Met Office

Flare forecasting developments at the Met Office

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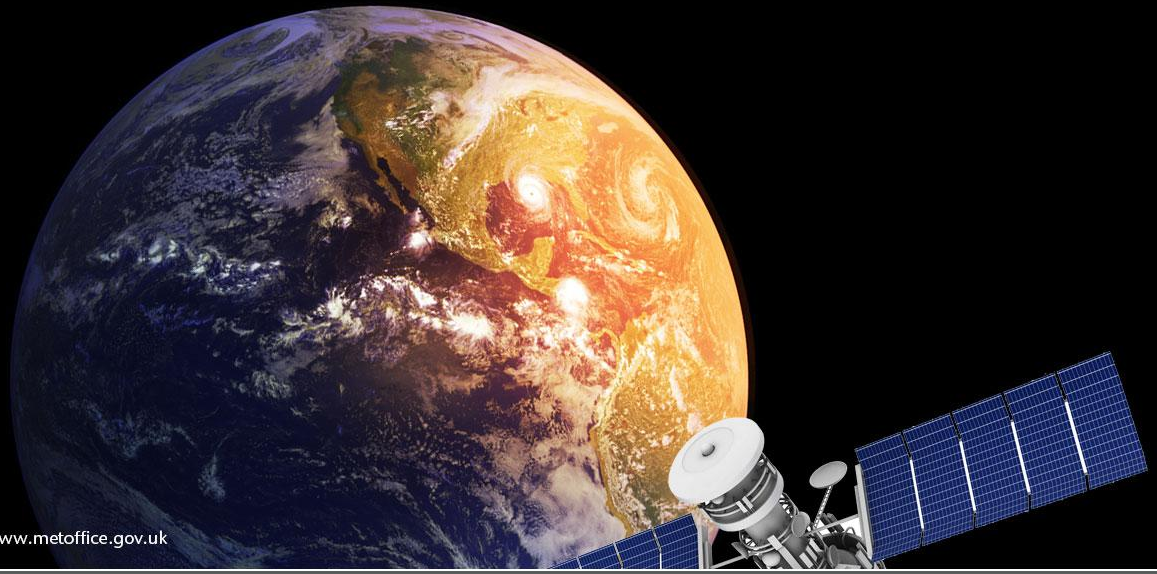

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Met Office Space Weather Operations Centre flare forecasting methods

- Forecasters first classify all active regions on disk.
- Average flare rate, μ, for each McIntosh class determined from data archive (see Bloomfield et al, 2012).
- Poisson flare probability, P, of observing N flares in next 24 hours is calculated for each active region,

$$P_{\mu}(N) = \mu^{N}/N!\ e^{(-\mu)}$$

- Forecasters can edit calculated values before issuing active region and total disk forecasts.

Flare forecast products:

McIntosh class *% probability*

No.	Loc	Lo	Area	Z	LL	NN	Mag Type	Growth	M	X	P
23xx	S13W23	102	20	Bxo	4	3	Beta	Increase	1	0	0
2393	N18W20	99	30	Hsx	1	1	Alpha	Nil	2	0	0
2394	N11E01	78	190	Cai	6	9	Gamma	Nil	12	0	1
2395	N12E51	28	40	Hsx	1	1	Alpha	Nil	2	0	0
2396	S18E42	37	270	Dai	9	12	Beta-Gamma	Increase	14	1	1
Total Raw %									28	1	2
Total Issued %									5	1	1

Sunspot Region Summaries are issued every six hours for each classified active region.

Radio Blackout Forecasts (whole disk) are issued at midnight, with a midday update if necessary.

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)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	N	5	10	10	15
Very Active	R3 to R5 X Class	N	1	1	1	5

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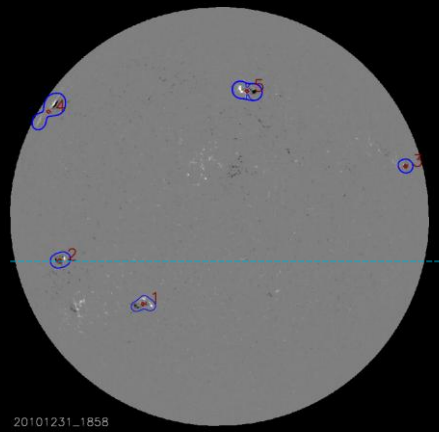
Solar Monitor Active Region Tracker

Forecasters track active regions of interest for flare activity potential.

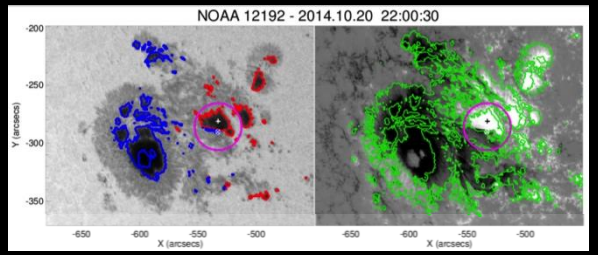
Large flares believed to occur preferentially in magnetic regions that are large, have a history of flaring, and are complex.

SMART (Higgins et al, 2011) automatically tracks regions of interest on disk.

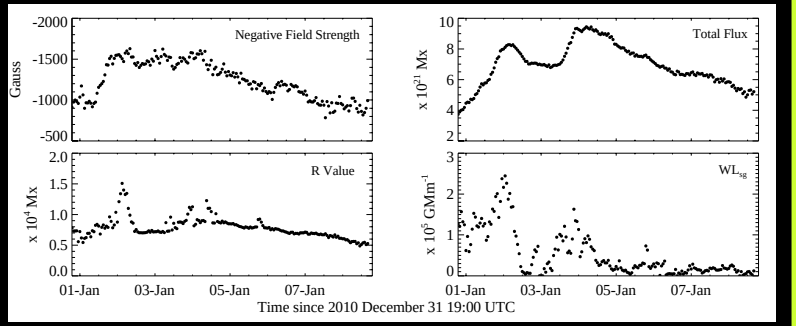
Evolution of magnetic properties such as flux, magnetic field strength, area, polarity separation line length, R value (Schrijver, 2007), and WL_{sg} (Falconer et al, 2008).



Tracking active region at this latitude



The SMART Delta Finder module automatically detects delta spots (Padinhatteeri et al, 2015).



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Coronal field extrapolations with SMART and Hexa

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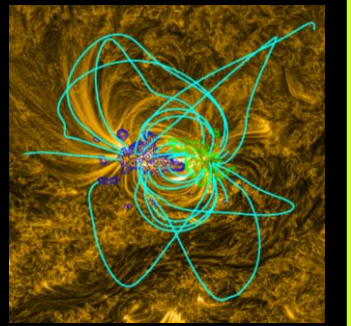
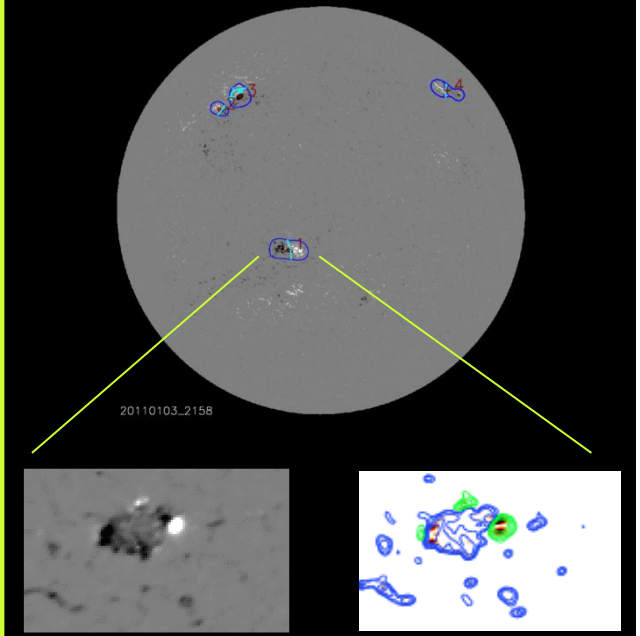
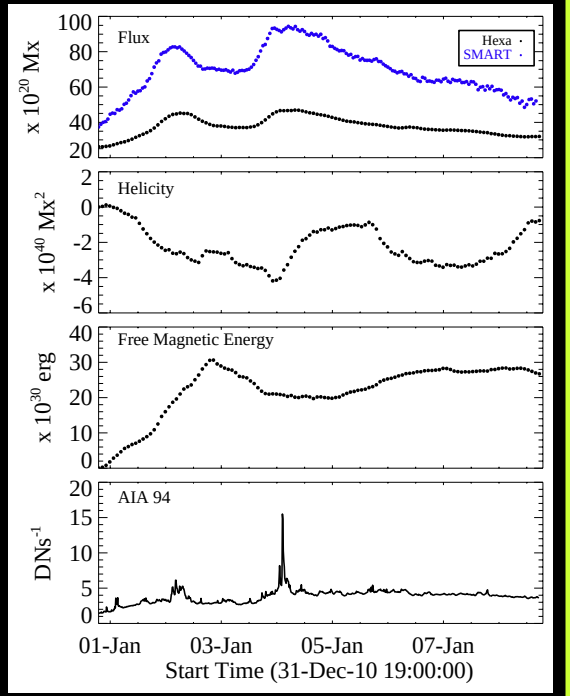
Using SMART to choose an active region to track, the Hexa code (Gibb et al, 2014) creates NLFFF extrapolation to calculate other magnetic field properties such as current density, free magnetic energy, and magnetic helicity.

3D magnetic field topology is useful for tracking changes in active region structure.



AIA 171Å processed image (Morgan et al, 2014) >>





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Flare forecast verification

Flare Scoreboard at NASA's CCMC is an automated system to compare flare forecasts in real time. Forecast submission can be made using the standardised ISES XML format.

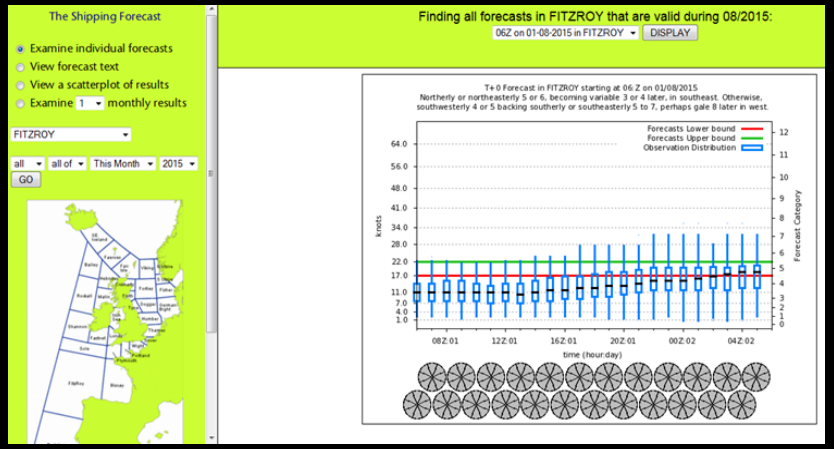
ISES is planning inter-comparison of operational centre outputs with Receiver Operating Characteristic curves and reliability diagrams.

FLARECAST is an EU Horizon 2020 project aiming to develop an automated flare forecasting system. Cloud infrastructure will allow anyone to plug in their methods to compare with others.

The system will be compared to the Met Office human-edited statistical forecast (see slide 1).

Learn more at **flarecast.eu**

In-house development of real-time verification of geomagnetic storm and flare forecasts is ongoing, using Ranked Probability Scores. Adapted from Area Forecast Verification System originally used to verify Shipping, High Seas, and Inshore Waters Forecasts (Sharpe, 2013).



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