Space weather at the UK Met Office: Operations and development

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Operations

The UK Met Office specialist forecasters monitor space weather 24/7 (Figure 1), enabling production of regular forecasts and timely alerts. The Met Office space weather research group works closely with the forecasters, developing suitable models and techniques to support space weather forecasting. The Technology and Information Services team applies innovative techniques to facilitate the operational implementation of models and provides clear visualisation of products and solar data ensuring that forecasters have access to the most up-to-date data available (Figure 2).
The Met Office actively seeks collaborations with national and international partners to develop and deliver space weather services. The Met Office is currently running the Enlil model (Figure 3) operationally, every 2 hours, thus providing a backup to the NOAA Space Weather Prediction Centre (SWPC) system. This magneto-hydrodynamic model produces a 2-D animation forecasting the solar wind as it propagates from the Sun to the Earth. Solar wind structures can create enhanced geomagnetic activity and high levels of radiation belt electrons, therefore, advance warning is critical for users such as defence, and the electric power and satellite industries.

Figure 1. The UK Met Office Hazard Centre.

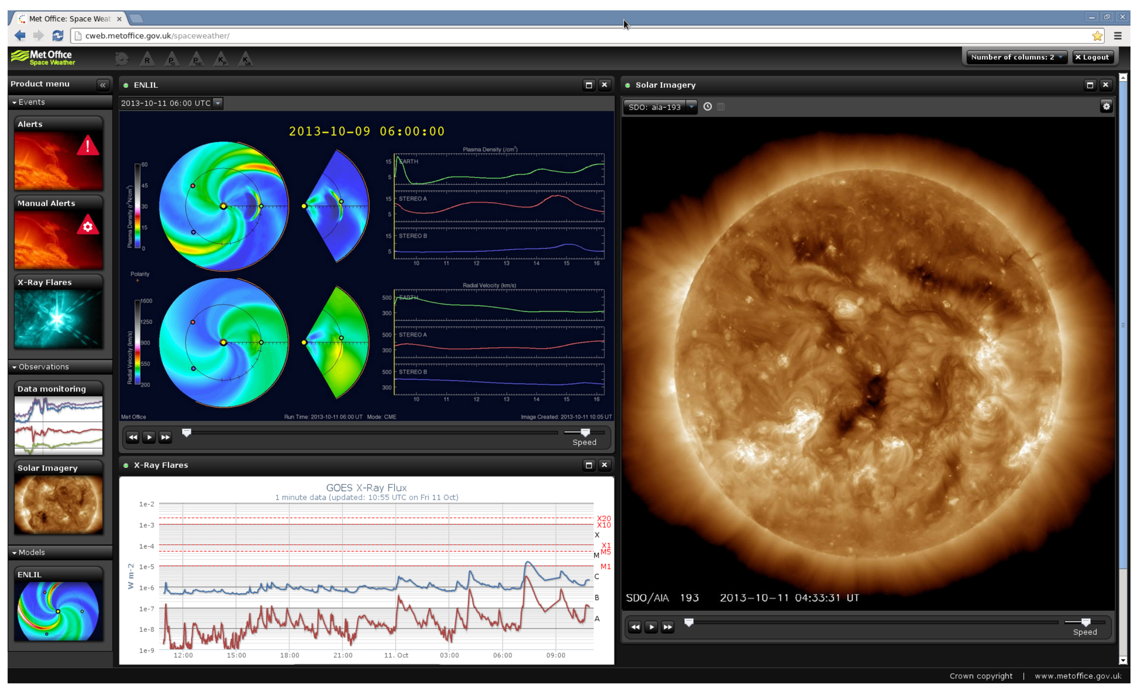


Figure 2. UK Met Office space weather webpages (for forecaster use).

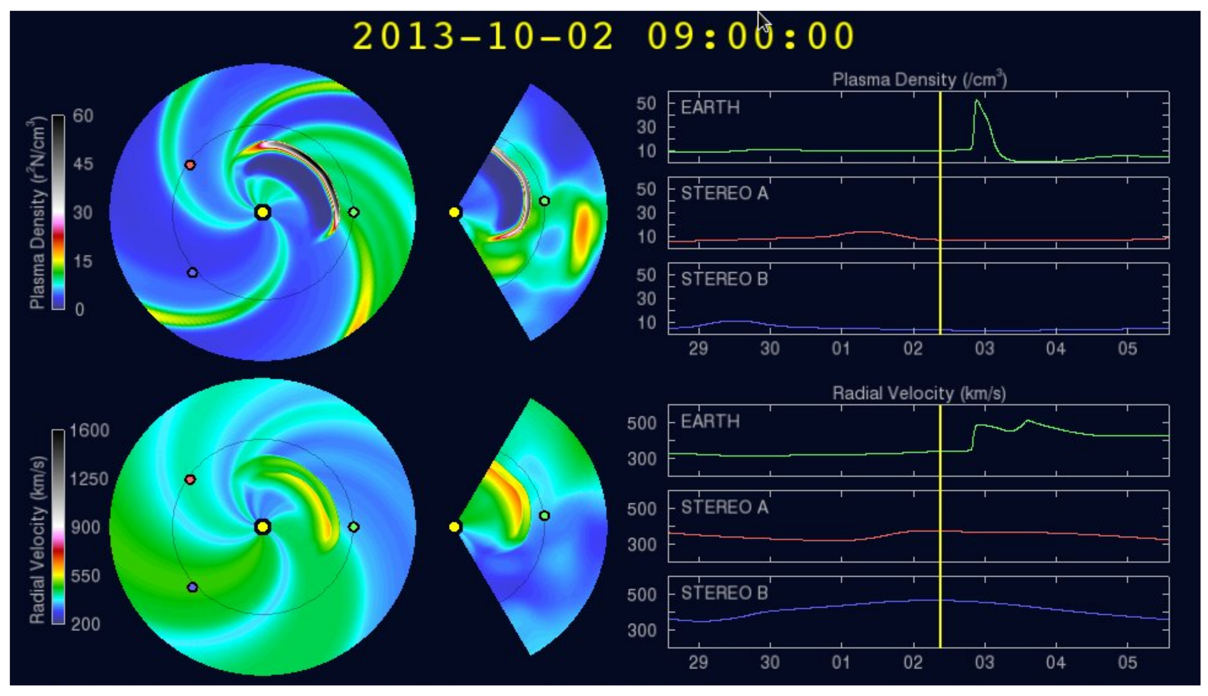


Figure 3. Enlil model output (developed by D.Odstrcil, George Mason University) showing predictions of plasma density (top panel) and plasma velocity (bottom panel). Left-hand images show a view from above the Sun's north pole and middle images show a side-on view of the Sun (yellow circle), Earth (green circle), STEREO A spacecraft (red) and STEREO B (purple). Right-hand images show the change in plasma parameters at Earth, STEREO A and STEREO B. This model run predicts the progression of a CME from a filament eruption on 29/9/13, arriving at Earth on 2/10/13.

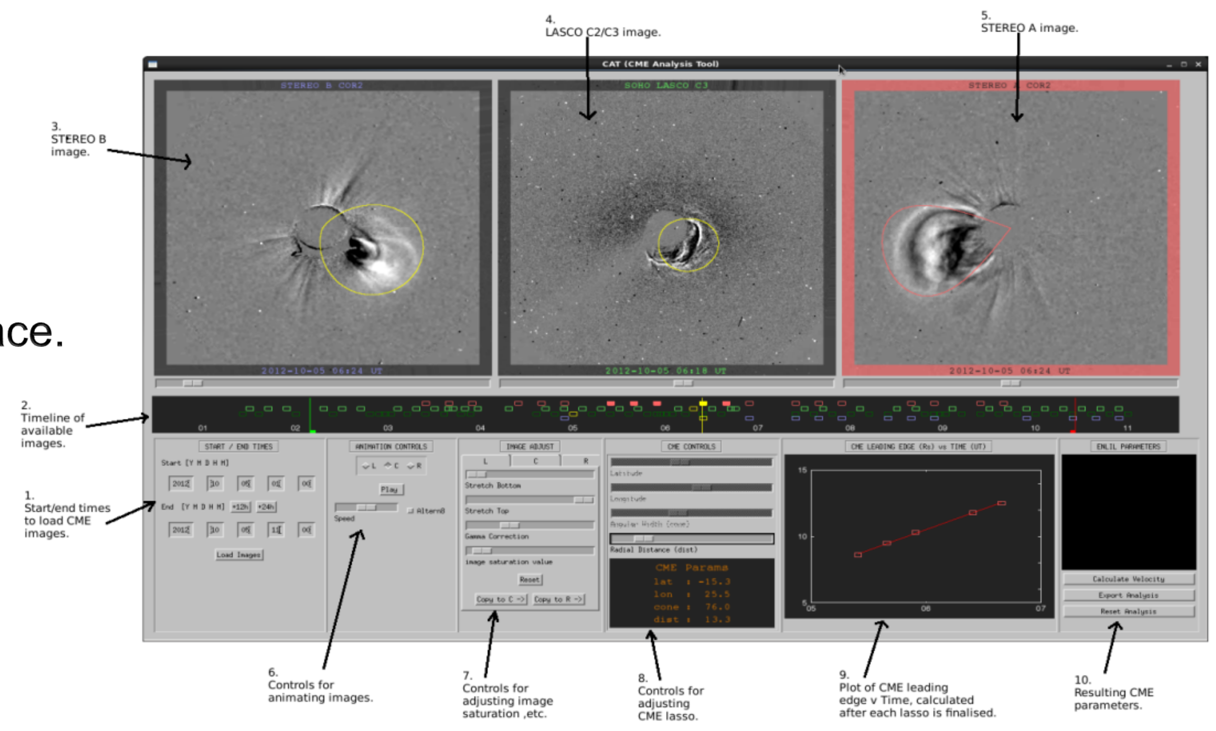
Development

The Met Office are working with a number of partners to run a variety of space weather models in-house. Some models planned for operational implementation are shown below.
Coronal mass ejection (CME) analysis tools are used by forecasters to determine CME parameters, for input into Enlil, to predict CME arrival time at Earth.
Forecasting electron fluence can warn of satellite charging conditions, enabling operators to take mitigating action. Real-time maps of ionosphere electron content and absorption conditions can be used by defence and airlines to aid in radio communications.

CME Analysis Tool

Name: CAT (CME Analysis Tool)
Developer: NOAA SWPC
Purpose: Triangulation tool to determine CME parameters from solar imagery by fitting a cone model.
Input: STEREO A, STEREO B and LASCO SOHO images.
Output: Size, speed and direction of CME propagation.

CAT user interface.



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CME Analysis Tool (CAT) v1.0
20121005T0932
-15
26
38
598

Time at 21.5Rs (yyyy-mm-dd hh:mm) : 2012-10-05 09:32
CME axis latitude       (degrees) :      -15.3000
CME axis longitude      (degrees) :       25.5000
half angle              (degrees) :       38.0000
Radial velocity            (km/s) :       598.453

Number of CME matches :           5
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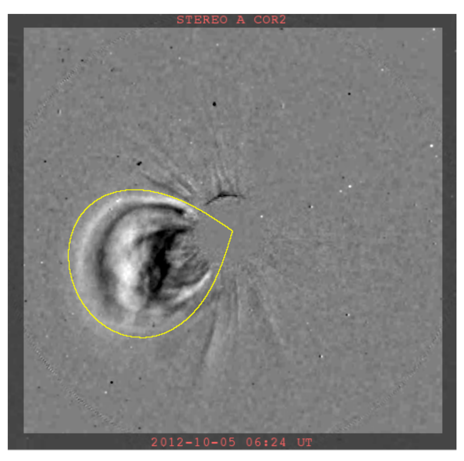
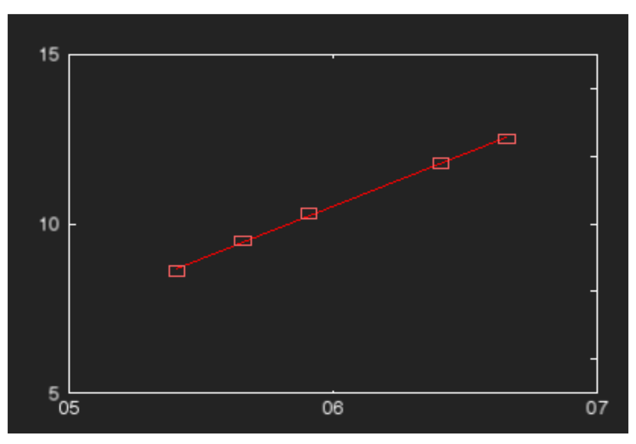
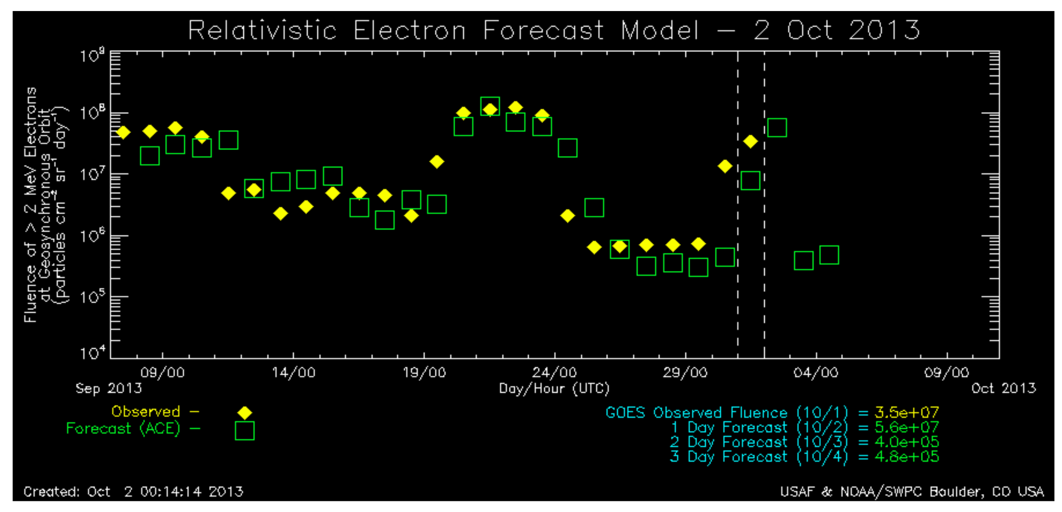
CAT result: Enlil parameters.



CAT result: representative image.



CAT result: CME leading edge v Time.

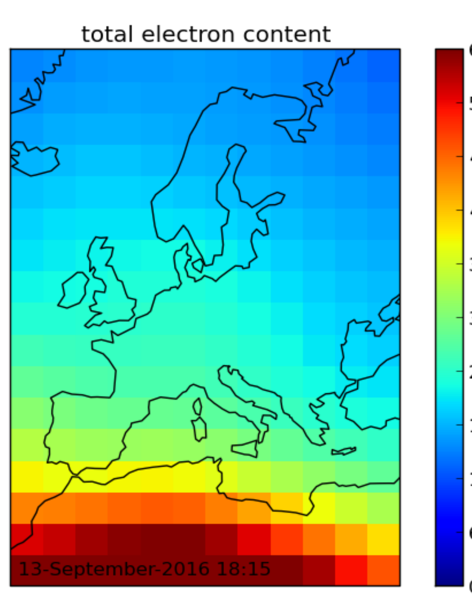


REFM

Name: Relativistic Electron Forecast Model
Developer: NOAA SWPC
Purpose: Provides daily electron fluence forecast at GEO orbit.
Region: GEO orbit (35,000km)
Input: ACE solar wind speed, GOES electron flux.
Output: Daily forecast of >2MeV electron fluence at GEO orbit.

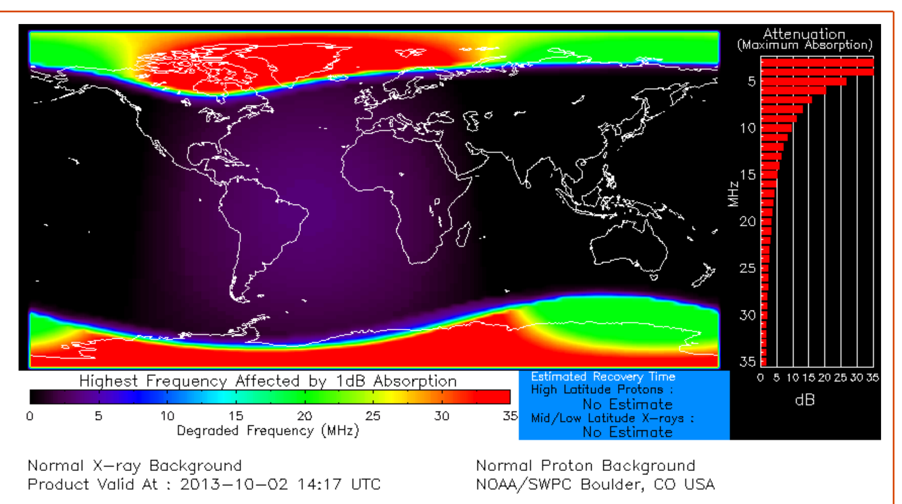
MIDAS

Name: Multi-Instrument Data Analysis System
Developer: Bath University
Purpose: Combines delays in GPS signals due to electrons to give a tomographic map of the ionosphere.
Region: Ionosphere (60-600km)
Input: Ground- and space-based GPS data, and point estimates of local electron density.
Output: Real-time 3-D map of total electron content over area of interest, e.g. Europe.



D-RAP

Name: D region Absorption Model
Developer: NOAA SWPC
Purpose: Real-time prediction of the absorption (radio propagation) conditions in the D-region.
Region: Ionosphere (50-90km)
Input: GOES satellite & ground magnetometer data.
Output: Global map of the highest HFs affected by 1dB attenuation in the D-region of the ionosphere.



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