risk forecasts

Why

- Growing dependency on space based infrastructure
- Need improved nowcast & forecast capability
  - multiple orbits
  - range of impacts
  - accuracy

N1: Improvement of satellite (radiation) risk forecasts

What

- NRT forecast of high energy electron radiation for user defined orbits in GEO, MEO & LEO
- Forecasts of risk of internal charging, dose, non-ionising dose and single event upsets along specified satellite orbits in LEO, MEO and GEO
- Forecast of risk of damage or degradation due to trapped particle radiation
- Nowcast of risk of damage due to surface charging and sources such as SEPs
- Ingest & driven by suitable data sources
- Support operational implementation in MOSWOC
- Validation & verification

N2: Improvement of aviation (radiation) risk forecasts

Why

- Radiation dose concern for aircrew & passengers
- Now part of ICAO Space Weather Advisory Service
- No UK capability to support response to a severe event

N2: Improvement of aviation (radiation) risk forecasts

What

- Global-scale 3D near real-time information and alerts for SEP (& GCR) impact for aircraft avionics, passengers and crew
  - hindcast, nowcast and potentially forecast
- Account for concurrent geomagnetic disturbances in admitting solar particles to lower latitudes.
- Ingest suitable data from ground, airborne and space networks to drive models in near real time (especially S1 & S5)
- Support operational implementation in MOSWOC
- Validation & verification

Note: should be capable of indicating threshold exceedance e.g. ICAO thresholds

Ionospheric & thermospheric effects

- N3: Improved forecasting of effects on GNSS and HF communications
- N5: Improved forecasts of space weather effects on satellite drag

N3: Improved forecasting of effects on GNSS and HF communications

Why

- Growing dependence on GNSS
- HF comms continue to be important for aviation & military
- Now part of ICAO Space Weather Advisory Service

N3: Improved forecasting of effects on GNSS and HF communications

What

- Coupled NRT ionosphere-thermosphere 3D assimilative forecast model.
- Assimilate range of data including
  - satellite orbit and accelerometer data,
  - thermospheric radiance data,
  - electron density profiles or virtual height profiles,
  - total electron content (TEC).
- Regional mapping of TIDs and/or TEC gradients.
- Low and high latitude scintillation mapping.
- Capable of delivering relevant GNSS, SBAS and HF products.
- Support operational implementation in MOSWOC following validation & verification

Note: should be capable of indicating threshold exceedance e.g. ICAO thresholds

N5: Improved forecasts of space weather effects on satellite drag

Why

- Supports UK sovereign launch strategy
- Support future UK funded satellite constellations
- Supports UK space surveillance & tracking

N5: Improved forecasts of space weather effects on satellite drag

What

- Coupled NRT ionosphere-thermosphere 3D assimilative forecast model.
- Assimilate range of data including
  - satellite orbit and accelerometer data,
  - thermospheric radiance data,
  - electron density profiles or virtual height profiles,
  - total electron content (TEC).
- A system level model capable of meeting the satellite orbit nowcasting and forecasting objectives.
- Support operational implementation in MOSWOC
- Validation & verification

N4: Improved forecasting of ground level current effects

Why

- Provide geoelectric field information
  - GIC to electricity Grid
  - Pipe-to-soil Potential (PSP) to pipeline operators
  - GIC in rail network

N4: Improved forecasting of ground level current effects

What

- NRT nowcast and forecast of ground-level geomagnetic and geoelectric fields across the UK.
- Nowcasts and forecasts of GIC in the UK high-voltage electricity transmission network.
- Nowcasts and forecasts of PSP in the UK high-pressure gas transmission network.
- In conjunction with the Met Office, a system of web displays that are updated by the forecasts and nowcasts.
- Support operational implementation in MOSWOC
- Validation & verification

S4: Forecasting from the Sun to L1

Why

- Improve arrival time prediction of CMEs
- Predict evolution of solar wind at L1

What

- Optimising existing techniques
  - Data assimilation
  - Ensembles
- More computational efficient models/tools

S3: Support for the transition from research to operations

Why

- Make research to operations more efficient

What

- Create a R2O environment similar to operational MOSWOC IT system
- Enable academic remote access
- Enable academics, Met Office Scientists & IT staff to collaborate

S6: Production of an updated space weather impact study

Why

- RAEng report remains the ‘Global standard’ but is nearly 10 years old

What

- Update the report

Additional requirements

Suitable for operational use

Meet user & technical requirements e.g.

- Models must
  - run automatically without human intervention
  - not fail when data is missing
  - use supportable software languages
  - Etc….
- Met Office requires royalty free, irrevocable, non-exclusive licence
  - Developing institute retains IPR

All detailed in the AO

Information day

Information day hosted at Met Office Exeter

Thursday 19th December

Details will appear on STFC SWIMMR web pages

AO encourages consultation with Met Office

Information day is optional

Information on requirements & approach

Opportunity for two-way discussion

Final day for consultation with Met Office15th January

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