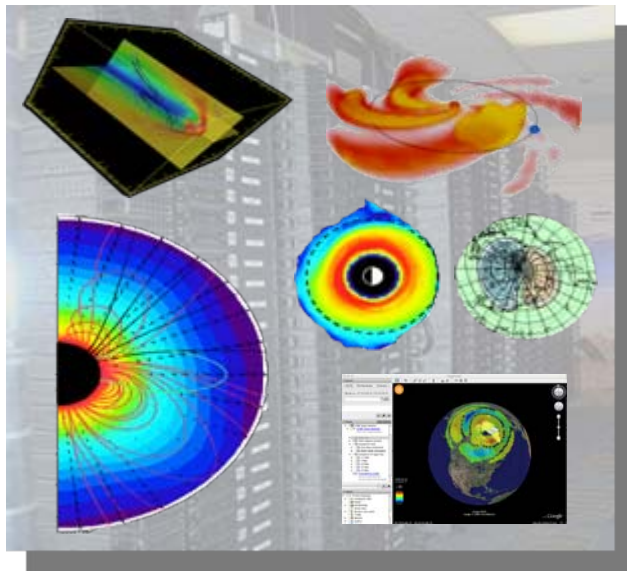


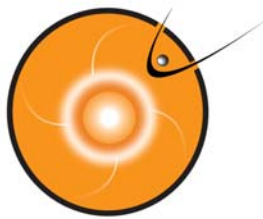
# CCMC's V&V Report: Magnetosphere/Ionosphere Models



*Antti Pulkkinen*

*UMBC/GEST at NASA/GSFC CCMC*

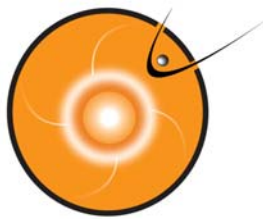




# Contents

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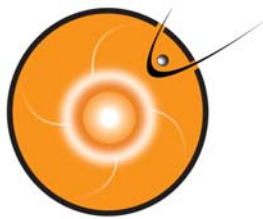
- The goals of CCMC's magnetosphere/ionosphere V&V.
- Summary of the magnetosphere/ionosphere V&V activities over the past two years.
- Future V&V plans.



# The goals of CCMC's V&V activities

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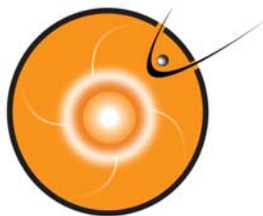
- Carry out independent V&V to:
  - Support further model development.
  - Support operational space weather modeling activities.
  - Quantify and monitor the performance of the state-of-the-art models.



# Inner magnetosphere V&V

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- Taktakishvili et al., Metrics analysis of the coupled Block Adaptive-Tree Solar Wind Roe-Type Upwind Scheme and Fok ring current model performance, *Space Weather*, 5, 11, doi:10.1029/2007SW000321, 2007.



# Inner magnetosphere V&V

Taktakishvili et al., *Space Weather*, 2007

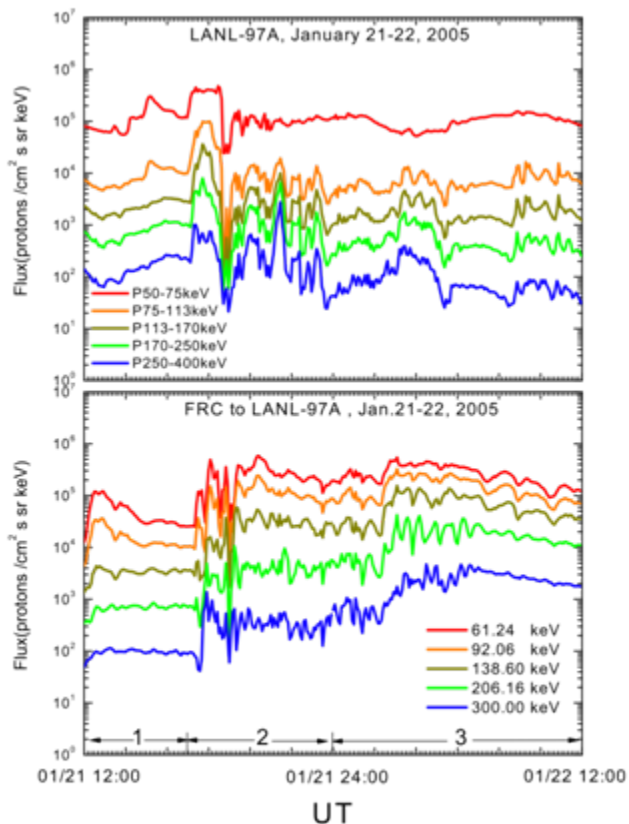


Figure 2. LANL-97A geosynchronous satellite proton flux data and the Fok ring current model results mapped to this satellite trajectory.

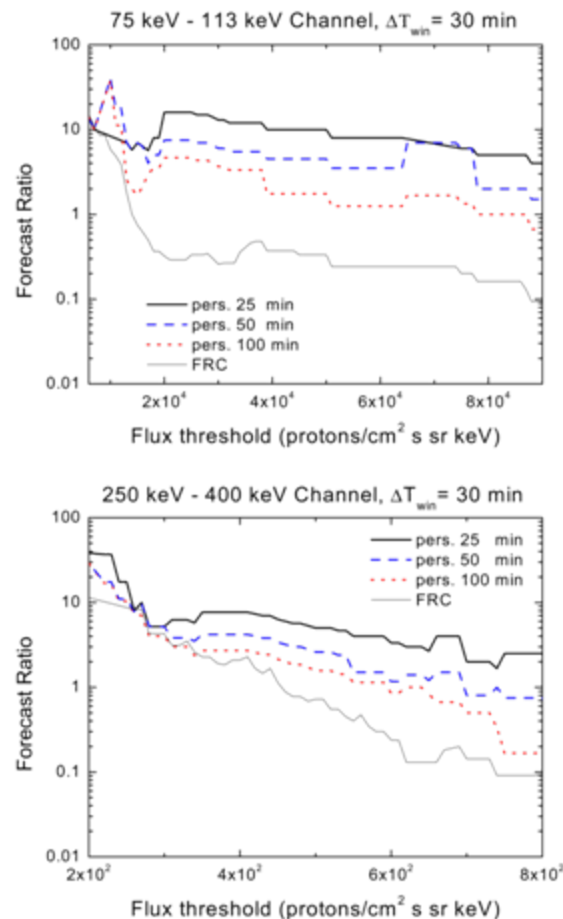
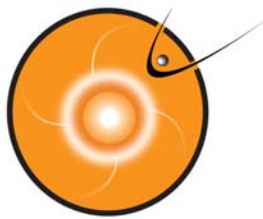


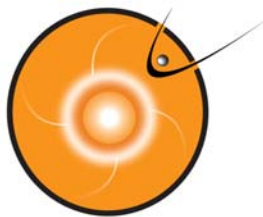
Figure 6. Forecast ratio versus flux threshold level for 30 min window length and different persistence models, showing (a) energy channel 50–75 keV and (b) energy channel 250–400 keV.



# Inner magnetosphere V&V

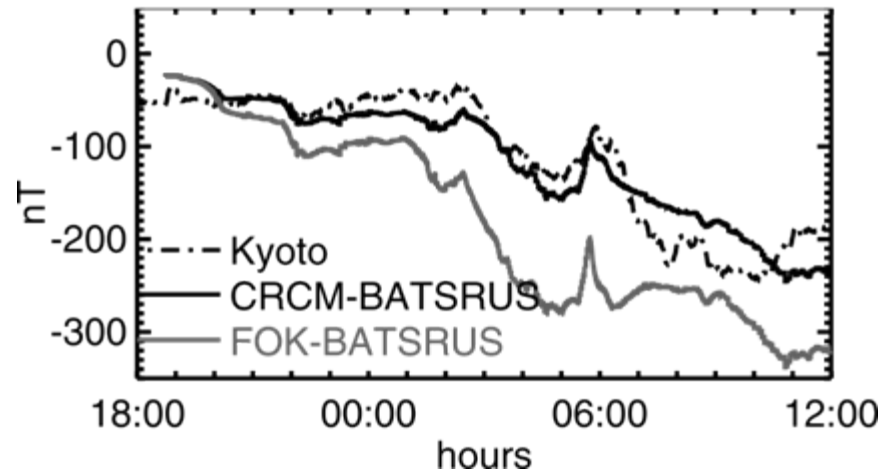
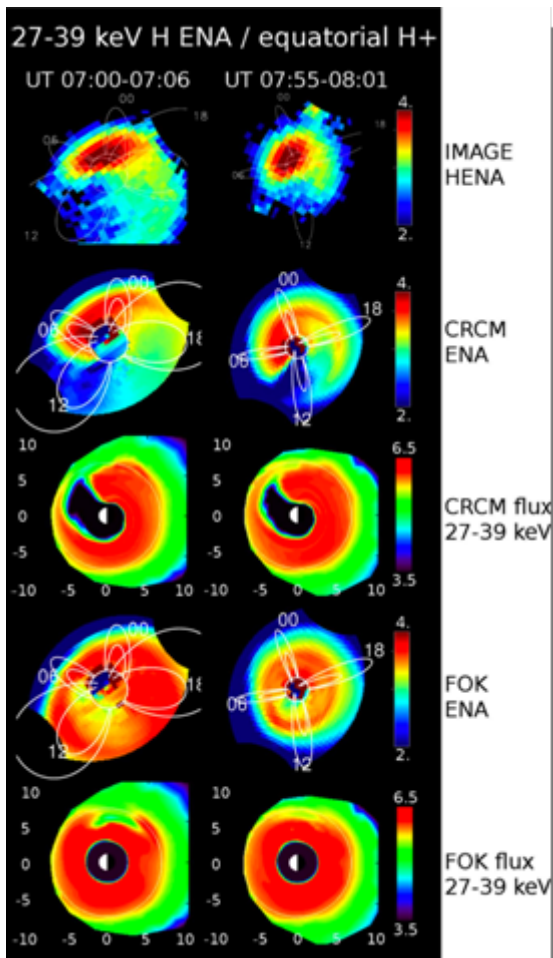
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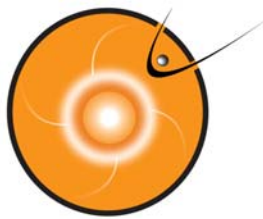
- Buzulukova et al., Dynamics of ring current and electric fields in the inner magnetosphere during disturbed periods: CRCM--BATS-R-US coupled model, *J. Geophys. Res.*, doi:10.1029/2009JA014621, in press.



# Inner magnetosphere V&V

Buzulukova et al., *J. Geophys. Res.*,  
2010



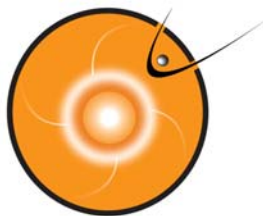


# Inner magnetosphere V&V

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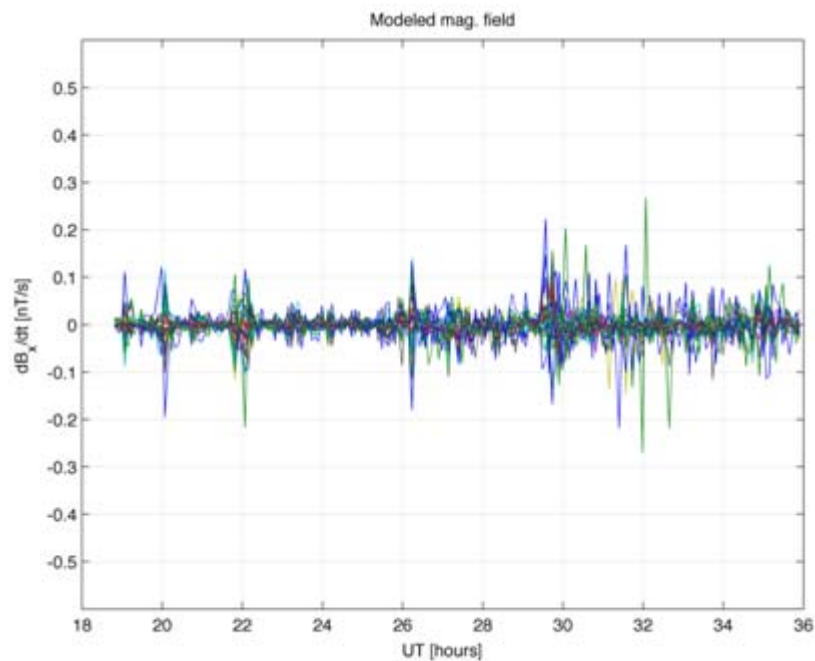
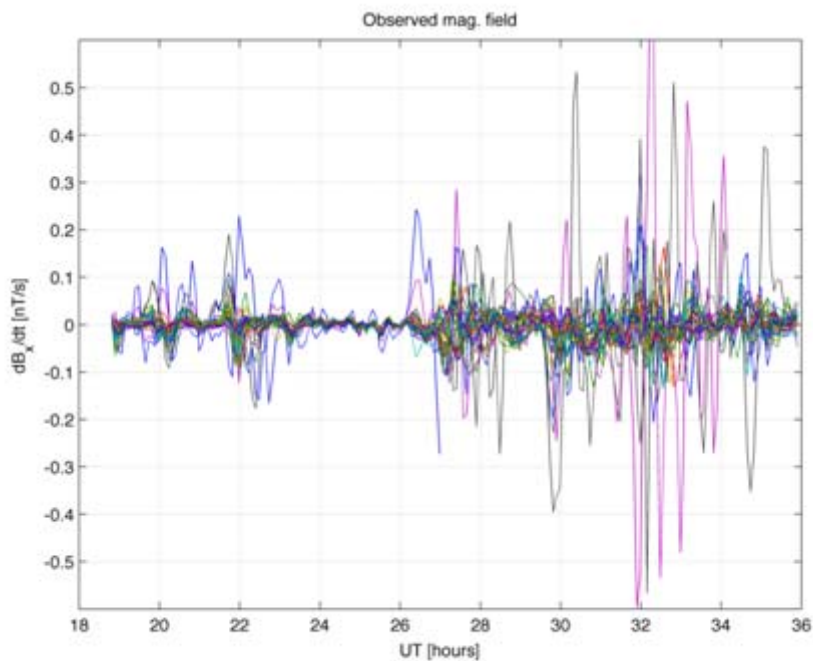
- Pulkkinen et al., First-principles-based modeling of geomagnetically induced currents (GIC) at mid- and low-latitudes, paper presented at fall AGU, San Francisco, CA, December 15-19, 2008.

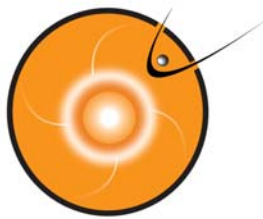




# Inner magnetosphere V&V

Pulkkinen et al., *fall AGU, 2008*

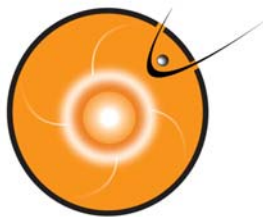




# Ionospheric V&V

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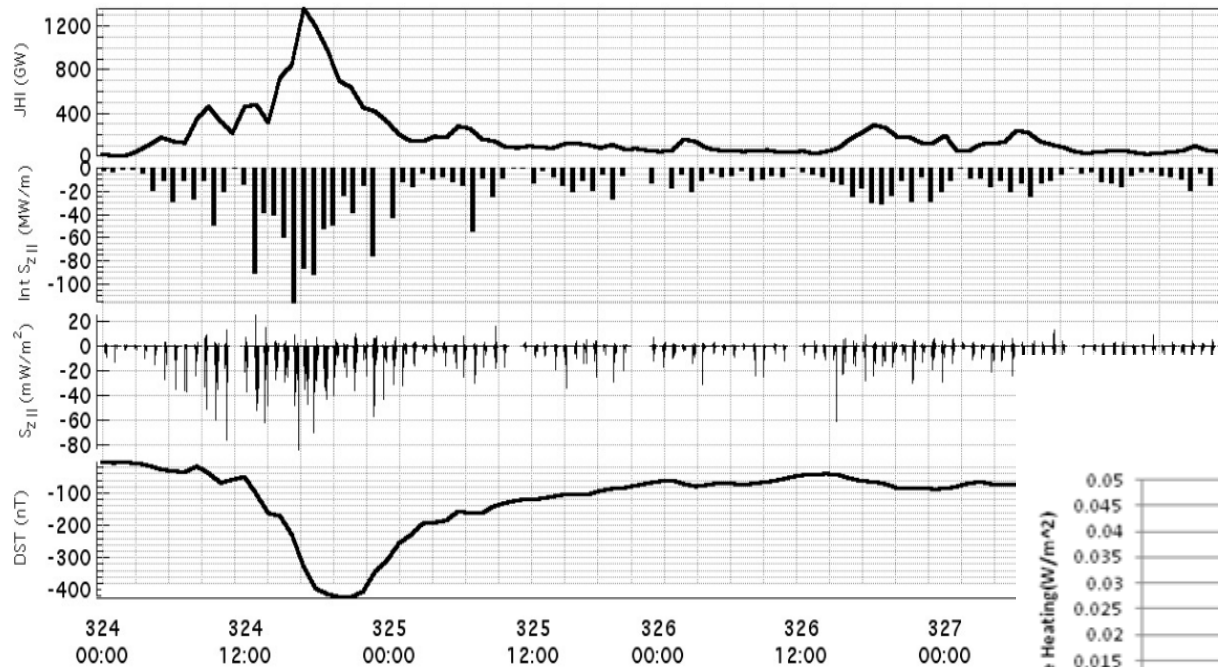
- D. Knipp's student D. Andeweg from US Air Force Academy worked summer 2008 at CCMC. Comparisons between DMSP observations and global MHD (BATS-R-US) predictions.
- Andeweg et al., Comparing Model and Data Energy During Geo Magnetic Storms, paper presented at the Space Weather Workshop, 2009.



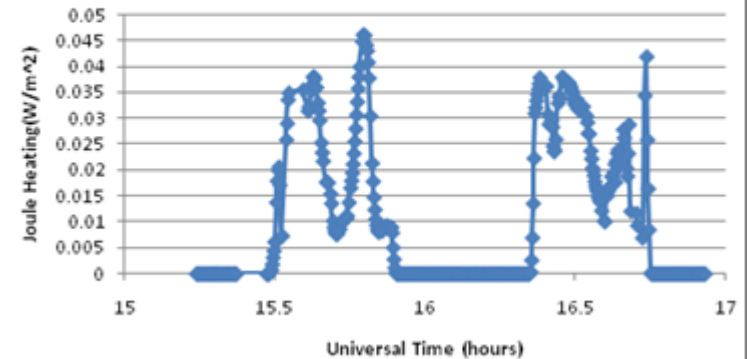
# Ionospheric V&V

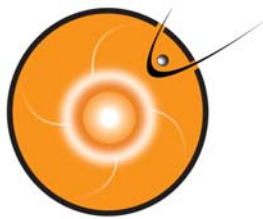
Andeweg et al., *Space Weather*

DMSP F15 2003 NOV 20 - 23 (324-327)



Joule Heating vs. UT  
DMSP\_15 Orbit 8

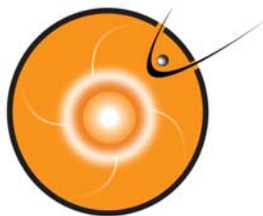




# Geomagnetic index V&V

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- RDst model (by V. Eccles) validation for the Air Force Weather Agency (AFWA). “V&V on request.”
- CCMC, Validation of the RDst model, *technical report provided to AFWA, 2009.*



# Geomagnetic index V&V

CCMC, *technical report*, 2009

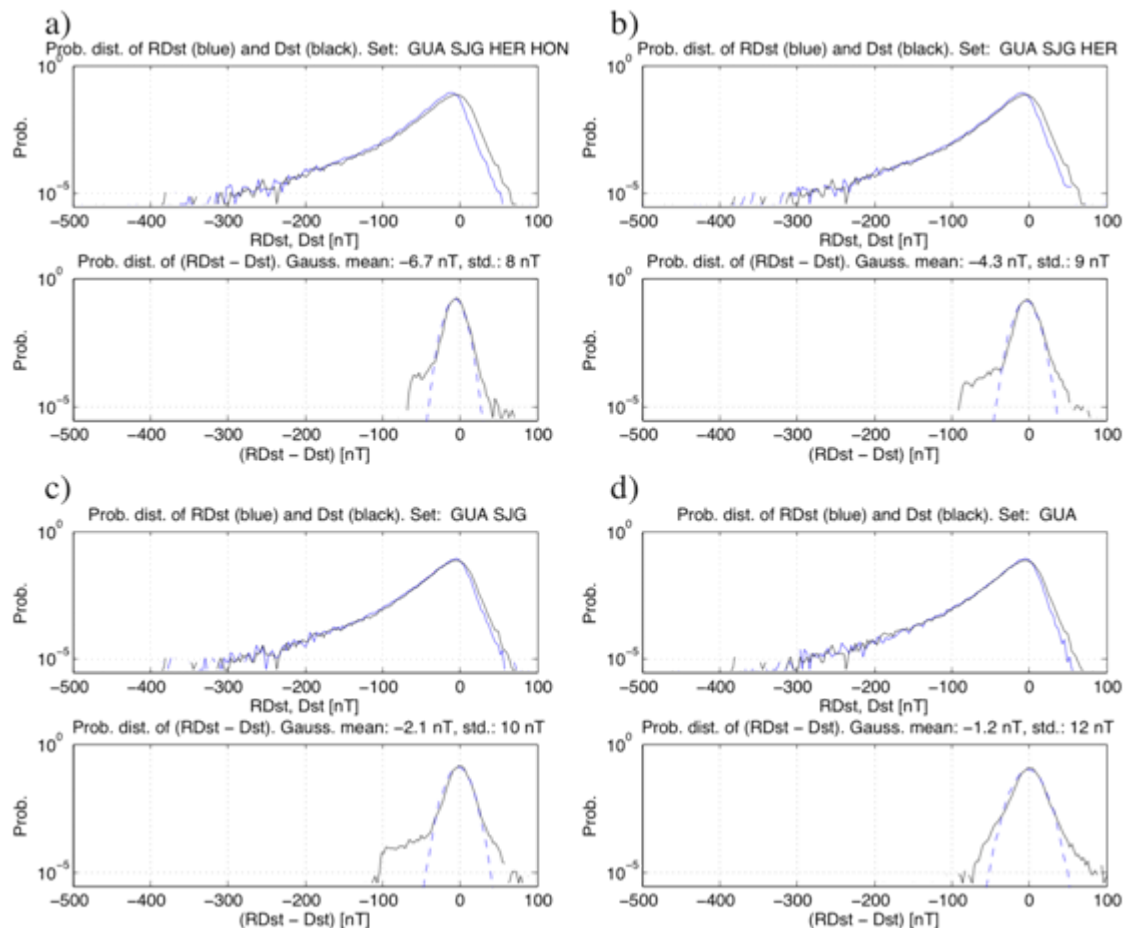
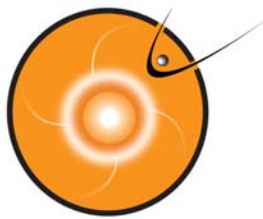


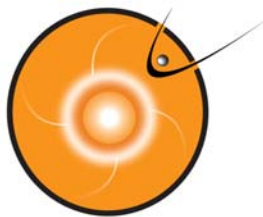
Figure 2: Top panels in a)-d): probability distributions of RDst and Dst. The distributions were computed using one-hour data covering years 1963-1994. Bottom panels in a)-d): probability distributions of the difference (RDst - Dst). The dashed lines show Gaussian distributions fitted to the difference distributions. The titles of the bottom panels indicate the mean and the standard deviation of the Gaussian distributions. RDst in panels a)-d) were computed using four different sets of stations. The used sets of stations are indicated in the titles of the top panels of a)-d).



# Solar wind propagation technique V&V

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- Pulkkinen and Rastätter, Minimum variance analysis-based propagation of the solar wind observations: Application to real-time global magnetohydrodynamic simulations, *Space Weather*, 7, 12, doi:10.1029/2009SW000468, 2009.



# Solar wind propagation technique V&V

Pulkkinen and Rastätter, *Space Weather*, 2009

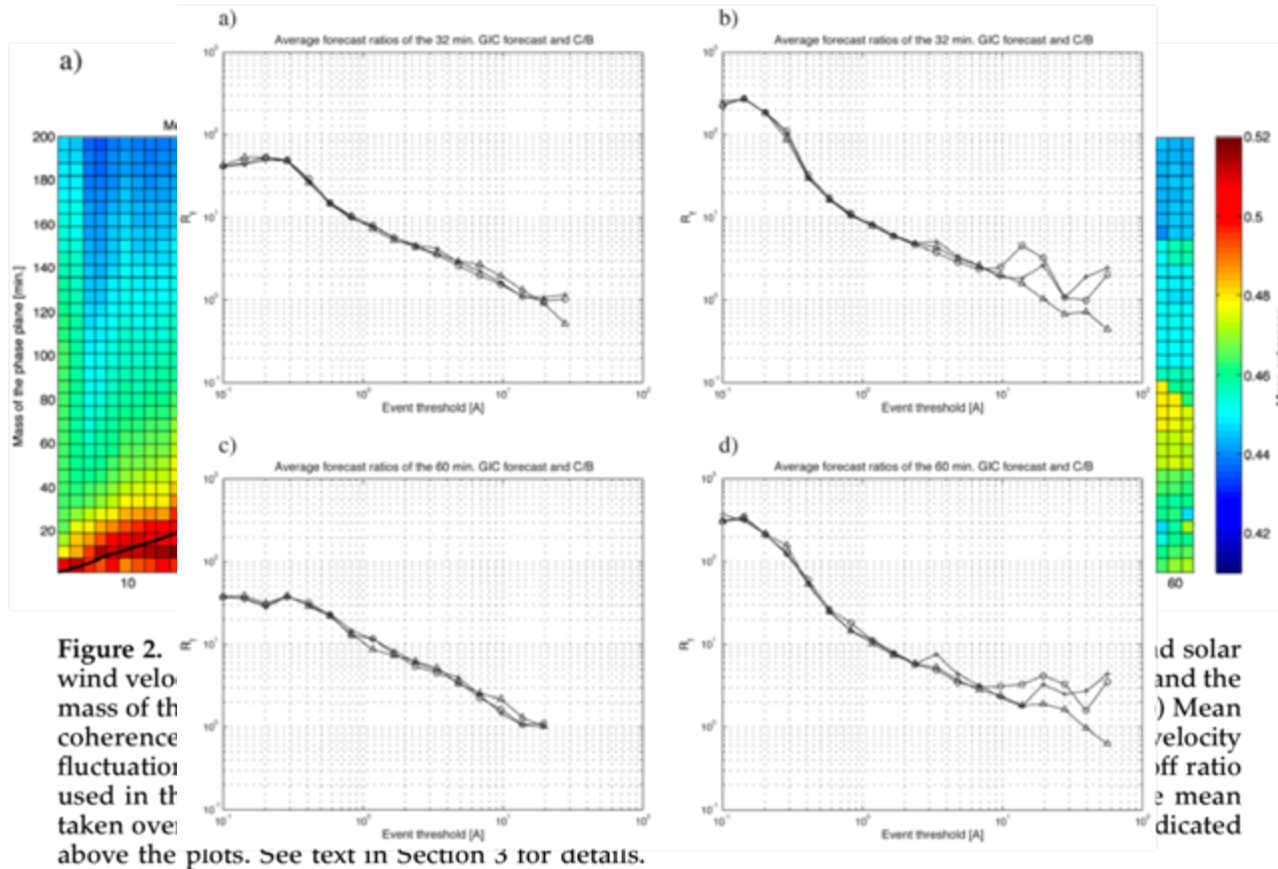
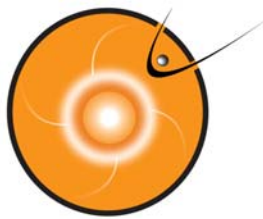


Figure 8. The forecast ratios of the GIC predictions obtained by applying the simple convection delay (triangles), the phase planes with stabilization (plusses), and the *Weimer and King* [2008] setup (circles). (a) The data was analyzed in nonoverlapping 32 minute long forecast windows. (b) The data was analyzed in overlapping 32 minute long forecast windows. (c) The data was analyzed in nonoverlapping 60 minute long forecast windows. (d) The data was analyzed in overlapping 60 minute long forecast windows. See the text and *Pulkkinen et al.* [2007] for details.

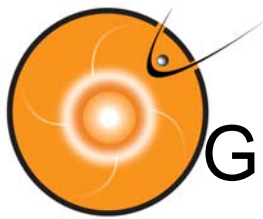


# GEM 2008-2009 Challenge

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- Metrics studies of inner magnetospheric dynamics and ground magnetic field perturbations. Four storm events studied.
- Challenge submissions via CCMC's metrics interface.
- CCMC carried out the metrics analyses.
- Number of different metrics used in the analyses.
- Analyses for the geostationary and ground magnetic field perturbations completed.
- Initial analyses reported by Pulkkinen et al., Systematic evaluation of ground and geostationary magnetic field predictions generated by global magnetohydrodynamic models, *J. Geophys. Res.*, in press.





# GEM 2008-2009 Challenge Metrics Interface

GEM Metrics 2008 Campaign Results At A Glance  
http://ccmc.gsfc.nasa.gov/support/GEM\_metrics\_08/display/metrics\_results.php

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### GEM 2008/2009 Modeling Challenge Results

**Challenge events:**

- Event 1: October 29th, 2003 06:00 UT - October 30th, 06:00 UT
- Event 2: December 14, 2006 12:00 UT - December 16, 00:00 UT
- Event 3: August 31, 2001 00:00 UT - September 1, 00:00 UT
- Event 4: August 31, 2005 10:00 UT - September 1, 12:00 UT

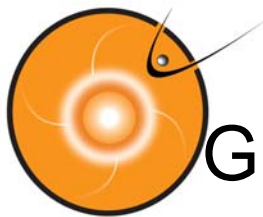
**Metrics studies:**

- 1: Magnetic field at geosynchronous orbit (GOES)
- 2: Magnetopause crossings by geosynchronous satellite (GOES and LANL)
- 3: Plasma density/temperature at geosynchronous orbit (LANL)
- 4: Ground magnetic perturbations (ground based magnetometers)

	Metrics Study 1	Metrics Study 2	Metrics Study 3	Metrics Study 4
<b>Event 1</b>	GOES12 GOES10	LANL02 LANL01 LANL97 LANL94 LANL91 LANL90 GOES12 GOES10	LANL02 LANL01 LANL97 LANL94 LANL91 LANL90	YKC MEA NEW FRN IQA PBQ OTT FRD HRN ABK WNG FUR
<b>Event 2</b>	GOES12 GOES11	LANL02 LANL01 LANL97 LANL94 LANL89 GOES12 GOES11	LANL02 LANL01 LANL97 LANL94 LANL89	YKC MEA NEW FRN IQA PBQ OTT FRD HRN ABK WNG FUR
<b>Event 3</b>	GOES10 GOES08	LANL01 LANL97 LANL94 LANL90 GOES10 GOES08	LANL01 LANL97 LANL94 LANL90	YKC MEA NEW FRN IQA PBQ OTT FRD ABK WNG FUR
<b>Event 4</b>	GOES12 GOES10	LANL02 LANL01 LANL97 LANL94 LANL90 GOES12 GOES10	LANL02 LANL01 LANL97 LANL94 LANL90	YKC MEA NEW FRN PBQ OTT FRD HRN ABK WNG FUR

Curator: Anna Chulaki | NASA Official: Dr. Michael Hesse | Privacy, Security Notices

CCMC logo designed by artist Nana Bagdavadze



# GEM 2008-2009 Challenge Metrics Interface

## **Plot Options:**

**Image magnification**

**Line thickness**

**Character thickness**  (all annotations)

**Lock plot range:**

Min.:  Max.:

## **Select model settings**

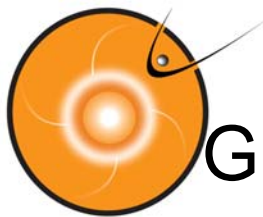
- 1\_SWMF: BATSRUS 7.73, 2M cells, CCMC
- 2\_SWMF: BATSRUS 7.73, 700k cells (real-time setup), CCMC
- 3\_SWMF: BATSRUS 8.01 with RCM, 2M cells, CCMC
- 4\_SWMF: BATSRUS 8.01, 3 M cells, CCMC
- 5\_SWMF: BATSRUS 8.01 with RCM, 3M cells, CCMC
- 6\_SWMF: SWMF V.20090403, BATSRUS+RCM2, 900k cells, RT on 64 procs., A. Ridley
- 1\_OPENGGCM: OpenGGCM 3.1, 3 M cells
- 1\_LFM: LFM, Michael\_Wiltberger (13/11/2008,15/05/2009)
- 1\_CMIT: CMIT 2.0, George\_Millward (28/05/2009, 04/06/2009)
- 1\_WEIMER: Weimer 2005, Daniel\_Weimer (12/05/2009)

*Reset Form* will reset changes to the defaults specified by the previous run of this script.

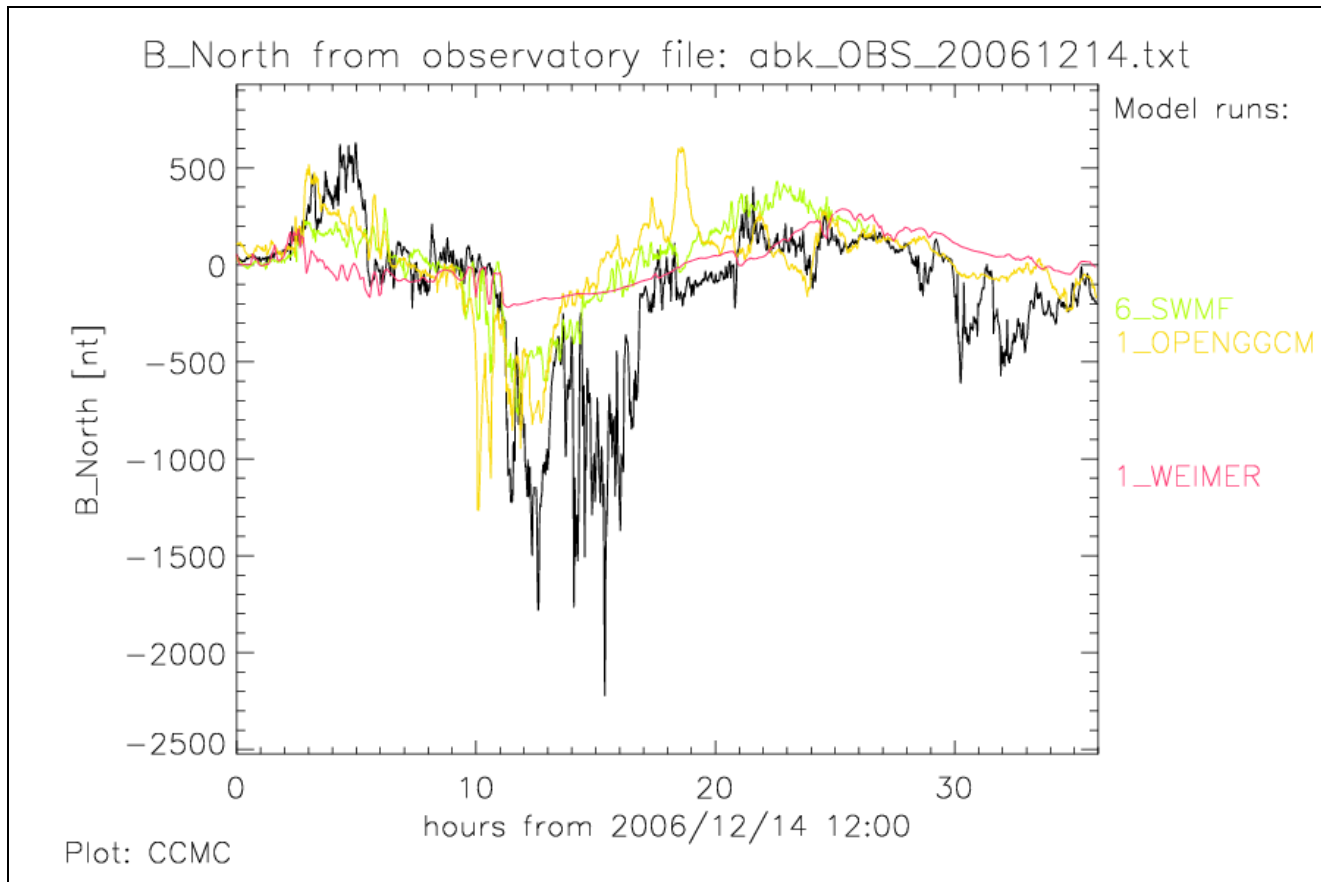
*Update Plot* will update (generate) the plot with the chosen time and plot parameters above.

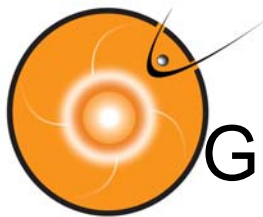
Runs-on-Request: [Contact CCMC Staff](#)

Visualization: [Dr. Lutz Rastätter](#)

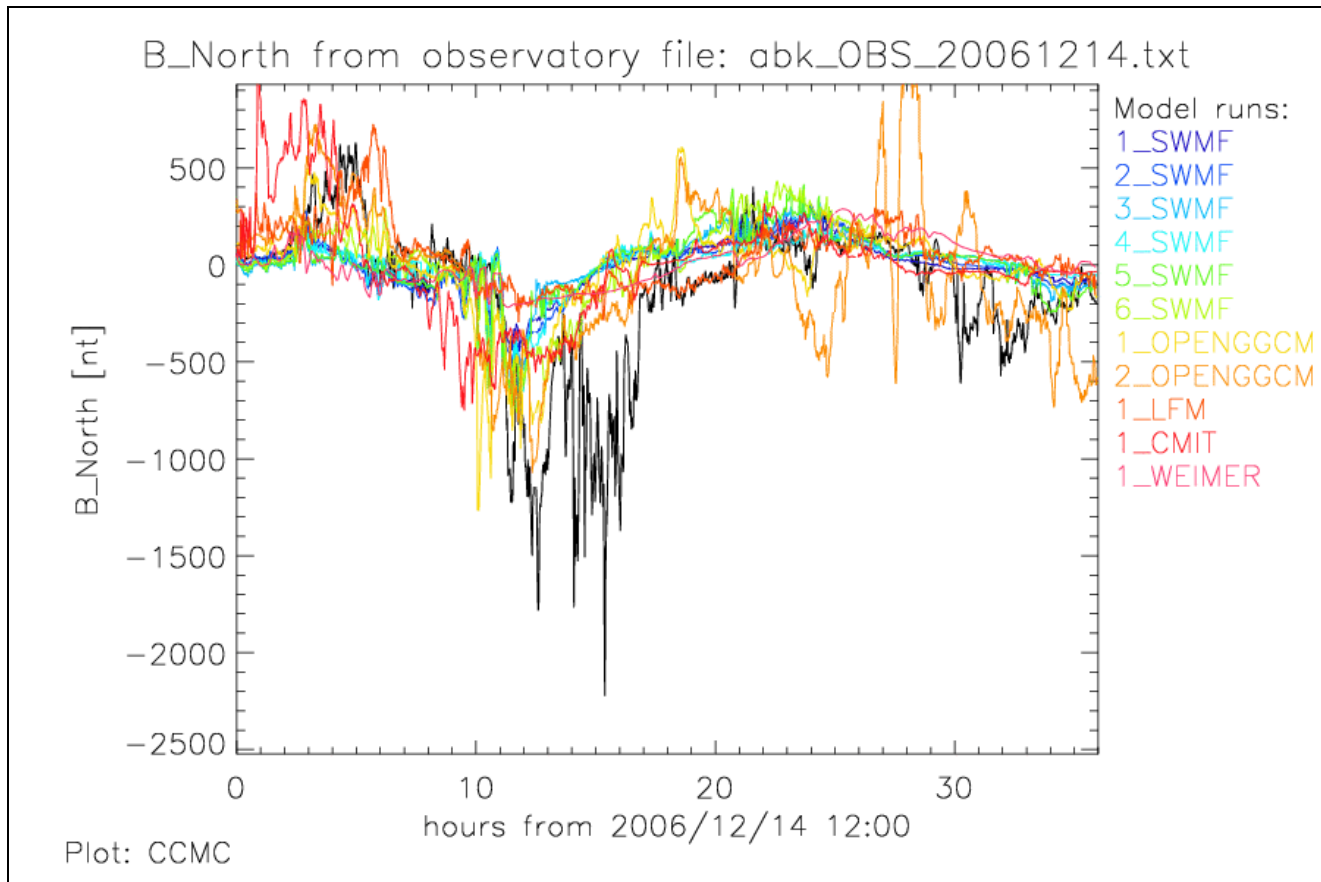


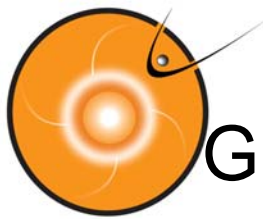
# GEM 2008-2009 Challenge Metrics Interface





# GEM 2008-2009 Challenge Metrics Interface







# GEM 2008-2009 Challenge Metrics Interface

GEM Metrics 2008 Campaign Database

http://ccmc.gsfc.nasa.gov/support/GEM\_metrics\_08/display/

The New York Times The Washington Post Krav Kaannos ISWA BJJ Family Tails Adobe Resources

ensemble : kaikki kielet :: Kaanno... GEM Metrics 2008 Campaign Data...

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## GEM 2008/2009 Modeling Challenge Database

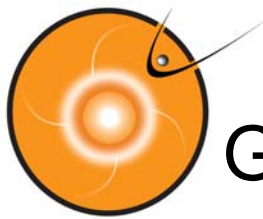
**Select desired metric study and skill score type(s):**

- Metric Study 1: Magnetic field at geosynchronous orbit**
  - Prediction efficiency
  - Log-spectral difference
- Metric Study 2: Magnetopause crossings by geosynchronous satellite: coming soon**
  - Metric 1
  - Metric 2
- Metric Study 3: Plasma density/temperature at geosynchronous orbit: coming soon**
  - Metric 1
  - Metric 2
- Metric Study 4: Ground magnetic perturbations**
  - Prediction efficiency
  - Log-spectral difference

**Select Event(s):**

- Event 1: October 29th, 2003 06:00 UT - October 30th, 06:00 UT
- Event 2: December 14, 2006 12:00 UT - December 16, 00:00 UT
- Event 3: August 31, 2001 00:00 UT - September 1, 00:00 UT
- Event 4: August 31, 2005 10:00 UT - September 1, 12:00 UT

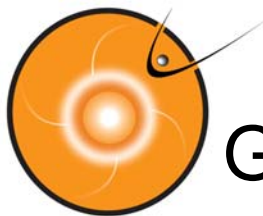
       



# GEM 2008-2009 Challenge Metrics Results

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- Metrics results will be reported in two manuscripts to be submitted to the *Space Weather* journal.
- Pulkkinen et al., *Geospace Environment Modeling 2008-2009 Challenge: ground magnetic field perturbations*, to be submitted to *Space Weather*, 2010.
- Rastätter et al., *Geospace Environment Modeling 2008-2009 Challenge: geostationary magnetic field perturbations*, to be submitted to *Space Weather*, 2010.



# GEM 2008-2009 Challenge Metrics Results

Pulkkinen et al., *Space Weather*, 2010

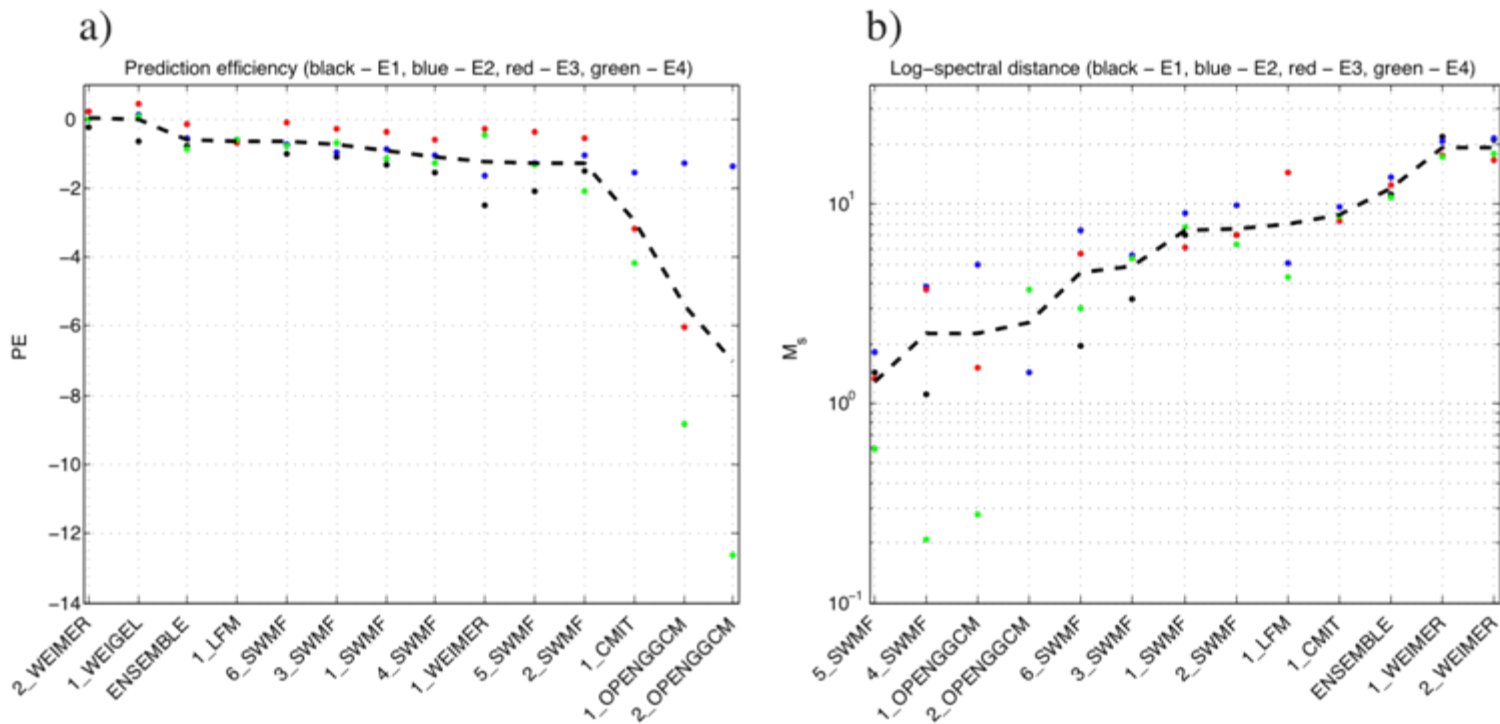
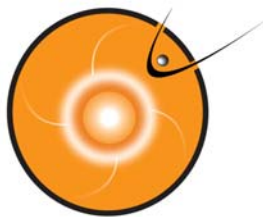


Figure 3: Ranking of the models according to a) the average prediction efficiency (average taken over stations and field components) and b) the average log-spectral distance (average taken over stations). In both panels the best performing model is located in the extreme left. Dots with different colors correspond to different events: black - event 1, blue - event 2, red - event 3, green - event 4. The thick dashed line gives the model average taken over different events. The ranking is based on the averages taken over the events. See Table 2 for model identifiers on the horizontal axis.



# Planned V&V Activities

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- Continued “V&V on request” support for AFWA: comparisons between CCMC’s and AFWA’s auroral oval tools, looking into GAIM validation with varying sets of input data.
- Continued GEM Challenge support and expansion of the Challenge activities to CEDAR.
- Support NOAA Space Weather Prediction Center in their geospace model validation and selection process.