FLARECAST: A project overview

D. Shaun Bloomfield (Northumbria University, UK) FLARECAST Consortium (Europe)







FLARECAST's Origins



First H2020 funding call (PROTEC-1-2014 – Space Weather)

- <u>Scope</u>:

"Exploratory work studying **new ideas for data analysis** and modelling of space weather with a view to **enhancing the performance of space weather prediction**"

– Expected impact:

"...to deliver new insights into the detailed processes that generate space weather. This should contribute to new services able to predict, with a significantly higher precision than today, space weather events affecting the Earth"

Aims and Objectives



- The Flare Likelihood And Region Eruption foreCASTing (FLARECAST) project aims to:
 - 1. understand the drivers of flare activity and improve flare prediction
 - 2. provide a globally accessible flare prediction service that facilitates expansion
 - 3. engage with space-weather end users and inform policy makers and the public

Consortium Partners



Institution		Country	Expertise	
Academy of Athens (AA) Pr	roject Coordinator	GR	Solar physics, flare forecasting	
Trinity College Dublin (TCD)		IE	Solar physics, flare forecasting	
Università degli Studi di Genov	va (UNIGE)	IT	Mathematical techniques	
Consiglio Nazionale delle Rice	rche (CNR)	IT	Mathematical techniques	
Centre National de la Recherc (CNRS)	he Scientifique	FR	Solar physics, magnetic field simulations	
Université Paris-Sud (PSUD)		FR	Infrastructure (MEDOC)	
Fachhochschule Nordwestschweiz (FHNW)		СН	Computer science	
Met Office (MO)		UK	Operational SpWx, verification	
Northumbria University (UNN) Project Scientist	UK	Solar physics, flare forecasting, verification	

Consortium Locations







Project Structure



WP1: Project Management



Project Management Board

PC, PS, WP leaders (min. 1 partner representative)

monthly telecons; 6 monthly physical meetings

<u>Steering Committee</u>

- Neal Hurlbert (USA feature extraction/infrastructure) CHAIR
- Graham Barnes (USA flare forecasting)
- Doug Biesecker (USA operational SpWx)
- Pedro Russo (NL EPO)
- *Silvia Villa* (IT machine learning) **being approached*
 - quarterly telecons; 2 attending today (Neal & Graham)



<u>Catalogued Properties</u>

• McIntosh and Mt. Wilson classes

• Line-of-sight (LOS) Magnetic Properties

- spatial distribution: Fourier power index, (multi) fractal dimension
- connectivity: B-effective
- polarity inversion lines (PILs): Schrijver's R value, Falconer's ^LWL_{SG}

<u>Vector-magnetic Properties</u>

- localized version of SHARP header quantities (beyond just totals and averages)
- helicity measures
- refined flow field measures (DAVE4VM)

• <u>Property association with flares</u>

• full GOES soft X-ray flare history included in property database



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- McIntosh and Mt. Wilson classes
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- <u>Vector-magnetic Properties</u>
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<u>Primary Data Sources</u>

- SDO/HMI near real-time
 SHARP vector-magnetograms
- NOAA/SWPC
 - solar region summaries
 - GOES soft X-ray events
- <u>Secondary Data Sources</u>
 - exploring ground-based line-of-sight and vector data



WP3: Flare Prediction Algorithms



- **Existing Algorithms** •
 - Poisson average flare rate
 discriminant analysis
- **Unsupervised Clustering Methods** •
 - k-means

clustering with simulated annealing

- possibilistic C-means
- **Supervised Learning Methods** ightarrow
 - multi-layer perceptron (MLP)
 support vector machine (SVM)
 - recurrent neural network (NN)

WP4: Data Storage and Processing



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all DB reading/writing via http JSON data types, extendable

RESTful API for Data Transfer
• Semi-structured Data Model



WP4: Data Storage and Processing



- <u>Docker Containers</u>
 - compatible with all major OS
- pick and mix installation

	webapp	workflow	pipeline	hmi _service	property _service	prediction _service	algorithm	
	webapp	_service	_service	db_service				
Docker Engine								
Linux								

WP5: Data and Forecast Validation



Data Validation

checks of input data integrity and continuity

Forecast Verification: Benchmarking

- application of standard verification metrics
- assessment of prediction algorithms and their results, feeding into WP6 to improve active region properties and prediction techniques
- Forecast Verification: Error Assessment

techniques to assign uncertainty estimates to verification metrics

WP6: Explorative Research



Understanding Magnetic Eruptions

- exploitation of existing MHD simulations
- investigate the properties and evolutions that trigger eruptions
- Improving Flare Prediction
 - test new properties as predictors
 - create novel time series prediction algorithms



WP6: Explorative Research



- <u>Suitability of Forecast Time Scales</u>
 - study differing forecast windows and forecast latency
 - needs to be driven by the requirements of SpWx end-users

- Advance CME Prediction
 - gain insight by correlating active region properties with CME occurrence
 - alignment/interaction with existing EU projects (HELCATS)

WP7: Dissemination



Education and Public Outreach

- social media activity (e.g., Twitter), press releases
- participate at public events
- educational material for formal/informal learning and publicity materials
- Dissemination to Scientific Community
 - publish peer-reviewed literature
 - participate in diverse science meetings, coordinating thematic sessions
 - organize informational sessions for junior post-grad students (PROGRESS)
- Dissemination to Industry and Government
 - raise awareness by presenting at SpWx meetings with industrial focus
 - highlight societal impacts to policy makers and Government officials
 - organise workshops for end users in industry and Government

Final Thoughts



- Project progressing nominally
 - property DB (designed); property extraction algorithms (integrated)
 - prediction DB (designed); prediction algorithms (being integrated)
 - forecast DB (undergoing design); verification algorithms (being tested)
- Crucial stage for relevance/utility of forecasts
 - end-user recommendations required to guide tailoring
 - <u>Breakout I</u>: User needs and goals
 - <u>Breakout II</u>: Roadmap for flare forecast developments

Web Resources



<u>Website</u>: <u>http://flarecast.eu</u>

Twitter: @FLARECAST_EU