DST index in 2008 GEM modeling challenge

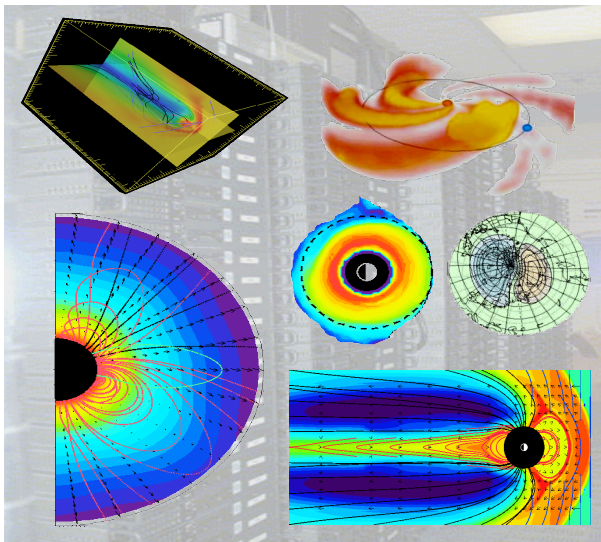**Community Coordinated Modeling Center**

L. Rastaetter, M. Kuznetsova,
A. Pulkkinen, A. Chulaki

Modelers:

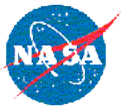J. Raeder, A. Vapirev, UNH

T. Gombosi, A. Ridley, U. Mich.

R. Weigel, GMU

D. Welling, LANL

Data: WDC, Kyoto

http://ccmc.gsfc.nasa.gov

DST

- 1-hour index (real-time, provisional, definitive) from KYOTO World Data Center

- Two types of "DST" calculations:

  1. SWMF, OpenGGCM, LFM magnetosphere models: "DST at Earth's center"
     Integral over $(\mathbf{J}\mathrm{x}\mathbf{R})_Z/R^3 * dV$ with

     - $\mathbf{R}=(-x,-y,-z)$ and dV the volume element at position $\mathbf{R}$.

     - Dst computed at center of Earth.

     - Use Z-component in SM coordinates.

  2. Ring Current models:
     Dessler-Parker-Sckopke relation from total energy.

Model runs

- **SWMF**
  - DST as written by model
  - DST computed from 3D magnetosphere outputs
- **OpenGGCM** (**LFM** runs to be added)
  - DST computed from 3D magnetosphere outputs

New models:

- **IRF-96:** Impulse Response Function with 96 lags, R. Weigel, GMU
- **RAMSCB**: Ring current model with self-consistent magnetic field, Daniel Welling, LANL
- **BFM92**: empirical relation by Burton et al. (1975), modified by Feldstein (1992) and Murayama (1982)
- **WINDMI**: W. Horton, L. Mays, 2009

Availability of run outputs

Run ID	Event 1: Oct. 29, 06:00 Oct. 30, 06:00 2003	Event 2 Dec. 14, 12:00 Dec. 16, 00:00 2006	Event 3: Aug. 31, 00:00 Sep. 1, 00:00 2001	Event 4: Aug. 31, 10:00 Sep. 1, 12:00 2005
1_SWMF	yes	yes	yes	yes
2_SWMF	yes	yes	yes	yes
3_SWMF	yes	yes	yes	yes
4_SWMF	yes	yes	yes	yes
5_SWMF	yes	yes	yes	yes
6_SMWF	no	yes	no	yes
1_OPENGGCM	no	yes	yes	yes
2_OPENGGCM	no	yes	yes	yes
1_LFM-MIX	yes	partial outputs	yes	yes
1_RAM-SCB	yes	yes	yes	yes
1_IRF96	yes	yes	yes	yes
1_BFM92	yes, only IMF	yes	yes	yes
1_WINDMI	yes, only IMF	yes	yes	yes
2_WINDMI	yes, only IMF	yes	yes	yes
3_WINDMI	yes, only IMF	yes	yes	yes

Physics-based models (MHD, kinetic)

Model Setting ID	Model/Version	Submitted by
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 3M 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, CSEM
1_OpenGGCM	OpenGGCM 3.1, 3 M cells	CCMC
2_OpenGGCM	OpenGGCM 3.1, 6.5M cells	CCMC
1_LFM	**LFM, 53x64x48 cells**	**CCMC**
1_RAMSCB	RAM-SCB stand-alone mode	D. Welling, LANL
~~2_RAMSCB~~	~~RAM-SCB driven by single fluid/species BATS-R-US~~	~~D. Welling, LANL~~
~~3_RAMSCB~~	~~RAM-SCB driven by multispecies BATS-R-US~~	~~D. Welling, LANL~~

Statistical models

Model Setting ID	Model/Version	Submitted by
1_BFM92	Burton, Feldstein & Murayama (1992)	L. Rastaetter, CCMC
1_IRF96	IRF-96, Impulse Response Function w. 96 lags	R. Weigel, GMU
1_WINDMI	**WINDMI-1.0 nominal, Rectified driver**	L. Rastaetter, CCMC
2_WINDMI	**WINDMI-1.0 nominal, Siscoe driver**	L. Rastaetter, CCMC
3_WINDMI	**WINDMI-1.0 nominal, Newell driver**	L. Rastaetter, CCMC

Updates to web interface

- Select **color** and **line style** of model runs.

Updates to web interface

- Select color and line style of model runs.

- Obtain skill scores.

Please review the default selections below and make your changes.

To start the graphics program click the *Update Plot* button. The resulting image will be displayed at this location of the page.

Should the result be a black image, then the graphics program encountered a programming error. Please report the set of input parameters used.

Go back to metrics challenge table

(Update Plot) *Update Plot* will update (generate) the plot with the chosen time and plot parameters below.
This will take some time (typically 10-30s) as data is read in and processed.

Start: Year: 2005 Month: 8 Day: 31 Hour: 10 Minute: 0 Second: 0
to End: Year: 2005 Month: 9 Day: 1 Hour: 12 Minute: 0 Second: 0

Choose **Quantity** to be displayed: [DST – Dst geomagnetic index ▼]

Plot Options:
Image magnification [1 ▼]
Line thickness [5 ▼]
Character thickness [5 ▼] (all annotations)
☐ **Lock plot range:**
  Min.: -1 Max.: 1

☑ **Show scores**
Select model settings

☐ [magenta ▼] [solid ▼] 1_SWMF: BATSRUS 7.73, 2M cells, CCMC
☐ [magenta ▼] [dotted ▼] 2_SWMF: BATSRUS 7.73, 700k cells (real-time setup), CCMC
☑ [magenta ▼] [solid ▼] 3_SWMF: BATSRUS 8.01 with RCM, 2M cells, CCMC
☐ [magenta ▼] [dash-dotted ▼] 4_SWMF: BATSRUS 8.01, 3 M cells, CCMC
☑ [red ▼] [solid ▼] 5_SWMF: BATSRUS 8.01 with RCM, 3M cells, CCMC
☑ [red ▼] [dashed ▼] 6_SWMF: SWMF V.20090403, BATSRUS+RCM2, 900k cells, RT on 64 procs., A. Ridley
☑ [blue ▼] [solid ▼] 1_OPENGGCM: OpenGGCM 3.1, 3 M cells
☑ [blue ▼] [dashed ▼] 2_OPENGGCM: OpenGGCM 3.1, 6.5M cells
☐ [green ▼] [dotted ▼] 1_LFM-MIX: GEM2008_CHALLENGE_061410 runs, CCMC (2010)
☐ [cyan ▼] [dashed ▼] 1_IRF96: IRF-96, Robert Weigel, 2010/06/04 Impulse Response Function with 96 lags (ver. 0)
☑ [dark cyan ▼] [dash-dotted ▼] 1_RAMSCB: GEM08_Daniel_Welling_101110_E4_1 RAM-SCB stand-alone mode driven by t89 LANL MPA
☐ [blue ▼] [solid ▼] 1_BFM92: Burton (1975) Feldstein (1992) and Murayama (1982)
☐ [blue ▼] [dashed ▼] 1_WINDMI: WINDMI-1.0-nominal, rectified solar wind driver
☐ [blue ▼] [dash-dotted ▼] 2_WINDMI: WINDMI-1.0-nominal, Siscoe solar wind driver
☐ [grey ▼] [solid ▼] 3_WINDMI: WINDMI-1.0-nominal, Newell solar wind driver

(Reset Form) *Reset Form* will reset changes to the defaults specified by the previous run of this script.
(Update Plot) *Update Plot* will update (generate) the plot with the chosen time and plot parameters above.

Updates to web interface

- Select color and line style of model runs.

- Obtain skill scores.

Please review the default selections below and make your changes.

To start the graphics program click the *Update Plot* button. The resulting image will be displayed at this location of the page.

Should the result be a black image, then the graphics program encountered a programming error. Please report the set of input parameters used.

Go back to metrics challenge table

(Update Plot)   *Update Plot* will update (generate) the plot with the chosen time and plot parameters below.
This will take some time (typically 10-30s) as data is read in and processed.

Start: Year: 2005   Month: 8   Day: 31   Hour: 10   Minute: 0   Second: 0
to End: Year: 2005   Month: 9   Day: 1   Hour: 12   Minute: 0   Second: 0

Choose **Quantity** to be displayed: [DST – Dst geomagnetic index ‡]

Plot Options:
Image magnification [1 ‡]
Line thickness [5 ‡]
Character thickness [5 ‡] (all annotations)
☐ **Lock plot range:**
   Min.: -1   Max.: 1

☑ **Show scores**
Select model settings
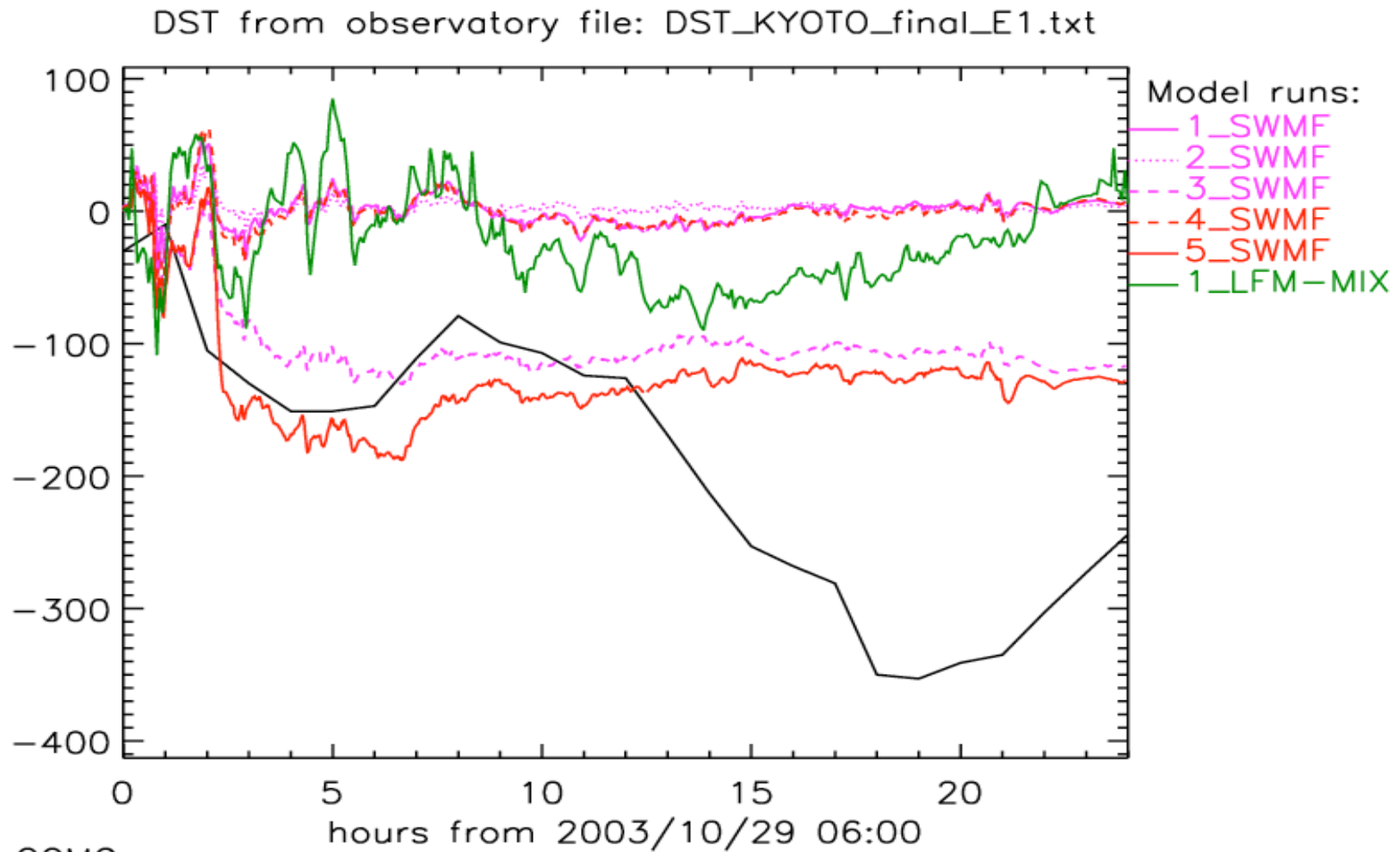
```
Variable: DST Observation file: DST_KYOTO_provisional_E2.txt
Model_Setting    PredEff    N_region    N_finite    LogSpecDist    nWin    PredYield
1_SWMF           -2.410     2161        2161        0.790          69      0.254
2_SWMF           -2.285     2161        2161        0.900          69      0.244
3_SWMF           -0.320     2161        2161        0.682          69      0.457
4_SWMF           -2.328     2161        2161        0.663          69      0.283
5_SWMF           -0.168     2161        2160        0.500          69      0.494
6_SWMF            0.532     2161        2160        0.294          68      0.748
1_OPENGGCM      -24.035     2161        2141        1.557          68      3.964
2_OPENGGCM       -0.602     2161        2161        0.205          69      0.709
1_LFM-MIX        -0.307     2161         972        0.193          29      0.592
1_IRF96           0.861     2161        2101        0.207          67      0.819
1_RAMSCB          0.441     2161        2161        0.343          69      0.822
1_BFM92          -0.161     2161        2161        0.429          69      0.612
1_WINDMI          0.397     2161        2160        0.150          69      1.037
2_WINDMI          0.034     2161        2160        0.256          69      1.137
3_WINDMI         -0.015     2161        2160        0.254          69      1.055
```
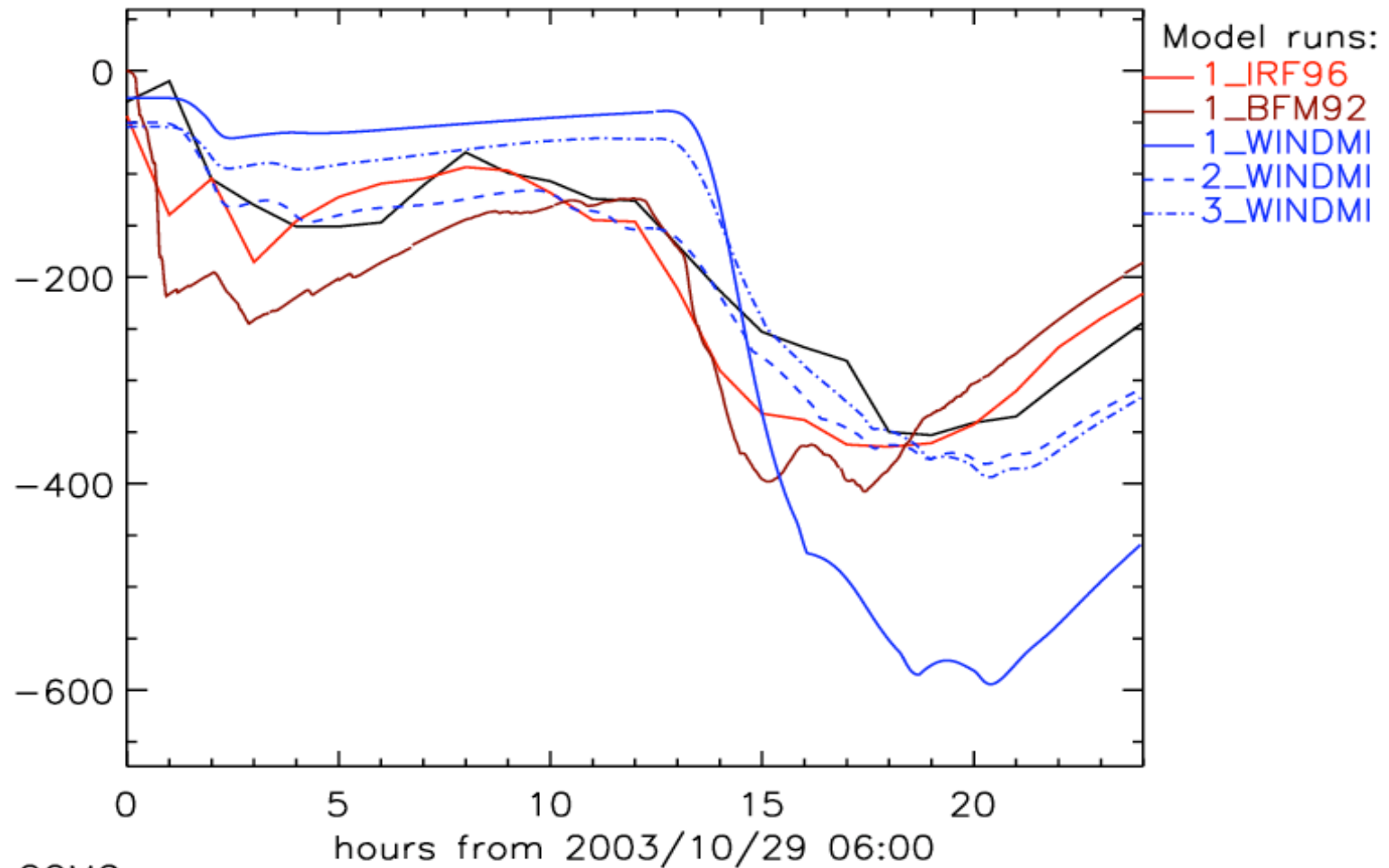
tup), CCMC
MC

MC

, 900k cells, RT on 64 procs., A. Ridley

uns, CCMC (2010)
pulse Response Function with 96 lags (ver. 0)
_1 RAM-SCB stand-alone mode driven by t89 LANL MPA
rayama (1982)
r wind driver
vind driver
wind driver

f this script.
arameters above.
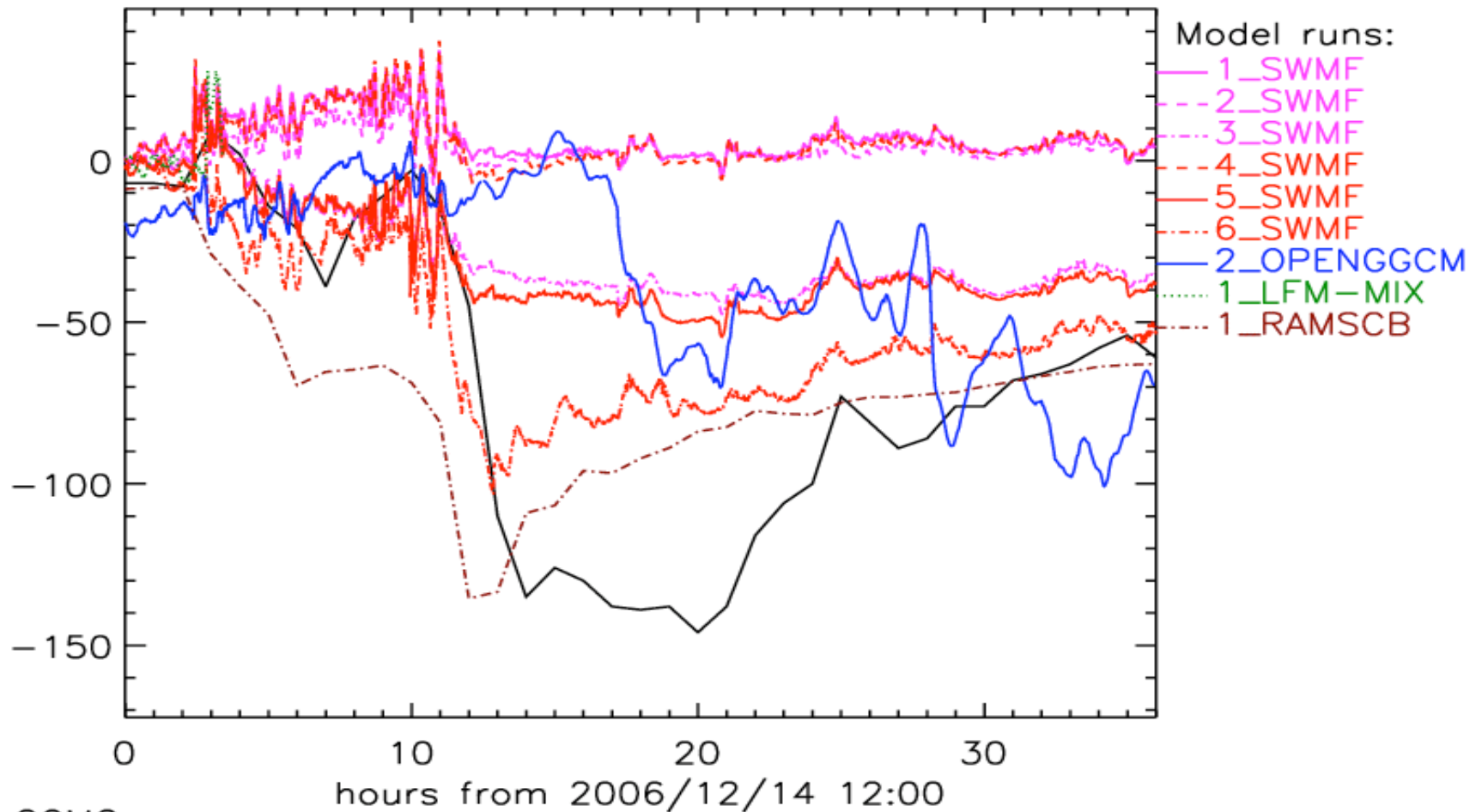
Event 1 – Halloween storm physics-based models

DST from observatory file: DST_KYOTO_final_E1.txt

Model runs:
1_SWMF
2_SWMF
3_SWMF
4_SWMF
5_SWMF
1_LFM-MIX

hours from 2003/10/29 06:00

Plot: CCMC

Event 1, Halloween Storm statistical models

DST from observatory file: DST_KYOTO_final_E1.txt

Model runs:
1_IRF96
1_BFM92
1_WINDMI
2_WINDMI
3_WINDMI

hours from 2003/10/29 06:00

Plot: CCMC

Event 2 – AGU storm physics-based models

DST from observatory file: DST_KYOTO_provisional_E2.txt

Model runs:
— 1_SWMF
— — 2_SWMF
— · — 3_SWMF
— — — 4_SWMF
— 5_SWMF
— · — 6_SWMF
— 2_OPENGGCM
· · · · 1_LFM−MIX
— · · — 1_RAMSCB

hours from 2006/12/14 12:00

Plot: CCMC

Event 2 – AGU storm statistical models

DST from observatory file: DST_KYOTO_provisional_E2.txt

Model runs:
1_IRF96
1_BFM92

hours from 2006/12/14 12:00
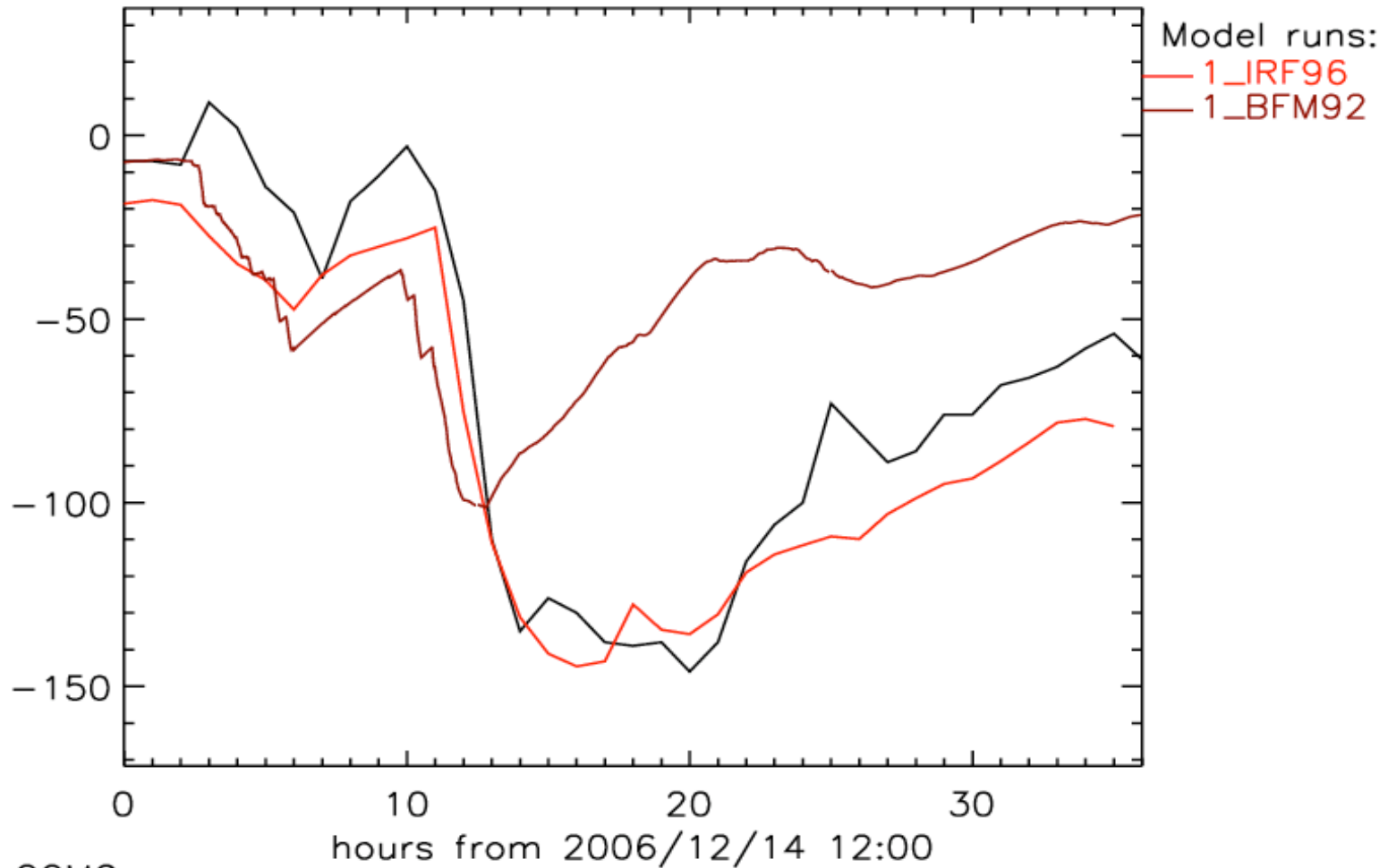
Plot: CCMC

Event 3, 2001/8/31 storm physics-based models

DST from observatory file: DST_KYOTO_provisional_E3.txt

Model runs:
1_SWMF
2_SWMF
3_SWMF
4_SWMF
5_SWMF
1_OPENGGCM
2_OPENGGCM
1_LFM-MIX
1_RAMSCB

hours from 2001/08/31 00:00
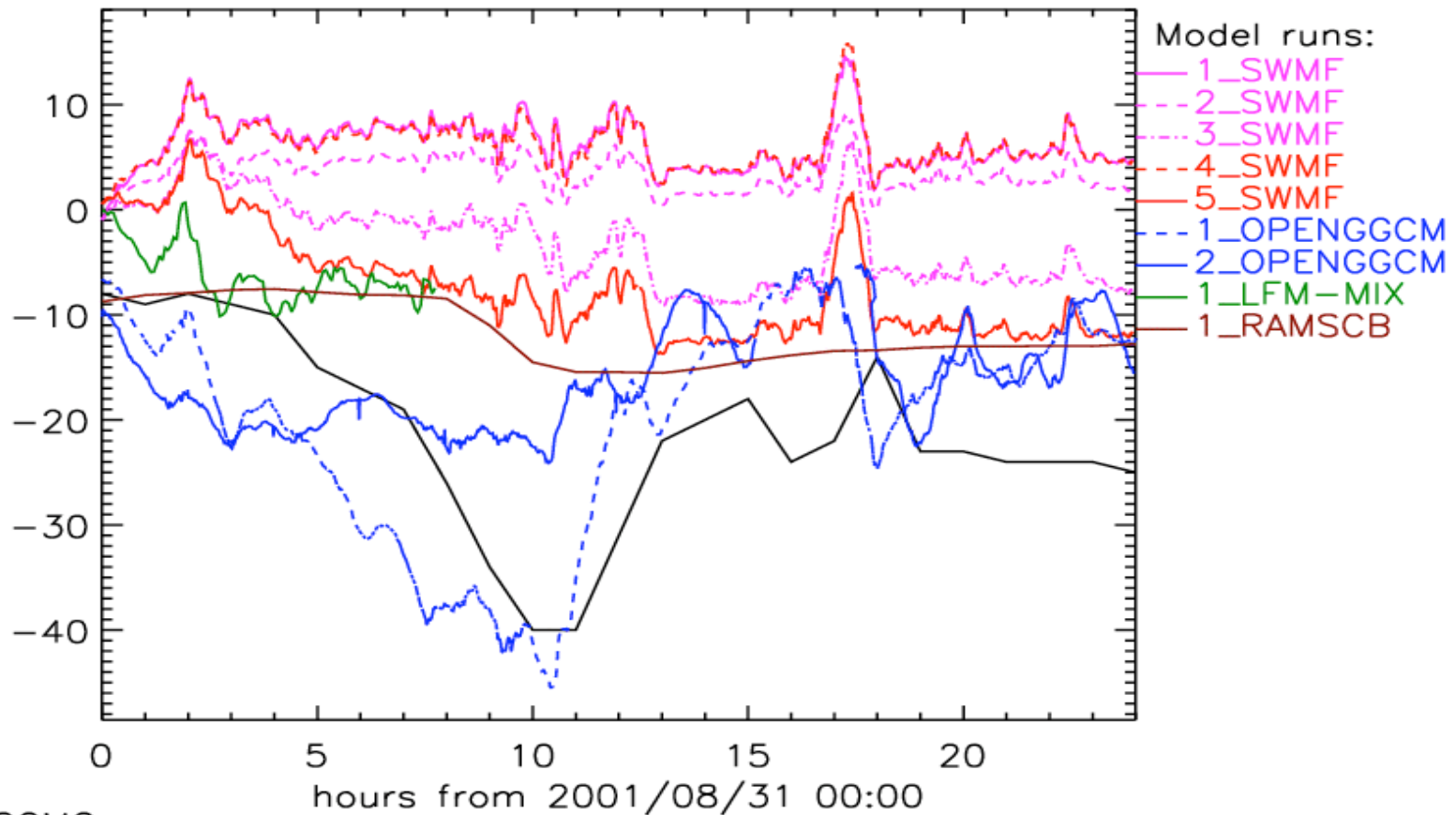
Plot: CCMC

Event 3, 2001/8/31 storm statistical models

DST from observatory file: DST_KYOTO_provisional_E3.txt

Model runs:
1_IRF96
1_BFM92
1_WINDMI
2_WINDMI
3_WINDMI

hours from 2001/08/31 00:00
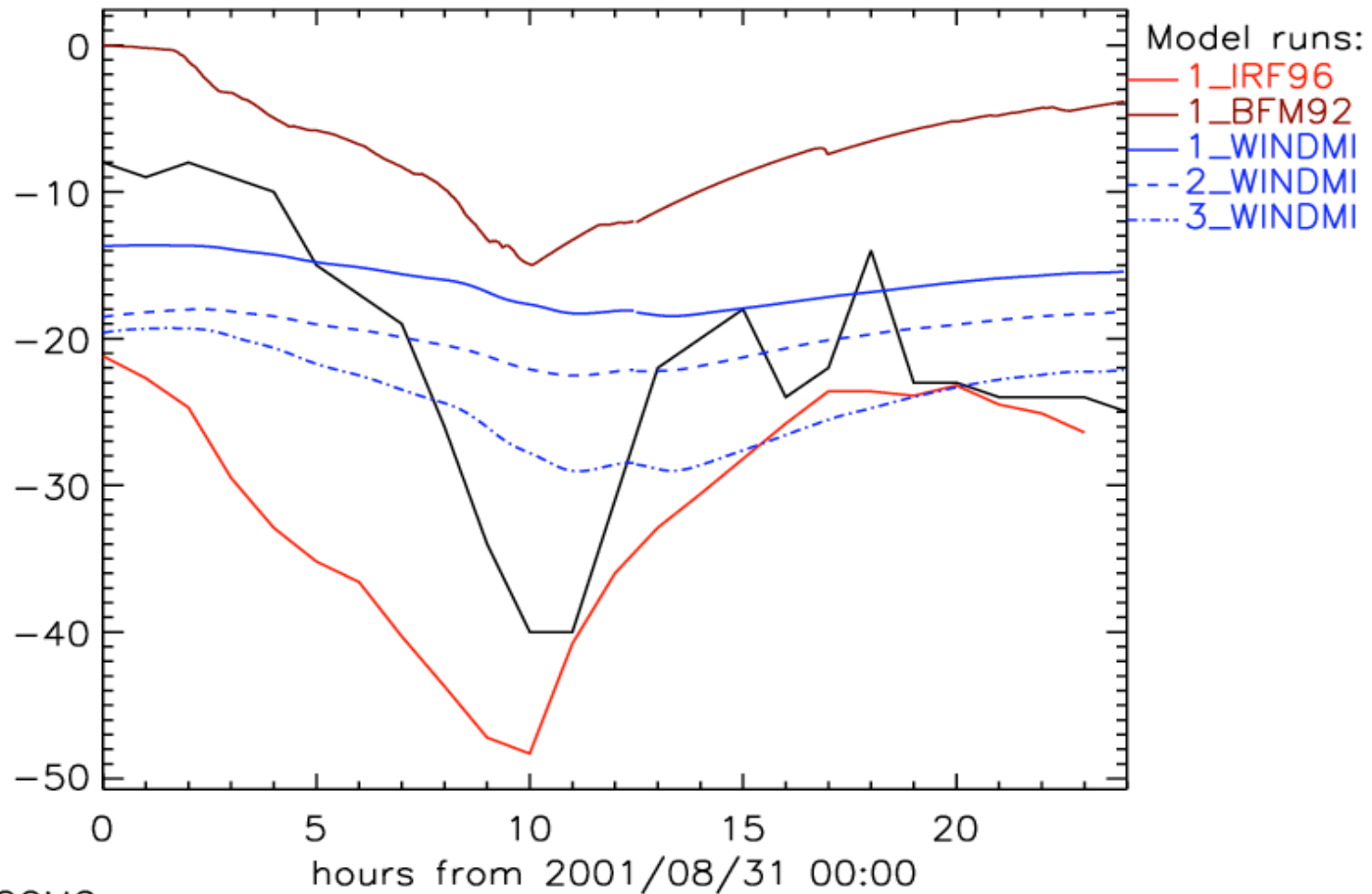
Plot: CCMC

Event 4, 2005/8/31 Storm physics-based models

DST from observatory file: DST_KYOTO_provisional_E4.txt

Model runs:
1_SWMF
2_SWMF
3_SWMF
4_SWMF
5_SWMF
6_SWMF
1_OPENGGCM
2_OPENGGCM
1_LFM-MIX
1_RAMSCB

hours from 2005/08/31 10:00
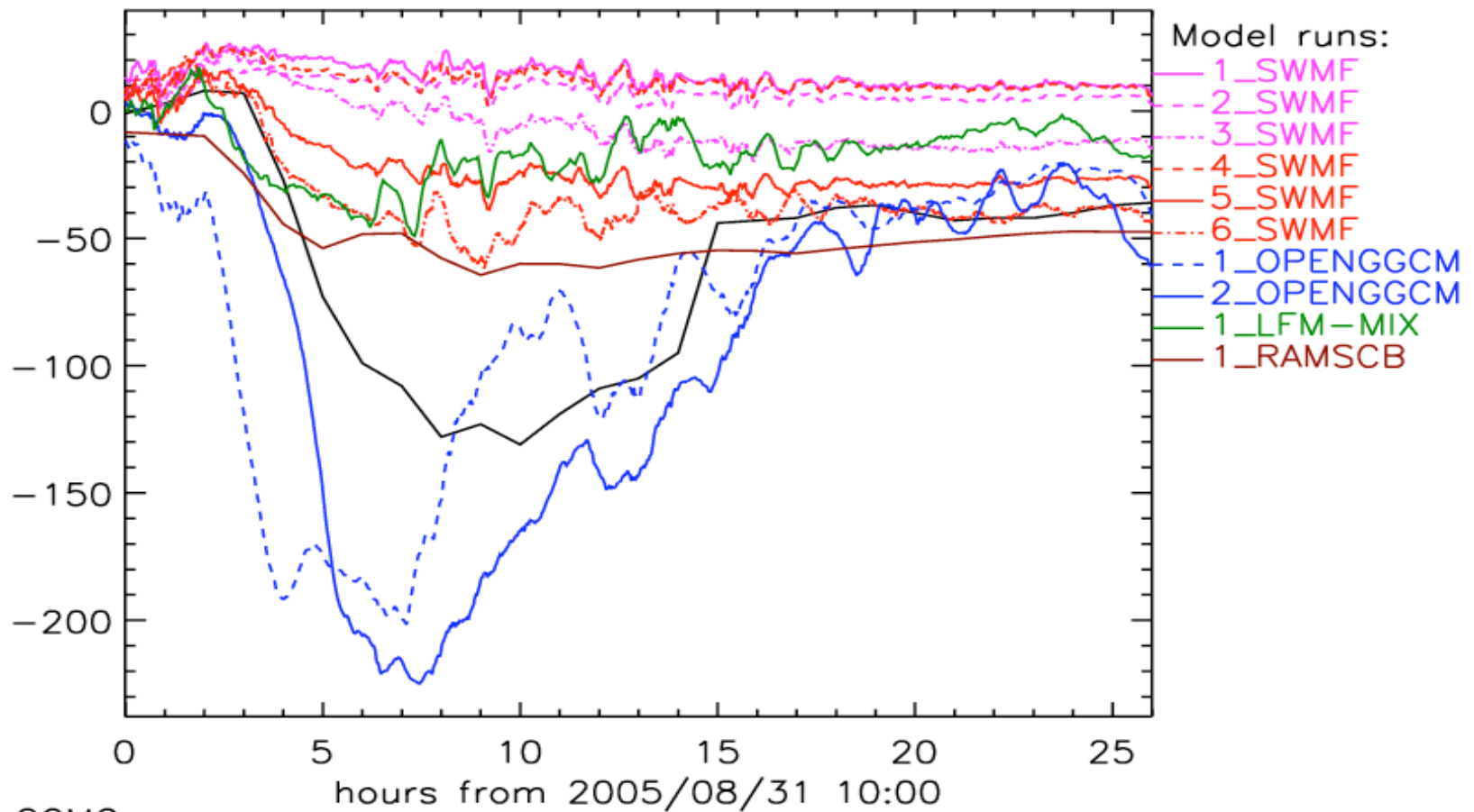
Plot: CCMC

Event 4, 2005/8/31 Storm statistical models

DST from observatory file: DST_KYOTO_provisional_E4.txt

Model runs:
1_IRF96
1_BFM92
1_WINDMI
2_WINDMI
3_WINDMI

hours from 2005/08/31 10:00

Plot: CCMC
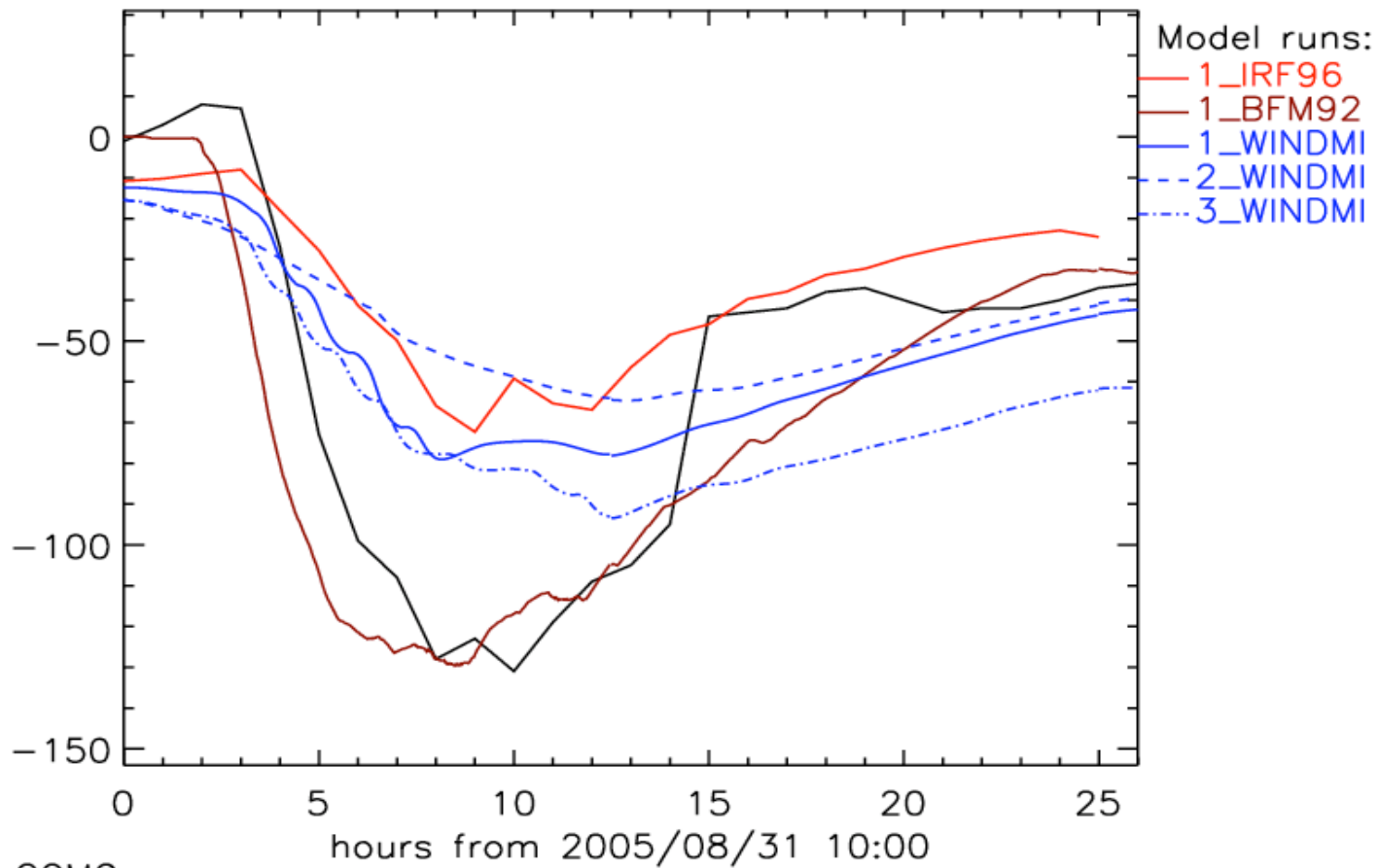
Efficiency to predict Dst
(modeled Dst range / observed Dst range)
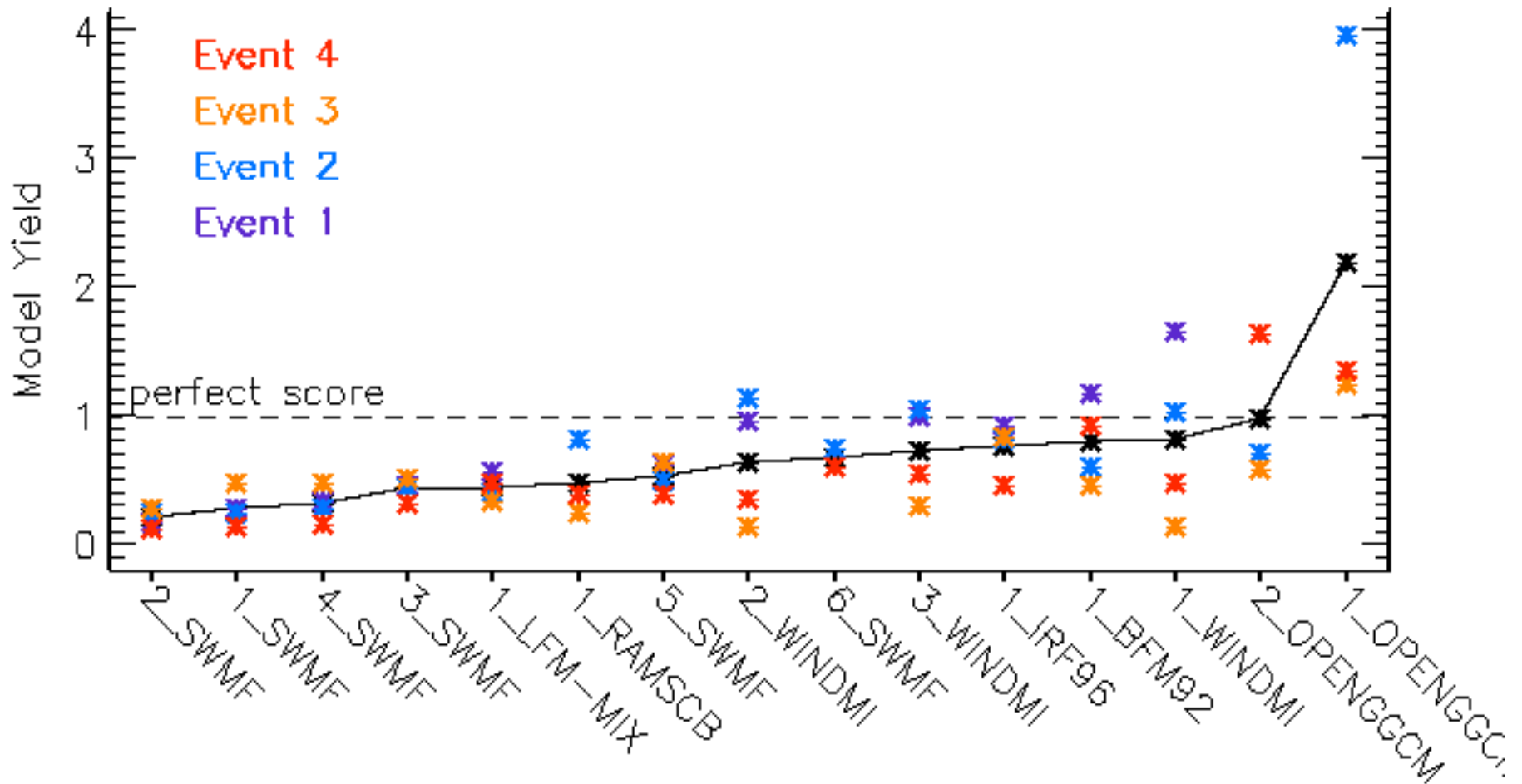
Prediction Efficiencies

Did we make computation errors?
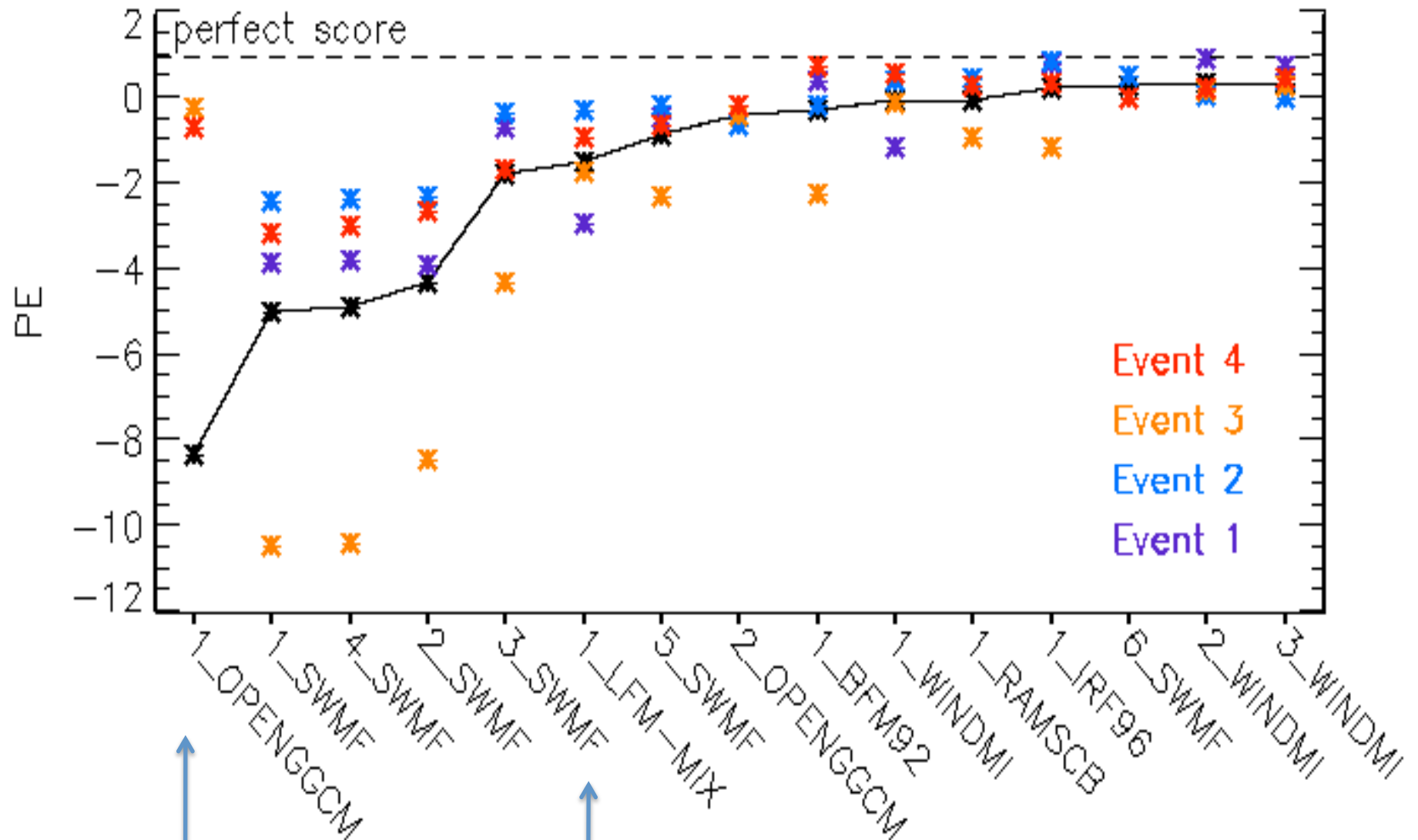
1_LFM run incomplete for **event 2**
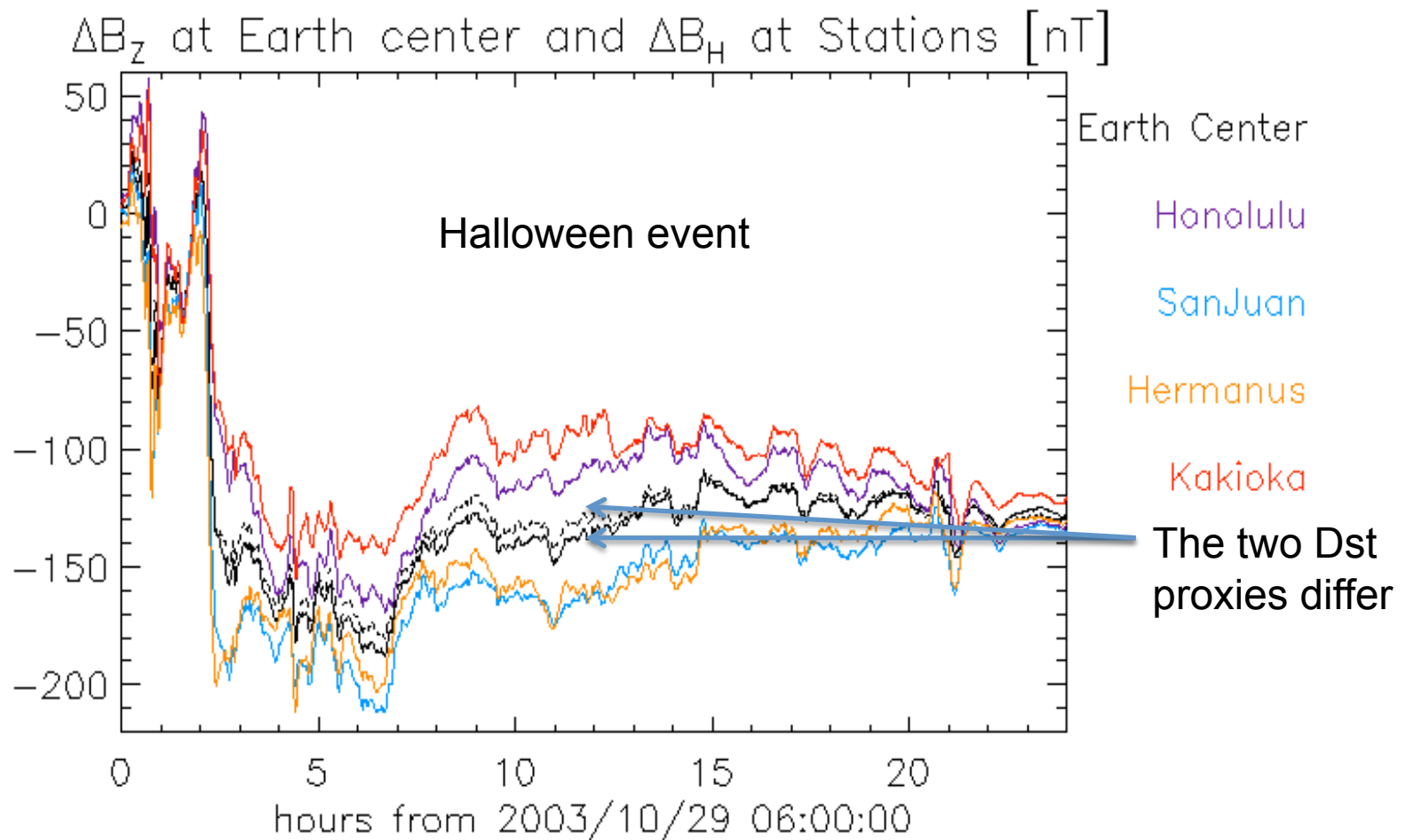
Issues / to do

- Check for errors:
  - Positive offset for 1_LFM
  - Results completely off for 1_OPENGGCM
- Investigate role of shielding at Earth
- Check responses at fixed "stations" (Noon, etc.) vs. Dst network

Dst station network

Dst derived from B_H at stations
vs. calculated ΔB_Z at Earth's center

Halloween event

The two Dst proxies differ

Dst station network

Dst derived from B_H at stations vs. calculated ΔB_Z at Earth's center