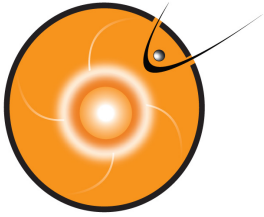


# dB/dt Challenge: Model Outputs, Visualization and Analysis

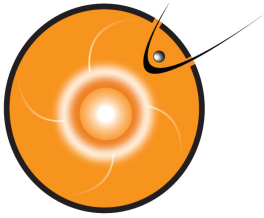
Lutz Rastaetter,  
Masha Kuznetsova, Antti Pulkkinen & Anna Chulaki

2012 GEM Summer Workshop



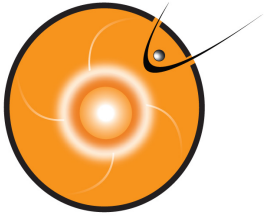
# The dB/dt Challenge

- **Collaboration with GEM community and modelers:**  
T. Gombosi, J. Raeder, J. Lyon, D. Weimer, R. Weigel
- **5 models:**
  - First-principles (MHD magnetosphere and ionosphere electrodynamics):  
SWMF, OpenGGCM, LFM (CMIT)
  - Statistical (magnetic perturbation models):  
Weimer, Weigel
- **Model delivery dates:**
  - SWMF: Jan. 31, 2011
  - OpenGGCM: Feb. 08, 2011
  - Weigel: Feb. 13, 2011
  - CMIT (LTR-2\_1\_1): Feb. 15, 2011
  - Weimer: April 19, 2011



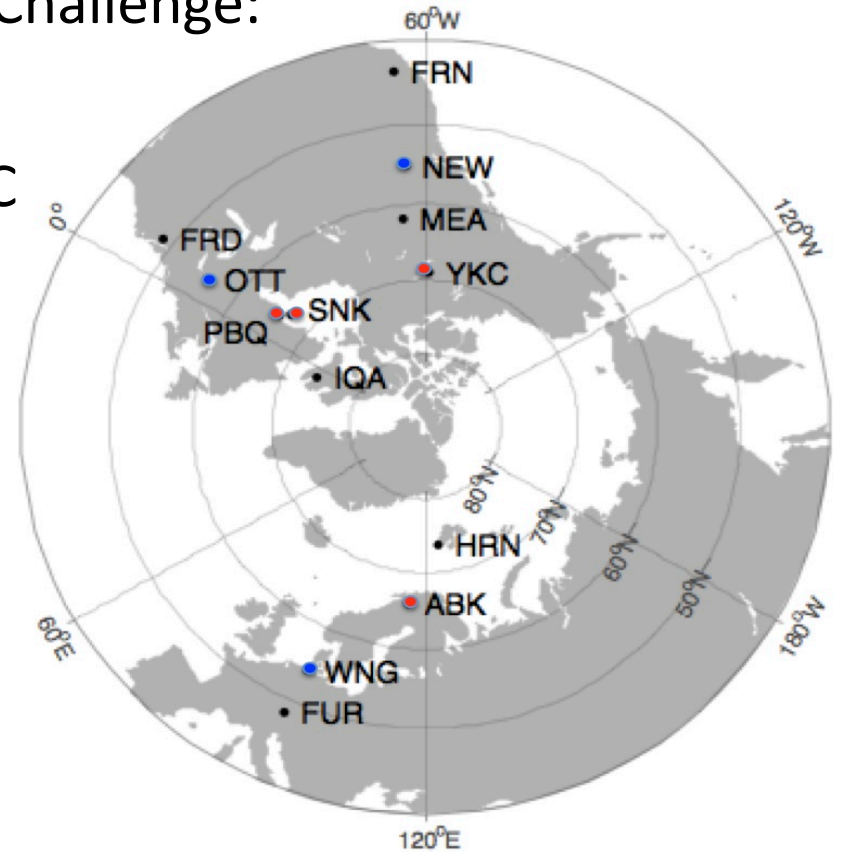
# Events

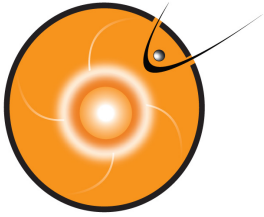
- Events from GEM 2008-2009 study:
  - 2003/10/29 06:00 – 2003/10/30 06:00  
(DST=-353 nT, KP=9, part of “Halloween Storm”)
  - 2006/12/14 12:00– 2006/12/16 00:00  
(DST=-162 nT, KP=8+, “AGU storm”)
  - 2001/08/30 00:00 – 2001/09/01 00:00 (DST= -40 nT, KP=4)
  - 2005/08/30 09:30 – 2005/09/01 12:00 (DST=-122 nT, KP=7)
- New events selected for this study:
  - 2010/04/05 00:00 – 2010/04/06 09:00 (DST= -67 nT, KP=8-)
  - 2011/08/05 09:00 – 2011/08/06 09:00 (DST=-113 nT, KP=8-)



# Magnetometer stations

- Station list defined for 2008 GEM Challenge:  
ABK, FRD, FRN, FUR, HRN, IQA,  
MEA, NEW, OTT, PBQ/SNK, WNG, YKC
- Stations in low to high latitudes covering large longitude range
  - Subset of list is used for dBdt study.
- Station data missing:
  - ABK (Abisko) for 2011 event
  - PBQ (Poste de la Baleine) for 2010, 2011 events.  
Was replaced by nearby SNK (Sanikiluaq) in 2009.





# Model runs

## Magnetosphere MHD:

**9\_SWMF**: real time setup with 1M cells and RCM inner magnetosphere  
(version of Jan. 31, 2011)

**4\_OPENGGCM**: OpenGGCM V. 4.0 real-time setup 3.88M cells,  
(model released, Feb. 8, 2011, with updates through Aug. 2011)

**1\_CMIT-LFM**: 53x48x64 grid, real-time setup (LTR-2\_1\_1, of Jan. 14, 2011)

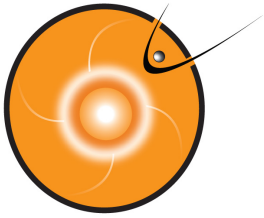
All magnetosphere models track changing dipole tilt.

Magnetosphere models designed to run in real-time on 64 processors  
on current hardware at CCMC (2 times slower on 2008 hardware).

## Statistical models:

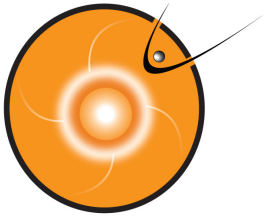
**5\_WEIMER**: results of Weimer deltaB model (version of Apr. 19, 2011)

**3\_WEIGEL**: Weigel deltaB model, optimized for dB/dt (version of Feb. 13, 2011)



# Timeline data

- Directly written by model:
  - **Weimer, Weigel**: models' only output
- CCMC post-processing:
  - **SWMF, CMIT-LFM, OpenGGCM**:
    - Biot-Savart integration over
      - magnetosphere currents,
      - field-aligned currents (FAC) between magnetosphere and ionosphere along dipole field lines,
      - ionosphere currents (from electrodynamics outputs).
    - FAC in gap region: Serial process, medium resolution (120 latitudes, 180 longitudes, 60 layers).

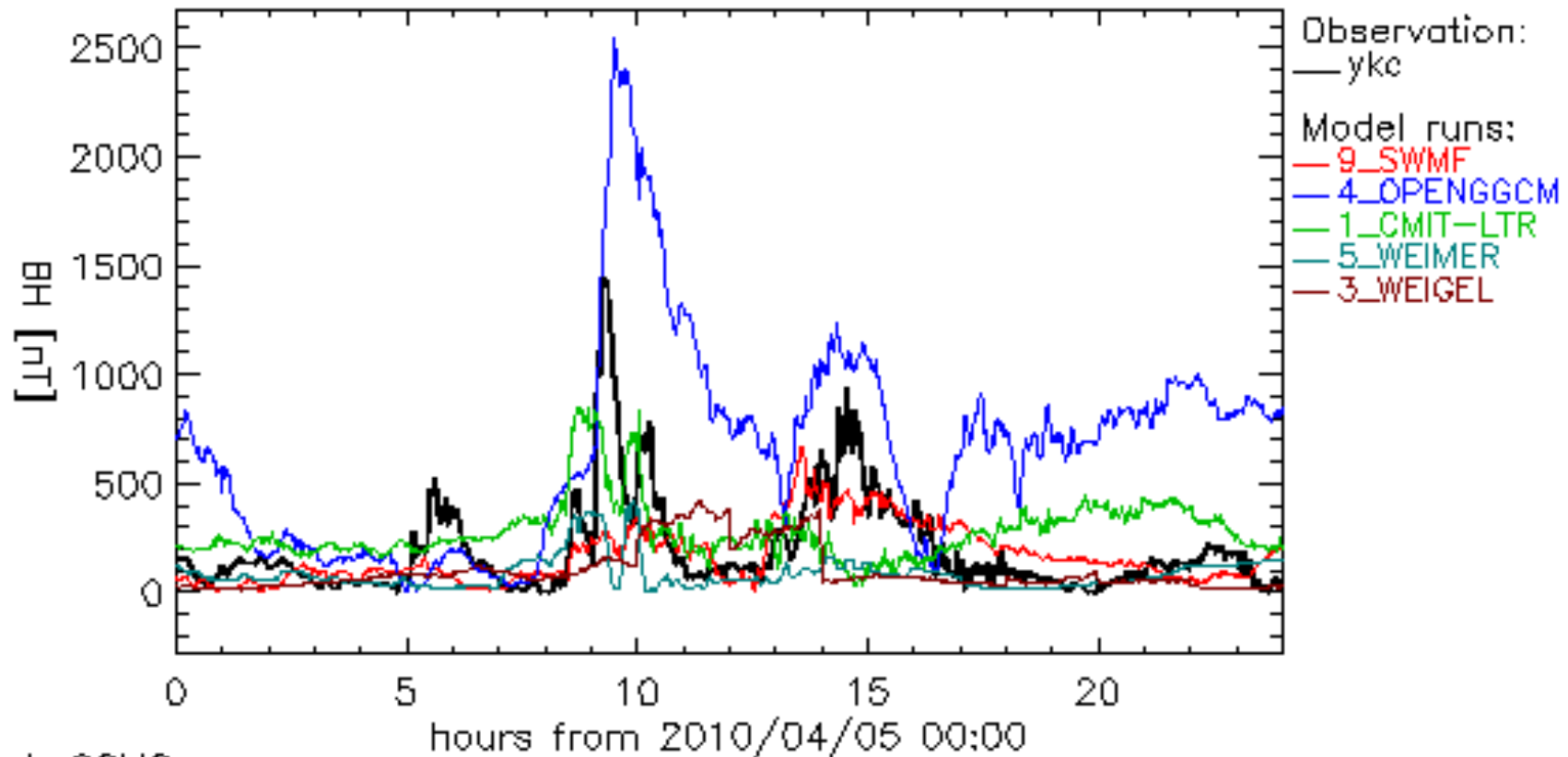


# Visualization

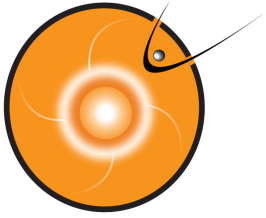
$\Delta B$  ( $|\Delta B_H|$ ,  $|\Delta B|$ , components: North, East, Down)

High latitude: ( $|\Delta B)_H|$  at YKC (2010 event)

BH from observatory file: ykc\_OBS\_20100405.txt



Plot: CCMC



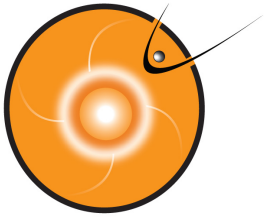
# $d\mathbf{B}/dt$

$$\left| \frac{d(\Delta B)}{dt} \right|_H = \sqrt{\left( \frac{d}{dt} (\Delta B)_X \right)^2 + \left( \frac{d}{dt} (\Delta B)_Y \right)^2}$$

Magnitude of the horizontal component of the time derivative of the magnetic perturbation.

1-minute  $\Delta B \rightarrow$  1-minute  $|(d\Delta B/dt)_H|$



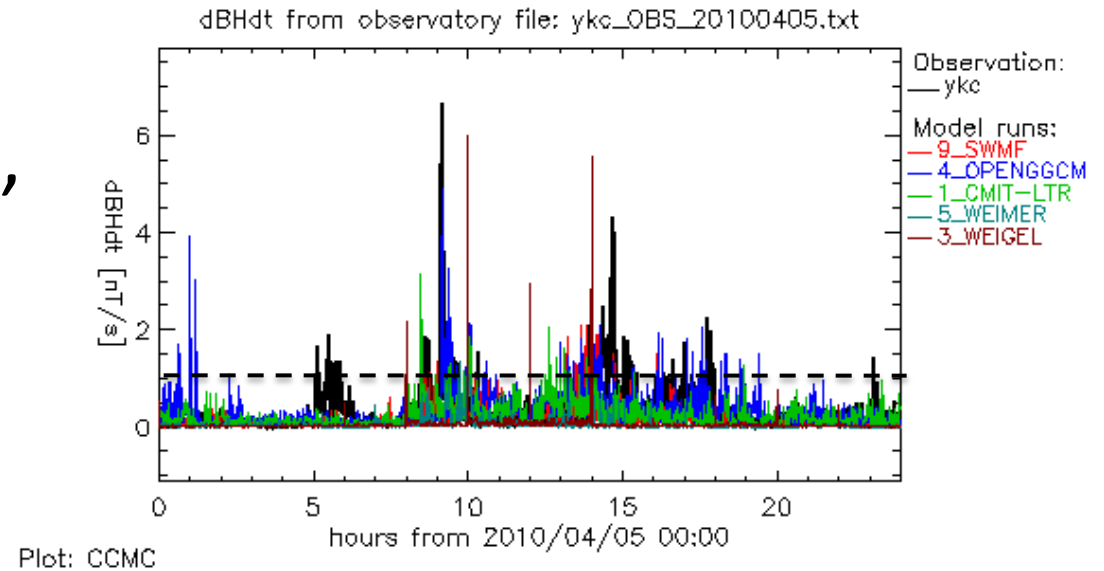


# Visualization

$|(d/dt \Delta B)_H|$  for YKC,  
Event 4  
with **new** skill scores

Threshold: 1.1nT/s

Window length 20 min.

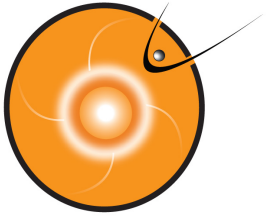


Variable: dBHdt Observation file: ykc\_OBS\_20031029.txt

Model Setting	T	OY	ON	H	F	M	N	A	B	POD	POFD	FAR	CSI	TSS	MTSS	HSS
9_SWMF	72	54	18	54	16	0	2	0.778	1.296	1.000	0.889	0.229	0.771	0.111	-15.000	0.158
4_OPENGGCM	72	54	18	14	0	40	18	0.444	0.259	0.259	0.000	0.000	0.259	0.259	-0.481	0.149
1_CMIT-LTR	72	54	18	39	9	15	9	0.667	0.889	0.722	0.500	0.188	0.619	0.222	-1.556	0.200
5_WEIMER	72	54	18	28	1	26	17	0.625	0.537	0.519	0.056	0.034	0.509	0.463	-0.081	0.316
3_WEIGEL	72	54	18	25	13	29	5	0.417	0.704	0.463	0.722	0.342	0.373	-0.259	-5.274	-0.200

N_Windows (T)	number of windows considered to create events (EventWindows = Plot Interval Length / Event Window Length)	
Events (OY)	number of windows where at least one observation exceeds threshold	
NoEvents (ON)	number of windows where observation does NOT exceed threshold	
Hits (H)	number of windows where model and observation exceed threshold at least once	
FalseHits (F)	number of windows where model does exceed threshold but observation does not	
Misses (M)	number of windows where model does not but at least one observation exceeds threshold	
NoForecast (N)	number of windows where model and observation do NOT exceed threshold	
Accuracy (A)	$(H+N)/(M+N+H+F)$	Range: [0,1], perfect score: 1, no skill: 0
Bias (B)	$(H+F)/(H+M)$	Range: [0,+Inf], perfect score: 1
POD	probability of Detection $H/(H+M)$	Range: [0,1], perfect score: 1, no skill: 0
POFD	probability of False Detection $F/(F+N)$	Range: [0,1], perfect score: 0
FAR	False Alarm Ratio $F/(H+F)$	Range: [0,1], perfect score: 0
CSI (TS)	Critical Success Index (Threat Score) $H/(H+M+F)$	Range: [0,1], perfect score: 1, no skill: 0
TSS	True Skill Score $POD-POFD=H/(H+M)-F/(N+F)$	Range: [0,1], perfect score: 1, no skill: 0
MTSS	Modified True Skill Score $(H-M)/(H+M) - 2F/N$	Range: [0,1], perfect score: 1, no skill: 0
HSS	Heidke Skill Score $2(H*N-M*F)/[(H+M)*(M+N) + (H+F)*(F+N)]$	Range: [-Inf,1], perfect score: 1, no skill: 0



# Work that was done

- Performed sensitivity study for event-based metrics:
  - Threshold levels between 0.3 and 1.5 nT/s
  - Window lengths between 10 and 45 minutes
- Time lines available on web visualization and FTP access via:

<http://ccmc.gsfc.nasa.gov/challenges/dBdt/>