http://flarecast.eu

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FLARECAST SCIENCE: A COMPREHENSIVE DATABASE OF SOLAR FLARE PREDICTORS

ESWW13 S5: DEVELOPING NEW SWE TOOLS

Oostende, BE, 14 - 18 Nov 2016

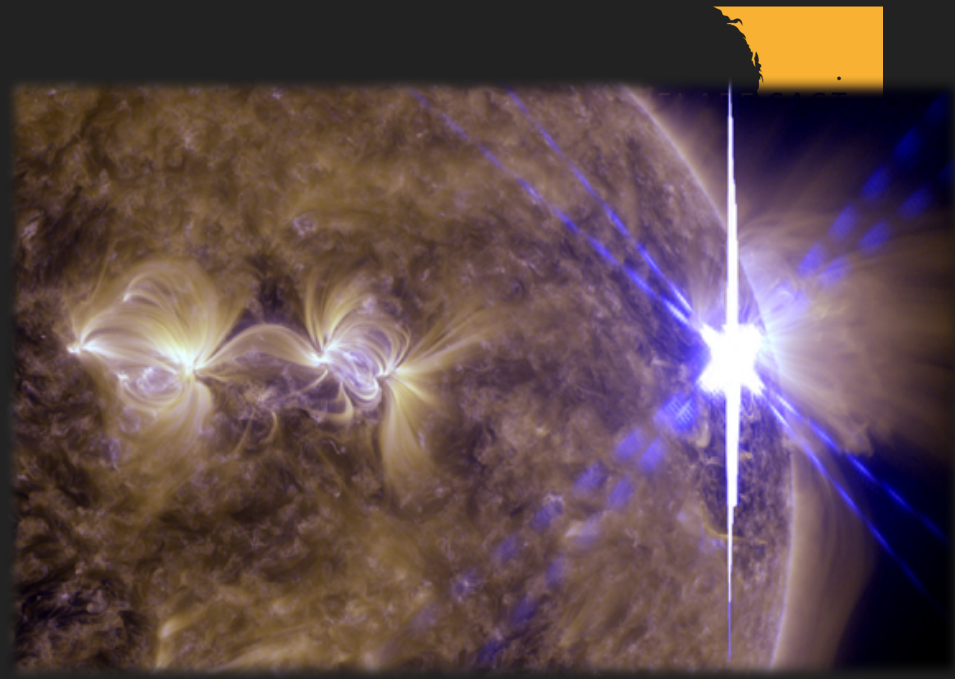
OUTLINE

- Introduction to FLARECAST
- FLARECAST under the hood
  - Data model
  - Science data
- Some preliminary results
- Conclusion

Source: thesuntoday.org

WHAT IS FLARECAST?

FLARECAST is an EC H2020 project that will develop an advanced solar flare prediction system based on automatically extracted physical properties of solar active regions, coupled with state-of-the-art solar flare prediction methods and validated using the most appropriate forecast verification measures.

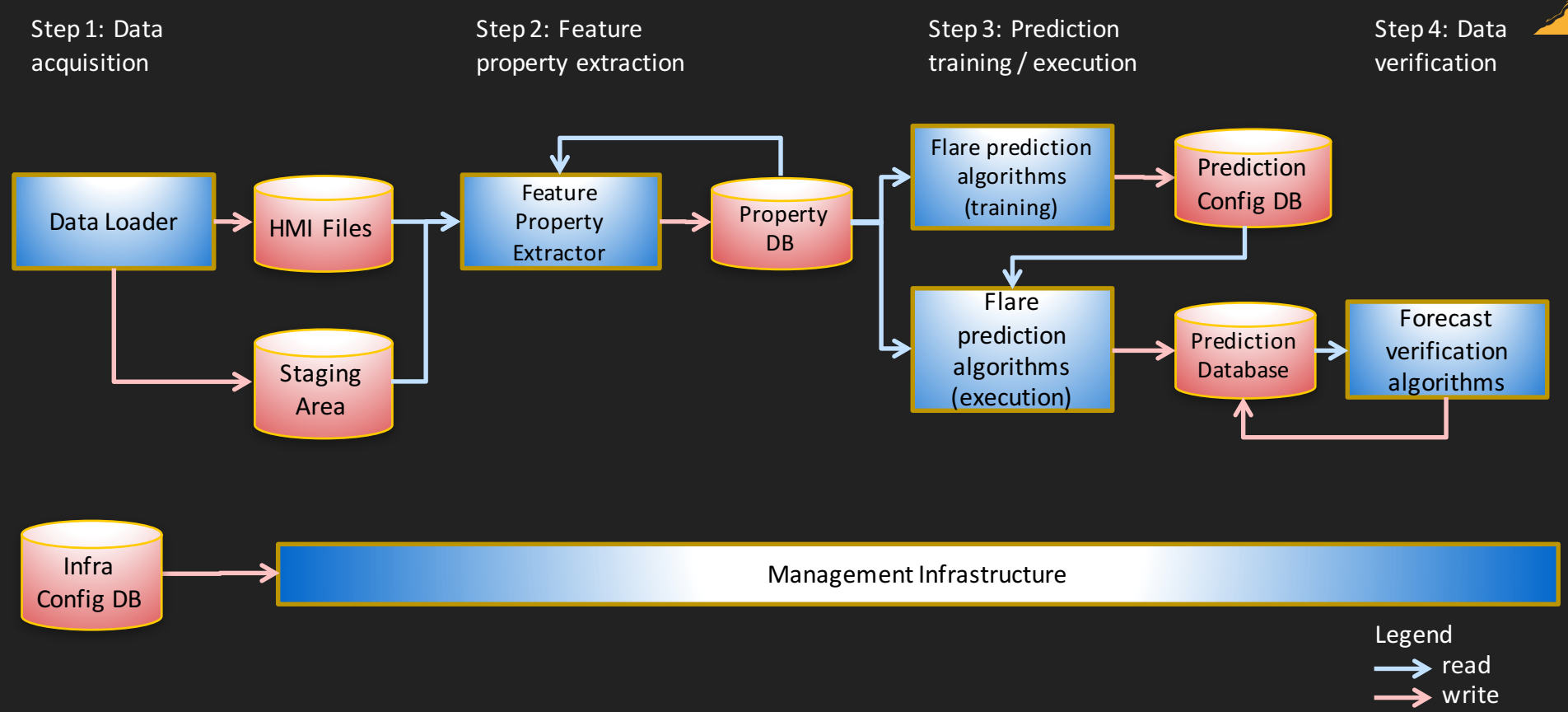


Source: NASA SDO

FLARECAST top-level objectives:

- To understand the drivers of solar flare activity and improve flare prediction
- To provide a globally accessible flare prediction service that facilitates expansion
- To engage with space weather end users and inform policy makers and the public

FLARECAST ARCHITECTURE



FLARECAST DATA TYPES

Overarching science question: how far can we go in predicting solar flares?

External data:

- SDO / HMI NRT SHARPs
- NOAA / SWPC SRS data
  - Active region numbers
  - AR locations
  - Flare occurrences

Science data:

- Extracted properties
- Prediction algorithm config.
- Predictions
- Validation

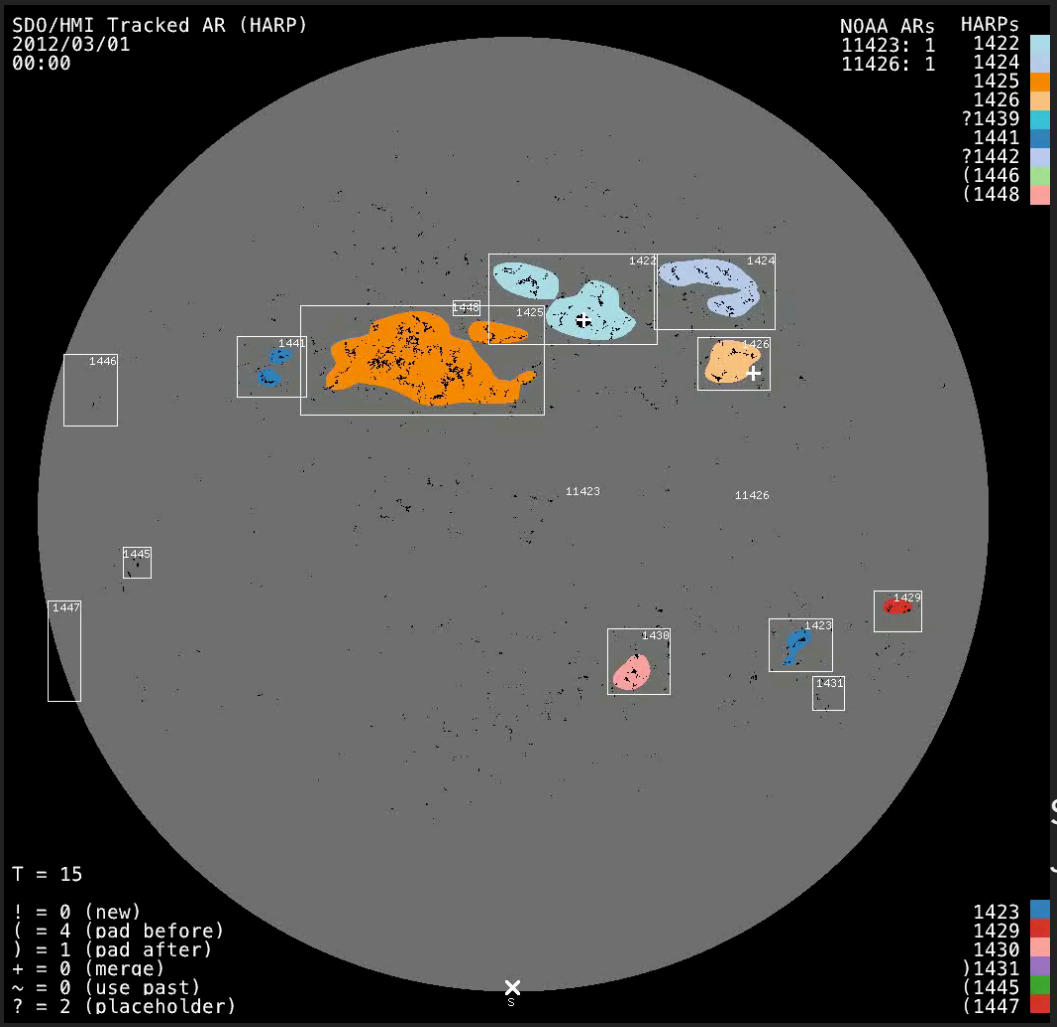
Infrastructure data:

- Algorithm management
- Workflow management

FLARECAST EXTERNAL DATA

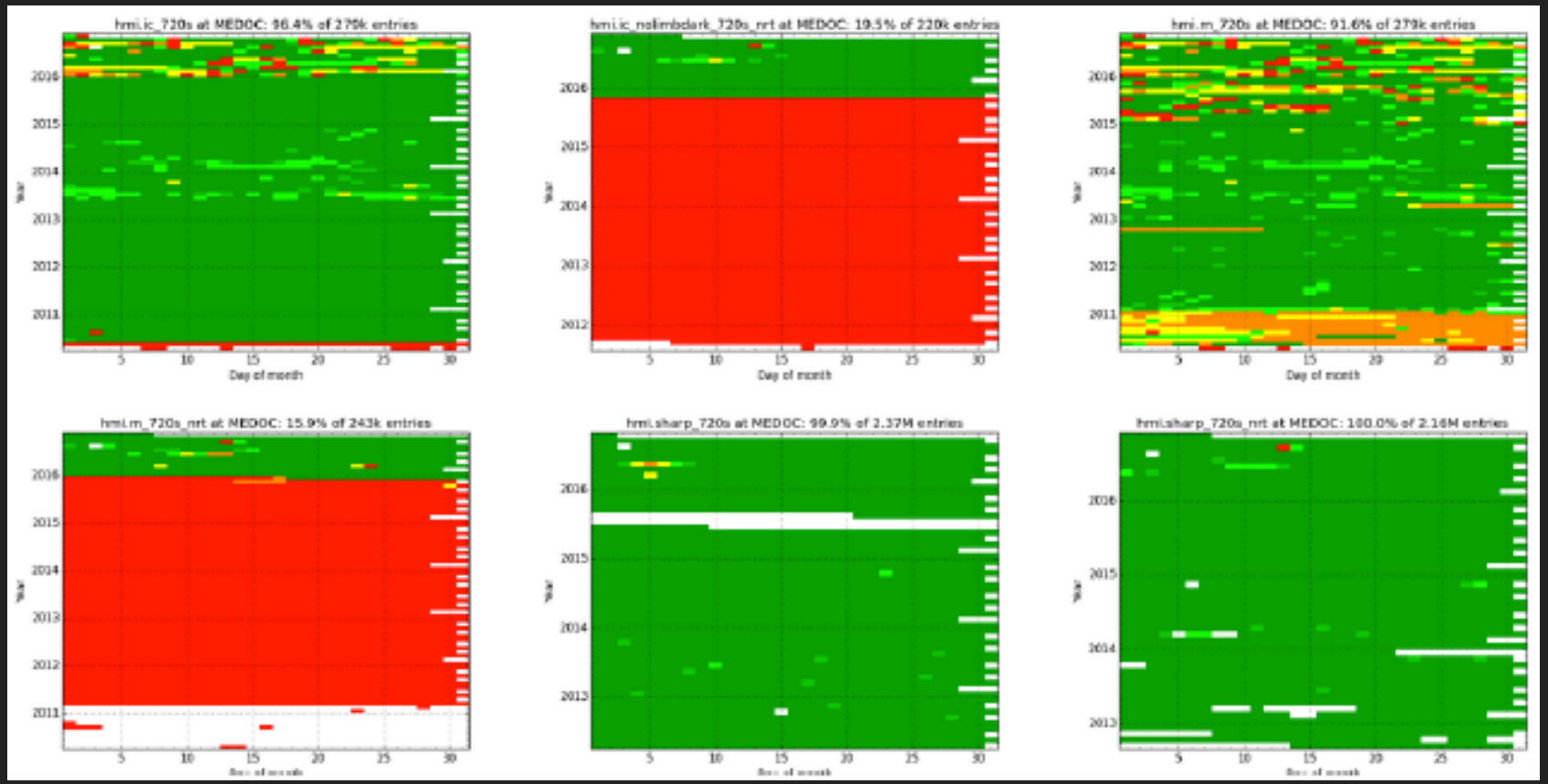
- **SDO / HMI data**
  - SHARP vector magnetograms - NRT (*hmi.sharp_720s_nrt*)
  - LOS magnetograms (*hmi.M_720s*)
  - SHARP vector magnetograms - definitive (*hmi.sharp_720s*)
- **SRS active region & flare data**

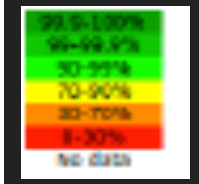
  (*YYYY_events.tar.gz*)



Source: SDO / HMI JSOC

CURRENT HMI JSOC DATA AVAILABILITY





Total data allocated space: ~240 TB

Courtesy: E. Buchlin

FLARECAST SCIENCE DATA : PROPERTIES

Properties utilizing LOS magnetograms

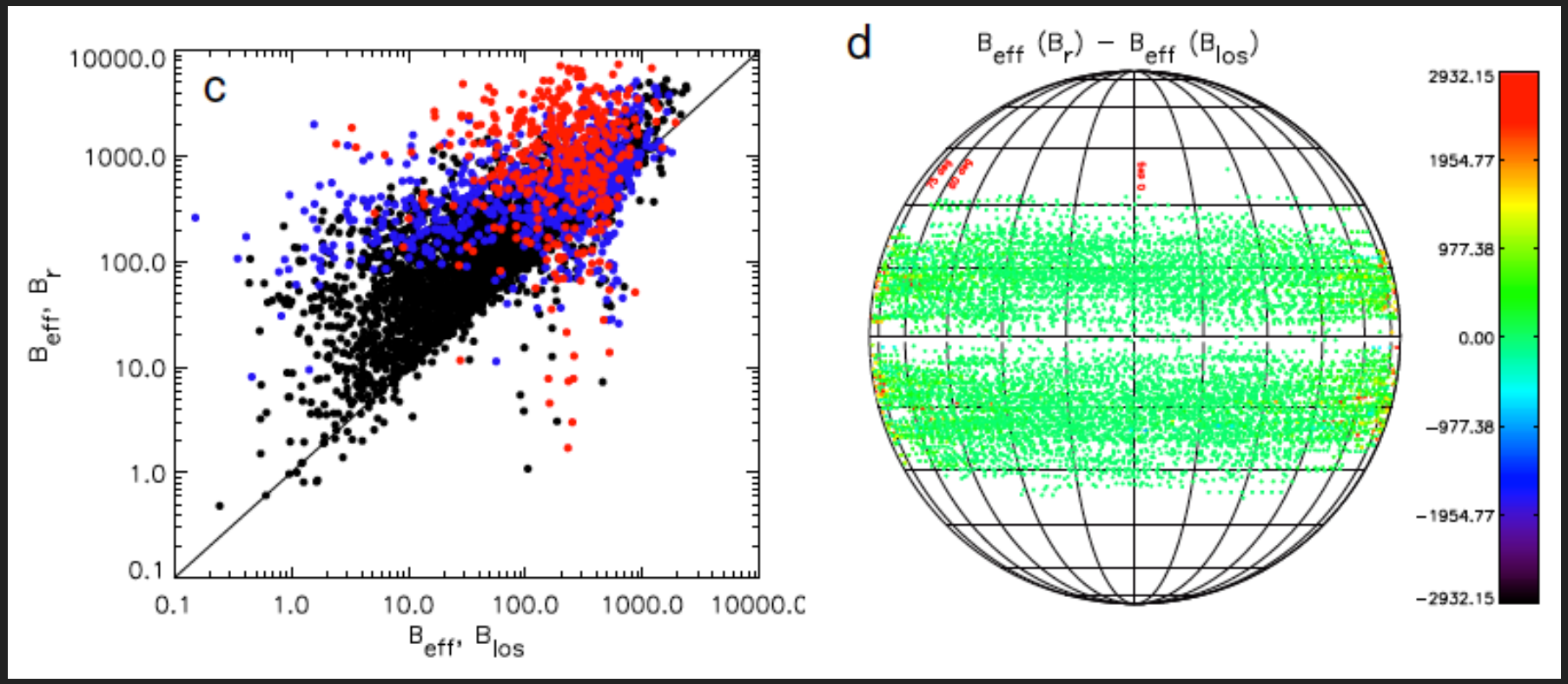
Properties provided by SHARPs + published over last ~25 years, until today

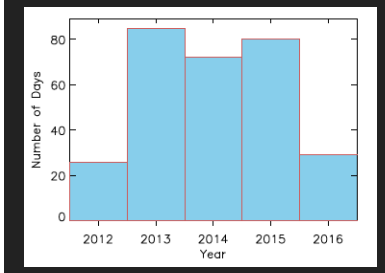
Properties utilizing vector magnetograms

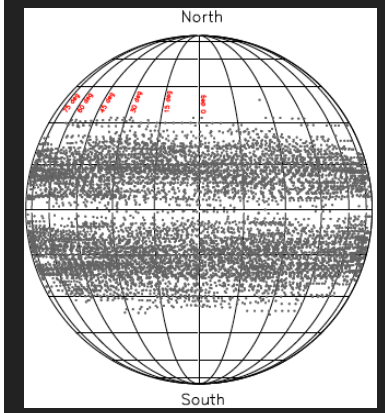
Data Source	Property Group	Developer	Status
SWPC catalogues			(To do / In progress / Under testing / Delivered)
	Solar Region Summary properties	TCD	
	GOES X-ray events	TCD	
LOS magnetograms			
	SMART-derived properties (Ahmed et al., 2013)	TCD	In progress
	SMART delta finder (Padirhatteeri et al., 2015)	TCD	To do
	Effective connected magnetic field strength (B_{eff}) (Georgoulis & Rust, 2007)	AA	Delivered
	Fractal dimension (Georgoulis, 2012)	AA	Delivered
	Multi-fractal structure function s(q) inertial range index k (Georgoulis, 2012)	AA	Delivered
	Fourier power spectral index (Guerra et. al., 2015)	AA / TCD	Under testing / Delivered
	CWT power spectral index (Hewett et. al., 2008)	TCD	Delivered
	Generalised correlation dimension (Georgoulis, 2012)	AA	Delivered
	Holder exponent h (Conlon et al., 2010)	AA	In progress
	Hausdorff dimension D(h) (Conlon et al., 2010)	AA	In progress
	WTMM (Conlon et al., 2010)	TCD	In progress
	Decay index (Zuccarello et al. 2014)	TCD	Delivered
	Magnetic polarity inversion line characteristics (Mason & Hoeksema 2010)	TCD	Delivered
	3D magnetic null point (Reid et al. 2012)	TCD	Under testing
	R (Schrijver 2007) *	TCD	Delivered
	$^{L}WL_{SG}$ (Falconer et al. 2008) *	TCD	Delivered
	Ising energy (Ahmed et al. 2010)	AA	Delivered
	WG_M and S_{LF} (Korsos et al. 2015)	AA	Under testing
	Magnetic helicity injection rate proxy (Park et al. 2010)	TCD	Under testing
Vector magnetograms			
	SHARP properties (Bobra et al. 2014)	TCD	Under testing
	Magnetic helicity injection rate (Berger & Field 1984)	TCD	Under testing
	Magnetic energy injection rate (Kusano et al. 2002)	TCD	Under testing
	Non-neutralized currents (Georgoulis et al., 2012)	AA	Delivered
	Flow fields (Wang et al. 2014)	TCD	Under testing
	Magnetic bipolar feature characteristics	TCD	Under testing
Intensity images			
	Flow fields	TCD	Under testing

FLARECAST SCIENCE DATA : PROPERTIES

Courtesy: J. Guerra et al.







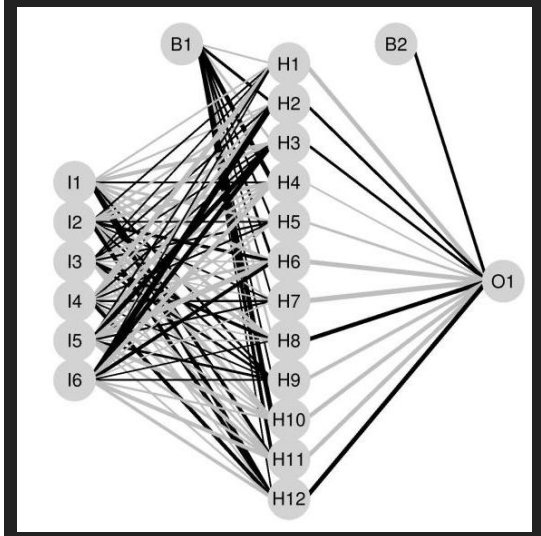
Studying the impact of LOS-inferred vs. vector-inferred predictors on selected data set

FLARECAST SCIENCE DATA: ALGORITHMS

- **Algorithms considered**
  - Standard ML
  - Advanced ML
  - Non-ML
  - Innovative ML

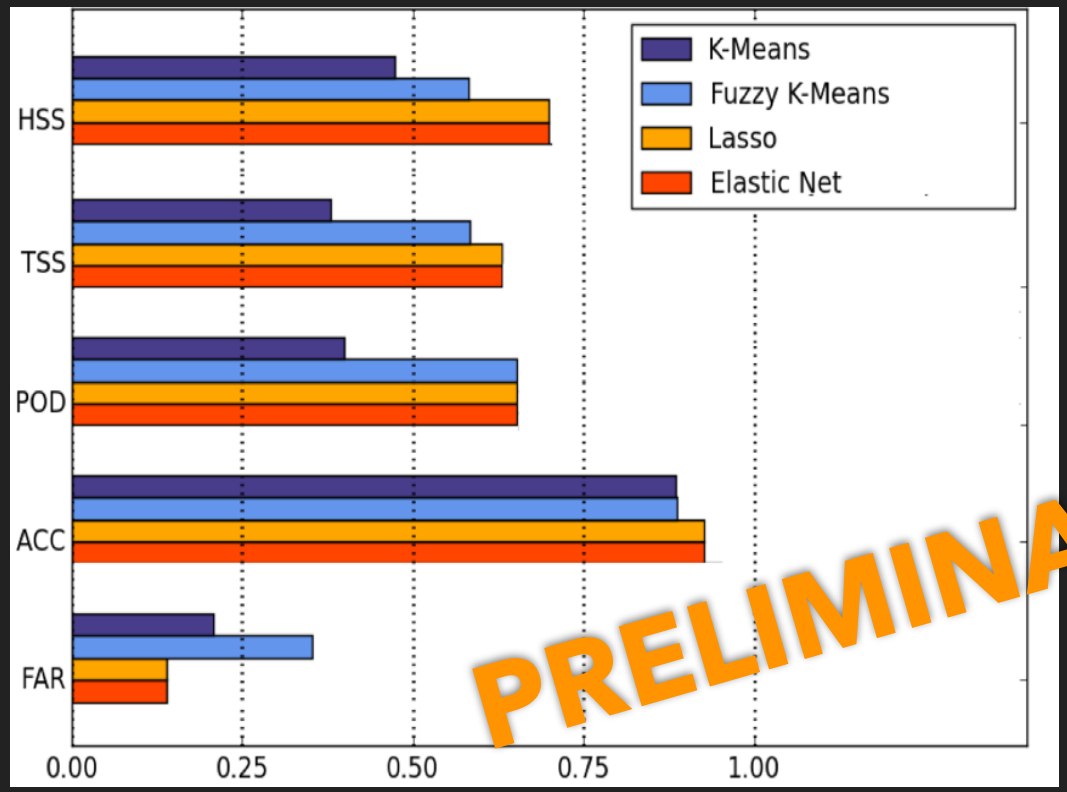
Parameter classification by means of their importance for prediction, using an advanced method

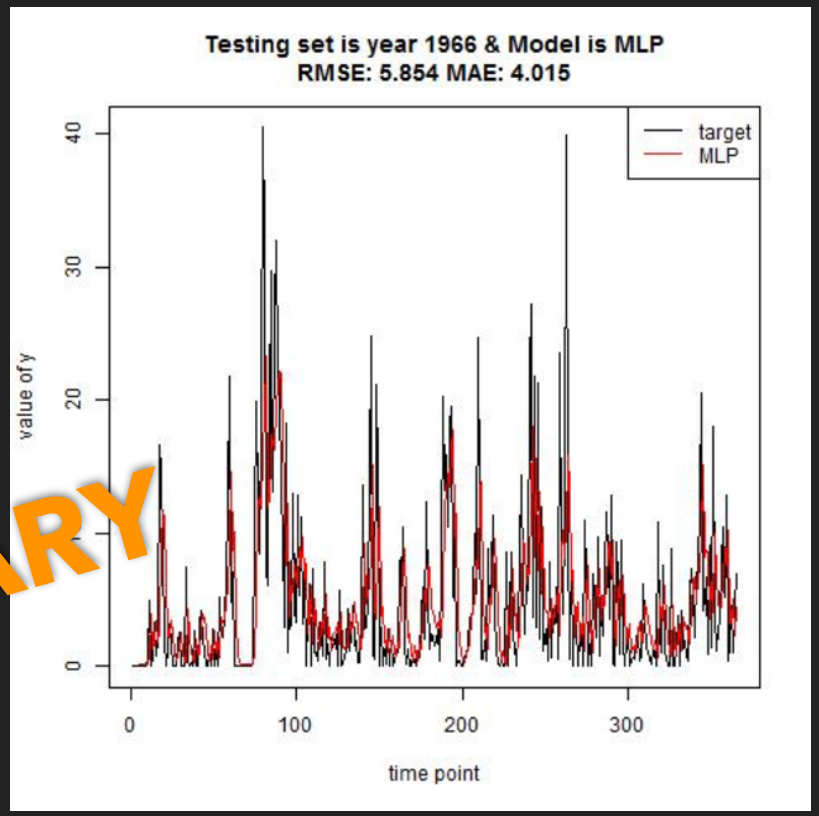
Courtesy: A. M. Massone et al.



Example of a multi-layer perceprton algorithm

FLARECAST SCIENCE DATA: VALIDATION





PRELIMINARY

Some validation results on specific methods and data subsets

CONCLUSION

- FLARECAST: a project in full swing
- Work delivered independently and at different levels – watch out for project-supported refereed papers in the next months
- **Science data model**: two [2] types of external data (HMI, SRS); four [4] types of science data (predictors, algorithms, prediction, validation)
- Property database on full data set is currently at work – prediction algorithms tested to a significant degree on partial data sets
- First comprehensive prediction results due in a few months – project expiring at the end of 2017

FLARECAST AT ESWW13

Courtesy: S.-H. Park

Date	Time	Session	Title	Author(s)
15/11 Tue	10:00-11:00	S4.p23	*Investigating the reliability of photospheric eruptivity proxies*	Guennou et al.
15/11 Tue	10:00-11:00	S4.p24	*Exploring the solar-flare predictive potential of non-neutralized currents and Ising energy in solar active regions*	Kontogiannis et al.
15/11 Tue	10:00-11:00	S4.p25	*Comparative Analysis of Flaring and Non-Flaring Active Regions*	Guerra et al.
15/11 Tue	10:00-11:00	S4.p26	*Parameterization of Solar Active Region Magnetic Fields and Flows for Flare Forecasting*	Park et al.
15/11 Tue	12:50-13:00	S5 talk	*FLARECAST Development Infrastructure: A science-oriented data processing framework*	Soldati et al.
16/11 Wed	12:10-12:25	S5 talk	*FLARECAST Science: A comprehensive database of solar flare predictors*	Georgoulis et al.
17/11 Thu	11:10-11:20	S11 talk	*FLARECAST Prediction Algorithms: Machine-learning methods for flare prediction and feature selection*	Piana et al.
17/11 Thu	11:30-11:40	S11 talk	*Solar Flare Forecasting from Magnetic Feature Properties Generated by the SMART Algorithm*	Bloomfield et al.

Don't miss the FLARECAST booth at the fair this afternoon!