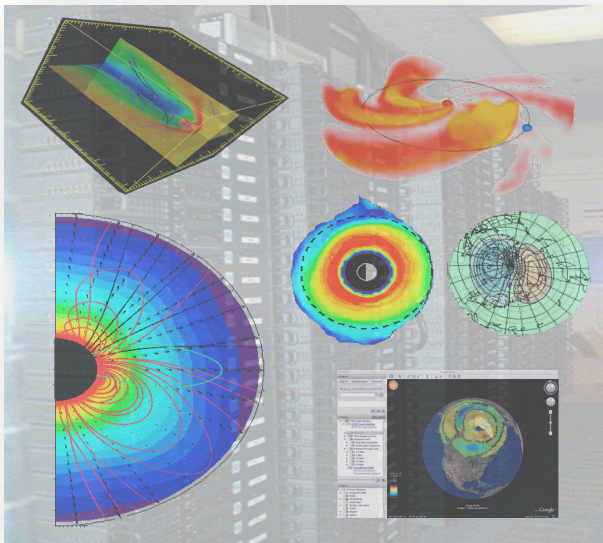
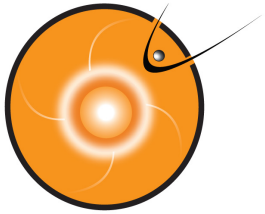


From GEM metrics studies to operational geospace model selection

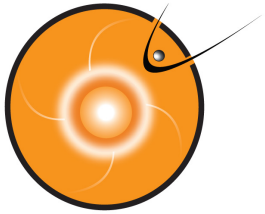
*A. Pulkkinen, M. Kuznetsova, M.
Hesse, L. Rastaetter, A. Chulaki,
J.S. Shim*





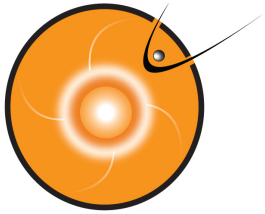
Contents

- Background.
- GEM 2008-2009 Challenge setup (note: will focus only on the ground part here).
- Metrics.
- Model submissions.
- Online metrics interface.
- Metrics-based results.
- Operational geospace model selection activity.
- Summary.



Background

- GEM community recognized need for a community-wide model validation effort: GEM 2008-2009 Challenge, which was supported by CCMC via GEM Metrics and Validation Focus Group.
- Similar activities supported by CCMC ongoing at CEDAR and SHINE programs.
- Goal to address both scientific and operational aspects of the model performance.



GEM 2008-2009 Challenge setup: events

Table 1. Geospace storm events studied in the Challenge. The last two columns give the minimum Dst index and the maximum Kp index of the event, respectively.

Event #	Date and time	min(Dst)	max(Kp)
1	October 29, 2003 06:00 UT - October 30, 06:00 UT	-353 nT	9
2	December 14, 2006 12:00 UT - December 16, 00:00 UT	-139 nT	8
3	August 31, 2001 00:00 UT - September 1, 00:00 UT	-40 nT	4
4	August 31, 2005 10:00 UT - September 1, 12:00 UT	-131 nT	7



GEM 2008-2009 Challenge setup: ground stations

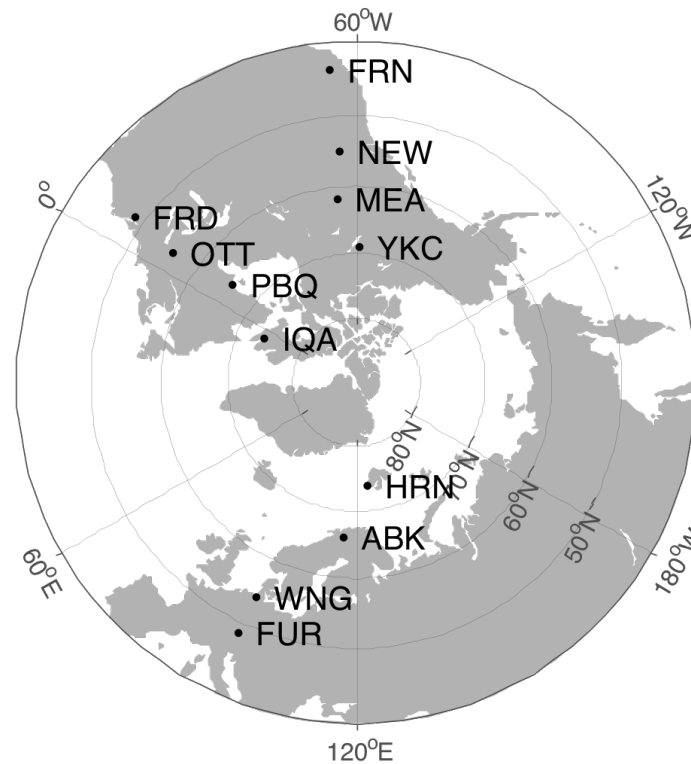
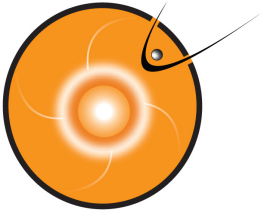


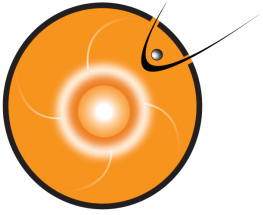
Figure 2. The locations and the station codes of the geomagnetic observatories used in the study. Geomagnetic dipole coordinates are used.



Metrics 1/4: prediction efficiency

$$PE = 1 - \frac{\langle (x_{obs} - x_{mod})^2 \rangle_i}{\sigma_{obs}^2}$$

- Perfect model prediction: $PE = 1$.

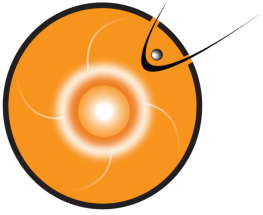


Metrics 2/4: log-spectral distance

$$m_s(\omega) = \log \left[\frac{|\tilde{B}_x|_{obs} + |\tilde{B}_y|_{obs}}{|\tilde{B}_x|_{mod} + |\tilde{B}_y|_{mod}} \right]$$

$$M_s = \sqrt{\frac{1}{N} \sum_{\omega} m_s^2}$$

- Perfect model prediction: $M_s = 0$.

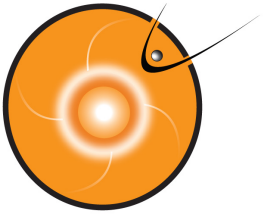


Metrics 3/4: utility metric (forecast ratio)

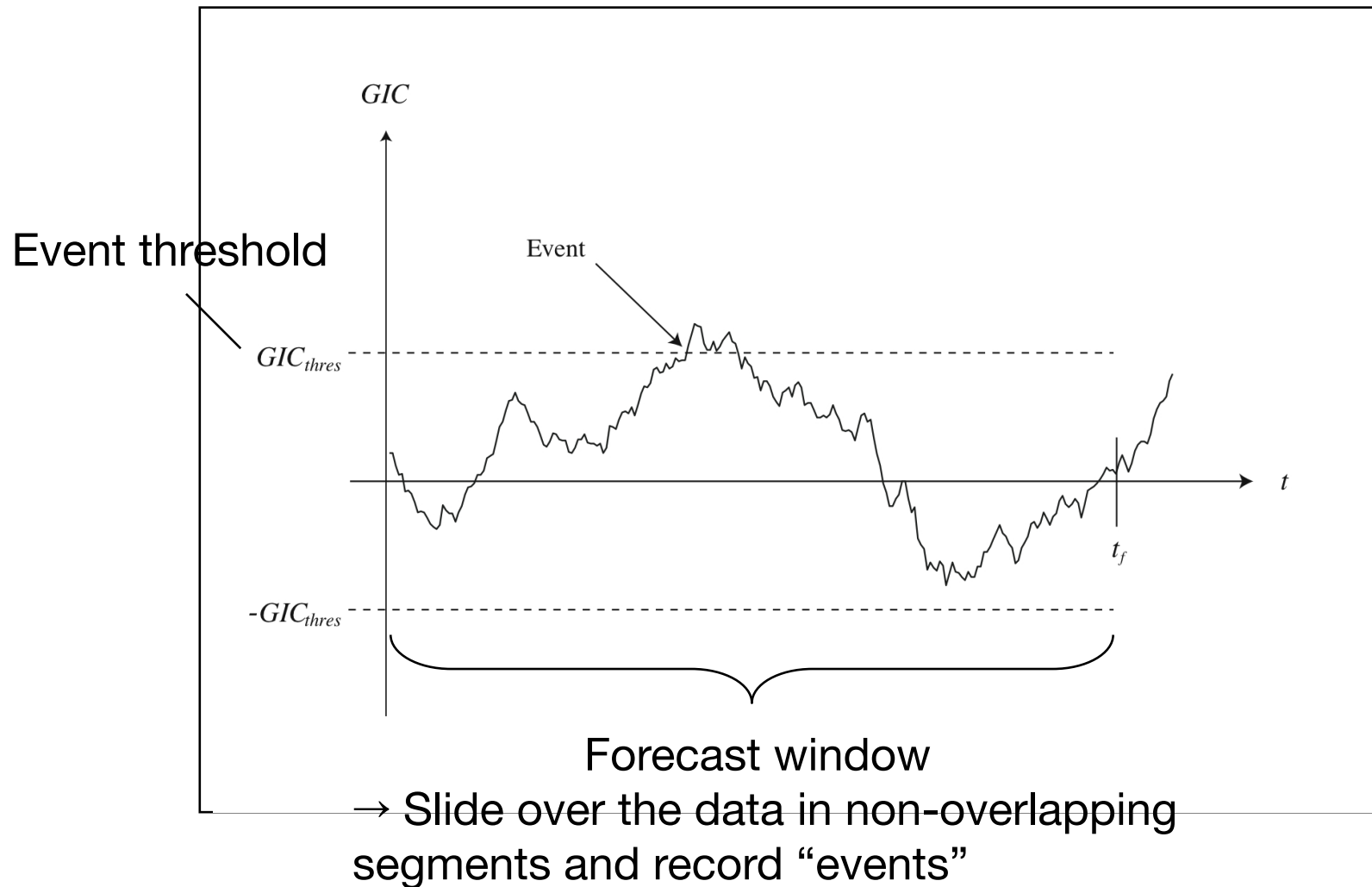
$$U_f = BN_H - CN_{\overline{H}}$$

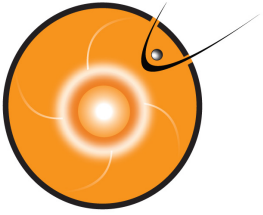
$$R_f = N_H / N_{\overline{H}}$$

- Perfect model prediction: $R_f = \text{Inf.}$
- 45 min. forecast window used.
- Compute R_f for both $|B_h| = \sqrt{B_x^2 + B_y^2}$ and $|dR_x/dt|$



Metrics 3/4: utility metric (forecast ratio)

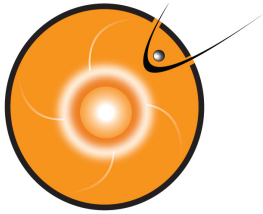




Metrics 4/4: ratio of maximum amplitudes

$$R_{max} = \frac{\max(|x_{mod}|_i)}{\max(|x_{obs}|_i)}$$

- Perfect model prediction: $R_{max} = 1$.
- Compute R_{max} for both $|\mathbf{B}_h| = \sqrt{B_x^2 + B_y^2}$ and $|d\mathbf{B}_h/dt|$



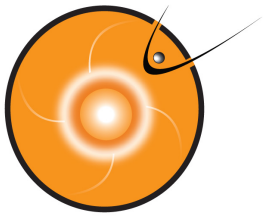
In addition, model ENSEMBLE

Model submissions

Table 3. Model Submissions Analyzed in the Challenge^a

Identifier	Model	Grid (Number of Cells, Min. Res.)
1_CMIT	CMIT 2.0, LFM coupled to TIEGCM	40,000, 0.5 R_e
1_LFM	LFM	160,000, 0.3 R_e
1_OPENGGCM	OpenGGCM v3.1 coupled to CTIM	3 million, 0.3 R_e
2_OPENGGCM	OpenGGCM v3.1 coupled to CTIM	6.5 million, 0.25 R_e
1_SWMF	SWMF v7.73, BATS-R-US	2 million, 0.25 R_e
2_SWMF	SWMF v7.73, BATS-R-US	700,000, 0.25 R_e
3_SWMF	SWMF v8.01 BATS-R-US coupled to RCM	2 million, 0.25 R_e
4_SWMF	SWMF v8.01, BATS-R-US	3 million, 0.125 R_e
5_SWMF	SWMF v8.01, BATS-R-US coupled to RCM	3 million, 0.125 R_e
6_SWMF	SWMF v20090403, BATS-R-US coupled to RCM	900,000, 0.25 R_e
1_WEIMER	<i>Weimer [2005]</i>	4 min output interpolated into 1 min
2_WEIMER	New empirical model by D. Weimer	4 min output interpolated into 1 min
1_WEIGEL	<i>Weigel et al. [2003]</i>	30 min output

^aEach model is assigned a unique model identifier given in the first column. The table indicates the model version, and if applicable, the number of cells and the minimum spatial resolution used in the global MHD part of the model. Note that different model setups are referred as different “models.”



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

The New York Times The Washington Post Wall Street Journal Krav Kaannos Manifolds

GEM Metrics 2008 Campai...

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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:

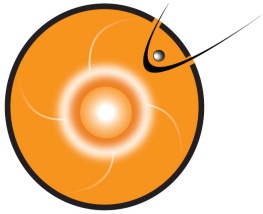
- 1: Magnetic field at geosynchronous orbit (GOES)
- 2: Magnetopause crossings by geosynchronous satellite (GOES and LANL)
- 3: Plasma density/temperature at geosynchronous orbit (LANL)
- 4: Ground magnetic perturbations (ground based magnetometers)

	Metrics Study 1	Metrics Study 2	Metrics Study 3	Metrics Study 4
Event 1	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
Event 2	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
Event 3	GOES10 GOES08	LANL01 LANL97 LANL94 LANL90 GOES10 GOES08	LANL01 LANL97 LANL94 LANL90	YKC MEA NEW FRN IQA PBQ OTT FRD ABK WNG FUR
Event 4	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

NASA NSF UNM

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

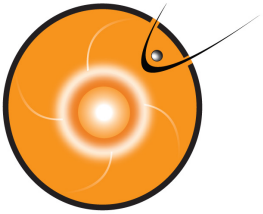
- 1_SWMF: BATSRUS 7.73, 2M cells, CCMC
- 2_SWMF: BATSRUS 7.73, 700k cells (real-time setup), CCMC
- 3_SWMF: BATSRUS 8.01 with RCM, 2M cells, CCMC
- 4_SWMF: BATSRUS 8.01, 3 M cells, CCMC
- 5_SWMF: BATSRUS 8.01 with RCM, 3M cells, CCMC
- 6_SWMF: SWMF V.20090403, BATSRUS+RCM2, 900k cells, RT on 64 procs., 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.

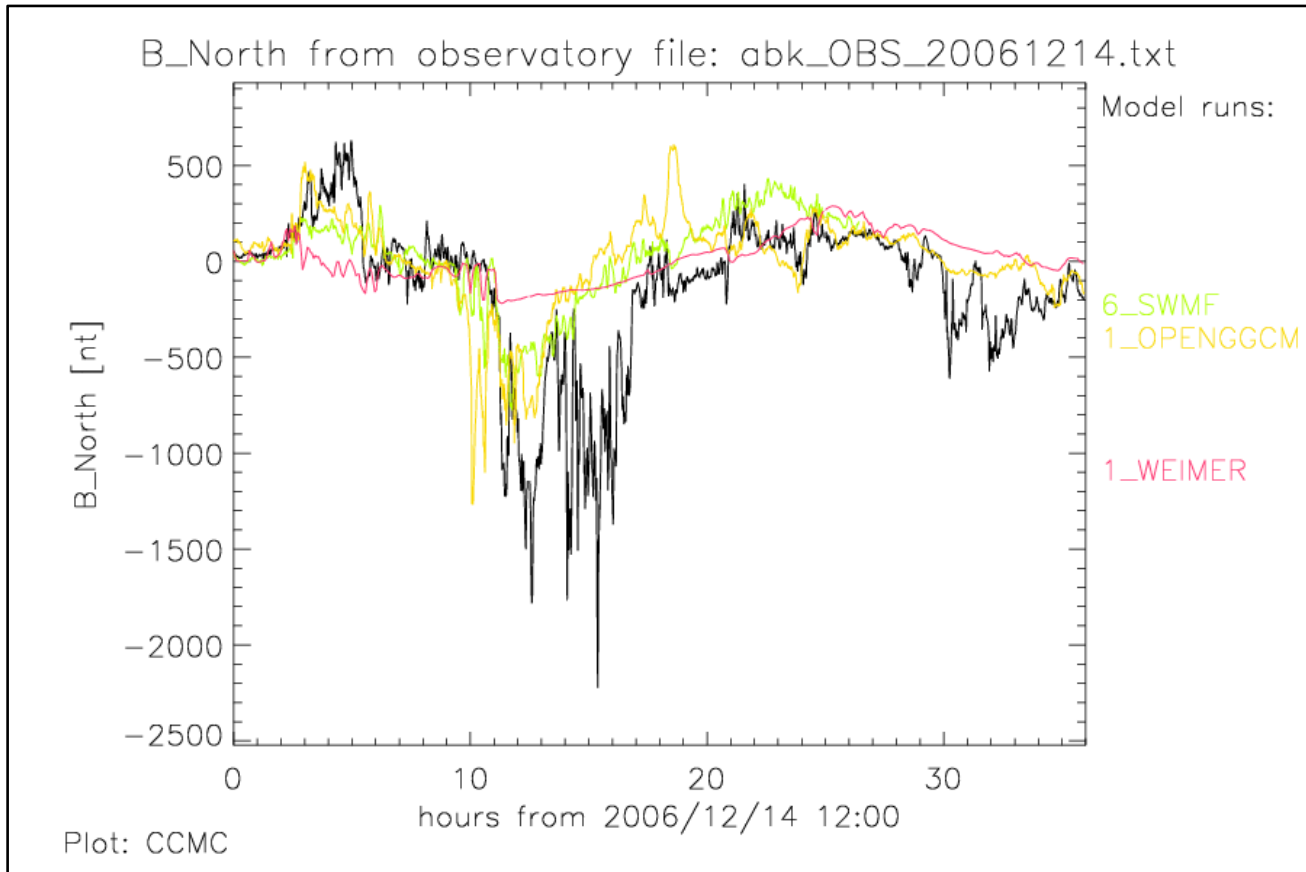
Update Plot will update (generate) the plot with the chosen time and plot parameters above.

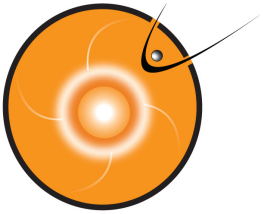
Runs-on-Request: [Contact CCMC Staff](#)

Visualization: [Dr. Lutz Rastätter](#)

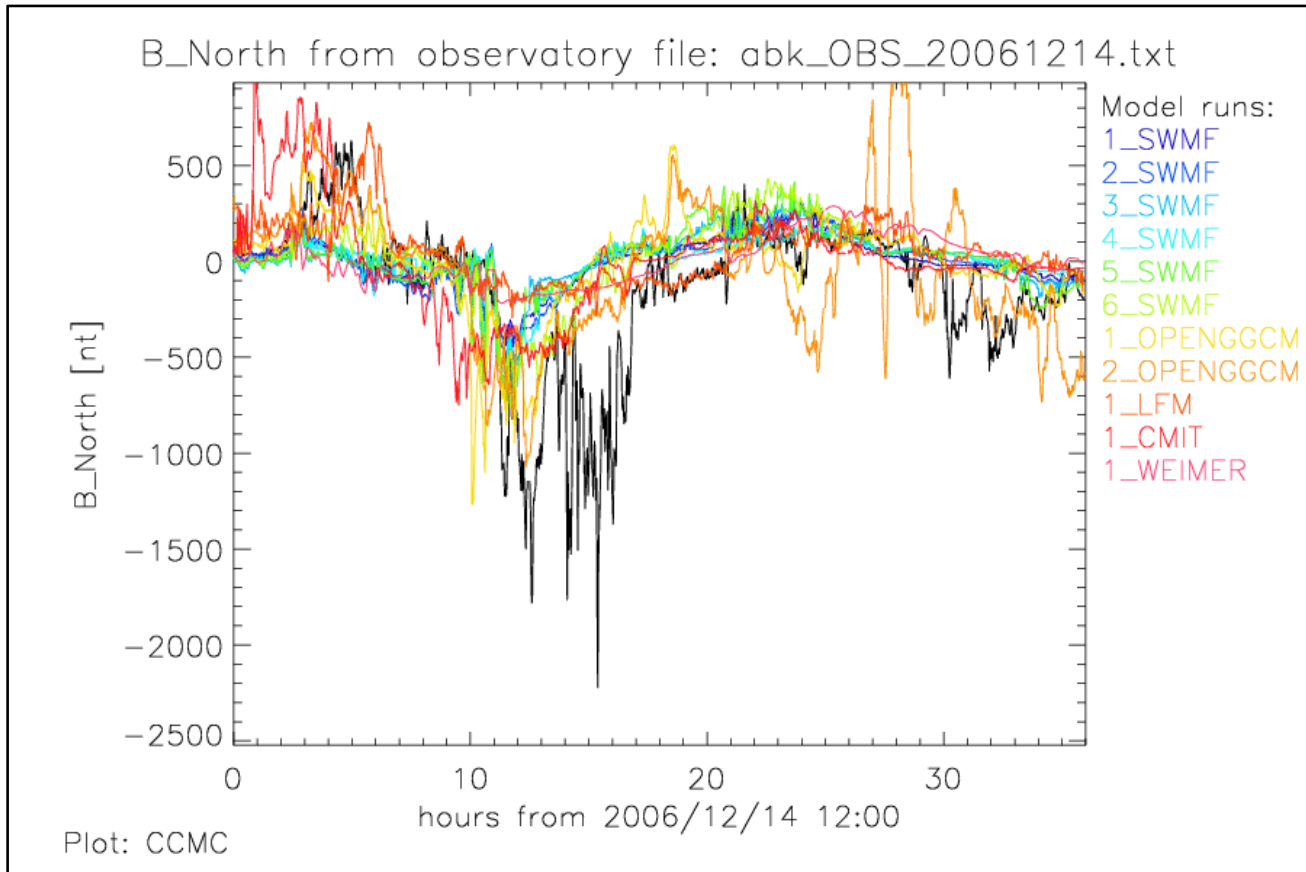


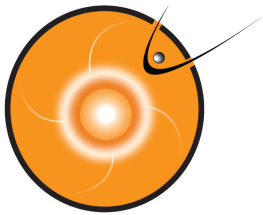
GEM 2008-2009 Challenge Metrics Interface





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/

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GEM 2008/2009 Modeling Challenge Database

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

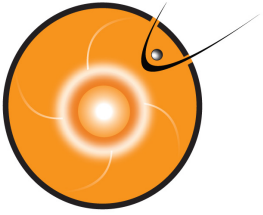
- Metric Study 1: Magnetic field at geosynchronous orbit
 - Prediction efficiency
 - Log-spectral difference
- Metric Study 2: Magnetopause crossings by geosynchronous satellite: coming soon
 - Metric 1
 - Metric 2
- Metric Study 3: Plasma density/temperature at geosynchronous orbit: coming soon
 - Metric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

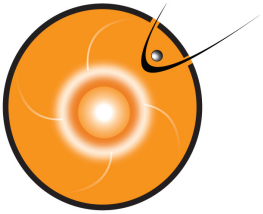
Continue

NASA GSFC

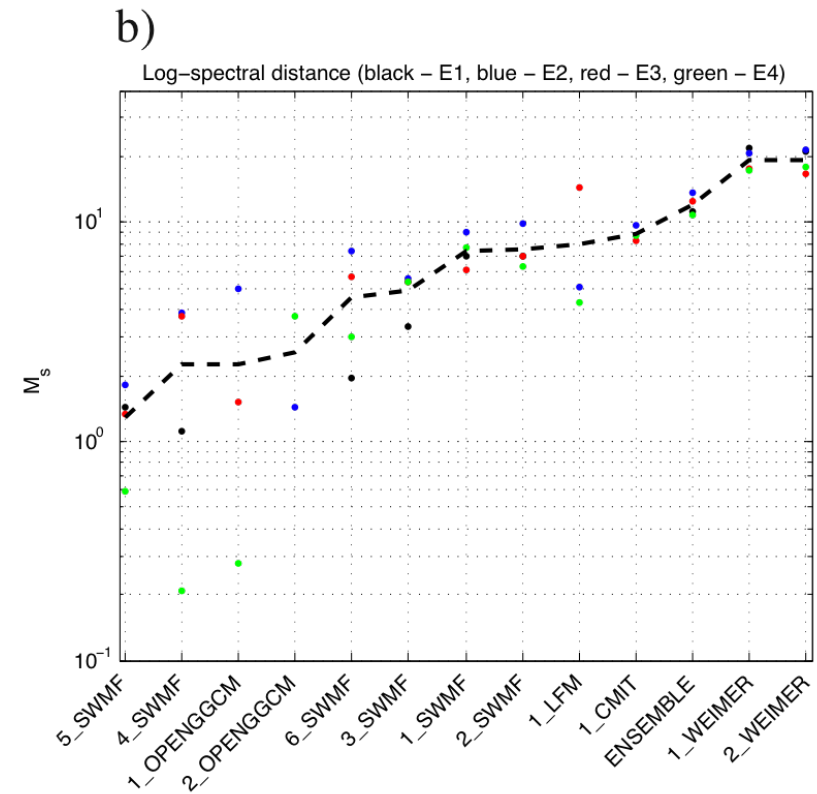
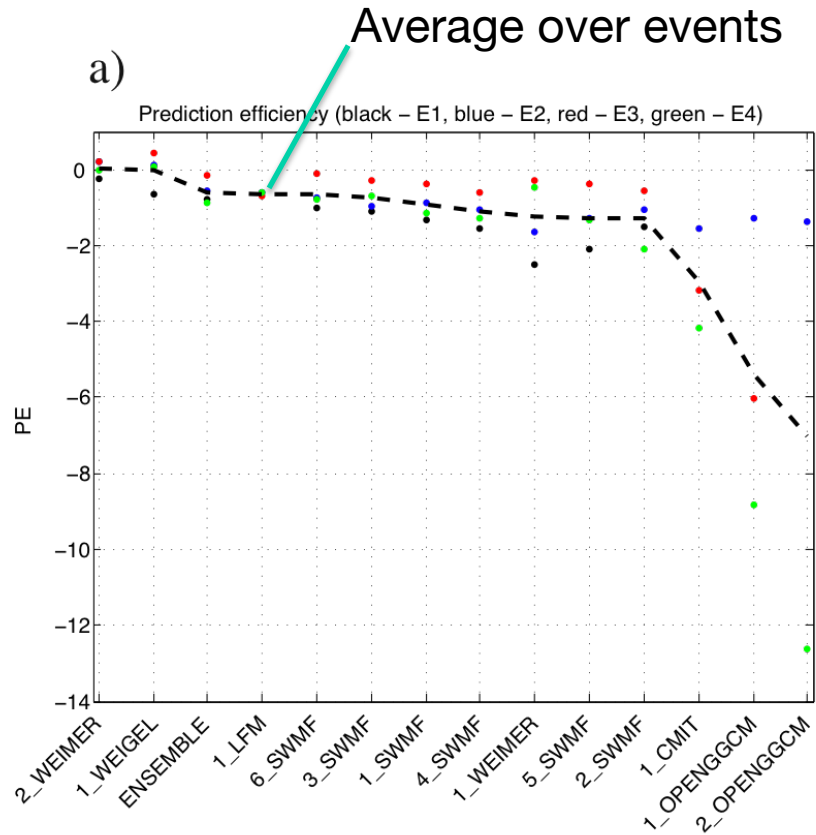


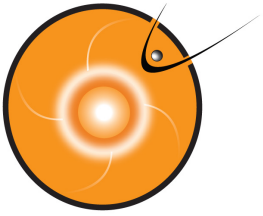
Metrics-based results

- In all figures averages (integration) over stations and, if applicable, over horizontal field components reported.
- Ranking based on averages (integration) over events.
- Caution: not all events included for all models/ setups.

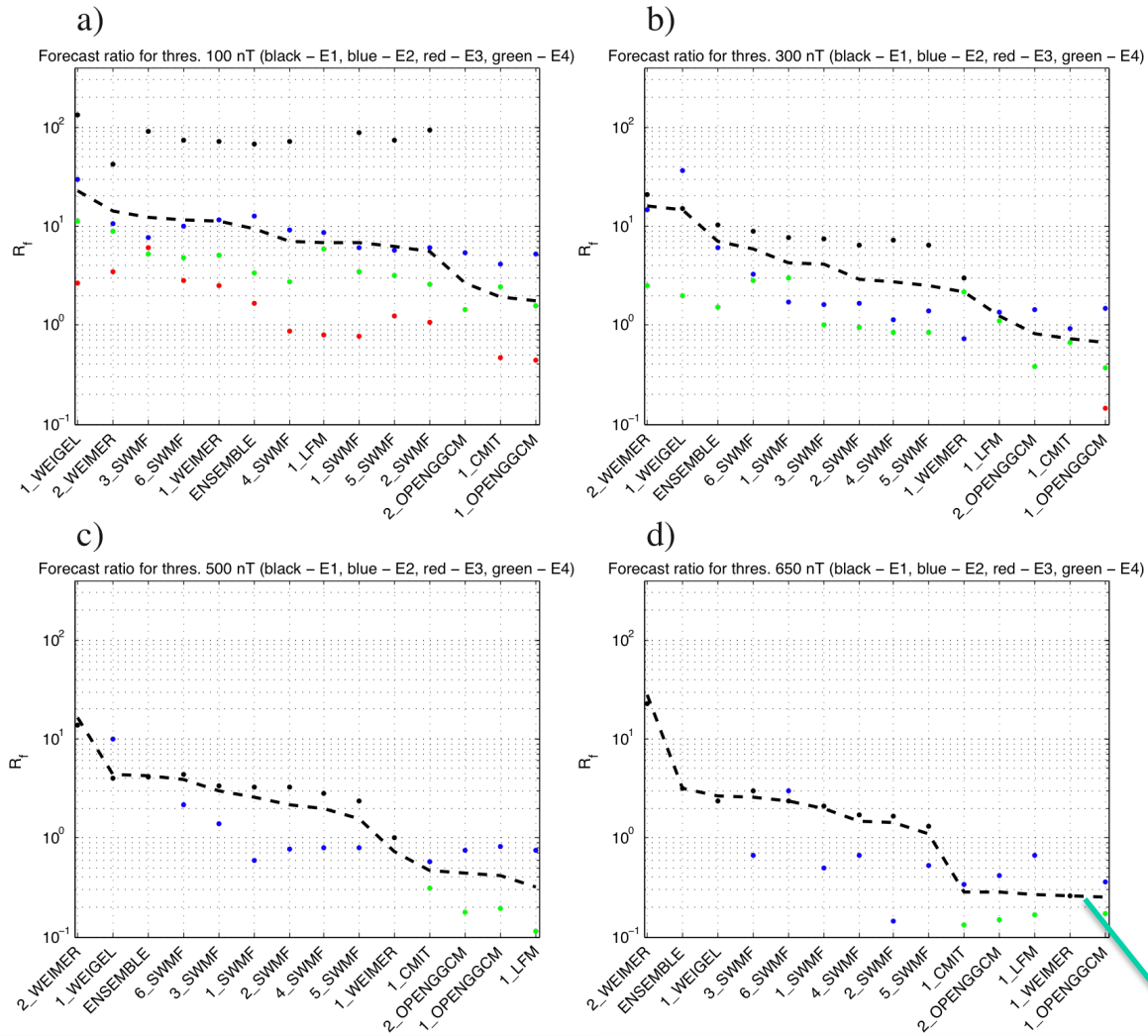


Metrics-based results: PE and M_s

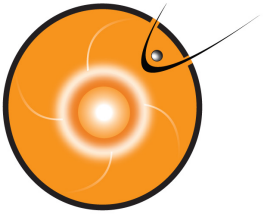




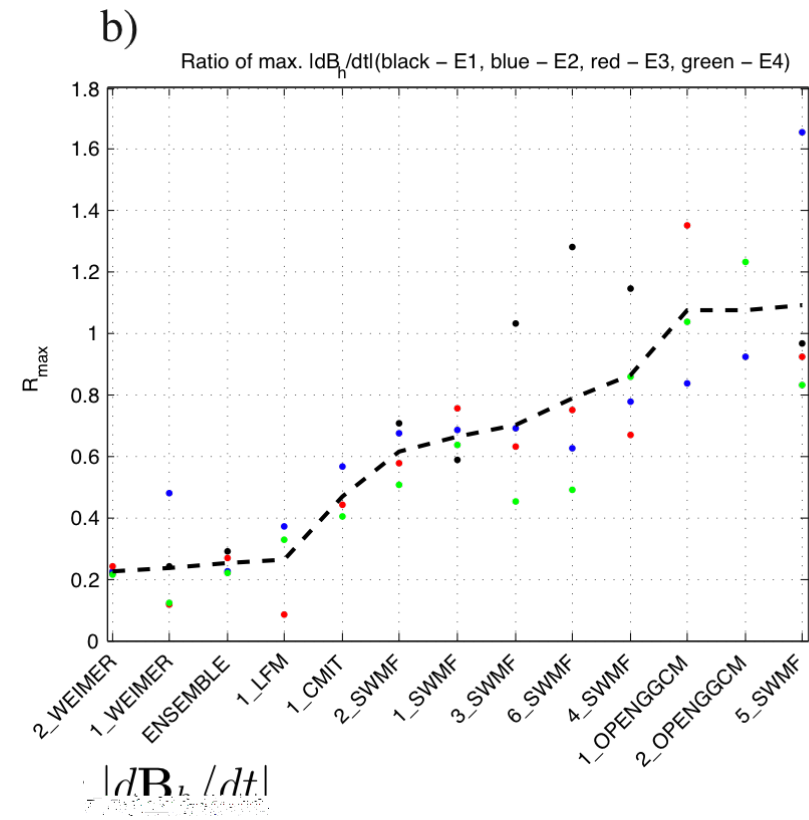
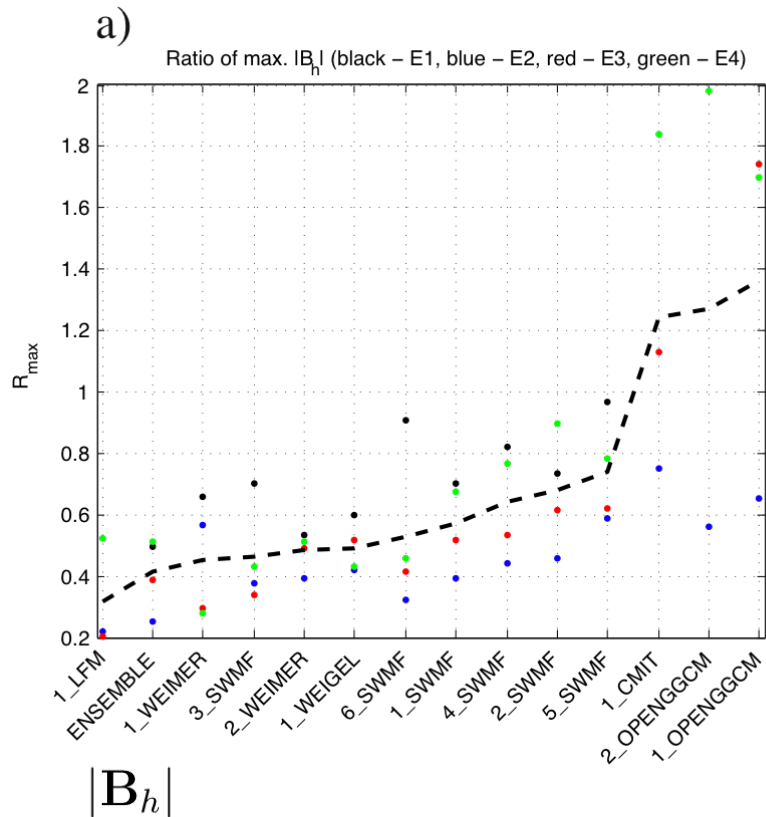
Metrics-based results: R_f for $|B_h|$



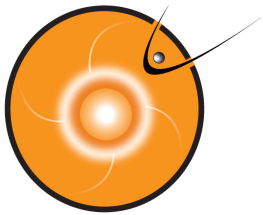
Integration over events



Metrics-based results: R_{max}

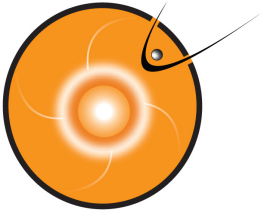


Note: no ranking here

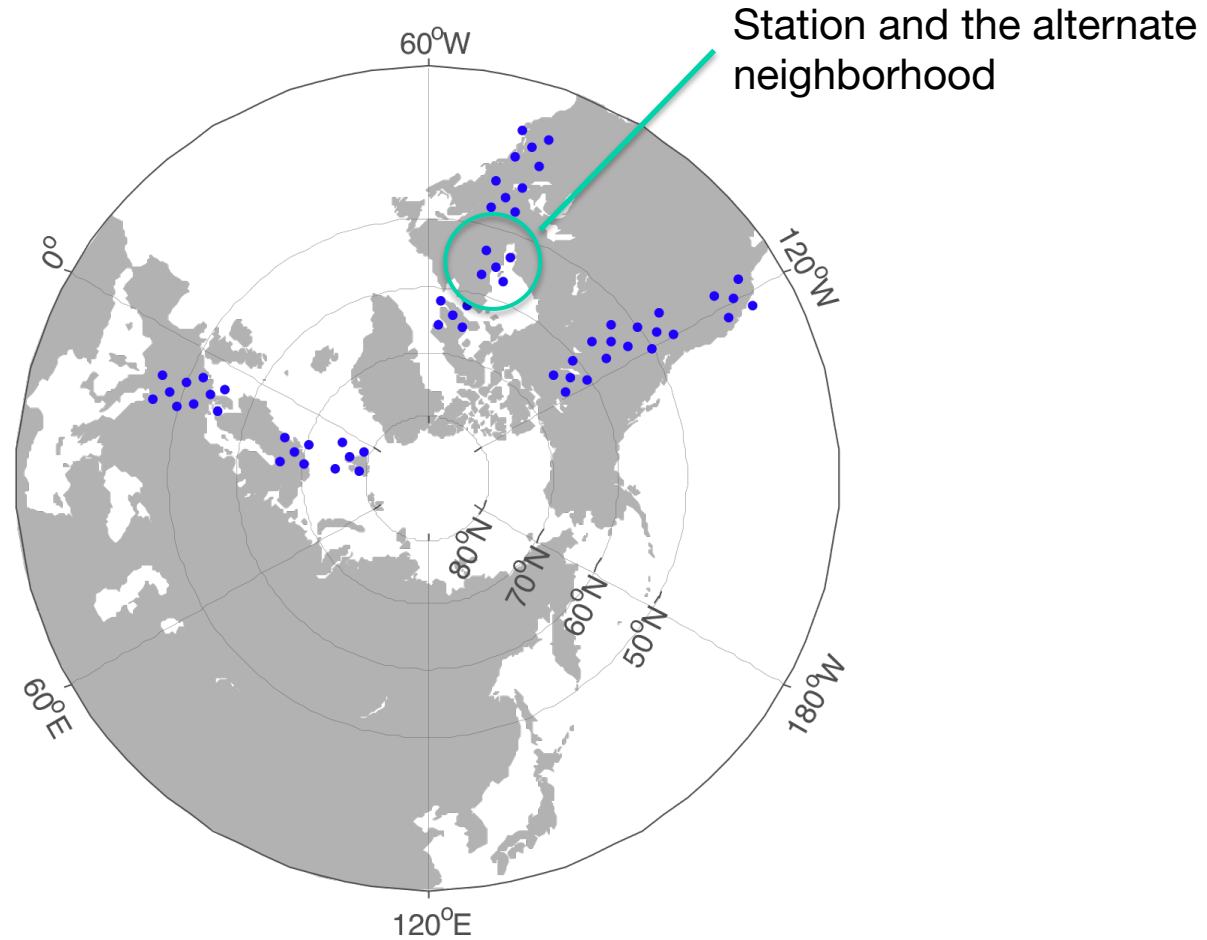


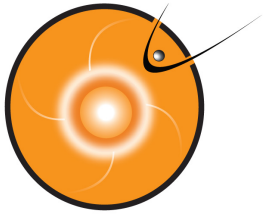
Operational model selection activity

- CCMC is supporting NOAA SWPC's geospace model selection. The goal to select a model for predicting the ground magnetic field fluctuations.
- All major US global 3D MHD models and two empirical models participating the activity.
- Lessons learned in the GEM activity utilized in the selection activity.
- Threshold-based metrics as well as GEM events and set of ground magnetometer stations used in the activity.
- Additional "sensitivity tests" not part of the original GEM Challenge carried out in the activity.



Operational model selection activity





Summary

- Recent CCMC supported community-wide model validation efforts under GEM, CEDAR and SHINE programs.
 - One of the ideas is to repeat the exercises every couple years to measure the progress in the field.
 - Pulkkinen et al., Geospace Environment Modeling 2008-2009 Challenge: ground magnetic field perturbations, Space Weather, 2011.
 - Rastaetter et al., Geospace Environment Modeling 2008-2009 Challenge: geostationary magnetic field perturbations, Space Weather, 2011.
 - GEM Challenge lessons support directly NOAA SWPC's geospace model validation and selection process.
-