

CME and solar flare forecasting at ROB and collaboration with CCMC

Andy Devos and Jesse Andries
Royal Observatory of Belgium (ROB)
Solar-Terrestrial Centre of Excellence (STCE)
Belgium

CCMC Workshop

April 14, 2016

Space Pole in Brussels

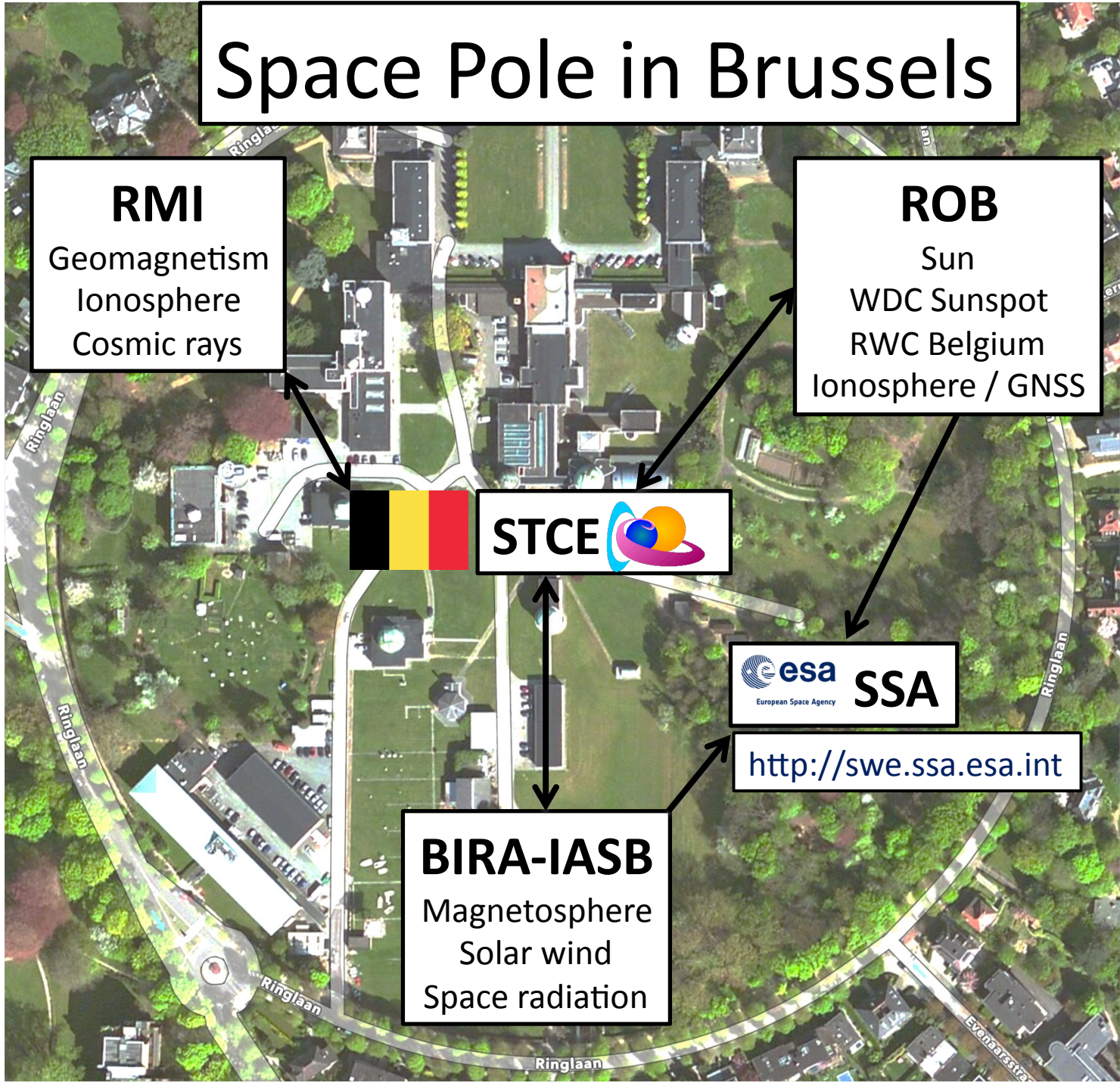
RMI
Geomagnetism
Ionosphere
Cosmic rays

ROB
Sun
WDC Sunspot
RWC Belgium
Ionosphere / GNSS

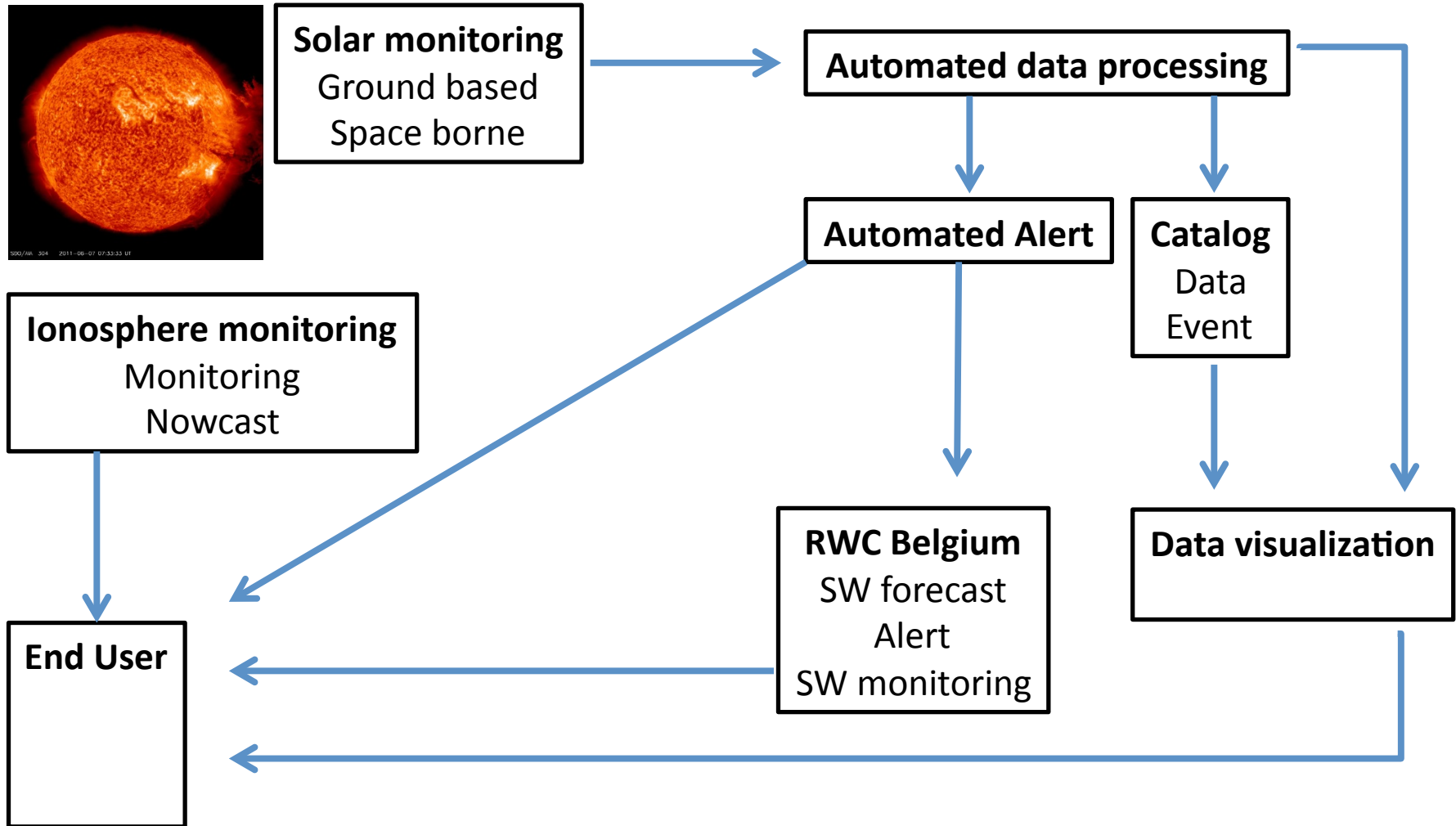


<http://swe.ssa.esa.int>

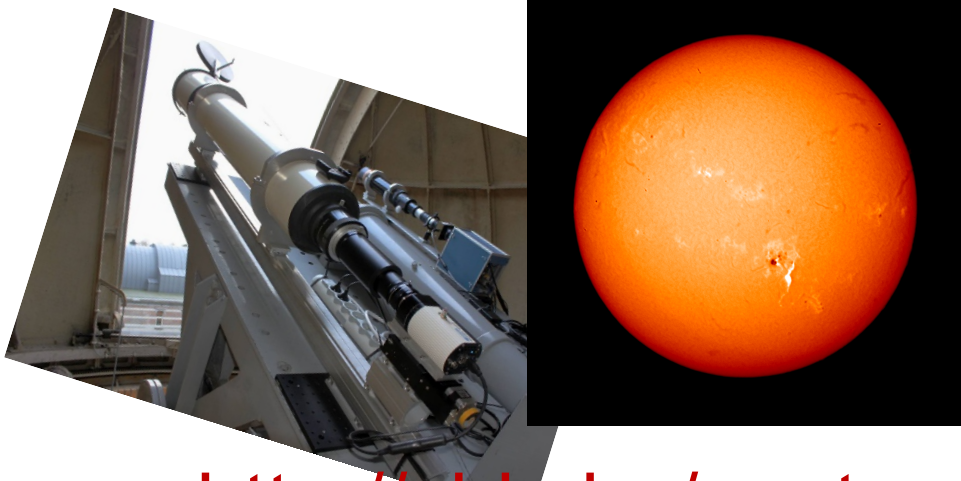
BIRA-IASB
Magnetosphere
Solar wind
Space radiation



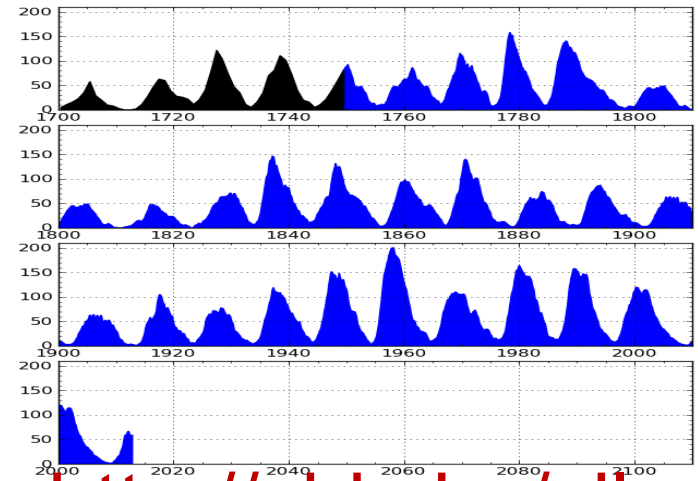
ROB assets & expertise at all stages of SW events



Ground and space observations

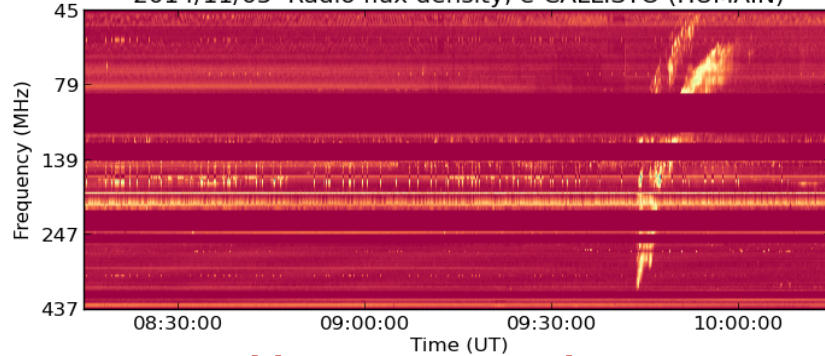
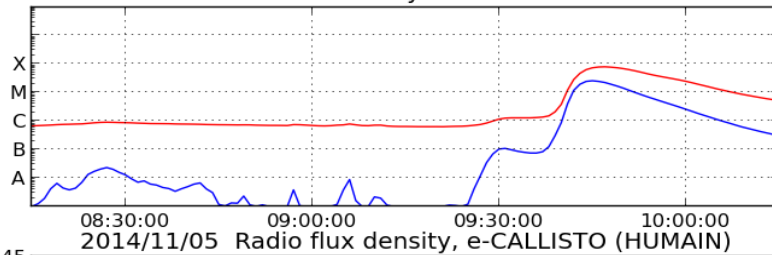


<http://sidc.be/uset>

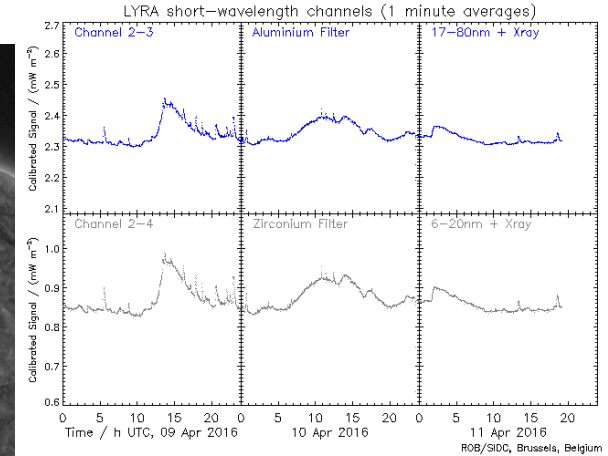
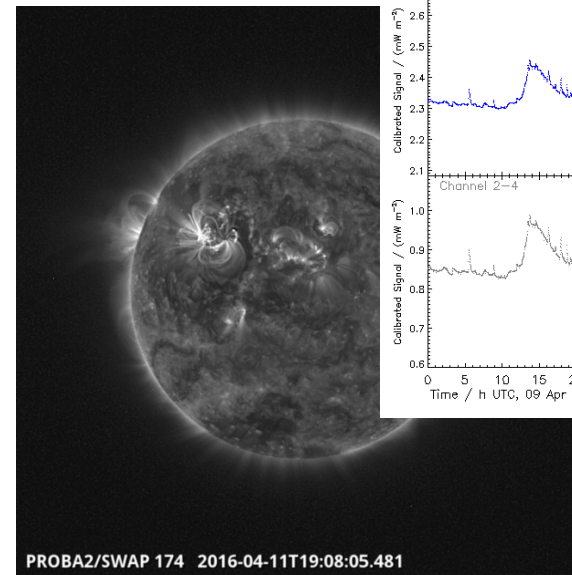


<http://sidc.be/silso>

GOES-15 Soft X-ray flux from NOAA

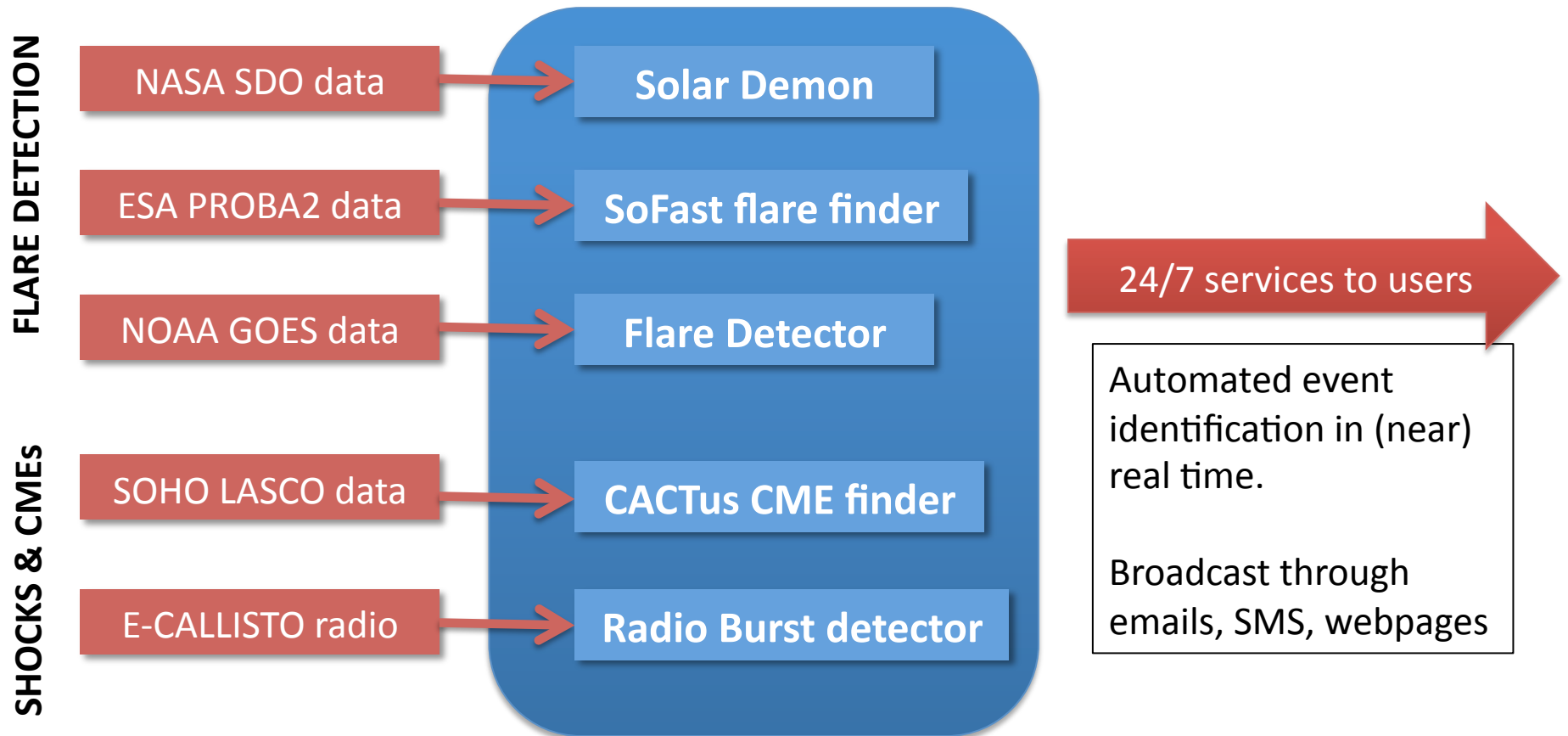


<http://sidc.be/humain>

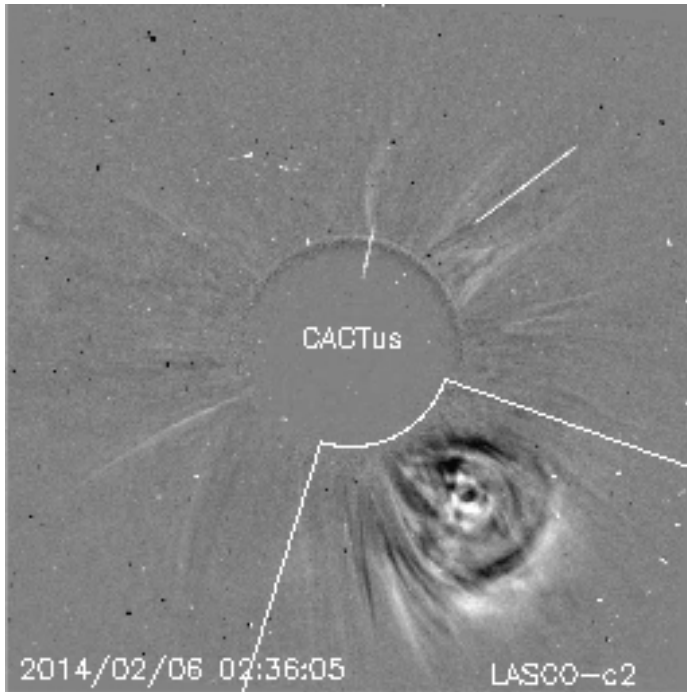


<http://proba2.sidc.be>

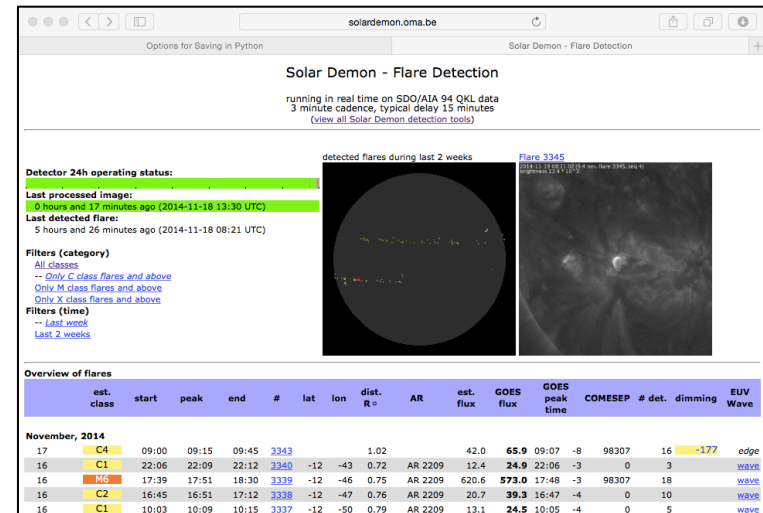
24/7 services through automated operations



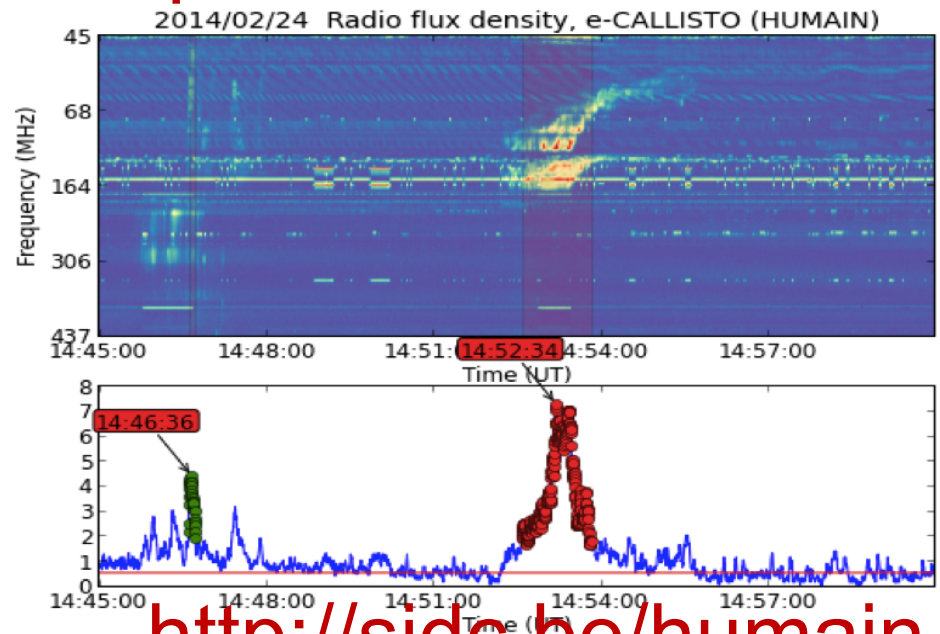
Detection tools



<http://sidc.be/cactus>



<http://solardemon.oma.be>

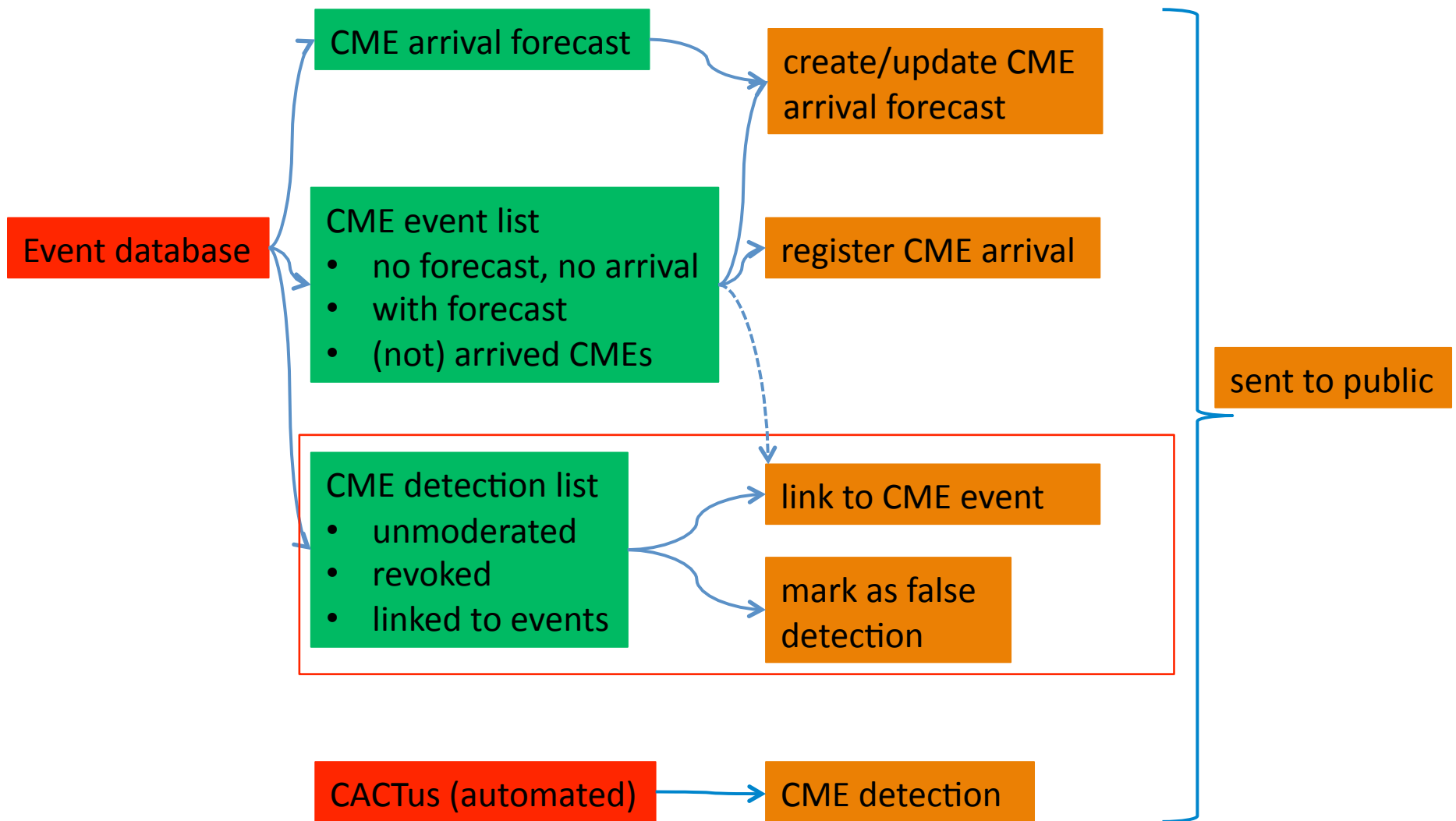


<http://sidc.be/humain>

Connect our data

- Many different tools, alerts and observations
- But
 - not connected
 - not in centralized database
 - no ability to add expert or forecast interpretation
 - ... **not yet**

Event database for CME arrival



Forecast verification

Parameters

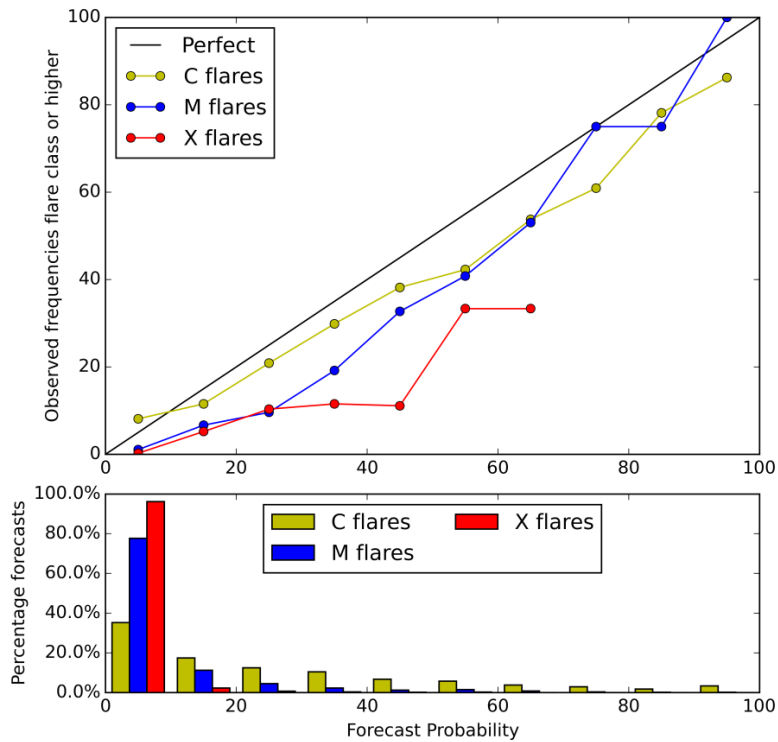
- Flares
- F10.7
- Local K-index

Verification

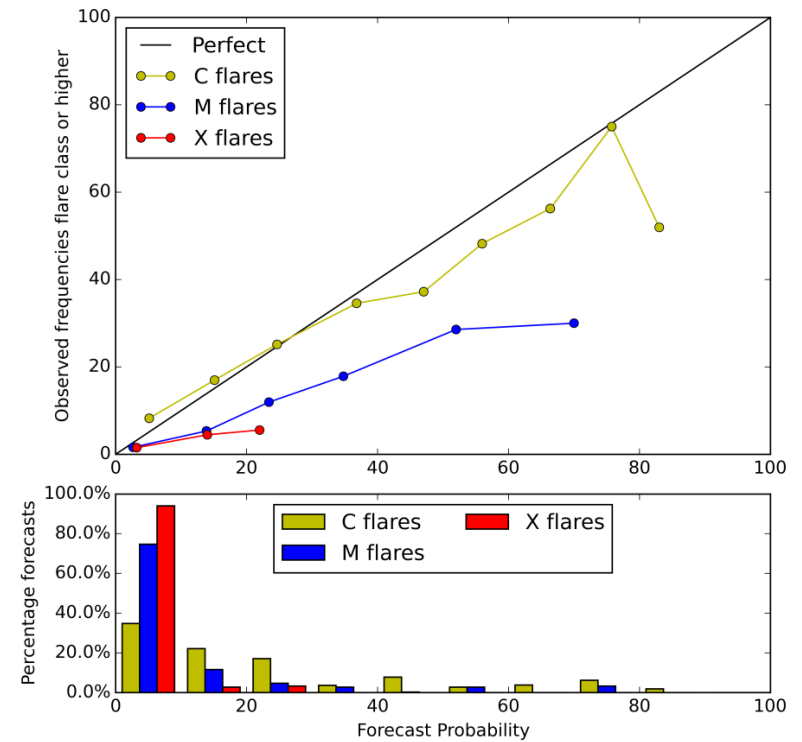
- Skill scores
- (Conditional) error analysis
- Reliability analysis
- ...

Forecast verification - flares

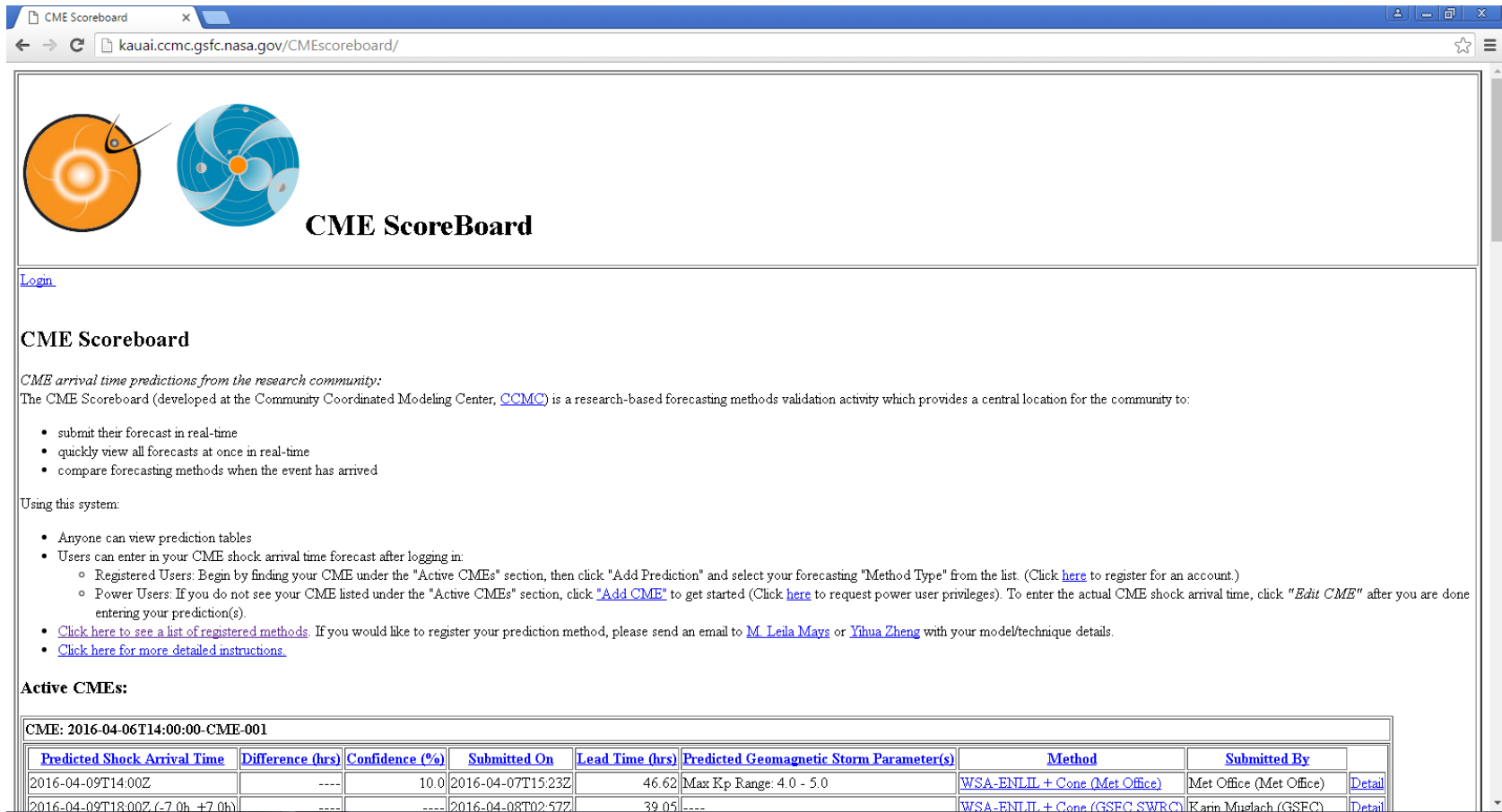
Manual forecast (N=8384)



Forecast using McIntosh (N=8278)



CME arrival estimation



CME ScoreBoard

[Login](#)

CME Scoreboard

CME arrival time predictions from the research community:
The CME Scoreboard (developed at the Community Coordinated Modeling Center, [CCMC](#)) is a research-based forecasting methods validation activity which provides a central location for the community to:

- submit their forecast in real-time
- quickly view all forecasts at once in real-time
- compare forecasting methods when the event has arrived

Using this system:

- Anyone can view prediction tables
- Users can enter in your CME shock arrival time forecast after logging in:
 - Registered Users: Begin by finding your CME under the "Active CMEs" section, then click "Add Prediction" and select your forecasting "Method Type" from the list. (Click [here](#) to register for an account.)
 - Power Users: If you do not see your CME listed under the "Active CMEs" section, click "[Add CME](#)" to get started (Click [here](#) to request power user privileges). To enter the actual CME shock arrival time, click "[Edit CME](#)" after you are done entering your prediction(s).
- [Click here to see a list of registered methods](#). If you would like to register your prediction method, please send an email to [M. Leila Mays](#) or [Yihua Zheng](#) with your model/technique details.
- [Click here for more detailed instructions](#).

Active CMEs:

CME: 2016-04-06T14:00:00-CME-001

Predicted Shock Arrival Time	Difference (hrs)	Confidence (%)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By	
2016-04-09T14:00Z	----	10.0	2016-04-07T15:23Z	46.62	Max Kp Range: 4.0 - 5.0	WSA-ENLIL + Cone (Met Office)	Met Office (Met Office)	Detail
2016-04-09T18:00Z (-7.0h +7.0h)	----	----	2016-04-08T02:57Z	39.05	----	WSA-ENLIL + Cone (GSEC, SWRC)	Karin Muslach (GSEC)	Detail

<http://kauai.ccmc.gsfc.nasa.gov/CMEScoreboard/>

Collaboration with M. L. Mays and M. Kuznetsova (CCMC)

CME arrival estimation

CME Scoreboard

kauai.ccmc.gsfc.nasa.gov/CMEScoreboard/

CME: 2016-02-11T21:28:00-CME-001
 Actual Shock Arrival Time: 2016-02-15T05:15Z
 Observed Geomagnetic Storm Parameters:

 CME Note: C8.9 flare originating from AR 12496/97 complex (with peak at 21:03), eruption from near the polarity inversion line between the 2 ARs, wave going to the north and west, AIA 304 shows dark absorption material being ejected, nice post-eruptive loops in AIA 193, CME is partial halo seen in LASCO and STA.

Predicted Shock Arrival Time	Difference (hrs)	Confidence (%)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By	
2016-02-15T03:00Z (-12.0h, +12.0h)	-2.25	70.0	2016-02-11T23:53Z	77.37	Max Kp Range: 4.0 - 7.0	Other (SIDC)	Leila Mays (GSFC)	Detail
2016-02-15T06:14Z (-7.0h, +7.0h)	0.98	----	2016-02-12T02:27Z	74.80	Max Kp Range: 3.0 - 5.0	WSA-ENLIL + Cone (GSFC SWRC)	Karin Muglach (GSFC)	Detail
2016-02-15T05:51Z (-7.0h, +7.0h)	0.60	----	2016-02-12T02:52Z	74.38	Max Kp Range: 3.0 - 5.0	WSA-ENLIL + Cone (GSFC SWRC)	Ethan Robinett (CUA)	Detail
2016-02-15T03:00Z	-2.25	----	2016-02-12T12:20Z	64.92	Max Kp Range: 3.0 - 5.0	WSA-ENLIL + Cone (Met Office)	Met Office (Met Office)	Detail
2016-02-15T01:00Z	-4.25	----	2016-02-12T17:19Z	59.93	Max Kp Range: --- - 5.0	WSA-ENLIL + Cone (NOAA/SWPC)	Leila Mays (GSFC)	Detail
2016-02-15T10:04Z	4.82	----	2016-02-12T18:33Z	58.70	----	SPM	Xinhua Zhao (NSSC CAS)	Detail
2016-02-14T18:37Z	-10.63	100.0	2016-02-12T18:39Z	58.60	----	SPM2	Xinhua Zhao (NSSC CAS)	Detail
2016-02-15T03:42Z	-1.55	83.6667	---	---	Max Kp Range: 3.2 - 5.33333	Average of all Methods	Auto Generated (CCMC)	Detail
2016-02-15T05:51Z (-7.0h, +7.0h)	0.60	81.0	2016-02-17T02:22Z	-45.12	Max Kp Range: 3.0 - 5.0	Ensemble WSA-ENLIL + Cone (GSFC SWRC)	Ethan Robinett (CUA)	Detail

CME: 2016-02-05T21:30:00-CME-001
 Actual Shock Arrival Time: 2016-02-11T15:54Z
 Observed Geomagnetic Storm Parameters:

Predicted Shock Arrival Time	Difference (hrs)	Confidence (%)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By	
2016-02-09T07:00Z (-12.0h, +12.0h)	-56.90	40.0	2016-02-06T12:17Z	123.62	Max Kp Range: 3.0 - 6.0	Other (SIDC)	Leila Mays (GSFC)	Detail
2016-02-08T21:00Z	-66.90	50.0	2016-02-06T16:00Z	119.90	Max Kp Range: 4.0 - 7.0	WSA-ENLIL + Cone (Met Office)	Met Office (Met Office)	Detail
2016-02-09T18:00Z (-7.0h, +7.0h)	-45.90	----	2016-02-06T16:19Z	119.58	----	WSA-ENLIL + Cone (GSFC SWRC)	Leila Mays (GSFC)	Detail
2016-02-08T23:03Z	-64.85	4.0	2016-02-07T03:11Z	108.72	----	Ensemble WSA-ENLIL + Cone (GSFC SWRC)	Leila Mays (GSFC)	Detail
2016-02-08T21:11Z	-66.72	0.0	2016-02-07T23:30Z	88.40	----	SPM2	Xinhua Zhao (NSSC CAS)	Detail
2016-02-09T03:38Z	-60.27	23.5	---	---	Max Kp Range: 3.5 - 6.5	Average of all Methods	Auto Generated (CCMC)	Detail







CME: 2016-01-15T00:00:00-CME-001

Flare forecast

Flare Scoreboard

ccmc.gsfc.nasa.gov/challenges/flare.php

Currently registered models:

ASSA Automatic Solar Synoptic Analyzer 	ASAP Automated Solar Activity Prediction 	BoM Data-driven probabilistic flare forecast model 
MAG4 MAG4 LOS and Vector Magnetogram Forecasts (four products) 	Met Office Space Weather Forecast (full disk) and Sunspot Region Summary 	SIDC SIDC human operator moderated 
AMOS Automatic McIntosh-based Occurrence probability of Solar activity		

UFCORIN method and more coming soon!

[Click here to learn how to download flare forecast files from the database.](#)

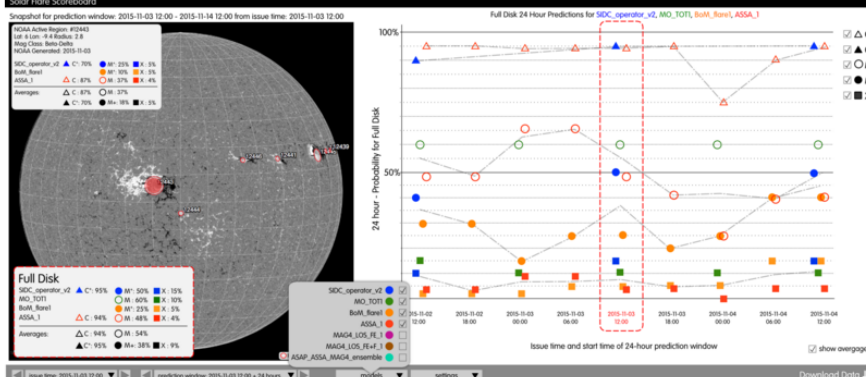
>>> [Link: Beta live display of real-time Flare Scoreboard full disk forecasts on iSWA](#) <<<
Tip: start by choosing an issue time of 00:00, 06:00, 09:00, 12:00, or 18:00 and then use the arrows to step by 6 hrs.

Flare Scoreboard Visualization Mock-up

Solar Flare Scoreboard

Snapshots for prediction window: 2015-11-03 12:00 - 2015-11-14 12:00 from issue time: 2015-11-03 12:00

Full Disk 24-Hour Predictions for SIDC_operator_v2, MO_TOTI, BoM, RRA_v1, ASSA_1



Feedback welcome!

<http://ccmc.gsfc.nasa.gov/challenges/flare.php>

Collaboration with M. L. Mays and M. Kuznetsova (CCMC)

Flare forecast

- Flare forecast probabilities in xml file
- Time of issue
- Forecast period
- Flare classes: C-flare = '>C1.0' or 'C1.0-C9.9'
- Forecast per region
- ...

Work in progress

- Event database is being setup
 - better integration of different type of events
 - better and more flexible service to users
 - easier post-event analysis
- Verification analysis: to be continued
- Scoreboards for flares and CMEs (@ CCMC)
 - comparisons of forecasts from multiple models & contributions