Solar Shield Project - Updates and Future Challenges

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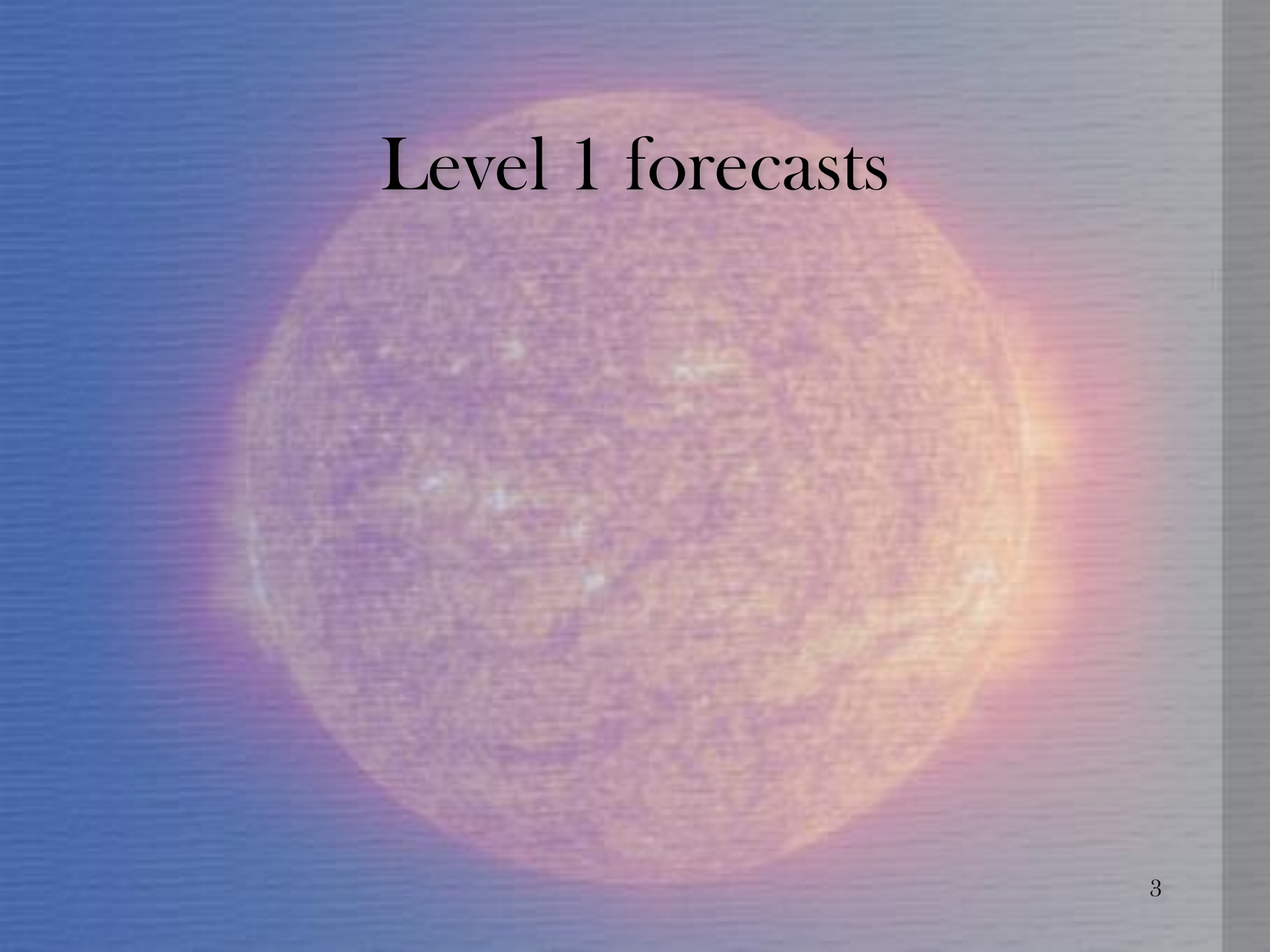
Solar Shield updates

- Solar Shield leverages the forecasting carried out at NASA GSFC Space Weather Center.
- In Solar Shield, we developed a two-level experimental system to forecast space weather effects on the North American power grid; initial development funded by NASA's Applied Sciences Program.
- NASA GSFC and Electric Power Research Institute (EPRI) the key players.
- Pulkkinen et al. (*Natural Hazards*, 2009).

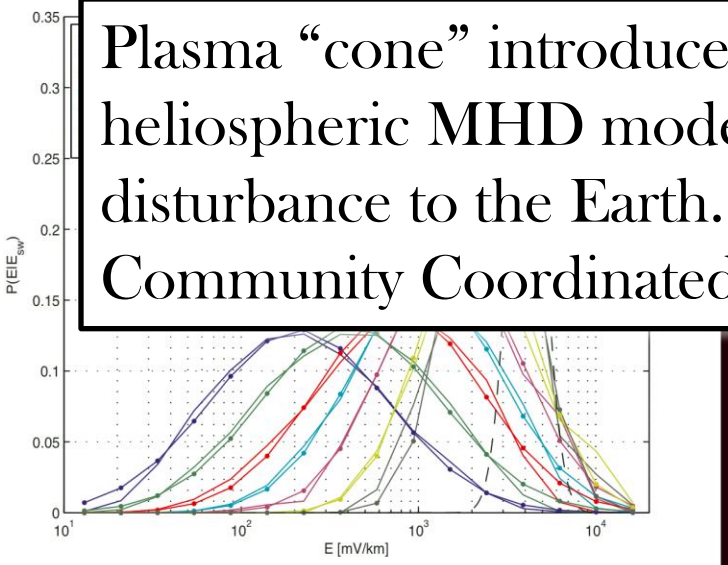
Level 1 forecasts



Solar observations of eruptive events are used to compute “cone model” parameters. NASA/ESA SO

MHD output at the Earth used in a statistical model providing probabilistic estimate for GIC at individual nodes of the power grid. GIC forecast file is generated.

Plasma “cone” introduced to the inner boundary of a heliospheric MHD model. Model propagates the disturbance to the Earth. Computations carried out at the Community Coordinated Modeling Center.

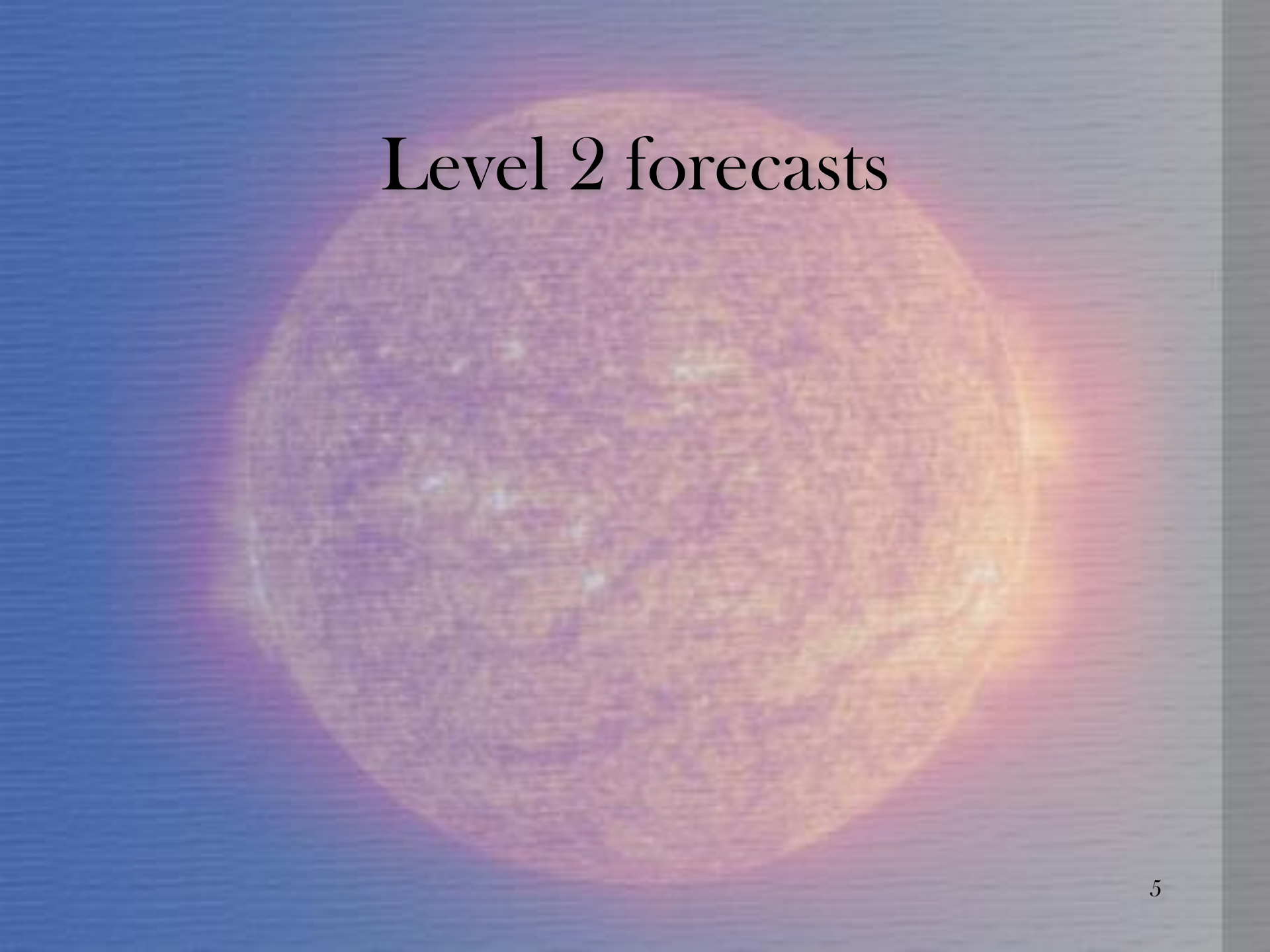


EVEL1

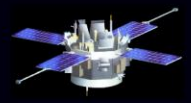
GIC2high ...

0 0 0 0 53.16 -99.29 45.39 -68.53
2006 12 14 14 6 76 15 153

Level 2 forecasts



Lagrange 1 observations used as boundary conditions for magnetospheric MHD. NASA's ACE



Magnetospheric MHD output used to drive geomagnetic induction and GIC code providing GIC at individual nodes of the power grid. GIC forecast file is generated.

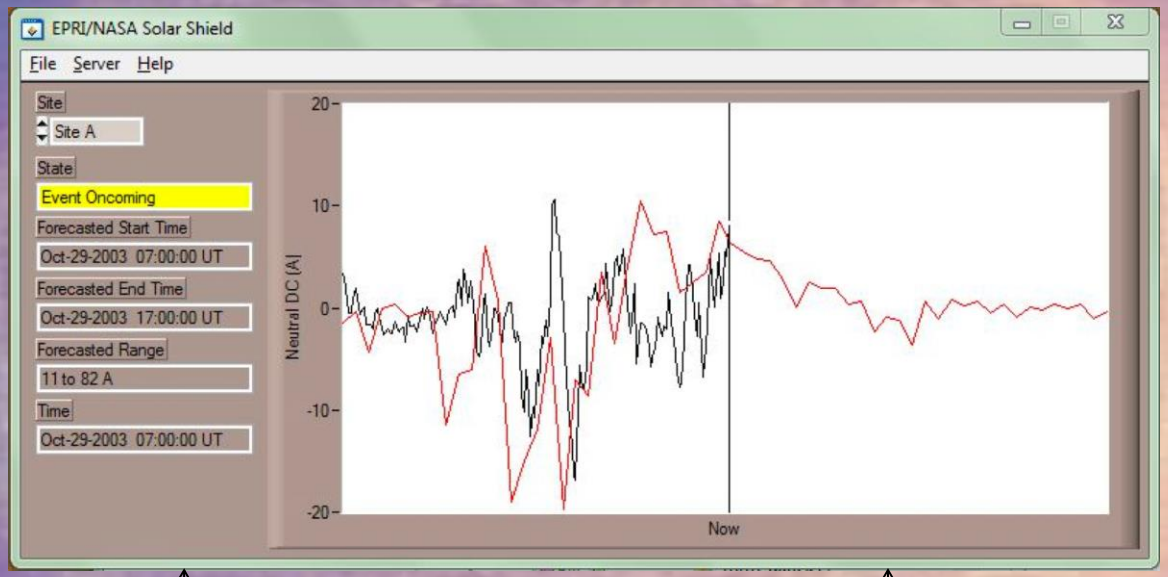
% Level 2 GIC forecast produced by REALTIMEGIC_LEVEL2
%
% The format of the data is as follows:

0 ...
0 ...

Magnetospheric MHD model used to model the magnetospheric-ionospheric dynamics. Computations carried out at the Community Coordinated Modeling Center.

2008 03 19 11 06 31	-0.02	0.00	0.04	0.00
2008 03 19 11 08 31	0.00	0.00	0.01	0.00
2008 03 19 11 10 31	0.01	0.00	-0.03	0.00
2008 03 19 11 12 31	0.00	0.00	0.02	0.00
2008 03 19 11 14 31	0.02	0.00	0.04	0.00
2008 03 19 11 16 31	-0.00	0.00	-0.05	0.00
2008 03 19 11 18 31	-0.01	0.00	-0.07	0.00
2008 03 19 11 20 31	0.03	0.00	0.00	0.00

Coupling to the SUNBURST research support tool




```
% Level 1 GIC forecast produced by REALTIMEGIC_LEVEL1
%
% The format of the data is as follows:
%  0  0  0  0  0  0 lat1    lon1     lat2    lon2     . . .
% yy mm dd hh mi GIC1low GIC1high GIC2low GIC2high . . .
%
  0 0 0 0    53.16  -99.29  45.39  -68.53
2006 12 14 14      6      76     15     153
```

```
% Level 2 GIC forecast produced by REALTIMEGIC_LEVEL2
%
% The format of the data is as follows:
%  0  0   0  0  0  0  0 lat1   lon1   lat2   lon2      . . .
%
  0 0 0 0 0 0 0    53.16  -99.29  45.39  -68.53
2008 03 19 11 02 31    -0.11    0.00    0.13    0.00
2008 03 19 11 04 31     0.02    0.00    0.03    0.00
2008 03 19 11 06 31    -0.02    0.00    0.04    0.00
2008 03 19 11 08 31     0.00    0.00    0.01    0.00
```

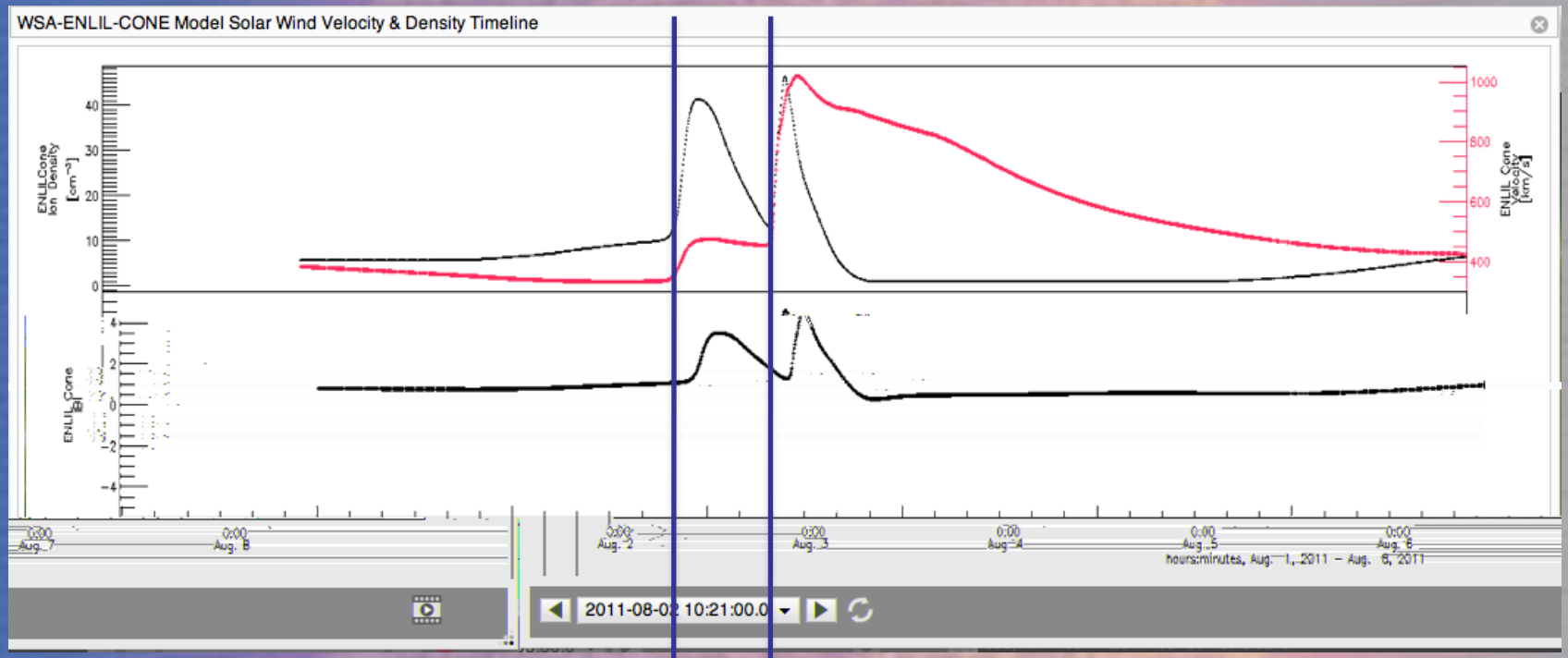
Solar Shield updates

- We are working on extension of the Level 2 part to cover also lower latitude locations.
- The system is being used for extreme GIC studies.
- Collaboration with EU FP7 EURISGIC activity.
- We have had the first good GIC events 2011-2012 and can now really start testing the system (no major GIC events so far).
- Ensemble CME simulations carried out at NASA GSFC Space Weather Center will be utilized in the system.

Aug 2-4, 2011 CME events

- Sequence of major CME events Aug 2-4, 2011.

Solar Shield Level 1 forecast



Predicted initial impact 2011-08-04 21:30Z

Observed initial impact 2011-08-04 21:00Z

Predicted GIC range: 1-36 A

Predicted major impact 2011-08-05 10:00Z

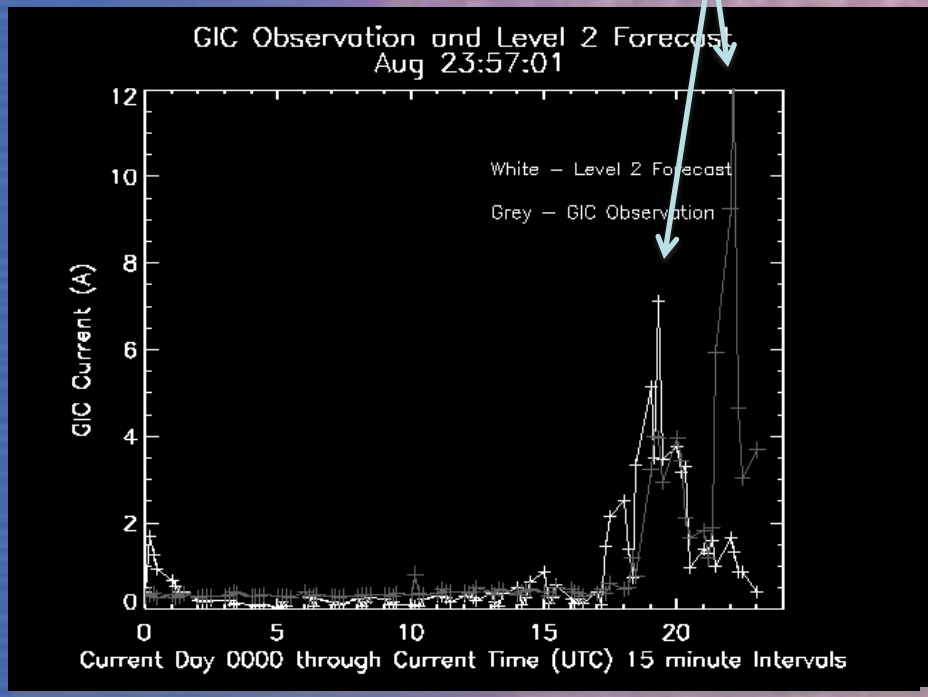
Observed major impact 2011-08-05 17:25Z

Observed max. GIC was 12 A

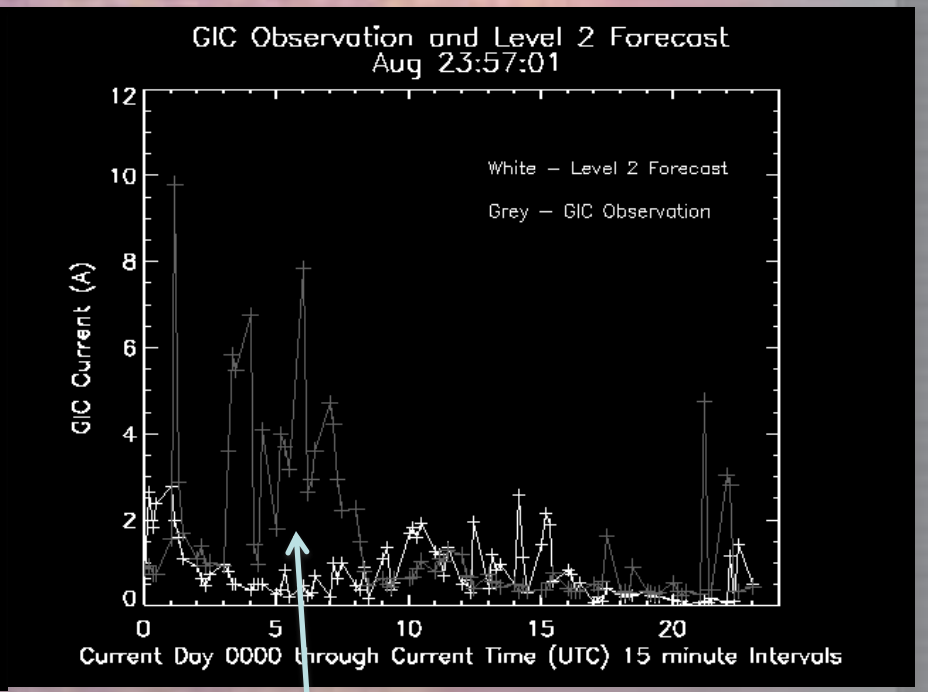
Solar Shield Level 2 forecast

Max. amplitudes captured fairly well

Aug 5, 2011



Aug 6, 2011



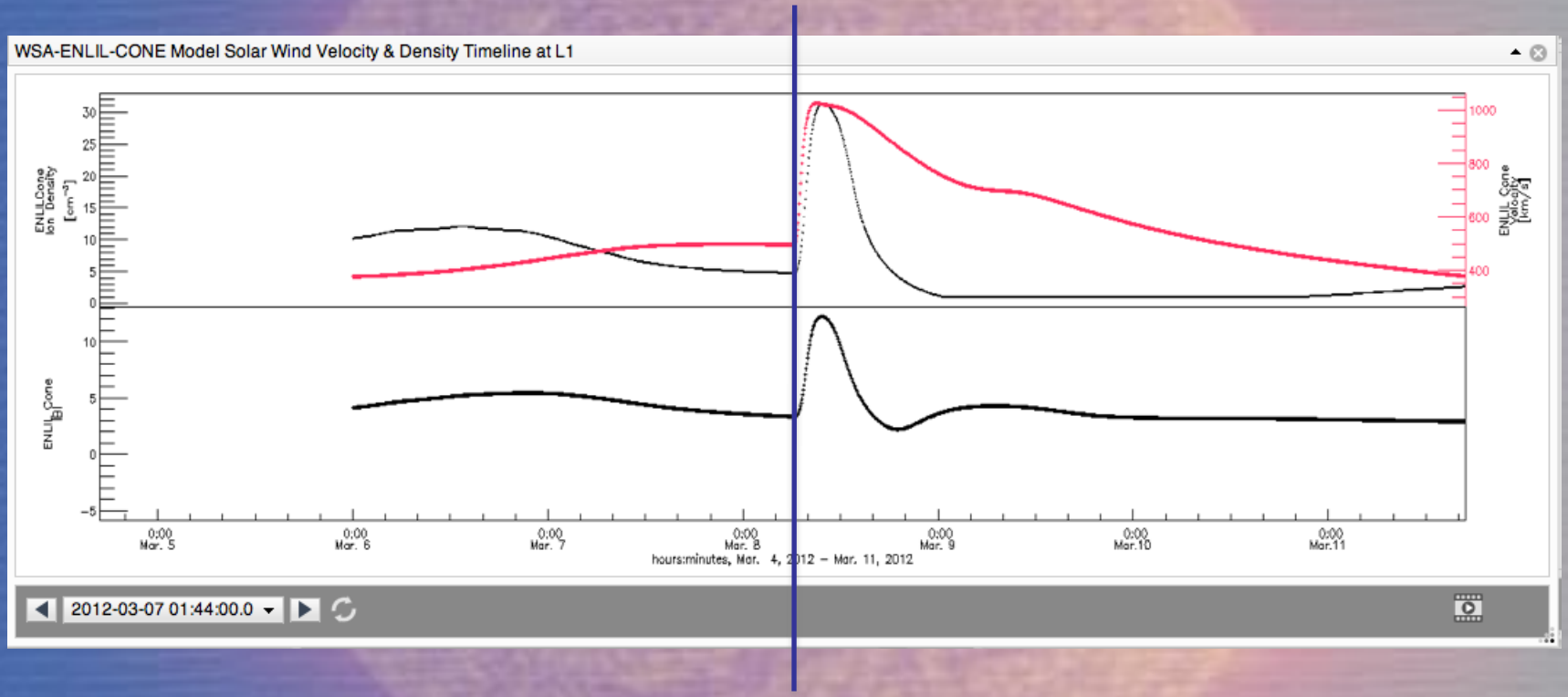
Beginning of the event was captured fairly well

Capturing the mid-storm evolution needs improvement

March 7, 2012 CME events

- Sequence of two major CME events March 7, 2011.

Solar Shield Level 1 forecast



Predicted impact
2012-03-08 06:10Z

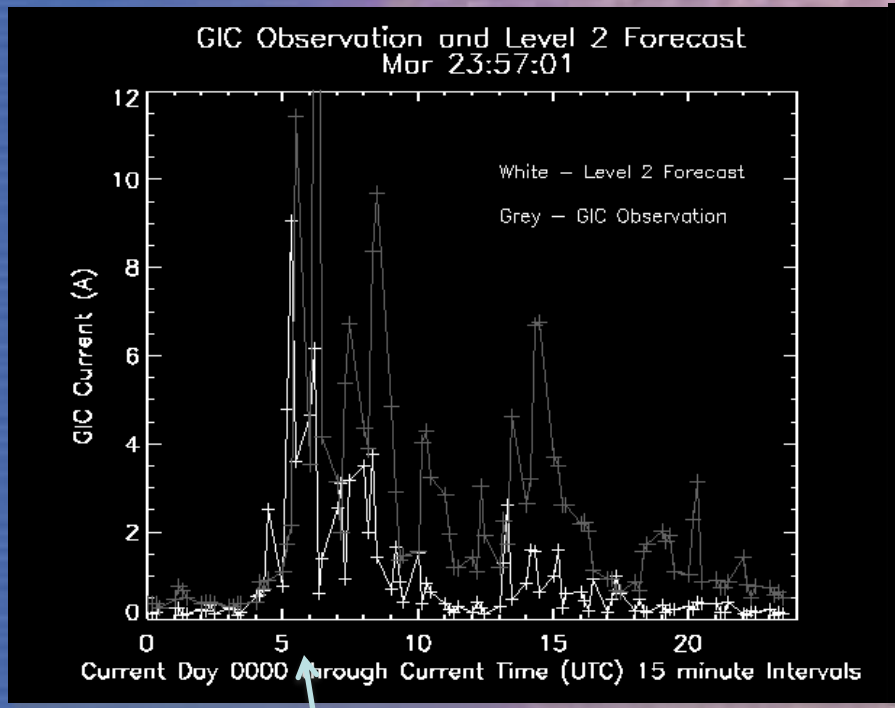
Observed impact
2011-03-08 11:00Z

Predicted GIC range: 8-80 A

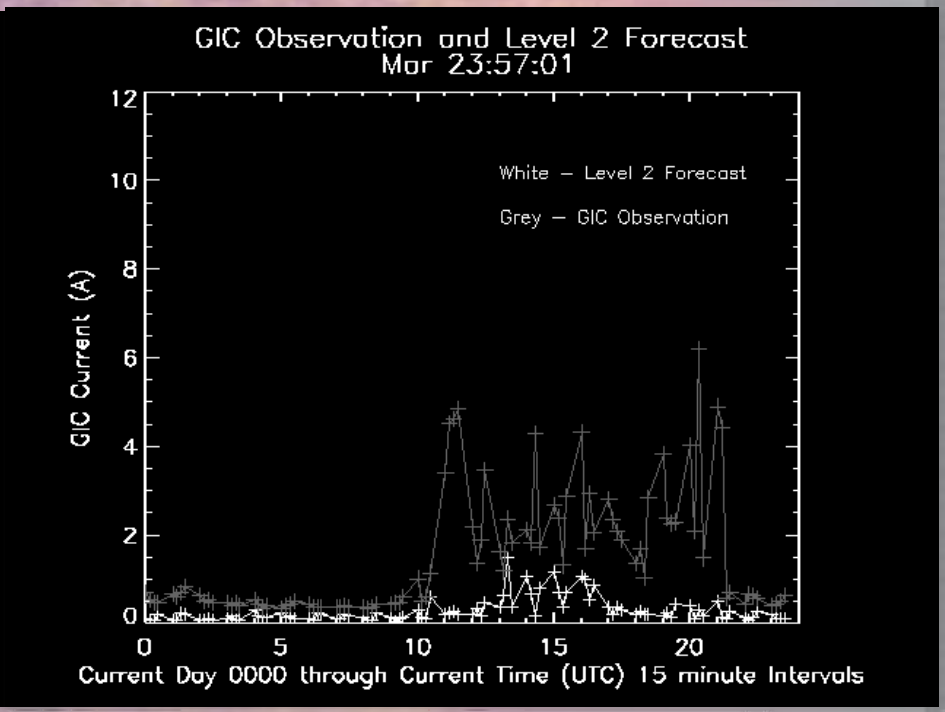
Observed max. GIC 20 A

Solar Shield Level 2 forecast

March 7, 2011



March 8, 2011

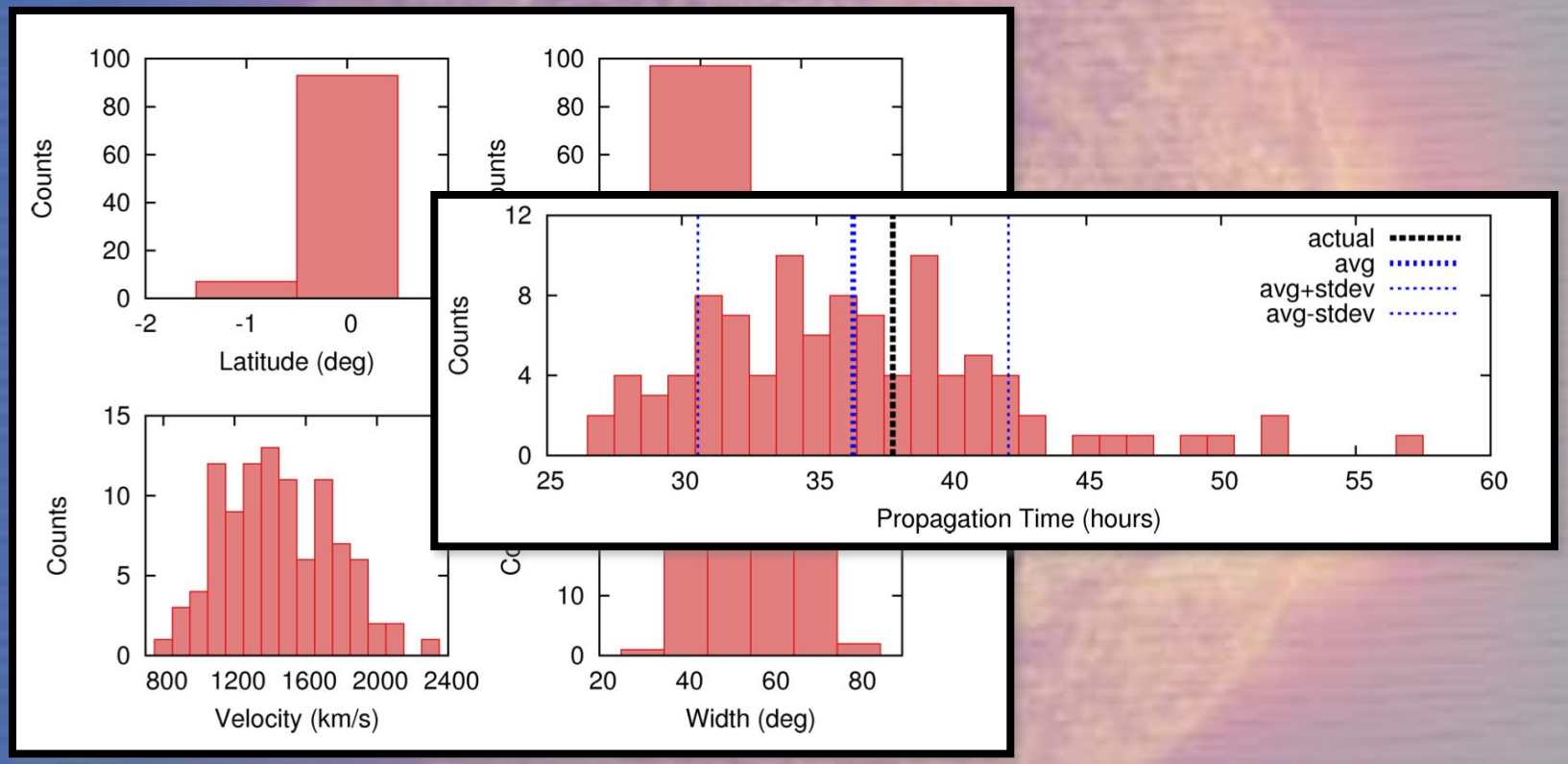


Earlier low-level activity captured well

ACE plasma data out

Ensemble CME forecasts

March 29, 2001 event



D. Emmons and A. Acebal, Air Force Institute of Technology

Summary

- Solar Shield system has been up and running since February 2008.
- With the approaching solar maximum we can now start to test the true capabilities of the system.
- Extension of the system underway.
- Utilization of the system in extreme event studies underway.