COMMUNITY
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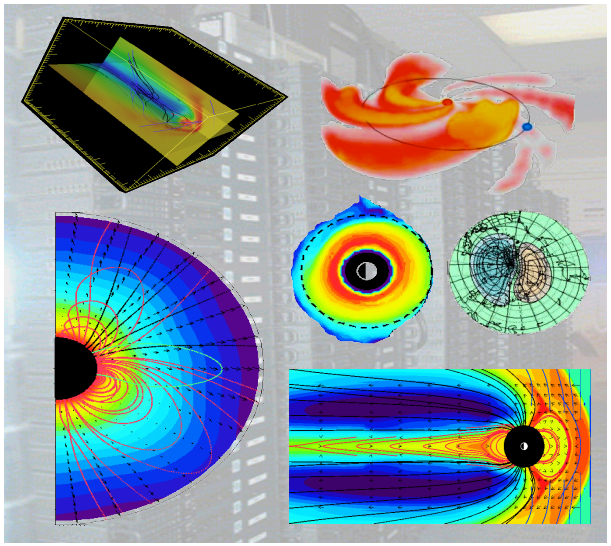
MODELING
CENTER

DST index in 2008 GEM modeling challenge



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http://ccmc.gsfc.nasa.gov

Contributors:

Modelers:

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S. Sazykin, R. Bala, Rice Univ.

D. Welling, V. Jordanova, LANL

V. Eccles, Space Env. Corp.

R. Boynton, H. Wei, U. Sheffield

Data:

WDC Kyoto

J. Gannon, USGS

DST

- 1-hour index (real-time, provisional, definitive) from World Data Center, KYOTO
- 1-minute real-time index from USGS **(new)**
- Two types of "DST" calculations:
  1. SWMF, OpenGGCM, LFM magnetosphere models:

     DST at Earth's center: $$Dst = \left(\frac{\mu_0}{4\pi} \sum_{GM} \frac{\mathbf{J} x \mathbf{R}}{R^3} dV \right)_{\mathrm{SM,\,Z}}$$

     R=(-x,-y,-z) and dV the volume element at position **R**.

     Use Z-component in SM coordinates.
  2. Ring Current models:
     Dessler-Parker-Sckopke relation from total energy.

Model runs

Magnetosphere:

- **SWMF**
  - DST as written by model
- **OpenGGCM**
  - DST computed from 3D magnetosphere outputs
- **CMIT-LFM** (**new**)
  - DST computed from 3D magnetosphere outputs
- **WINDMI** DST written by model

Ring Current (all new):

- **RAM-SCB**:
  LANL ring current, stand alone or with SWMF, D. Welling
- **RCM**: multiple drivers and boundary conditions, S. Sasykin
- **FRC**: Fok ring current, run with outputs from SWMF, CCMC

Model runs (cont.)

Statistical:

- **IRF-96:** Impulse Response Function with 96 lags, R. Weigel, GMU
- **BFM92**: empirical relation by Burton et al. (1975), modified by Feldstein (1992) and Murayama (1982)
- **NARMAX**: polynomial derivation, R. Boynton et al. **(new)**
- **RiceDst**: Rice Univ. neural network Spec., R. Bala **(new)**
- **RDST**: Real-time Dst Spec., Space Env. Corp, V. Eccles **(new)**

Runs of magnetospheric models

Run ID	Model Description	E 1	E 2	E 3	E 4
1_SWMF	SWMF v7.73, BATS-R-US, 2 million cells, min. res. ¼ RE	yes	yes	yes	yes
2_SWMF	SWMF v7.73, BATS-R-US, 700000 cells, min. res. ¼ RE	yes	yes	yes	yes
3_SWMF	SWMF v8.01, BATS-R-US coupled to RCM, 2 million cells, min. res ¼ RE	yes	yes	yes	yes
4_SWMF	SWMF v8.01, BATS-R-US, 3 million cells, min. res. ⅛ RE	yes	yes	yes	yes
5_SWMF	SWMF v8.01, BATS-R-US coupled to RCM, 3 million cells, min. res ⅛ RE	yes	yes	yes	yes
6_SWMF	SWMF v20090403 BATS-R-US+RCM2, 900k cells, RT on 64 procs, res. ¼ RE	yes	yes	yes	yes
7_SWMF	SWMF V. 20110215 BATSRUS+CRCM, 1.78M cells, 1/8 RE res.	yes	yes	yes	yes
8_SWMF	SWMF V20110111 BATS-R-US+RCM2, 1M cells, res. ¼ RE, InnerBc density0.2/cc RCM ions ratio NH/NO9/1	yes	yes	yes	yes
9_SWMF	SWMF.v20110131_SWPC, 1,007,616 cells with RCM2, res. ¼ RE, CCMC	yes	yes	yes	yes
1_OpenGGCM	OpenGGCM v3.1 coupled to CTIM, 3 million cells, min. res. ⅓ RE	no	yes	yes	yes
2_OpenGGCM	OpenGGCM v3.1 coupled to CTIM, 6.5 million cells, min. res. ¼ RE	no	yes	yes	yes
1_LFM-MIX	CMIT-LFM-MIX_1-0-4, LFMwith 53x48x64 cells, min. res. ⅙ RE radial	yes	yes	yes	yes
1_CMIT-LTR	CMIT-LTR_2-1-1, LFM with 53x48x64 cells, min. res. ⅙ RE radial	yes	yes	yes	yes
1_WINDMI	WINDMI 1.0 with nominal parameters, rectified solar wind driver	only IMF	yes	yes	yes
2_WINDMI	WINDMI 1.0 with nominal parameters, Siscoe solar wind driver	only IMF	yes	yes	yes
3_WINDMI	WINDMI 1.0 with nominal parameters, Newell solar wind driver	only IMF	yes	yes	yes

Runs of ring current models

Run ID	Description	E 1	E 2	E 3	E 4
1_FRC	Fok Ring current model run off 4_SWMF data	yes	yes	yes	yes
2_FRC	Fok Ring current model run off 5_SWMF data	yes	yes	yes	yes
3_FRC	Fok Ring current model run off 8_SWMF data	yes	yes	yes	yes
1_RCM	RCM, Hilmer and Voigt B, Siscoe-Hill PCPC, Tsyganenko and Mukai (2003) plasma at outer L	yes	yes	yes	yes
2_RCM	RCM, Hilmer and Voigt B, Siscoe-Hill PCPC, Borovsky 1998 plasma at outer L	yes	yes	yes	yes
3_RCM	RCM, Hilmer and Voigt B, Siscoe-Hill PCPC, MSM plasma at outer L	yes	yes	yes	yes
4_RCM	RCM, Hilmer and Voigt B, Weimer 2005 PCPC, Borovsky 1998 plasma at outer L	yes	yes	yes	yes
1_RAMSCB	RAM-SCB, stand-alone, LANL particles, Volland-Stern E, Dipole B	no	yes	yes	yes
2_RAMSCB	RAM-SCB, stand-alone, LANL particles, Weimer-2K E, Dipole B	no	yes	yes	yes
3_RAMSCB	RAM-SCB, stand-alone, LANL particles, Weimer-2K E, T89 B	no	yes	yes	yes
4_RAMSCB	RAM-SCBdriven by SWMA/BATSRUS+RIM	no	no	yes	yes
5_RAMSCB	RAM-SCBdriven by SWMA/BATSRUS+RIM+PWOM	no	no	yes	yes

Statistical Specifications

Run ID	Model Description	E 1	E 2	E 3	E 4
1_IRF	IRF, Impulse Response Function with 96 lags (ver. 0)	yes	yes	yes	yes
1_BFM	Burton (1975) Feldstein (1992) and Murayama (1982) (	yes	yes	yes	yes
1_RDST	Real-time Dst derivation (RDST), Space Environment Corp.	yes	yes	yes	yes
1_NARMAX	NARMAX polynomial derivation from previous DST, 1-hour OMNI solar wind, no ring current effects	no	yes	yes	yes
2_NARMAX	NARMAX polynomial derivation from previous DST, 1-hour OMNI solar wind, with ring current effects	no	yes	yes	yes
1_RiceDst	Rice Univ. neural network, Boyle (1997) solar wind driver and dynamic pressure	yes	yes	yes	yes

Updates to web interface

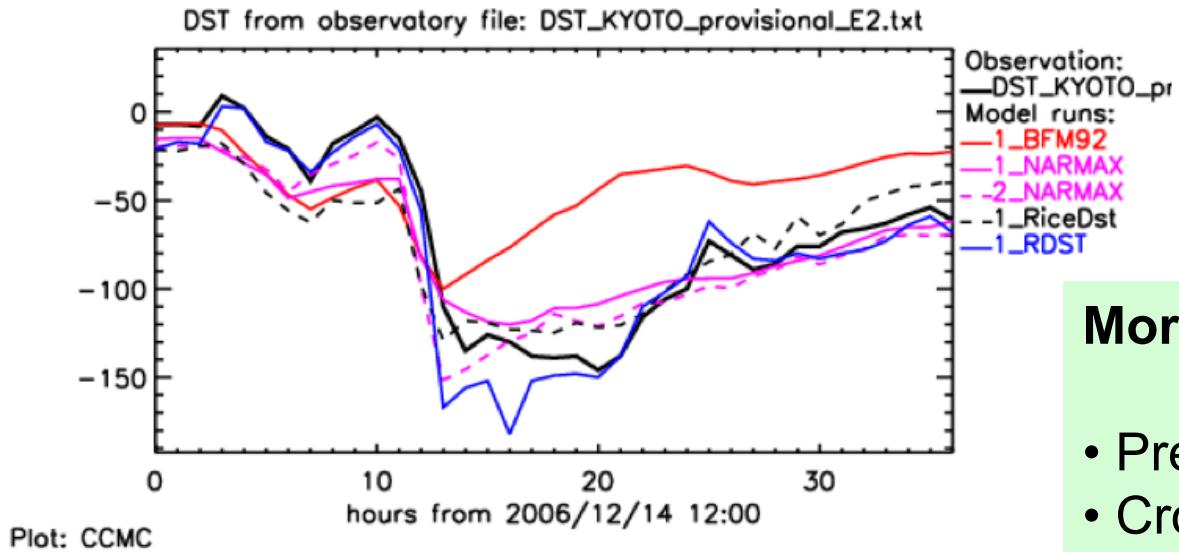


Figure: DST from observatory KYOTO and model runs
Campaign: GEM2008
Metric study: Dst
Event: December 14, 2006 12 00 UT - December 16, 00 00 UT

More skill scores:

- Prediction Yield
- Cross-Correlation
- Timing errors (not shown)

Explanations

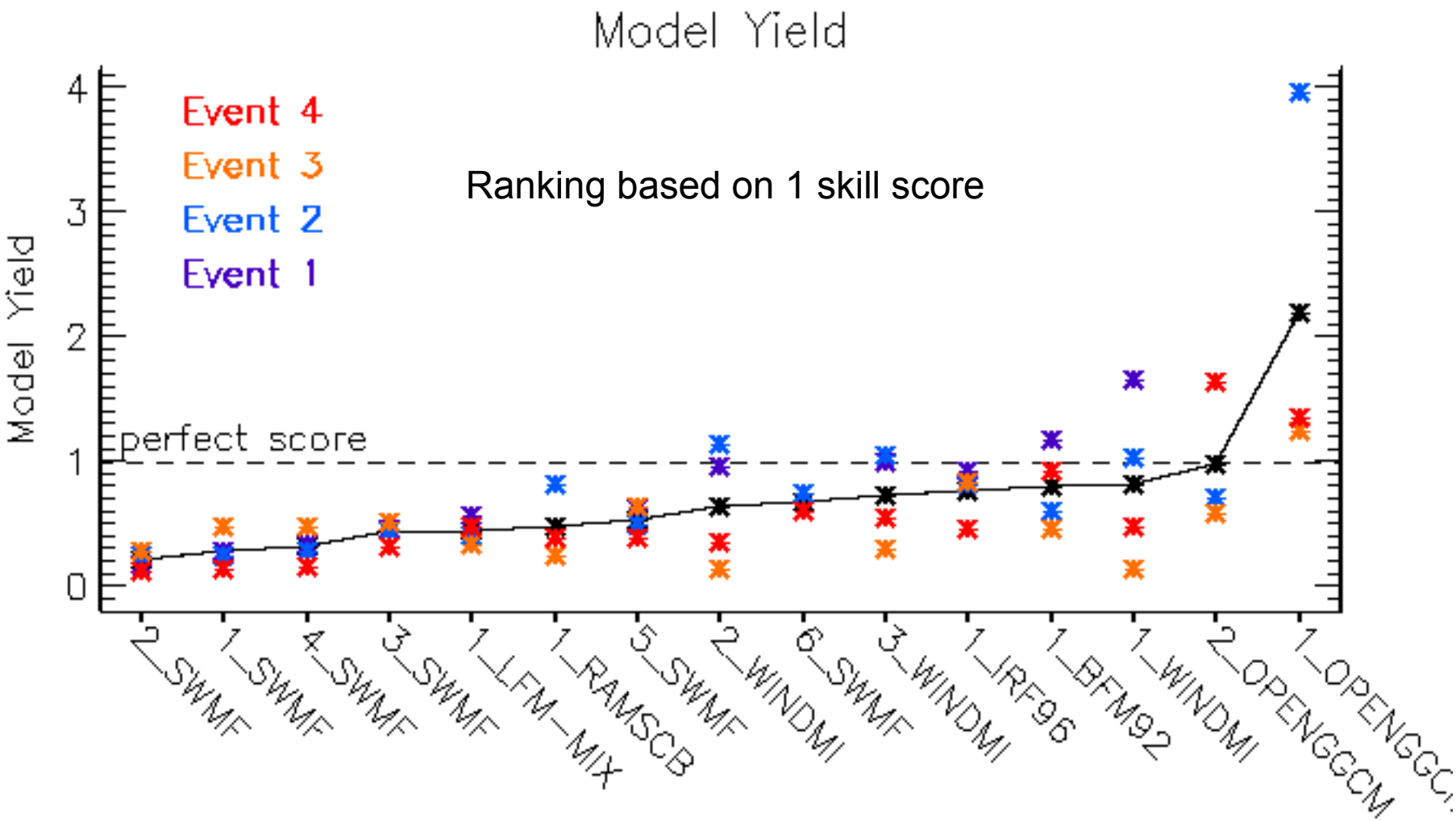
Variable: DST Observation file: DST_KYOTO_provisional_E2.txt

Model_Setting	PredEff	N_region	N_finite	PredYield	MinTimingError	MaxTimingError	Correlation
1_BFM92	-0.111	37	37	0.592	7.000	2.000	0.411
1_NARMAX	0.837	37	37	0.680	4.000	2.000	0.959
2_NARMAX	0.855	37	37	0.866	7.000	7.000	0.946
1_RiceDst	0.791	37	37	0.718	7.000	0.000	0.906
1_RDST	0.899	37	37	1.194	4.000	0.000	0.969

PredEff	Prediction Efficiency metric
N_region	the number of samples in the seletcted time wintow
N_finite	the number of points that were used for comparison (ie., those that were not NaN or infinite)
LogSpectDist	Log-Spectral Distance metric
nWin	the number of windows used for the spectral analysis (2-hour windows, offset by 30 minutes from the nei
PredYield	is the ratio of the range of modeled values (max minus min) compared to the observation (max minus min)

Efficiency to predict Dst

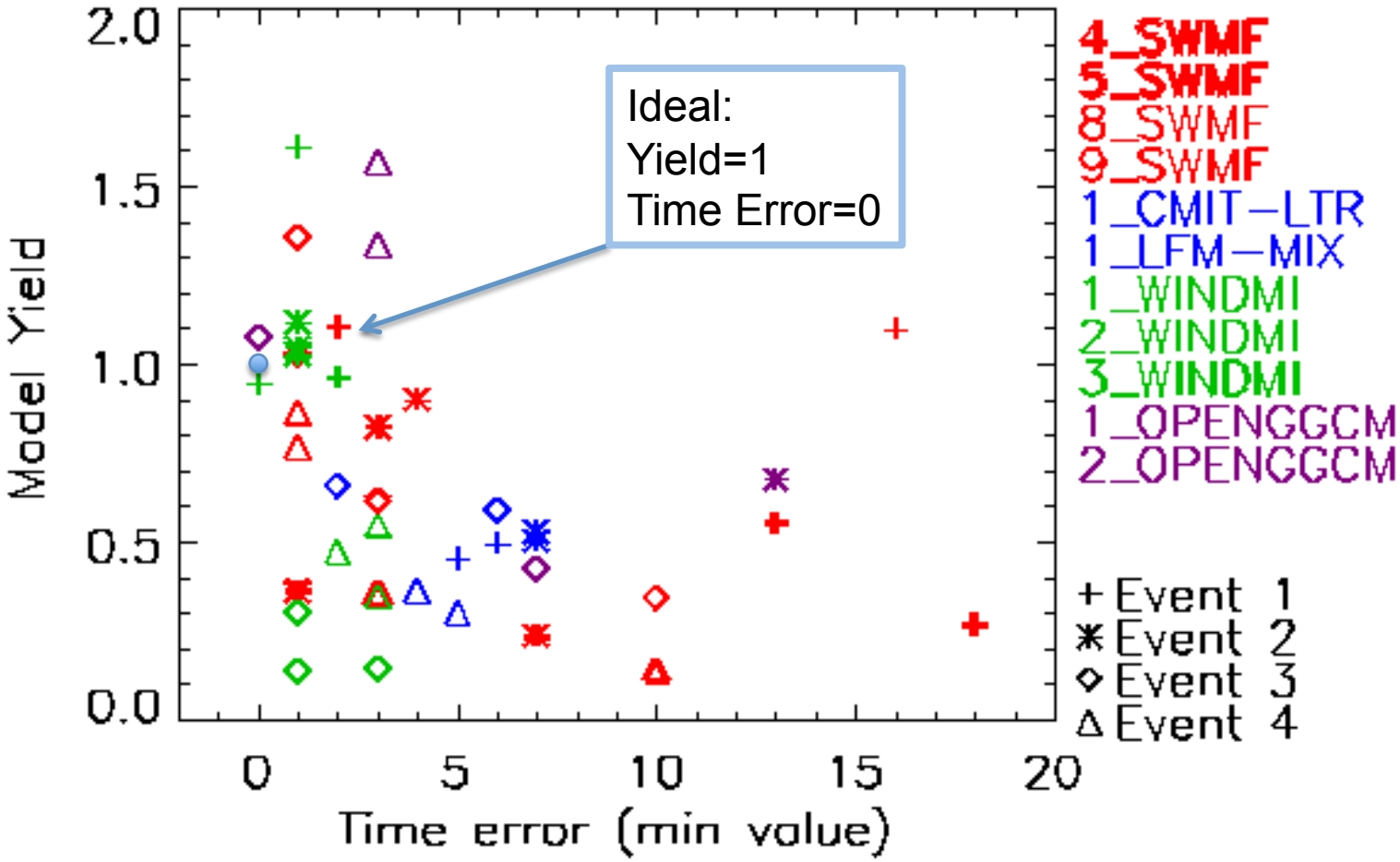
(modeled Dst range / observed Dst range)



Efficiency to predict Dst

(scatter plot combines model yield with timing error)

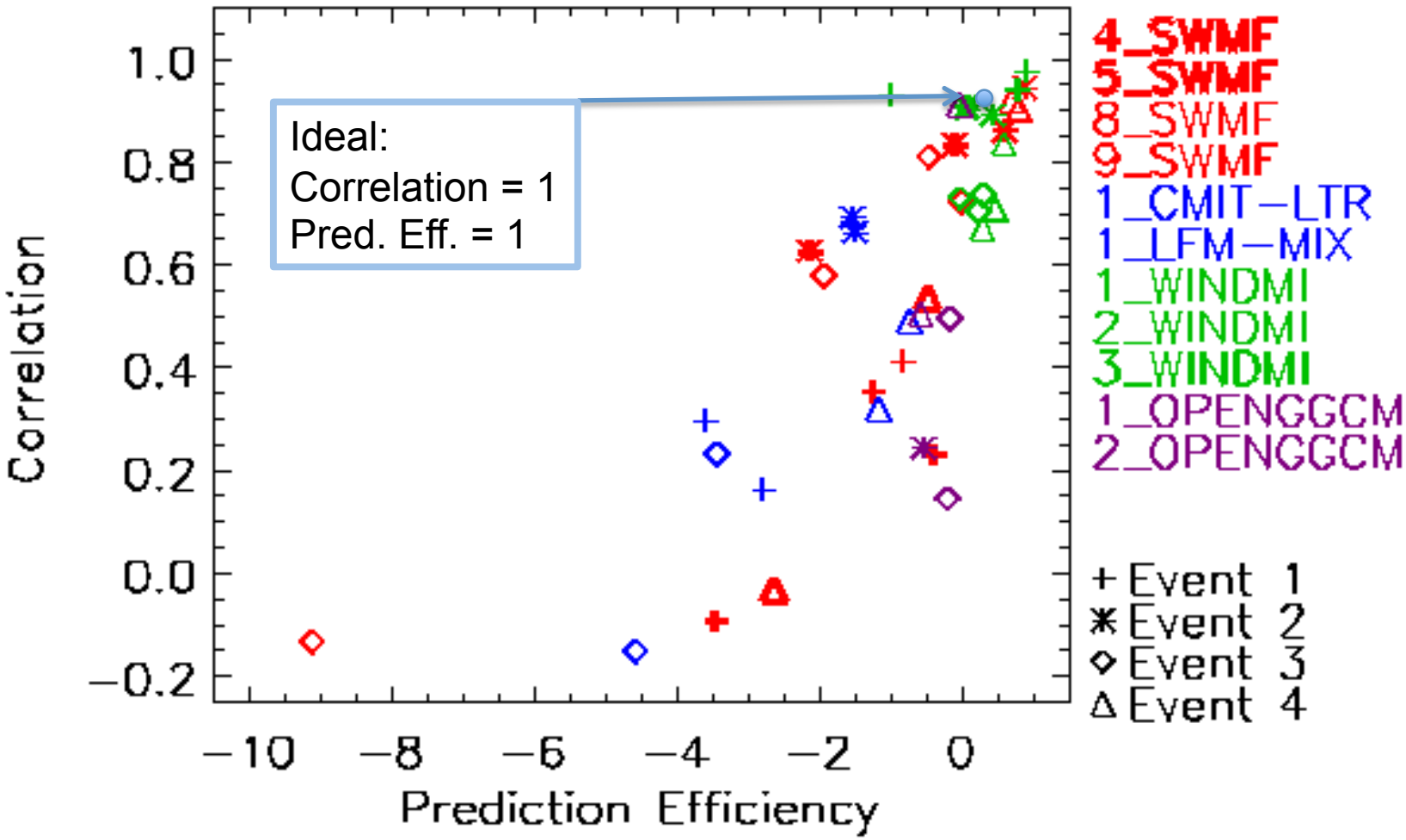
Magnetosphere model runs



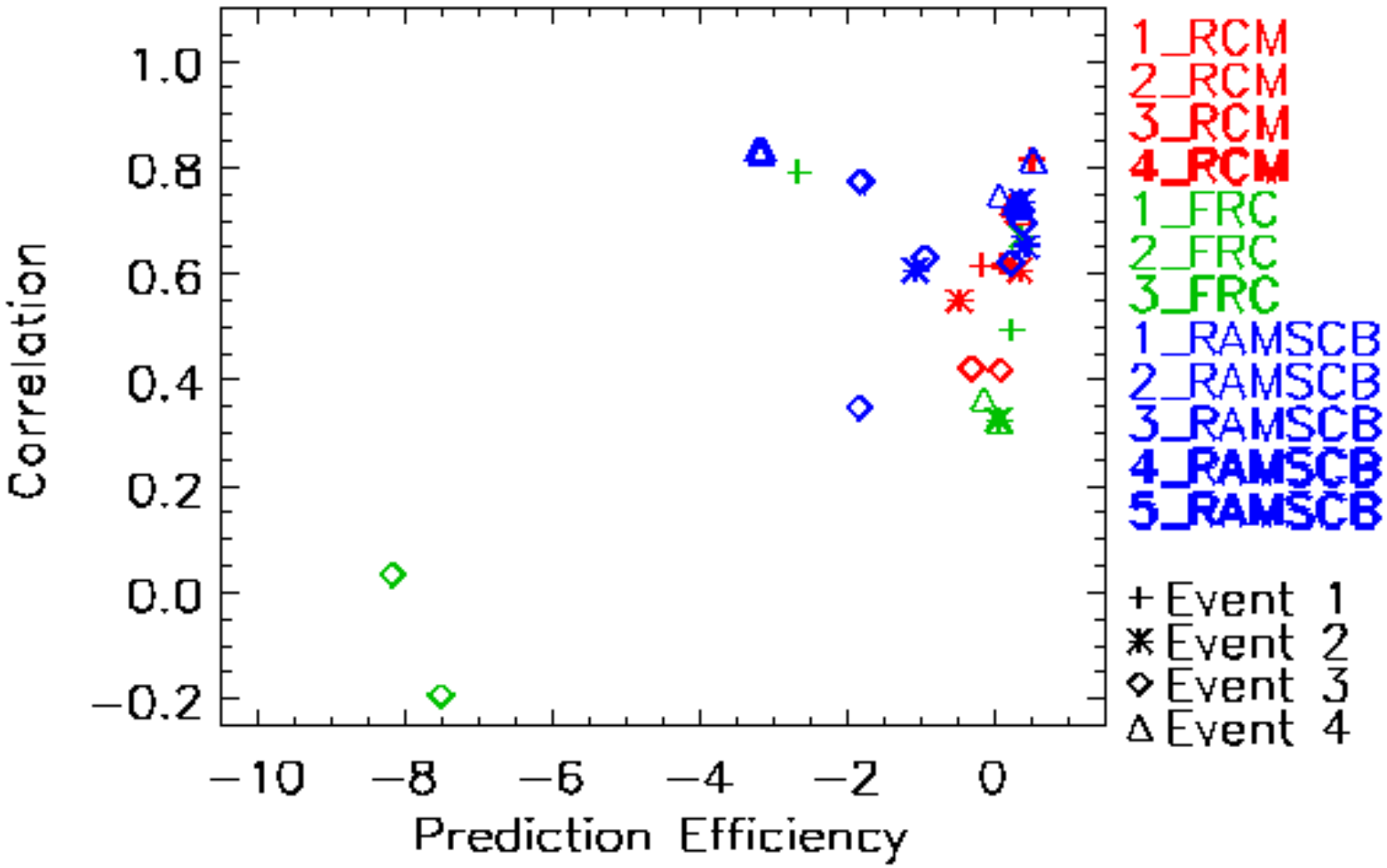
Efficiency to predict Dst

(combine correlation with prediction efficiency)

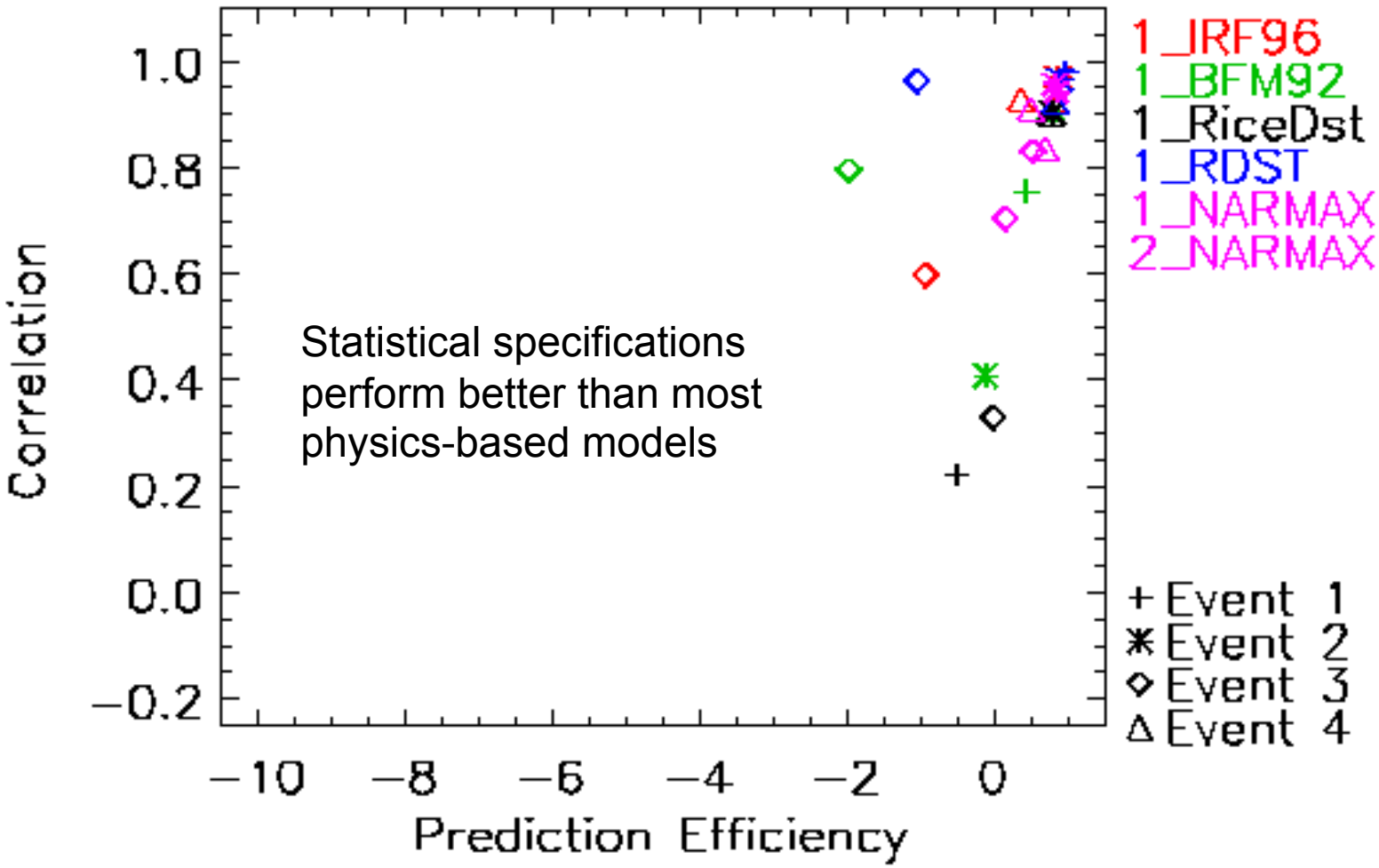
Magnetosphere model runs



Ring current models



Statistical specifications



Done / To Do

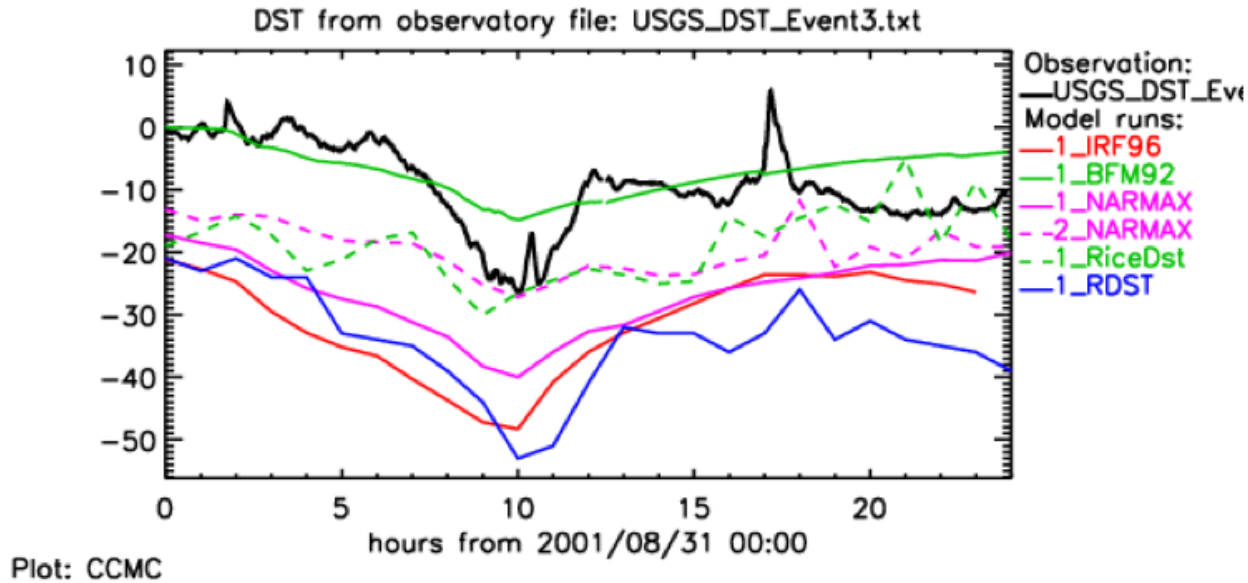
Done:

- Add models:
  - NARMAX, RiceDst, RAM-SCB, RDST, CMIT-LTR (LFM-MIX)
- Add USGS 1-minute Dst for comparisons
- Check for errors:
  - Large positive offset for 1_LFM-MIX (1_CMIT-LTR, new) FIXED (use **J** for > 3 R_E distance only)

To Do:

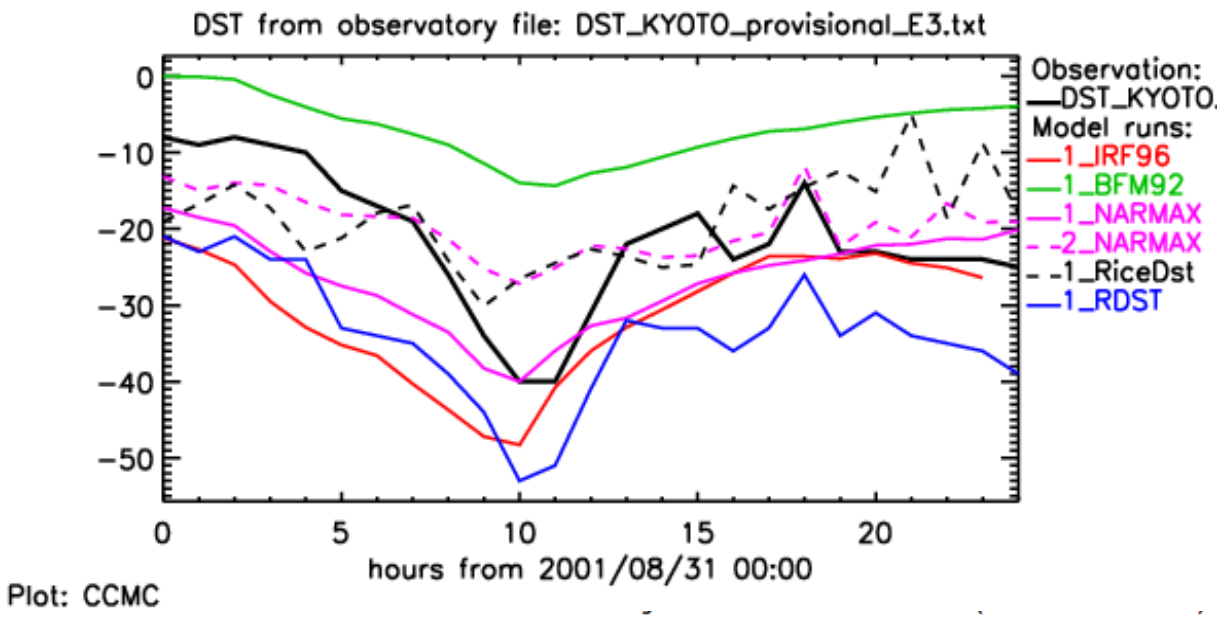
- Run new version of OpenGGCM
- Investigate role of shielding at Earth
- Check responses at fixed "stations" (Noon, etc.) vs. Dst network
- Request resubmissions of specifications with 1-hour resolution

Challenges



Event 3:

USGS Dst



KYOTO Dst

Difference: +8 nT