Community-wide space weather Scoreboards:

Research assessment of real-time forecasting models and techniques

http://ccmc.gsfc.nasa.gov/challenges

ESWW13 Thursday Nov17th, 15:00 - 16:30, Ridderzaal

Organizers:

M. Leila Mays (CUA/GSFC)
Mark Dierckxsens (BIRA-IASB)
Mike Marsh (UK Met Office)
Sophie Murray (TCD)
Jesse Andries (ROB)
Shaun Bloomfield (Northumbria University)
Jordan Guerra (TCD)
Masha Kuznetsova (GSFC)

KOREAN SPACE WEATHER CENTER

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THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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Australian Government Bureau of Meteorology

Korea Meteorological Administration

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SPACE ENVIRONMENT TECHNOLOGIES
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COMMUNITY COORDINATED MODELING CENTER

Met Office

BIRA·IASB

aeronomie·be

Royal Observatory of Belgium

northumbria UNIVERSITY NEWCASTLE

TRINITY COLLEGE DUBLIN

Agenda

- Introduction and general overview of agenda items (Leila)
- CME Scoreboard (Leila Mays):
  - Demo of CME Scoreboard
  - Initial CME scoreboard verficiation from the UK Met Office (Suzy Bingham)
  - Discussion of CME arrival time validation techniques (Leila)
  - Open to the floor for further ideas
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  - Brief introduction to the flare scoreboard and demo (Sophie)
  - Discussion regarding mock-up of time-series display (Leila)
  - Validation discussion (Sophie)
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  - General introduction: What is the scoreboard, how to register, how to submit forecast (Mark)
  - XML Schema for submission of forecasts; quantities and observations to compare (Mark)
  - SEP Scoreboard display mock-ups: Probility chart and flux profiles, Probability chart time-series (Leila)
  - Comparisons using historic SEP events (Mark)
  - Verification techniques: metrics, skill scores,... (Mark)
  - Linking flare & CME forecasts with SEP forecasts through scoreboard (Leila)

http://ccmc.gsfc.nasa.gov/challenges/scoreboards/esww13_wm.php

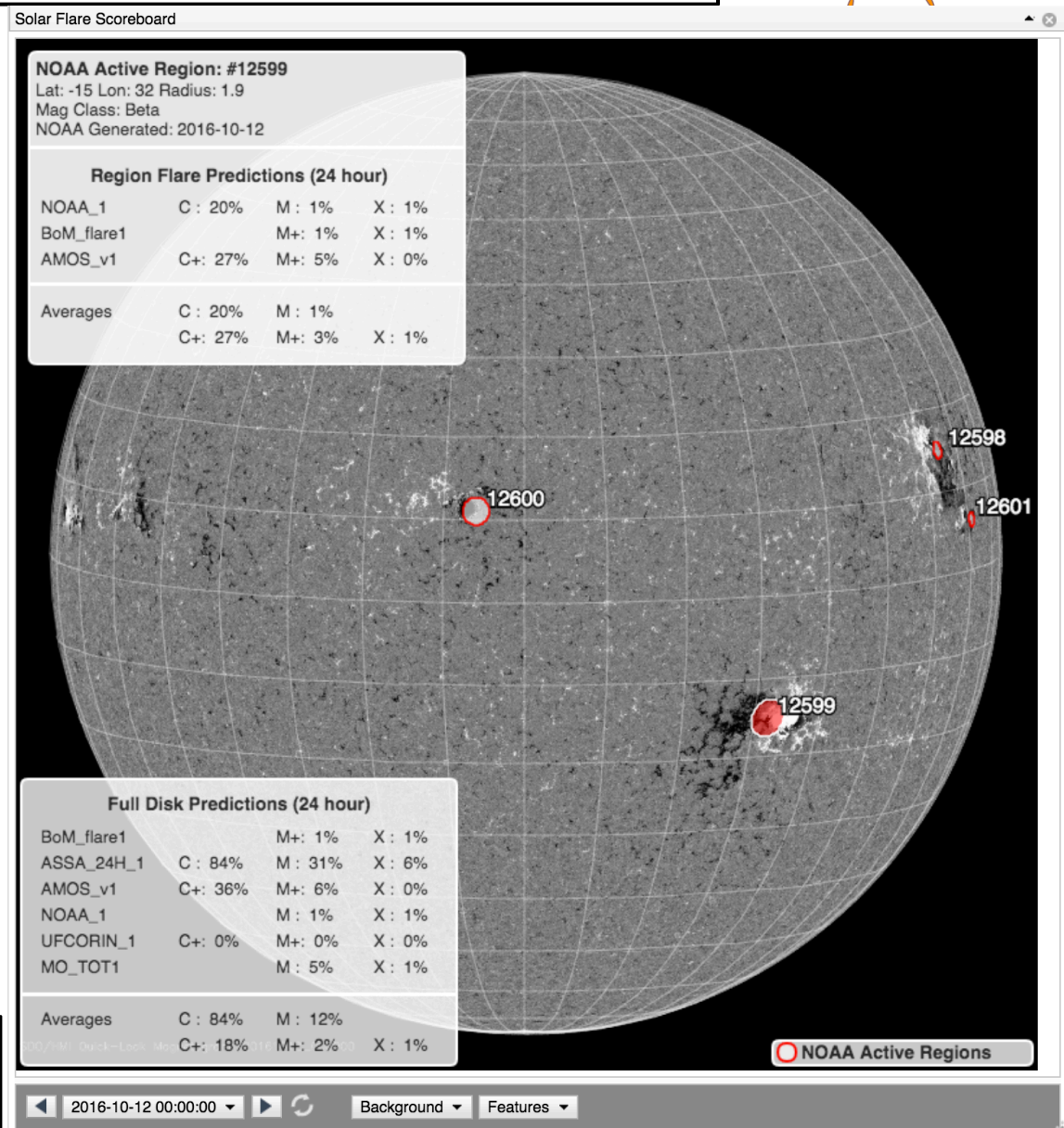
Introduction to community scoreboards

- Fostering world-wide community validation projects that ultimately help researchers improve their CME, flare, and SEP forecasts and determine their usefulness.
- Allow a consistent **real-time** comparison of various operational and research forecasts. Complementary to non-real time model assessments such as **CCMC Challenges**.
- The flare and SEP system is automated such that model developers can routinely upload their predictions.
- Forecast data is parsed and stored in a database accessible to anyone via an API.

Flare Scoreboard

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

- Allows a consistent real-time comparison of various operational and research flare forecasts.
- Automated system; model developers can routinely upload their predictions to an anonymous ftp
- Forecast data is parsed and stored in a database which accessible to anyonevia an API
- This project is led by Sophie Murray (TCD) and the planning group includes expert scientists as well as operational space weather prediction centers.



Royal Observatory of Belgium

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Met Office

SEP Scoreboard

http://ccmc.gsfc.nasa.gov/challenges/sep.php

- Planning for the SEP Scoreboard has started (led by BIRA-IASB and the UK Met Office)
- Builds upon the flare scoreboard and CME arrival time scoreboard
- Automated system; model developers can routinely upload their predictions to an anonymous ftp. Forecast data will be parsed and stored in a database which accessible to anyone via an API
- SEP forecasts can be roughly divided into three categories:

- The SEP scoreboard will focus on real-time forecasts (first and second categories) and will collect: proton flux profile, threshold crossing probability, onset time, and duration.
- The SEP scoreboard team will also coordinate a set of historical events for a **SEP Challenge**" with different models, particularly those physics-based models in the third category that are not ready or relevant for real-time modeling.

CME Arrival Time Scoreboard

The CME scoreboard 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
- view the average of all forecasts for each event (ensemble).

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

All prediction methods are welcome and all are encouraged to participate.

Participation from the community:

- All prediction models and methods are welcome from the world-wide research
- community (currently 19 methods are registered)
- Users submit their predictions for ongoing CME events, listing their method
- assumptions and input parameters
- Researchers can then view all of the predictions, modeling details, and the
- ensemble average of all predicted arrival times submitted by participants

Community predictions for the 5 Nov 2016 CME

CME: 2016-11-05T04:48:00-CME-001

Actual Shock Arrival Time: 2016-11-09T05:28Z

Observed Geomagnetic Storm Parameters:

CME Note: Filament Eruption off the northern Hemisphere giving a very wide-angle partial halo. Another CME came off the farside and eastern limb at a similar time. Evident in SOHO and STEREO imagery after 05/0200UTC.

Predicted Shock Arrival Time	Difference (hrs)	Confidence (%)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By	
2016-11-08T19:00Z (-12.0h, +12.0h)	-10.47	75.0	2016-11-06T11:10Z	66.30	Max Kp Range: 4.0 - 6.0	Other (SIDC)	Leila Mays (GSFC)	Detail
2016-11-08T16:00Z (-7.0h, +7.0h)	-13.47	----	2016-11-05T17:52Z	83.60	----	WSA-ENLIL + Cone (GSFC SWRC)	Karin Muglach (GSFC)	Detail
2016-11-08T11:15Z	-18.22	57.5	---	---	Max Kp Range: 3.5 - 5.33333	Average of all Methods	Auto Generated (CCMC)	Detail
2016-11-08T10:00Z	-19.47	----	2016-11-06T00:30Z	76.97	Max Kp Range: -- - 5.0	WSA-ENLIL + Cone (NOAA/SWPC)	Barbara Thompson (GSFC)	Detail
2016-11-08T00:00Z (-9.0h, +6.0h)	-29.47	40.0	2016-11-06T01:00Z	76.47	Max Kp Range: 3.0 - 5.0	WSA-ENLIL + Cone (Met Office)	Met Office (Met Office)	Detail

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http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

Please join! All prediction methods are welcome and all are encouraged to participate.

Community predictions for the January 7, 2014 CME (X1.2 flare):

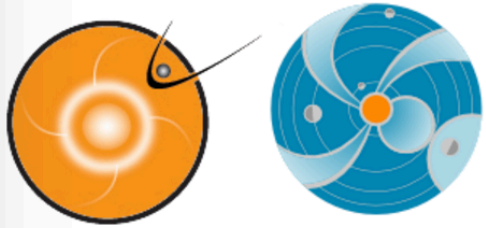
15 submissions
Average of all submissions: **12 hours early, Kp geomagnetic index 6 to 7.6**

CME: 2014-01-07T18:24:00-CME-001
Actual Shock Arrival Time: 2014-01-09T19:32Z
Observed Geomagnetic Storm Parameters:
Max Kp: 3.0

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

Predicted Shock Arrival Time	Difference (hrs)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method
2014-01-10T04:04Z (-16.0h, +36.0h)	8.53	2014-01-08T14:56Z	28.60	Max Kp Range: 8.0 - 8.0 Dst min. in nT: -300	COMESEP
2014-01-09T19:26Z (-10.0h, +10.0h)	-0.10	2014-01-07T21:00Z	46.53	----	STOA
2014-01-09T13:00Z (-7.0h, +7.0h)	-6.53	2014-01-08T23:17Z	20.25	Max Kp Range: 6.0 - 8.0	WSA-ENLIL + Cone
2014-01-09T12:00Z (-7.0h, +7.0h)	-7.53	2014-01-08T06:32Z	37.00	----	WSA-ENLIL + Cone
2014-01-09T11:22Z (-11.7h, +9.1h)	-8.17	2014-01-09T18:57Z	0.58	Max Kp Range: 3.0 - 5.0	Ensemble WSA-ENLIL + Cone (GSFC SWRC)
2014-01-09T08:02Z	-11.50	2014-01-08T16:37Z	26.92	----	Expansion Speed Prediction Model
2014-01-09T08:00Z	-11.53	2014-01-08T01:31Z	42.02	Max Kp Range: 6.0 - 7.0	WSA-ENLIL + Cone (NOAA/SWPC)
2014-01-09T06:35Z	-12.95	---	---	Max Kp Range: 6.0 - 7.625	Average of all Methods
2014-01-09T04:30Z (-2.5h, +2.5h)	-15.03	2014-01-08T05:02Z	38.50	Max Kp Range: 5.0 - 8.0	Other (SIDC)
2014-01-09T04:00Z (-6.0h, +6.0h)	-15.53	2014-01-08T09:42Z	33.83	----	DBM
2014-01-09T02:00Z	-17.53	2014-01-08T17:53Z	25.65	Max Kp Range: 8.0 - 9.0	BHV
2014-01-09T01:00Z	-18.53	2014-01-08T23:00Z	20.53	Dst min. in nT: -142 Dst min. time: 2014-01-09T12:00Z	Anemomilos
2014-01-09T00:38Z (-7.0h, +7.0h)	-18.90	2014-01-08T00:41Z	42.85	Max Kp Range: 6.0 - 8.0	WSA-ENLIL + Cone (GSFC SWRC)
2014-01-09T00:17Z (-6.9h, +9.2h)	-19.25	2014-01-08T04:11Z	39.35	Max Kp Range: 6.0 - 8.0	Ensemble WSA-ENLIL + Cone (GSFC SWRC)
2014-01-08T22:00Z	-21.53	2014-01-08T03:17Z	40.25	Dst min. in nT: -146 Dst min. time: 2014-01-09T11:00Z	Anemomilos
2014-01-08T12:30Z	-31.03	2014-01-08T05:58Z	37.57	----	ESA

Please join! All prediction methods are welcome and all are encouraged to participate. There are currently 19 registered models.



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:

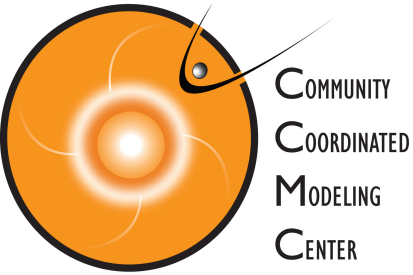
- submit their forecast in real-time
- quickly view all forecasts at once in real-time
- compare forecasting methods when the event has arrived

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.

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

Anyone can view predictions, please register to submit predictions.



Begin by clicking **Add Prediction** under the "Active CMEs" section and select your forecasting "Method Type" from the list.
While logged in, if you do not see any CMEs listed under the "Active CMEs" section, click **Add CME** to get started.

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Active CMEs:

Note: If you can't find your CME below, please click "Add CME" to add your CME. To enter the actual CME shock arrival time, click "*Edit CME*" after you are done entering your prediction(s).

CME: 2015-01-01T00:00:00-CME-001
Edit CME
Delete CME
Add Prediction
No Prediction Entered for this CME yet!

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

COMMUNITY COORDINATED MODELING CENTER

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

Prediction Form for CME (2014-01-01T00:00:00-CME-001)

Enter submission time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) :

Method Type (details):

Prediction notes: (Please include all initial conditions/parameters used in your prediction)

- --- Select ---
- Anemomilos
- Ballistic projection
- BHV
- DBM
- ECA
- ESA
- H3DMHD (HAFv.3+3DMHD)
- HAFv.3
- HAFv2w
- HI J-map
- Other
- Other (ips.gov.au)
- Other (SIDC)
- STOA
- TH
- WSA-Enlil + Cone
- WSA-Enlil + Cone (GSFC SWRC)
- WSA-Enlil + Cone (NOAA/SWPC)

Enter predicted CME shock arrival time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) :

Positive Error Bar in hours (optional):

Negative Error Bar in hours (optional):

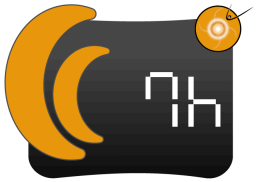
Kp Range Lower Limit (optional):

Kp Range Upper Limit (optional):

Dst min. in nT (optional):

Dst min. time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) (optional):

CME Arrival Time Scoreboard



Suggested improvements coming soon:

- Automatic forecast submission via an XML file
- Mailing list that notifies users when a new CME has been added to the scoreboard
- Separate geomagnetic storm scoreboard that can link to CME scoreboard

Future plans:

- Showing data in table in plot form
- Automatic skill score calculations
- Quality factor for confidence in observed ICME associated shock arrival
- Quality factor for confidence in linking observed ICME arrival with CME in coronagraph
- Your ideas?

http://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard

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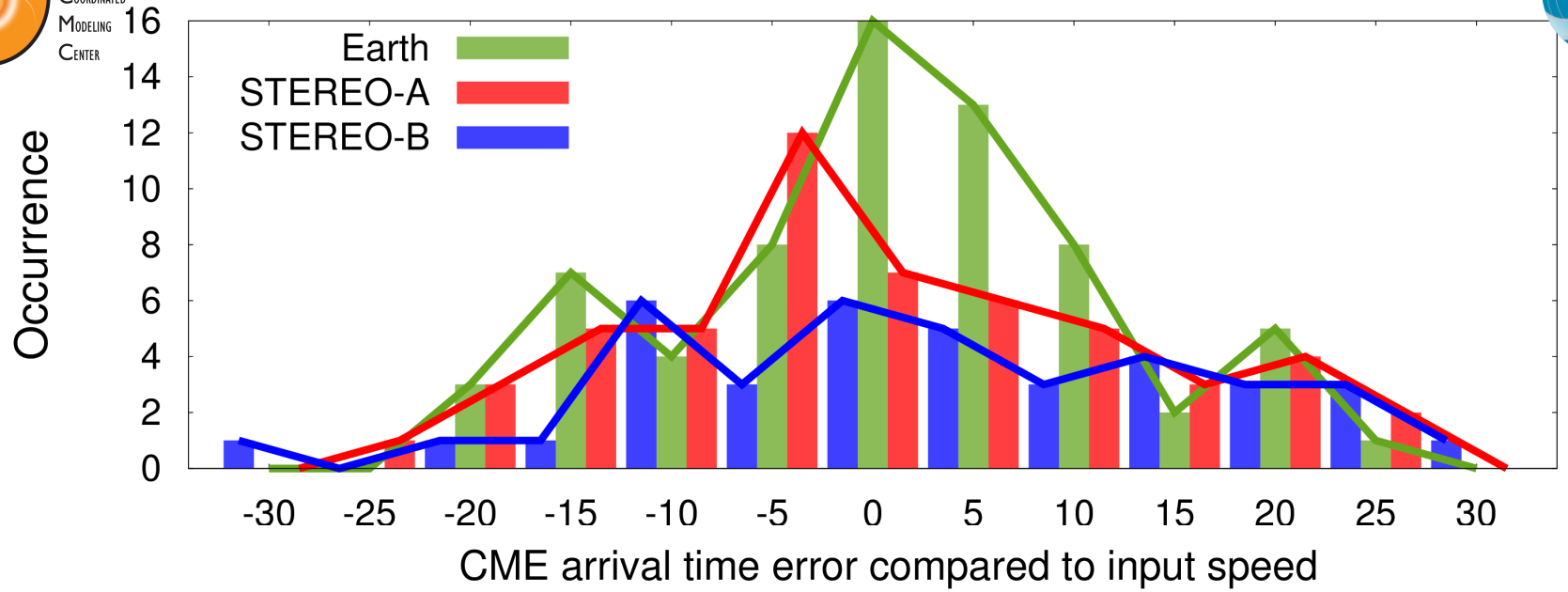
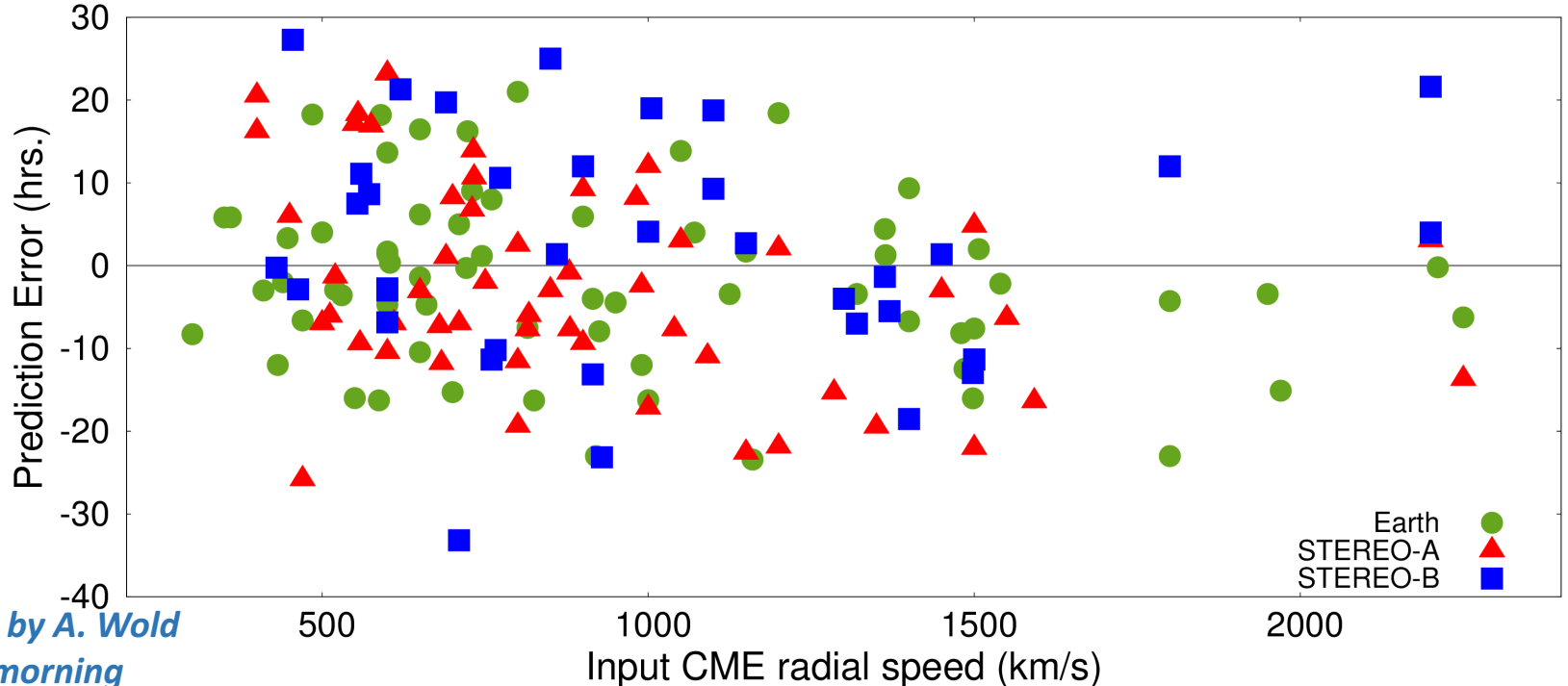
http://ccmc.gsfc.nasa.gov/challenges/scoreboards/esww13_wm.php

Discussion on CME arrival time validation techniques

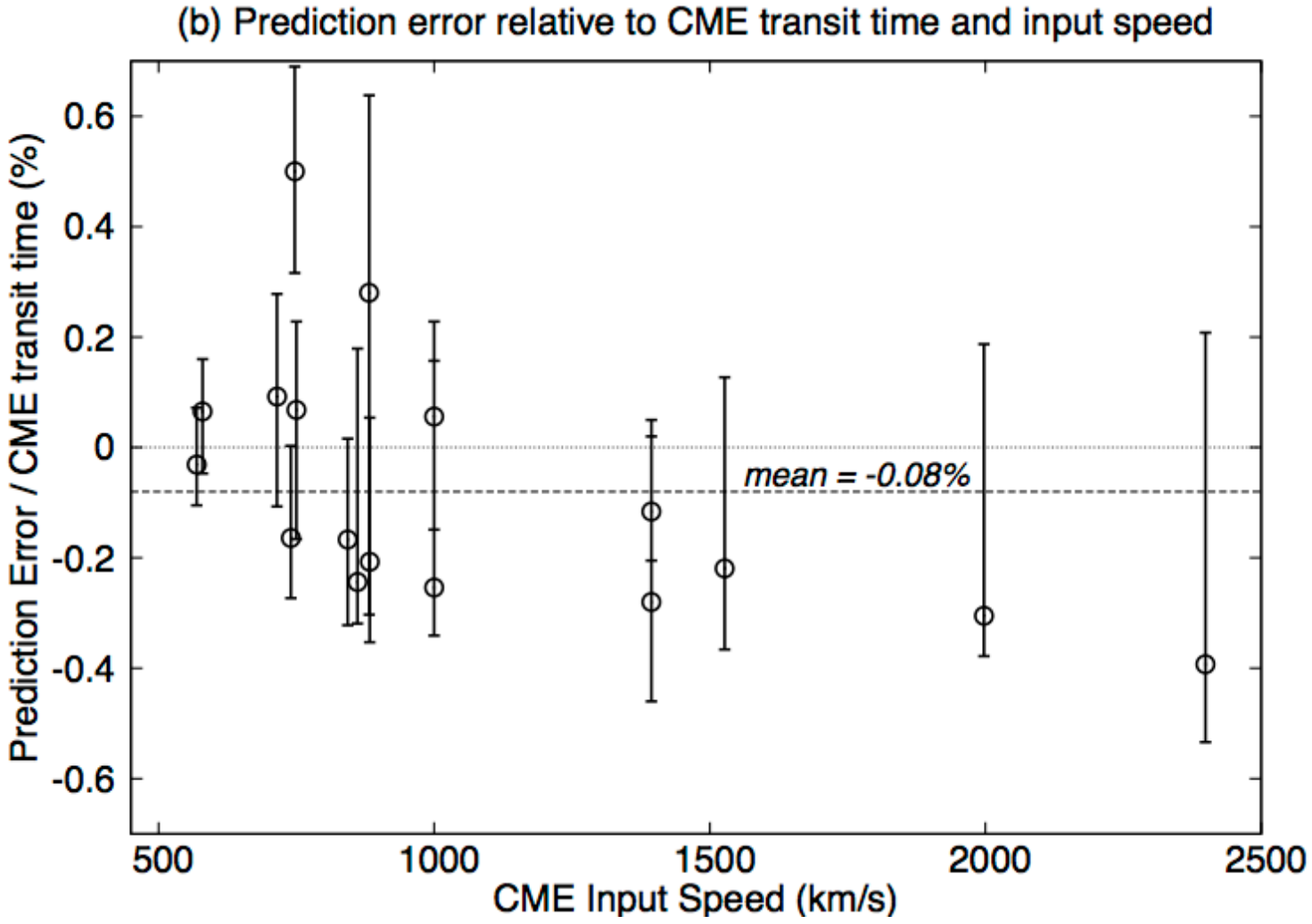
CME Arrival Time Error Validation Examples



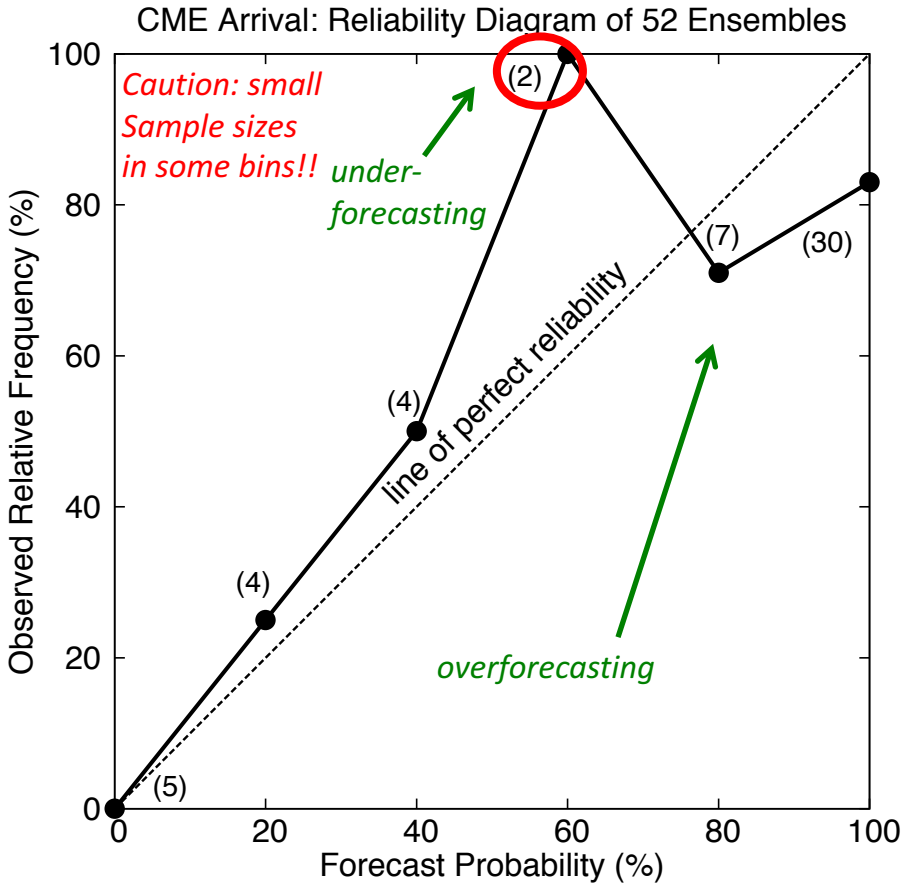


See poster by A. Wold on Friday morning

CME Arrival Time Error Validation Examples



Assessment: Confidence (likelihood) in CME arrival



- Example reliability diagram for CCMC/SWRC arrival time forecasts
- Underforecasting in the forecast bins between 40-80%
- Slightly overforecasting in the 80-100% forecast bins

Need to improve confidence in CME arrival forecast:

- Consider better way of translating CME "impact parameter" into probability that the CME will arrive which more accurately represents head-on vs. grazing impacts (and the ranges in between)

Likelihood of CME arrival forecast verification: Brier Score

Using the forecast probability about the likelihood that the CME will arrive submitted on the scoreboard.

A method defining the mean squared probability forecast errors is the Brier Score:

$$BS = \frac{1}{N}\sum_{i=1}^{N}(p_i - o_i)^2$$

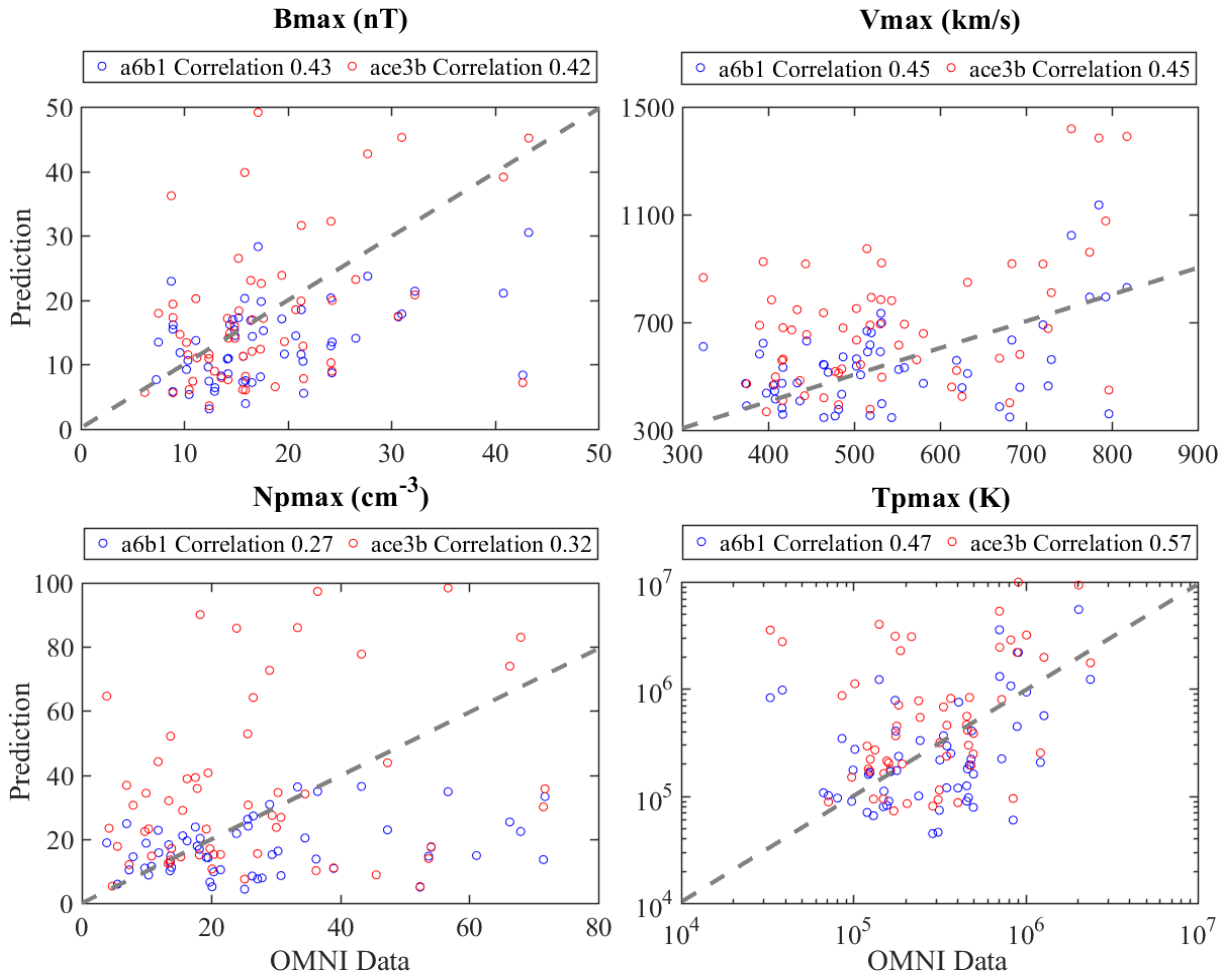
N = number of events,
p_i = forecast probability of occurrence for event i,
o_i = 1 if the event was observed to occur and 0 if it did not.

Ranges from 0 to 1, with 0 being a perfect forecast.

The Brier Skill Score (BSS) is the the Brier score relative to climatology

Note: confidence intervals should be computed for verification scores

Simulated vs. Observed CME Parameters



- The difference from **different observation data** can affect the results. For example, the difference of V_{max} from OMNI and ACE is >200 km/s for 3 CMEs. The correlation for N_{pmax} is weaker if using ACE
- In several cases where the CME V_{max} is overestimated, there are interactions of multiple CMEs

- Using the fixed parameters (a6b1), the V_{max} and N_{pmax} are underestimated. They are overestimated in the case of self-adjusted parameters (ace3b)
- Similar trends are found for the correlations of mean values of CME parameters. The mean temperature are overestimated in both settings

From Lan Jian

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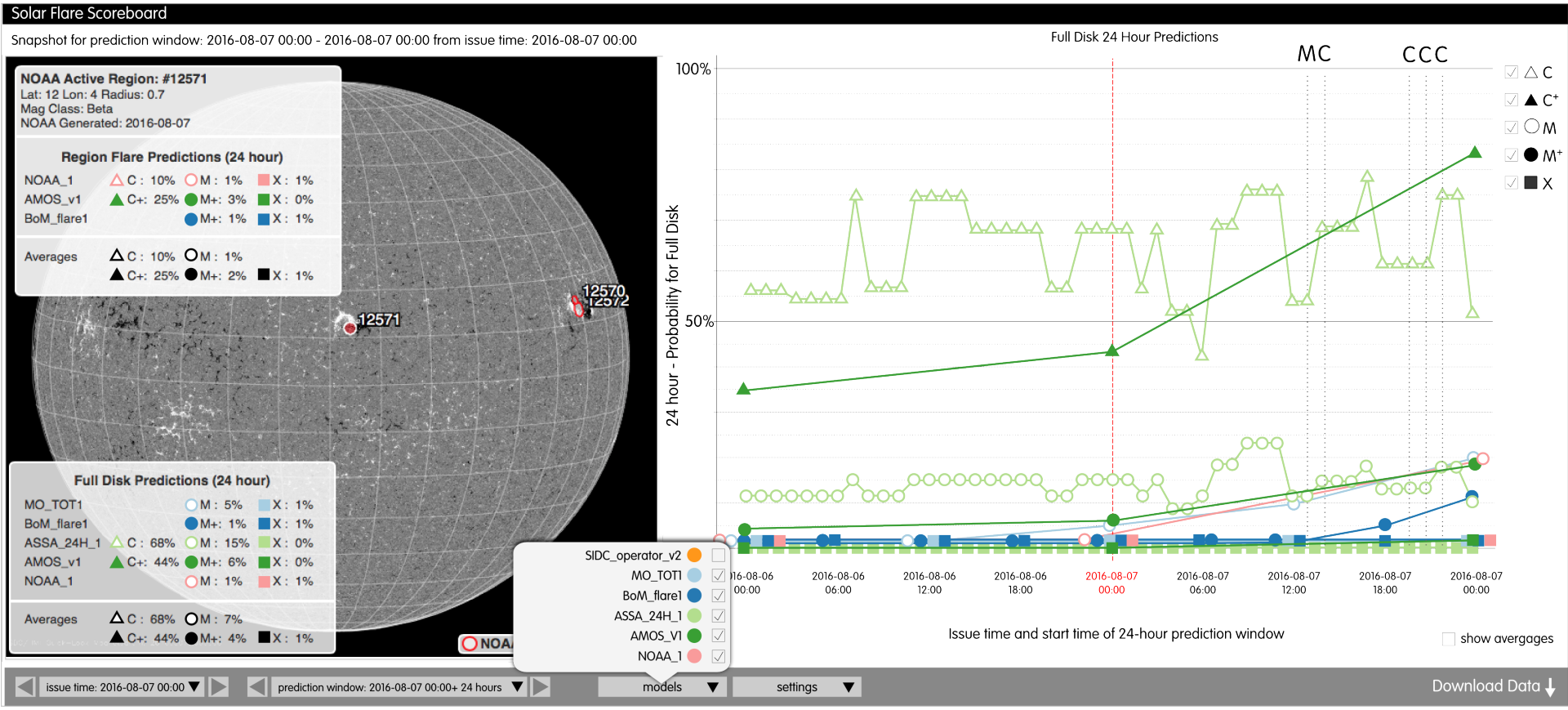
http://ccmc.gsfc.nasa.gov/challenges/scoreboards/esww13_wm.php

Display mock-ups

Flare Scoreboard

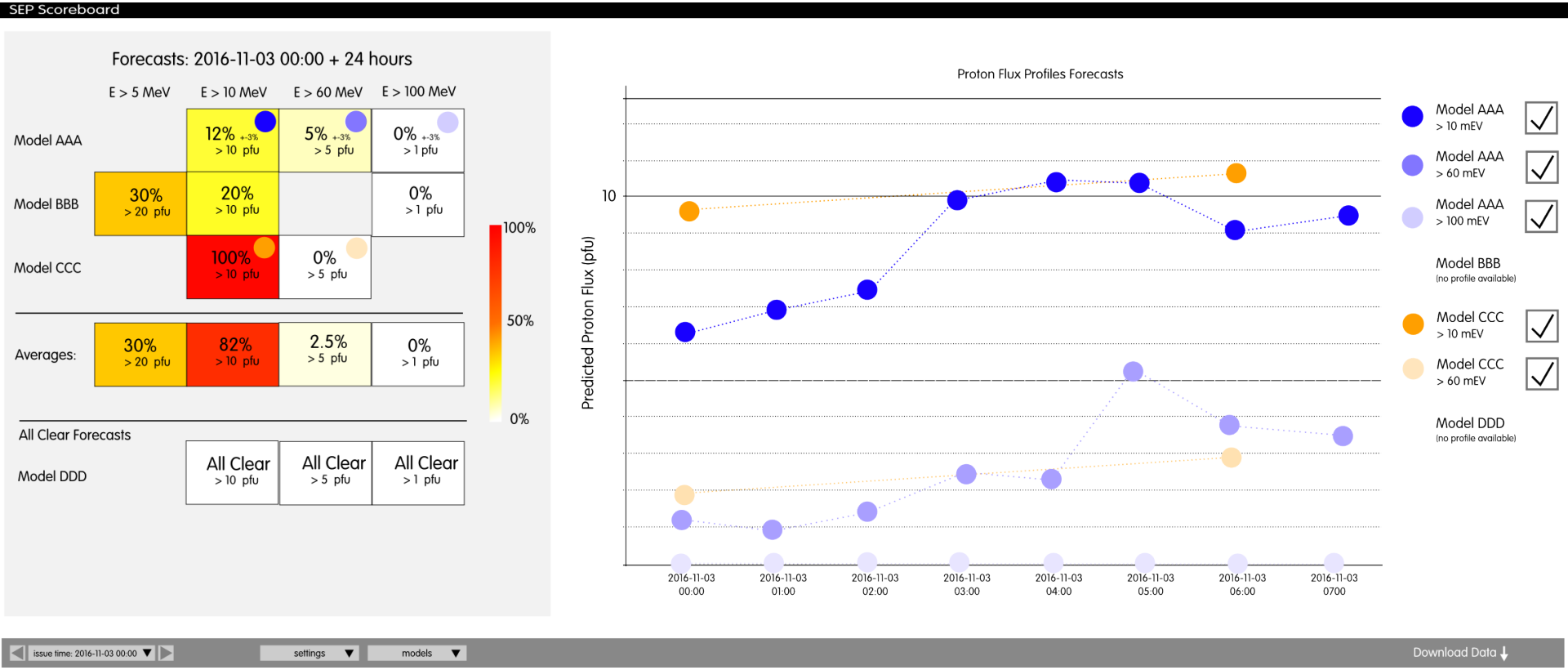
http://ccmc.gsfc.nasa.gov/challenges/flare.php



The full disk and active region flare forecasts can currently be viewed on an interactive display overlaid on an SDO/AIA or HMI image of then Sun and will be dynamically paired with a graph of flare probability vs. time (coming soon)

SEP Scoreboard

Display ideas

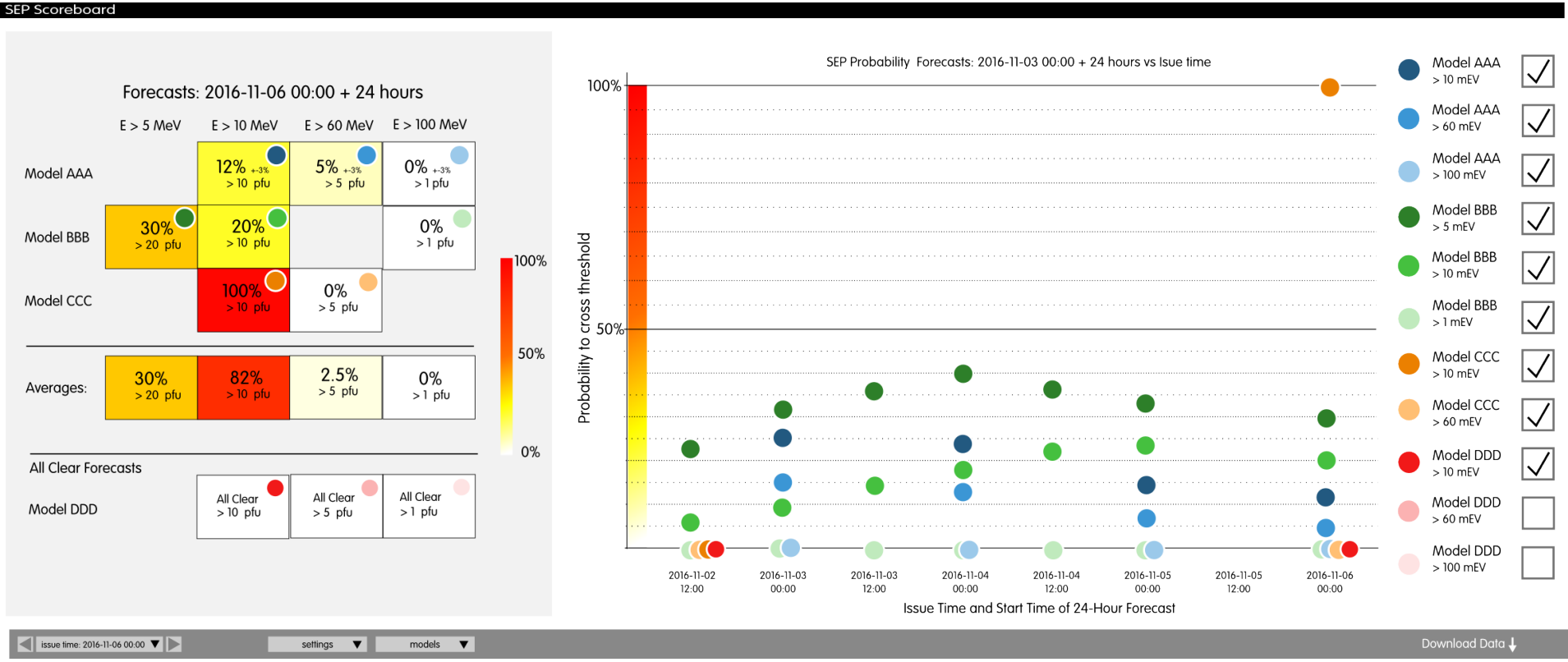


Probability heat map at a single time

Predicted proton flux time-series

SEP Scoreboard

Display ideas



Probability heat map at a single time

Probability time-series

Linking the Scoreboards

Example of activities linked to a CME event in the CCMC DONKI database:
http://kauai.ccmc.gsfc.nasa.gov/DONKI

Coronal Mass Ejection
Catalog: SWRC_CATALOG
Start Time: 2015-03-15T02:00Z (SOHO: LASCO/C2)
All Detecting Spacecrafts:
SOHO: LASCO/C2
SOHO: LASCO/C3
Activity ID: 2015-03-15T02:00:00-CME-001 (version 4)
Source Location: S15W24
Active Region Number: 12297
Note: This CME is connected to the long duration C9.1 flare erupting, bright post-flare arcade later in AR 2297
Submitted on 2015-03-15T14:17Z by Karin Muglach

2015-03-15T01:15:00-FLR-001
FLR Type: C9.1

2015-03-16T07:36:00-SEP-001
SOHO: COSTEP 15.8-39.8 MeV

2015-03-17T04:05:00-IPS-001
Location: Earth

2015-03-17T06:00:00-GST-001
NOAA Kp: 6 (2015-03-17T09:00Z)
NOAA Kp: 6 (2015-03-17T12:00Z)
NOAA Kp: 8 (2015-03-17T15:00Z)
NOAA Kp: 8 (2015-03-17T18:00Z)
NOAA Kp: 7 (2015-03-17T21:00Z)
NOAA Kp: 8 (2015-03-18T00:00Z)
NOAA Kp: 6 (2015-03-18T03:00Z)
NOAA Kp: 6 (2015-03-18T18:00Z)

2015-03-17T06:23:00-MPC-001

Workshop announcement

International CCMC – LWS Workshop

Assessment of Space Weather Development: Understanding, Operational Readiness, Forecasting Skills.

When: April 3-7, 2017

Where: TBD (near KSC, Florida ?)

What: Assess current capabilities based on Event-based World Challenges & ScoreBoards. Agree on metrics, metadata. Identify a path forward.

Hands-on working groups. Discussions. Deliverables.