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# Flare forecasting: a beginners guide

Sophie A. Murray First FLARECAST User Workshop 2017-01-12

### Flares

a reminder..



### **Forecast Types**

- Continuous
  - Soft X-ray flux over the next 24 hours.
- Probabilistic
  - There is a 20% chance of an M-class flare in the next 24 hours.
- Yes/no
  - There will be NO M-class flare in the next 24 hours.

### Making a forecast

- Identify property related to flaring
- Parameters to characterise this property

• Method to convert parameter values to a forecast

• Method to quantify the result

### Some operational methods









Australian Government

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**Royal Observatory** of Belgium

**NWRA** DAFFS



Korea Meteorological **KYUNG HEE** Administration UNIVERSITY



The University of Dublin www.SelarMenitor.org











### **Active Regions**

#### a reminder..





### **Active Region Classification**

#### McIntosh



- General distribution and size
- Primary penumbra shape
- Interior spot compactness

### **Active Region Classification**

#### McIntosh



#### Mt Wilson



unipolar



bipolar





mixing of polarities opposite polarity umbrae within one penumbra

### **MOSWOC Solar Synoptic Map**



### Calculating the probability

- Historical database of several decades of active region classifications and solar flare events
  - Calculate average flare rate for each classification
- Probability of flare occuring in next 24 hours is calculated from a simple equation using this rate

Combine each active region's probability to calculate a full-disk probability

### Issued flare forecasts

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			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	No	35	35	35	35

### Other operational methods







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# Are they any good? Which one is the best?

### Verification

Yes/no forecasts - skill scores

	Forecast flare	Forecast no flare	
Observed flare	True Positive (hit)	False Negative (miss)	
Observed no flare	False Positive (false alarm)	True Negative (correct negative)	

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN}$$

$$Skill = \frac{A_{forecast} - A_{reference}}{A_{perfect} - A_{reference}}$$

### Verification

#### Probabilistic forecasts - Reliability diagram



### Verification

#### Probabilistic forecasts - ROC curve



### **Scientific Results**

#### All-Clear Workshop

Georgoulis & Rust 2007 Colak & Qahwaji 2008, 2009 Yuan et al. 2010, 2011 Falconer et al. 2008 Leka & Barnes 2003a Schrijver 2007 McAteer et al. 2010 Barnes et al. 2010 Barnes et al. 2005 Higgins et al. 2011 Wheatland 2004 Gallagher et al. 2002; Bloomfield et al. 2012



'... no one method clearly outperformed all others'

'For M-class flares and above....with no participating method proving substantially better than climatological forecasts'

### **Operational Results**

#### Human vs machine



False Alarm Rate

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Hit Rate

Guerra et al



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## What can we do?

### **Operations** NASA/CCMC Flare Scoreboard





#### http://ccmc.gsfc.nasa.gov/challenges/flare.php



Ensembles



### Human vs machine

Ensembles

Hit Rate



False Alarm Rate

Guerra et al

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#### Flare Likelihood And Region Eruption ForeCASTing



#### FLARECAST

Flare Likelihood And Region Eruption foreCASTing THE FULLY AUTOMATED SOLAR FLARE FORECASTING SYSTEM A Horizon2020 PROTEC (Protection of our Assets in Space) Research and Innovation Action

#### http://www.flarecast.eu/



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