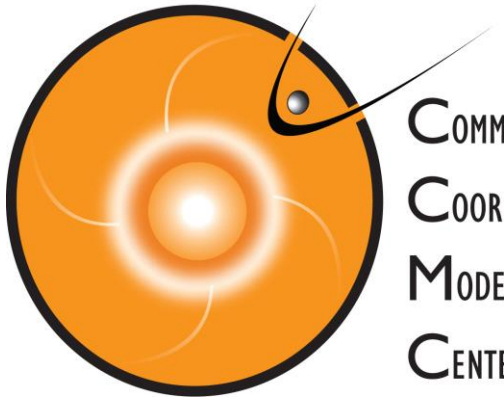
CCMC: Prototyping & Accelerating Implementation of Advanced Space Weather Models & Forecasting Systems.



Masha Kuznetsova
& CCMC team

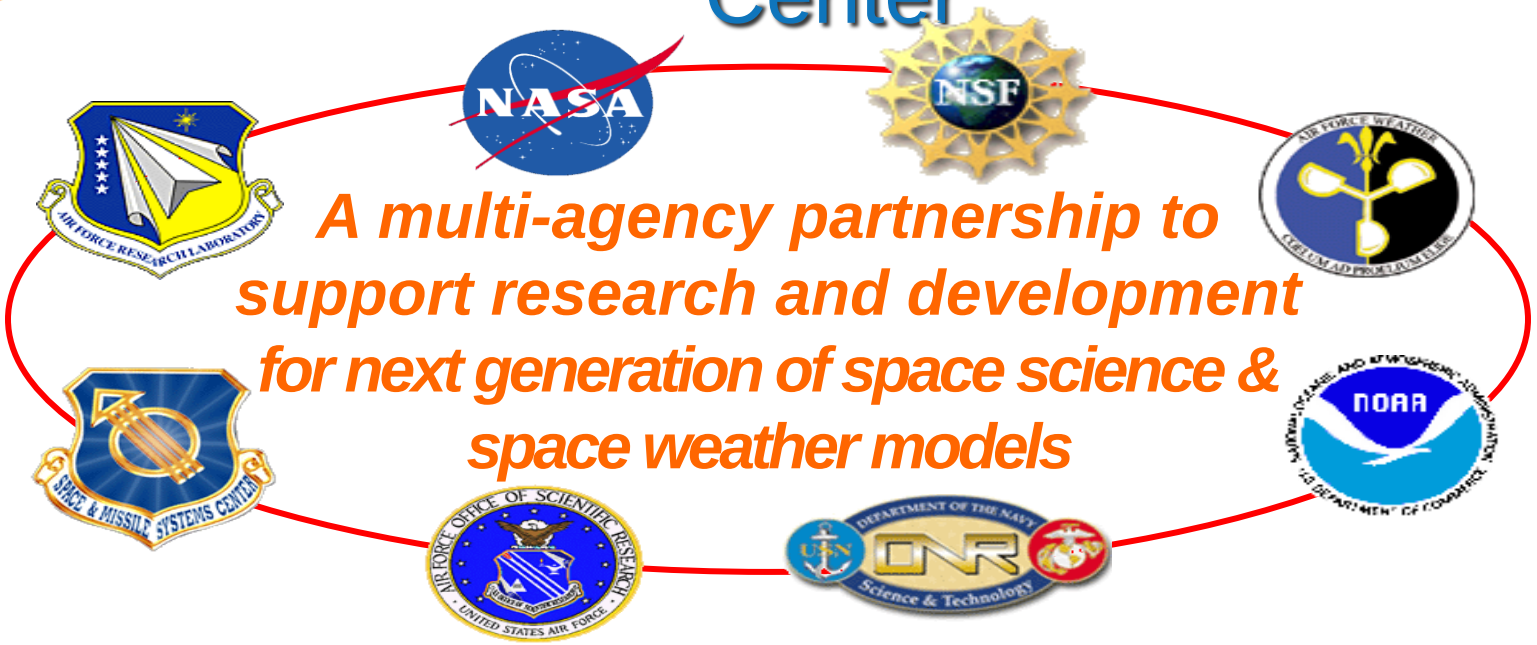
Space Weather Workshop
April 8-11, 2014

MODELS • DATA • TOOLS • SYSTEMS • SERVICES • INNOVATIVE SOLUTIONS

Outline

- CCMC Now: brief overview.
- What CCMC is doing to accelerate implementation of advanced models.
- Focus on geospace models and partnership with NOAA/SWPC.
- Summary & outlook

Community Coordinate Modeling Center



Established in 2000 as an essential element of the National Space Weather Program

Designed to be a long-term solution to the R2O problem.

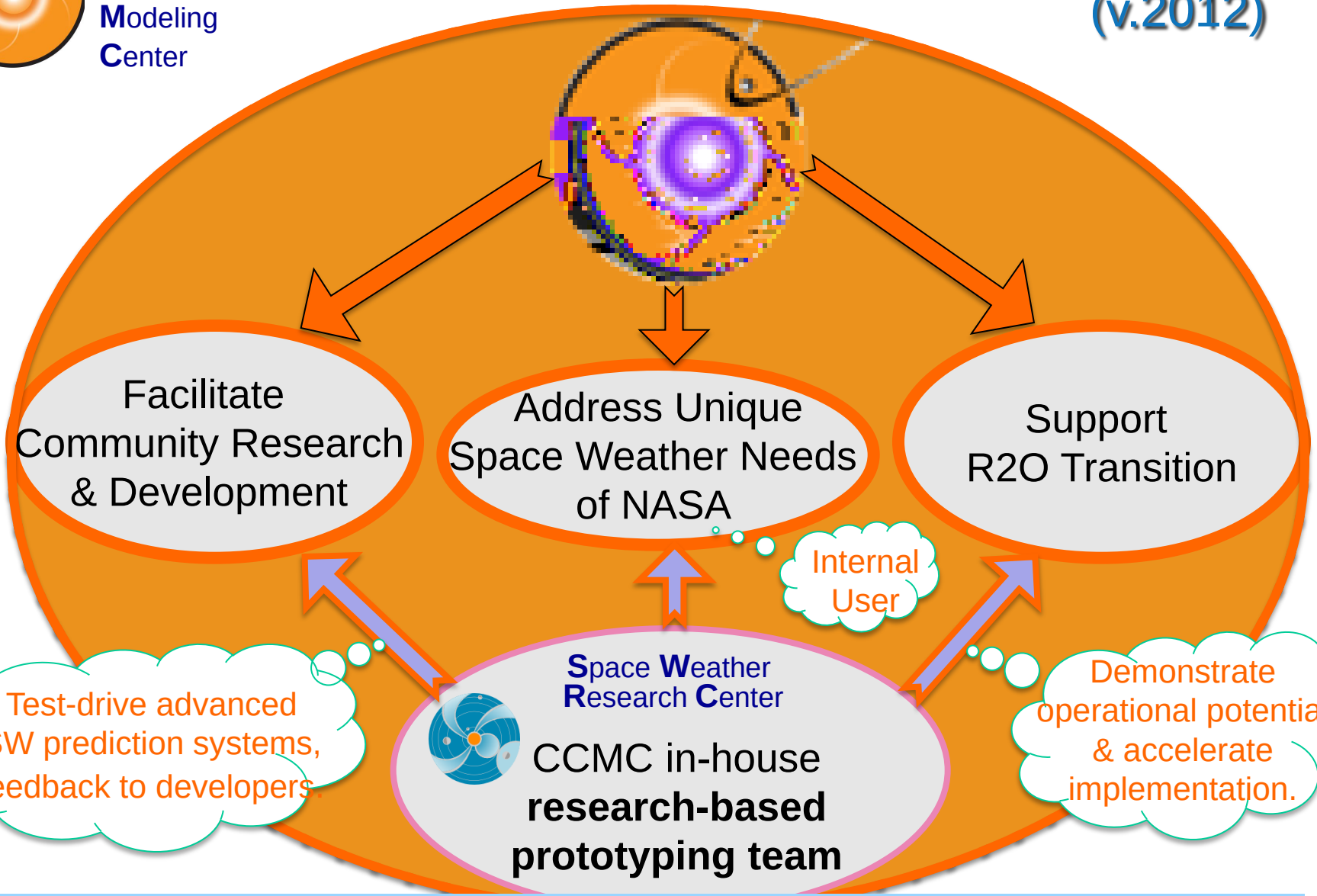
CCMC is fast and flexible with customer driven priorities.

Goals & functions are evolving in response to lessons learned & emerging needs.

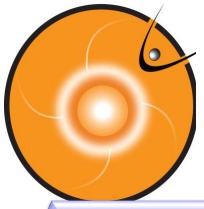
Community Coordinated Modeling Center

CCMC Now

CCMC+ (v.2012)



Partnership is a key: with international research community, model owners, space weather operational agencies, NASA engineers and mission operators.



Community
Coordinated
Modeling
Center

CCMC/SWRC Activities at a Glance

Space
Weather
Research
Center

Science Support

Models

R2O Support

Collaborative
Development

Runs on Request

Data

Real-Time Systems:
Simulations.
Data Streams,
SW Widgets

Space
Environment
Monitoring
by Experts

LWS
Deliverables
Recipient

Innovative Solutions For Research, Analysis & Forecasting

Interplanetary
Space Weather

Missions
Science
Support

Visualization & Analysis

Services
for NASA
missions

Notifications,
& Reports

Community
Projects
Leadership

Testing & Validation

Anomaly
Analysis

I/O
Standards

Access &
Interpolation
Libraries

Forecasting Methods
Scoreboard

Prototyping
&
Knowledgebase

Database *of Run Results*

Flexible
Dissemination

S
Database *of SW Events*

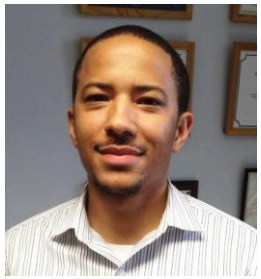
CCMC Staff

~ 13 FTEs
NASA+NSF

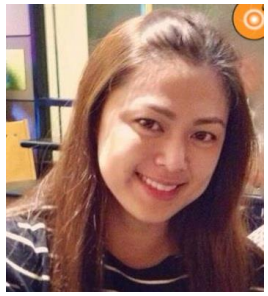

S. Bakshi


Anna Chulaki


M.Kuznetsova (**Director**)


Marlo Maddox (**Deputy**)


P. Macneice

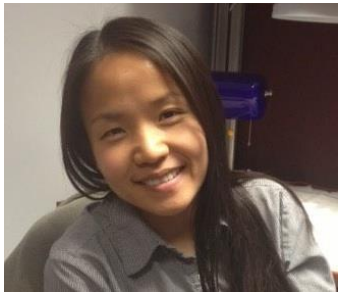

M. Mendoza


R.Mullinix

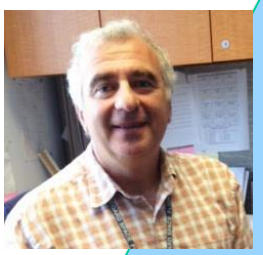

L. Rastaetter


Ja Soon Shim


M. Swindell


Chiu Wiegand


Kiran Patel


A. Taktakishvili

Space Weather Research Center (in-house prototyping team)


Yihua Zheng


A. Pulkkinen **(Lead)**


Y. Collado-Vega

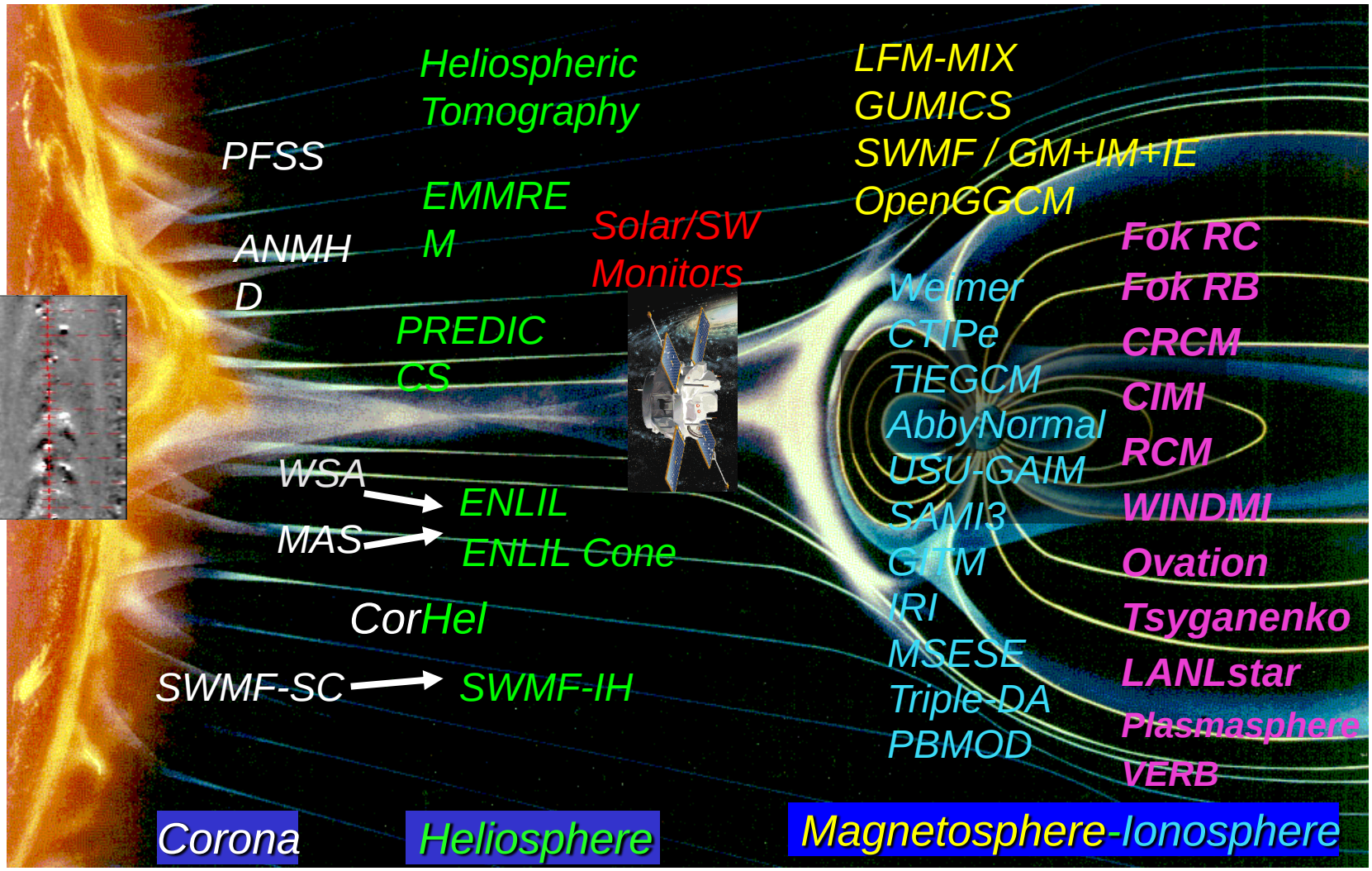

Leila Mays


Alex Gloce

CCMC/SWRC Lab at NASA/GSFC
Bld. 21, Rm 261

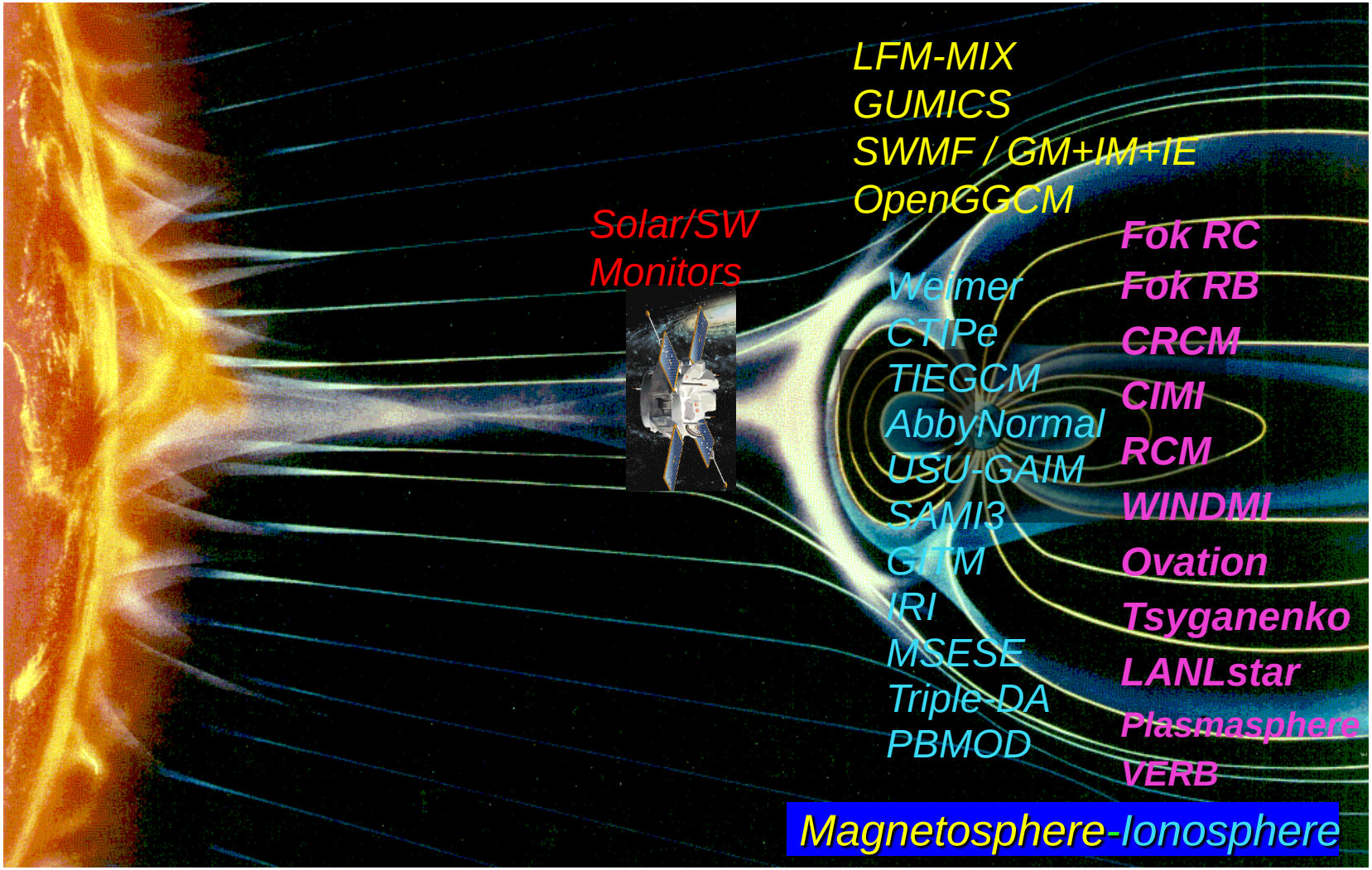
You are welcome to visit for a tour and a demo

Expanding Collection of Models



> 60, from Sun to Earth and beyond

Expanding Collection of Models



> 40, from L1 to Geospace

Magnetosphere Models Highlights:

Recent Upgrades, Model Combinations

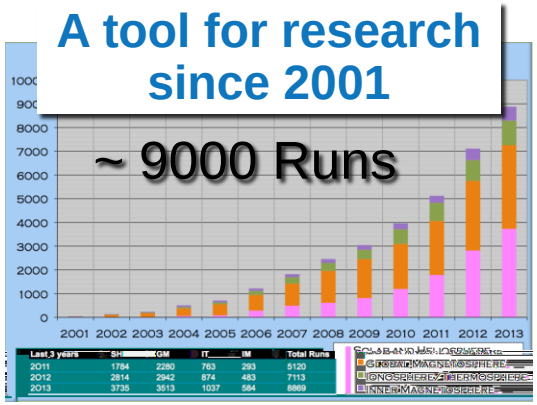
Global Magnetosphere *(physics-based)*

- **Space Weather Modeling Framework (SWMF) –** *(Gombosi et al,* U. Mich*)*
  - **SWMF with RCM (v20110131)** (selected by NOAA/SWPC)
  - SWMF with RCM+RBE (Radiation Belt Environment)
  - SWMF with CRCM (Comprehensive Ring Current Model)
- **LFM Magnetosphere** *(Lyon et al*, Dartmouth/NCAR/JHU-APL/CISM)
  - LFM-MIX
  - **CMIT**: fully coupled LFM-MIX & TIEGCM, version 2.2.0
- **OpenGGCM** v4.0 (*Raeder*, UNH)

Inner Magnetosphere *(physics-based)*

- **RCM** (*Sazykin et al*, Rice. U)
- **Fok** Models (*M-C. Fok* et al, GSFC)
  - Radiation Belt Environment (RBE)
  - Comprehensive Ring Current Model (CRCM)
  - **CIMI**: CRCM + RBE
- **Plasmasphere** model (*Pierrard et al*, IASB, Belgium)
- **VERB** radiation belt model (*Y. Shrits*) (test mode)

CCMC Signature Services
(Simulations)



Runs-on-Request Service

Web-base interactive system to serve advanced models to the international research community

- User-configurable input parameters and settings.
- Comprehensive on-line visualization & downloads

A tool for designing of sw products (widgets).

Event-Triggered Simulations
(real-time & historic)

FastTrack Request Option

- Input files are automatically downloaded.
- Optimal setting for real-time simulations.

Examples: Enlil Cone Model and/or SWMF simulations triggered when earth-directed CME is detected.

A 1-Click tool for forecasting and real-time validation

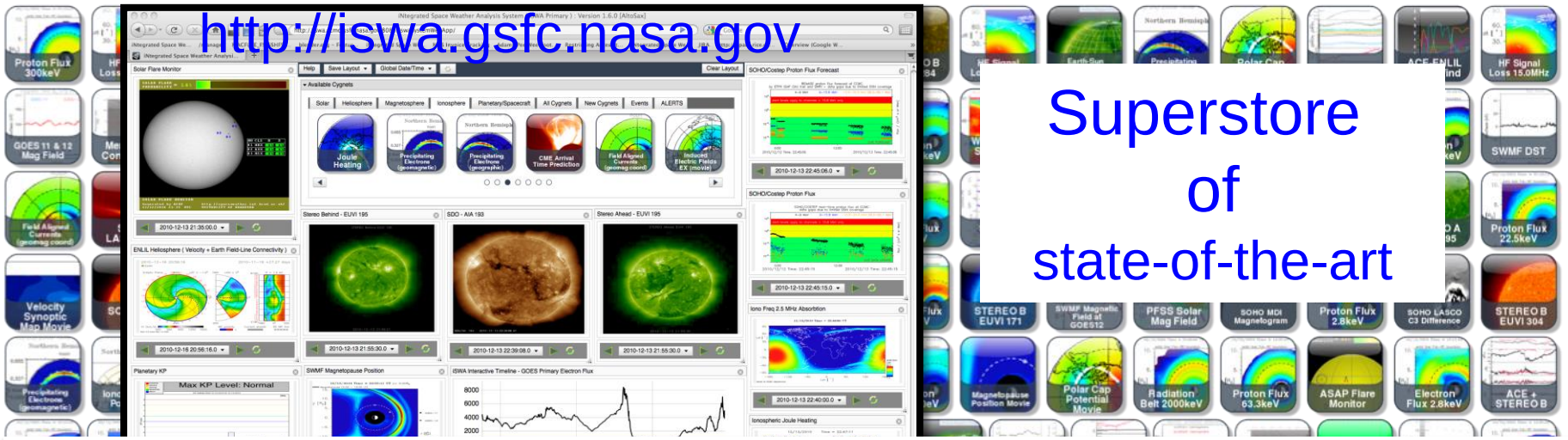
Continuous Real-Time Simulations

- Real-time data drivers.
- Data flow monitoring and controlling systems.

Example: SWMF (without RCM) since 2002.

Provide feeds to real-time widgets & displays.

CCMC Signature Services: iSWA
Integrated Space Weather Analysis System
(Innovative Dissemination)

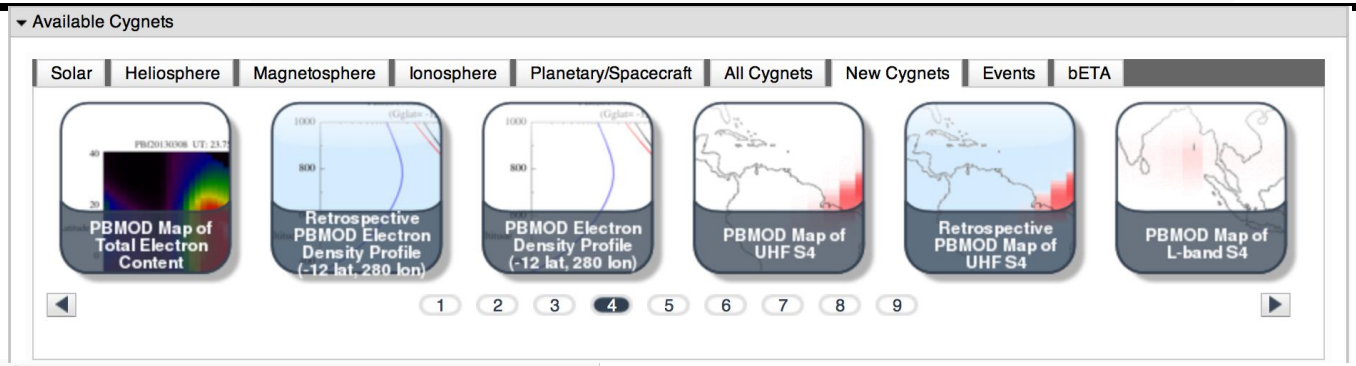


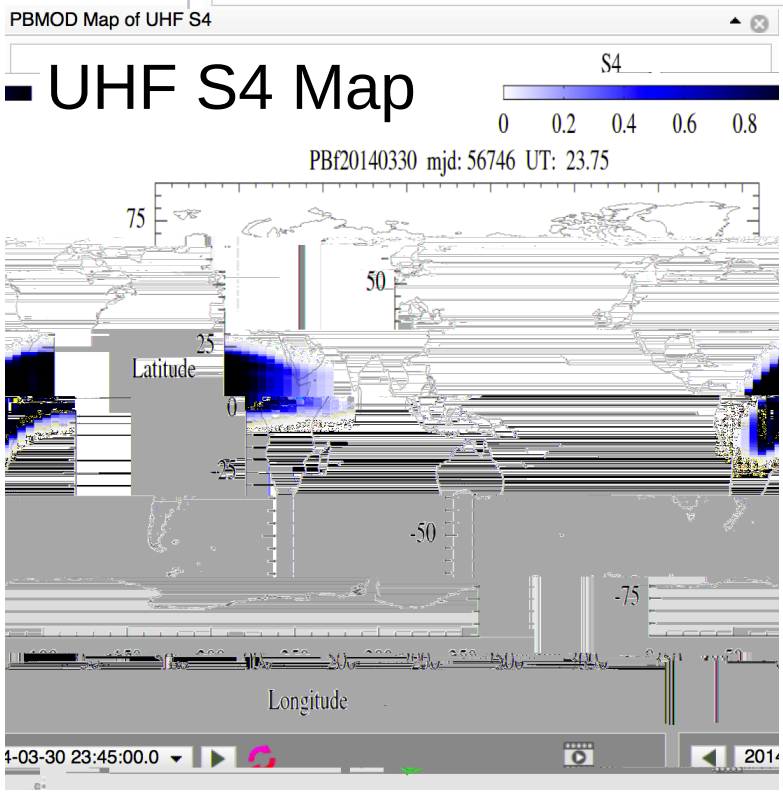
- Custom displays composed interactively by user from catalog of > 350 different widgets (cygnets), > 270 feeds from CCMC models.
- Cygnets are designed in collaboration with users of sw products & CCMC partners: NOAA/SWPC, AFWA, NASA mission operators.
- Combines simulations results & observational data (real-time & archives).

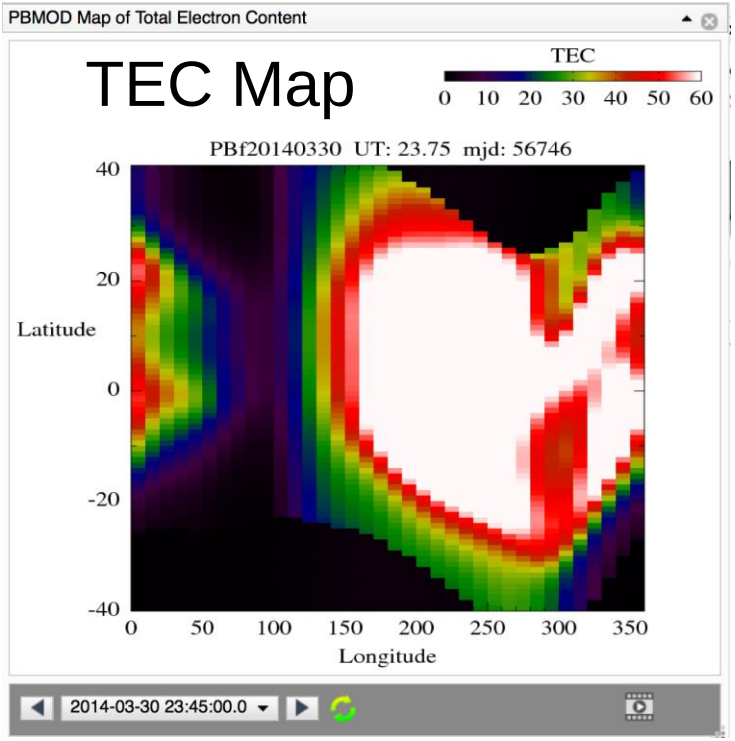
A multi-purpose tool for real-time space environment monitoring, event analysis, validation, education & forecaster training, collaboration.

M. Maddox, R. Mullinix, A. Chulaki

iSWA Cygnets: PBMOD (Ionosphere Scintillations)



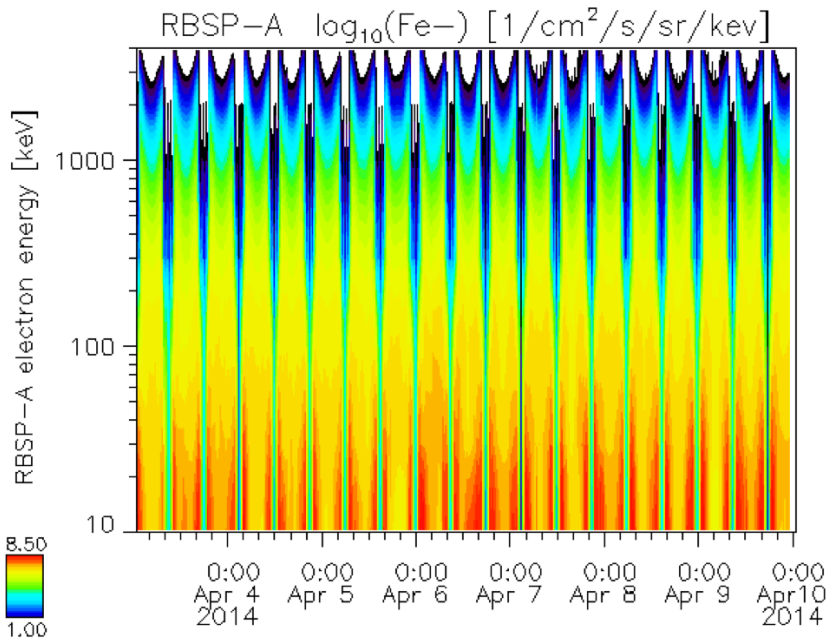




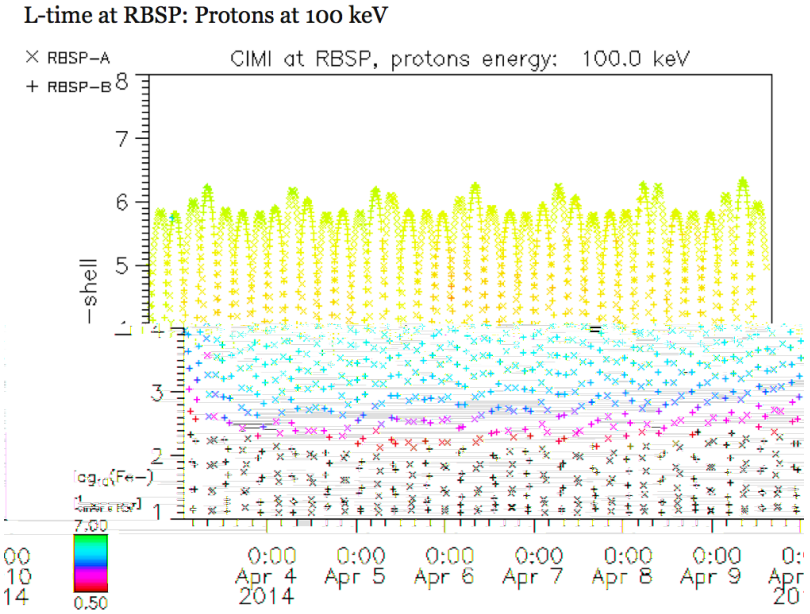
J. Retterer, CCMC: J-S. Shim

Comprehensive Inner Magnetosphere-Ionosphere (CIMI) Model: Real-Time Fluxes at VAP Orbit

Electrons at RBSP-A



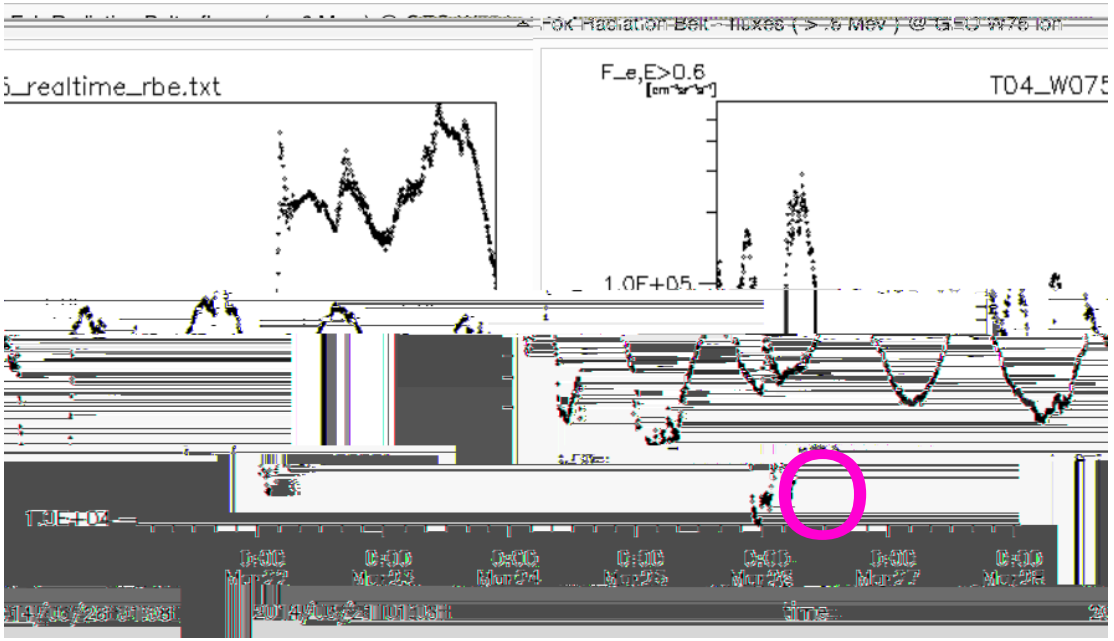
100 keV protons at RBSP (L-time)



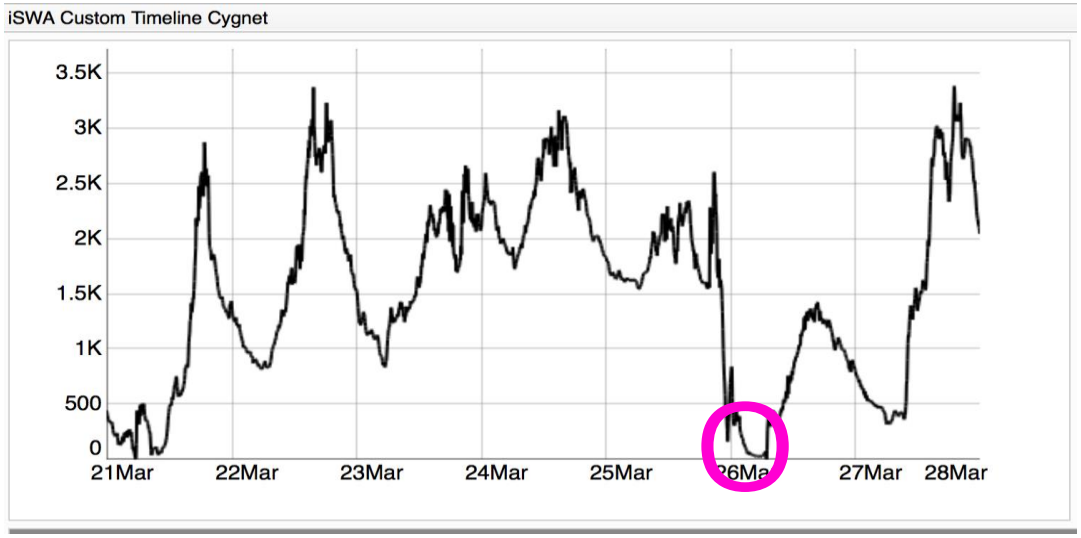
M-C. Fok, N. Buzulukova, CCMC: L. Rastaetter

iSWA Cygnets: Radiation Belt Environment (RBE) Model

RBE electron flux
(> 0.6 MeV)
at GEO W75



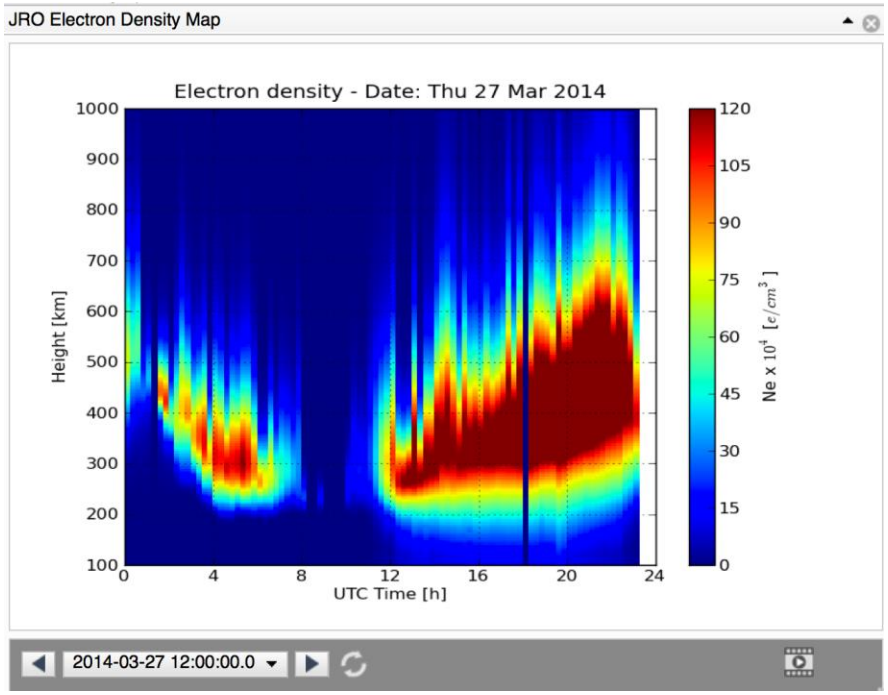
GOES electron flux
(> 0.8 MeV)



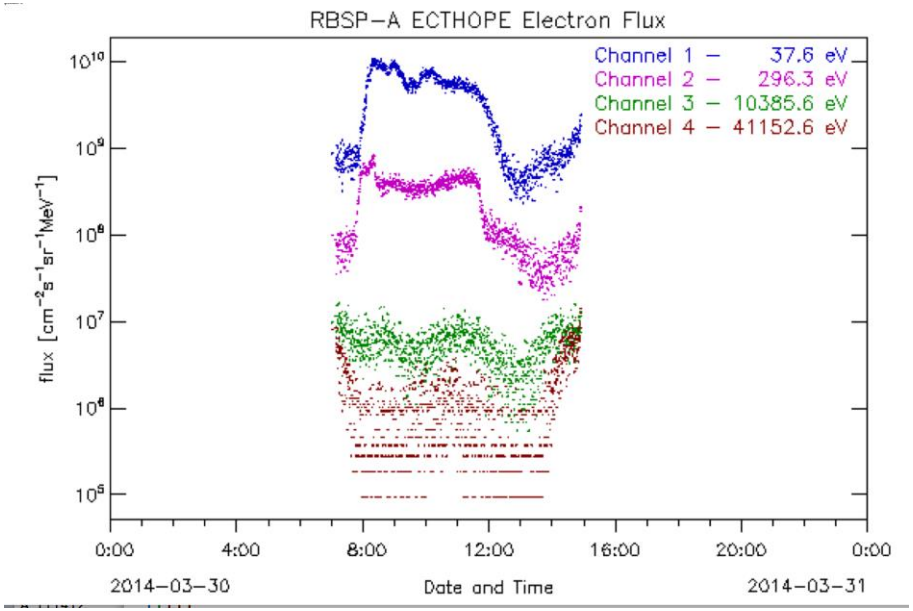
M-C. Fok, CCMC: L. Rastaetter

iSWA Cygnets:
Realtime Observational Data

JRO Electron Density

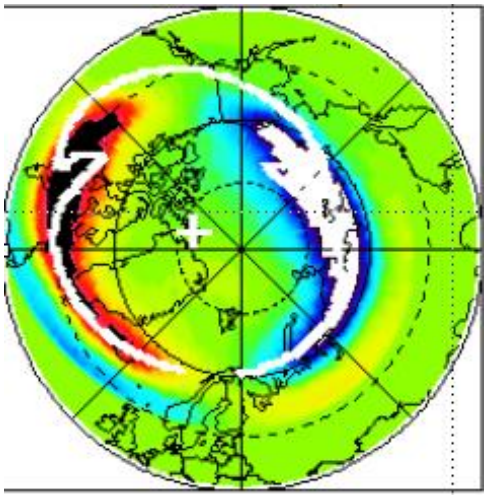


Van Allen Electron Flux

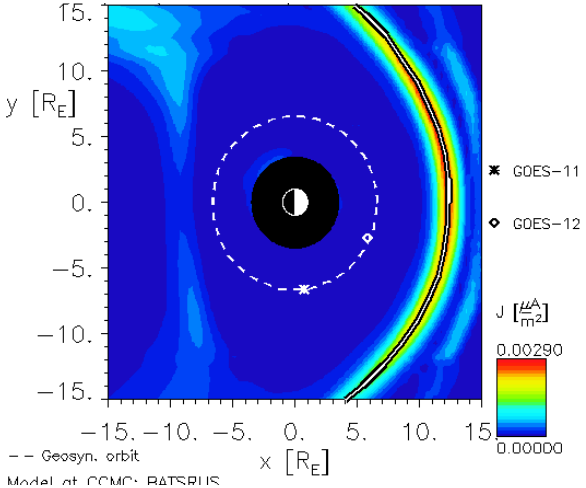


Global Magnetosphere Models
Space Weather Widget Examples

Auroral boundaries and polar cap absoption

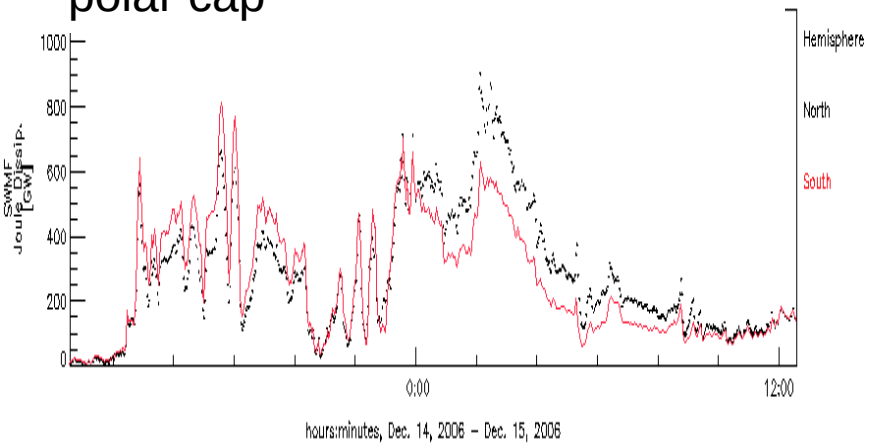


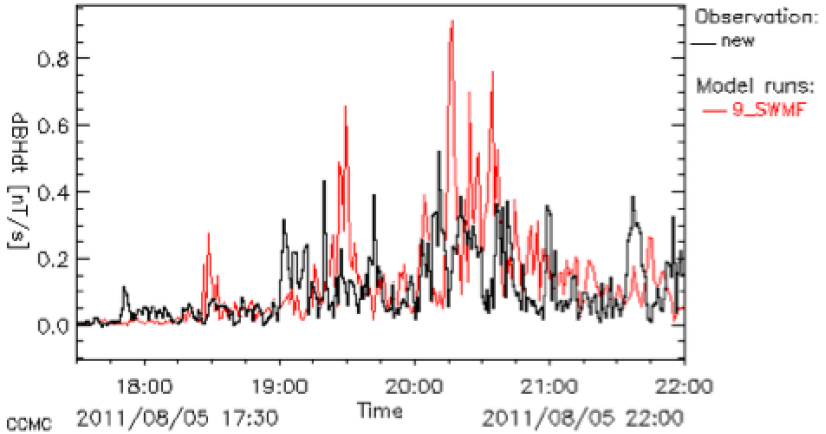
Magnetopause position



Ground magnetic perturbations, dB/dt.
Primary interest of NOAA/SWPC
(key to GICs).

Joule heating integrated over polar cap





Geospace Model Validation Efforts

Build upon GEM 2008 Modeling Challenge (community-wide effort).

Select physical parameter of interest to users: ΔB, dB/dt, Regional-K (critical role of NOAA/SWPC).

Agree on metrics format (threshold-based metrics parameters and skill score formula) (critical role of NOAA/SWPC).

Develop (and test) a post processing tool that derives ground magnetic perturbations from global magnetosphere model outputs from all current systems (*L. Rastaetter*, CCMC). Can be applied to all models.

Develop interactive on-line validation system, that

- allow access to simulation results archive,
- automatically calculates skill scores for selected events and stations,
- trace model performance over time.

Make validation process a seamless part of model development circle. Real-time prototyping and validation.

Validation System for 6 Events

Groundbased magnetic perturbations dB/dt and Regional-K study results

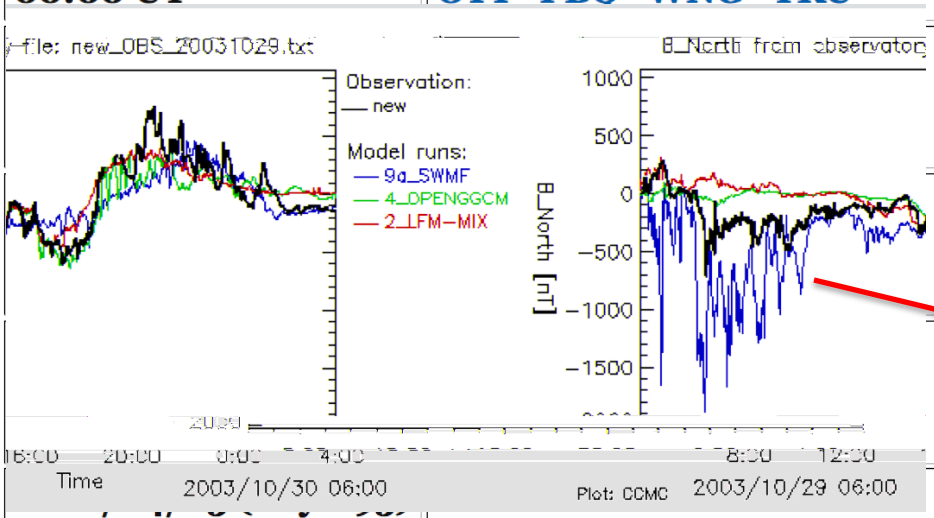
Event	Magnetic perturbations on the ground dB/dt	Magnetic perturbations on the ground Delta B	Regional-K
2006/12/14 (doy 348) 12:00 UT - 12/16 00:00 UT	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
2001/08/31 (doy 243) 00:00 UT - 09/01 00:00 UT	ABK FRD FRN FUR IQA MEA NEW OTT PBQ WNG YKC	ABK FRD FRN FUR IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
2005/08/31 (doy 243) 10:00 UT - 09/01 12:00 UT	ABK FRD FRN FUR HRN MEA NEW OTT PBQ WNG YKC	ABK FRD FRN FUR HRN MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
2003/10/29 (doy 302) 06:00 UT - 10/30 06:00 UT	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
2010/04/05 (doy 095) 00:00 UT - 2010/04/06 00:00	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK NEW OTT SNK WNG YKC
2011/08/05 (doy 217) 09:00 UT - 2011/08/05 09:00	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK NEW OTT SNK WNG YKC

You can also download Delta B, dB/dt and K-index timeseries files.

Validation System for 6 Events

Groundbased magnetic perturbations dB/dt and Regional-K study results

Event	Magnetic perturbations on the ground dB/dt	Magnetic perturbations on the ground Delta B	Regional-K
2006/12/14 (doy 348) 12:00 UT - 12/16 00:00 UT	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBO WNG YKC	ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
		ABK FRD FRN FUR IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
		ABK FRD FRN FUR HRN MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
		ABK FRD FRN FUR HRN IQA MEA NEW OTT PBQ WNG YKC	ABK NEW OTT PBQ WNG YKC
00:00 UT - 2010/04/06 00:00	HRN IQA NEW OTT SNK WNG YKC	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK NEW OTT SNK WNG YKC
2011/08/05 (doy 217) 09:00 UT - 2011/08/05 09:00	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK FRD FRN FUR HRN IQA NEW OTT SNK WNG YKC	ABK NEW OTT SNK WNG YKC



You can also download Delta B, dB/dt and K-index timeseries files.

Run on Requests
ΔB at 130 magnetometer positions for all magnetospere models

COMMUNITY COORDINATED MODELING CENTER

About | Models at CCMC | Request A Run | View Results | Instant Run | Metrics and Validation | Education | R2O Su

Paul_Tenfjord_033114_4

Title/Introduction:

Key Word: sharp turn in B_y

Model Type: GM
Model: LFM version LTR-2_2_0

Inflow Boundary Conditions:
Start Time: 2000/01/01 00:00
End Time: 2000/01/01 03:04
Dipole Tilt at Start in X-Z Plane: 0.00 deg.
Dipole Tilt in Y-Z GSE Plane: 0.00 deg.
Dipole Update With Time: no
Ionospheric Conductance: auroral

Radio Flux 10.7 cm: 150
Grid:
Coordinate System for the Output: SM
Initial Solar Wind (SW) Parameters in SM Coordinates:

SW Density: 8.00000 n/cc
SW Temperature [Kelvin]: 13335.20000 Kelvin
X Component of SW Velocity: -400.00000
Y Component of SW Velocity: 0.00000 km/sec
Z Component of SW Velocity: 0.00000 km/sec
IMF Bx: 0.00000 nT
IMF By: 0.00000 nT
IMF Bz: 0.00000 nT
IMF |B|: 0.00000 nT
IMF Clock Angle: 0 deg.

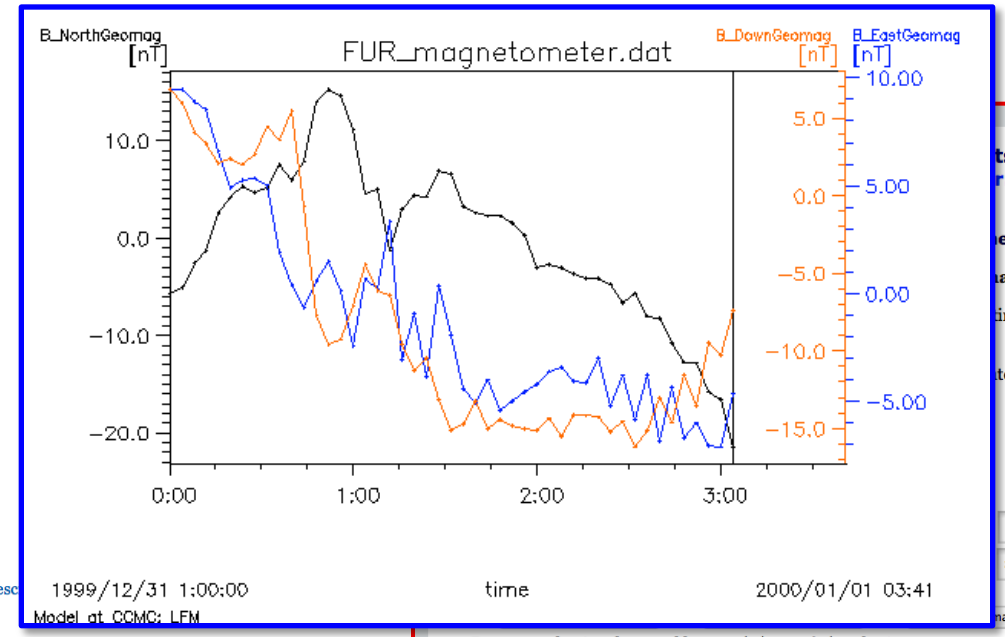
- View solar wind input data
- List solar wind input data in ASCII format (see format desc
- View Magnetosphere
- Create Timeseries in Magnetosphere
- View Ionosphere

View pre-computed timeseries data:
- Northern hemisphere polar cap flux and area
- Southern hemisphere polar cap flux and area
- Magnetopause standoff and closest approach within 30 deg. of Sun-Earth line (local noon)
- Polar cap boundary at 24 magnetic local times in northern hemisphere
- Polar cap boundary at 24 magnetic local times in southern hemisphere
- Ionospheric dissipation

- View Quick look graphics for the run

View Magnetic perturbation calculated for magnetometer stations:

AAA	AAE	ABG	ABK	AIA	ALE	AMS	API	AQU	ARS	ASC	ASP	BDV
BEL	BFE	BFO	BLC	BMT	BNG	BOU	BOX	BRW	BSL	CBB	CLF	CMO
CNB	CNH	CSY	CTA	CZT	DED	DLR	DMC	DOU	DRV	DUR	EBR	ESK
EYR	FCC	FRD	FRN	FUR	GCK	GDH	GLN	GNA	GUA	GUI	GZH	HAD
HBK	HER	HLP	HON	HRB	HRN	HUA	HYB	IPM	IQA	IRT	ISK	IZN



Model: LFM

e-dimensional model output.

anges.

ing image will be displayed at this location

tered a programming error. Please report

Second: 0

Second: 59.99998

Log scale (apply to all quantities > 0 in plot)

Lock plot data range: Min.: 0 Max.: 1

Image magnification: 1

Line style: no line Plot symbols: diamonds Symbol size: 0.2

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

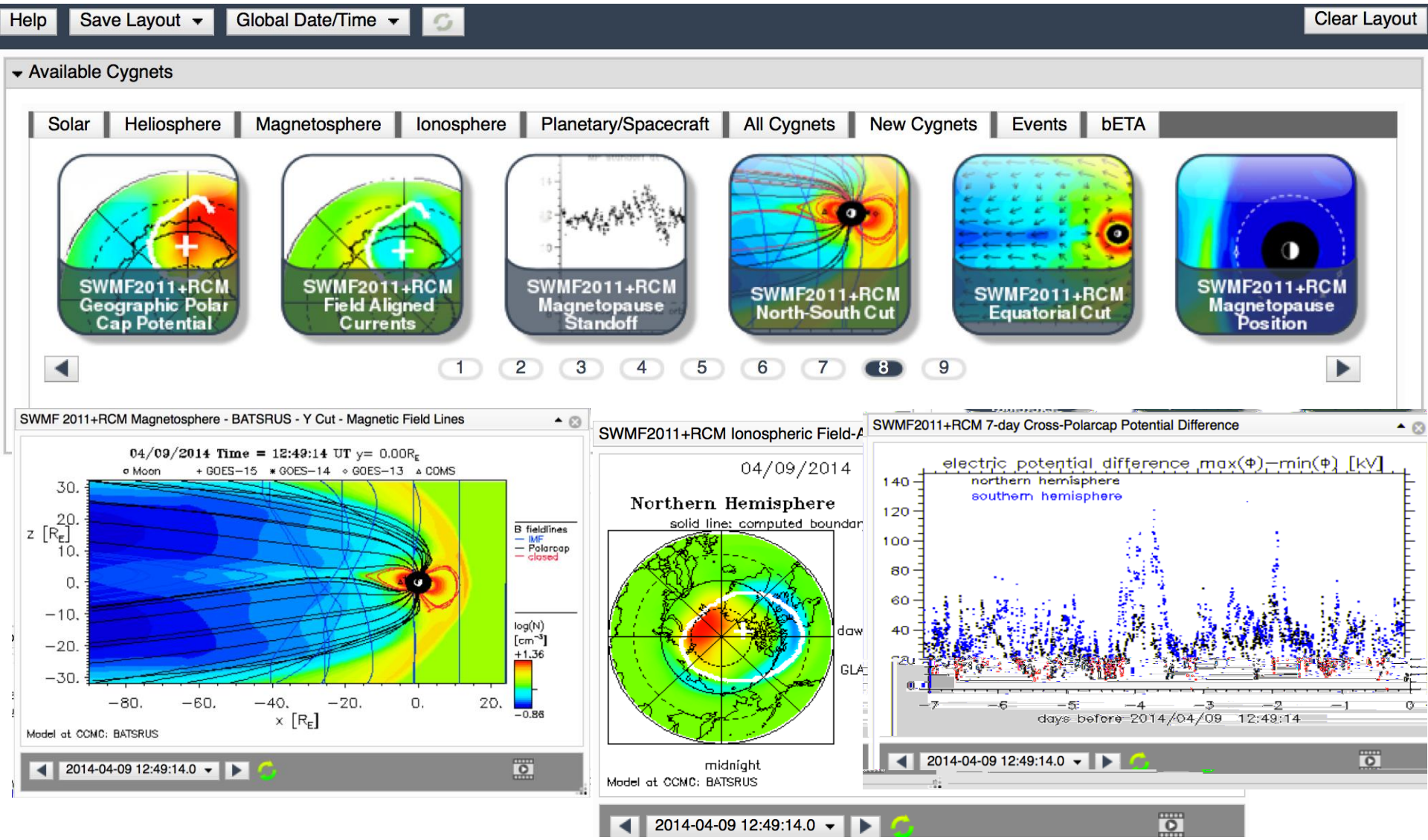
Update Plot — *Update Plot* will update (generate) the plot with the chosen time and plot parameters above or will print the entire file to screen.

Have data printed to text file.
The file format is slightly different from the original file visualized and can include computed quantities if offered and selected for plotting (i.e. quantities beyond basic MHD quantities N, P, **V**, **B**), such as B, V, J, **E**,**J**par.

Runs-on-Request: Contact CCMC Staff
Visualization: Dr. Lutz Rastätter

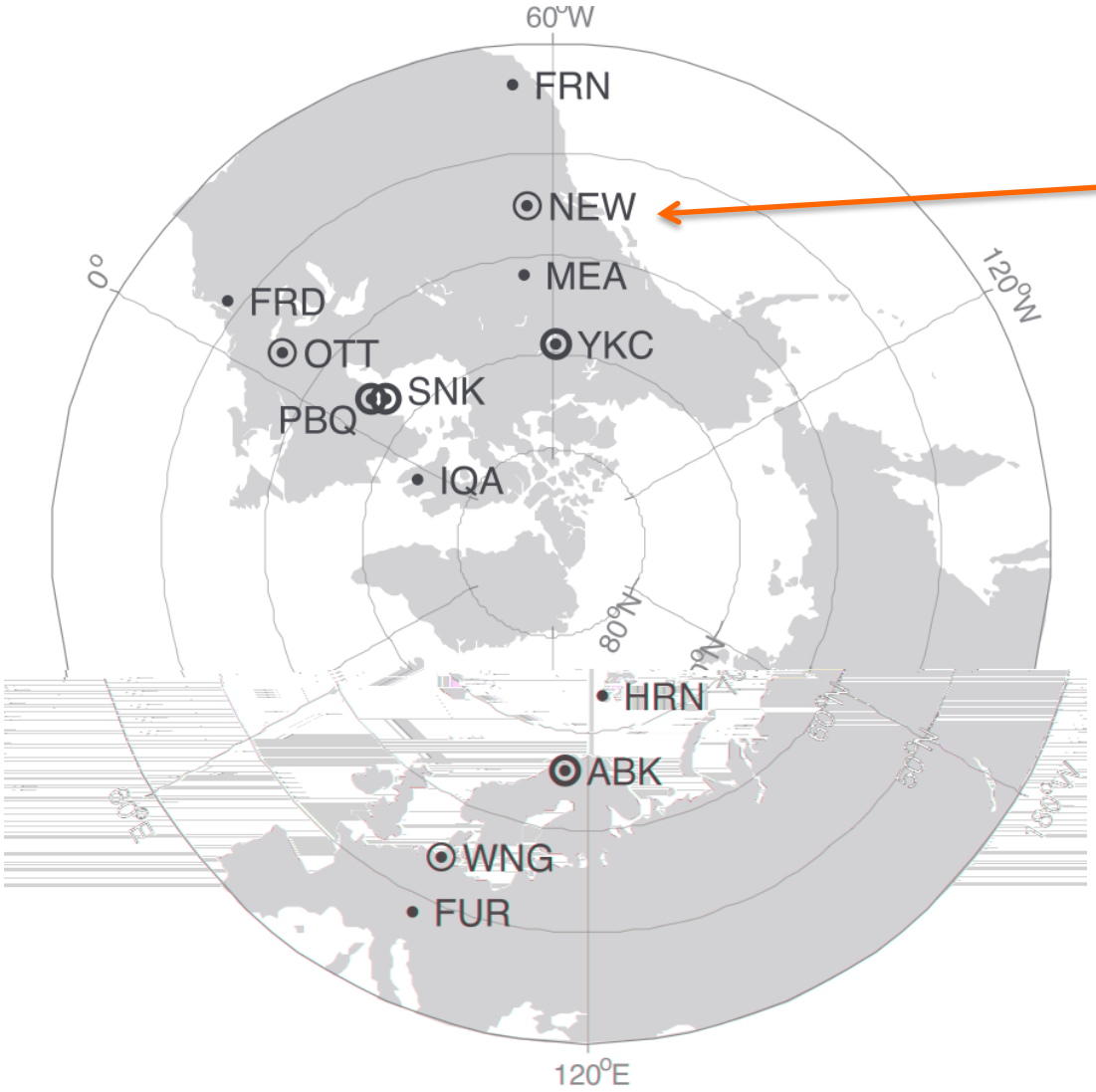
Last script update: August 18, 2011.

iSWA: SWMF (BATSRUS + RCM) v. 20110131 (U. Mich)



DST, Ground peturbations (delta-B, dB/dt) timelines – *coming soon.*

Sensitivity Analysis to Station Location

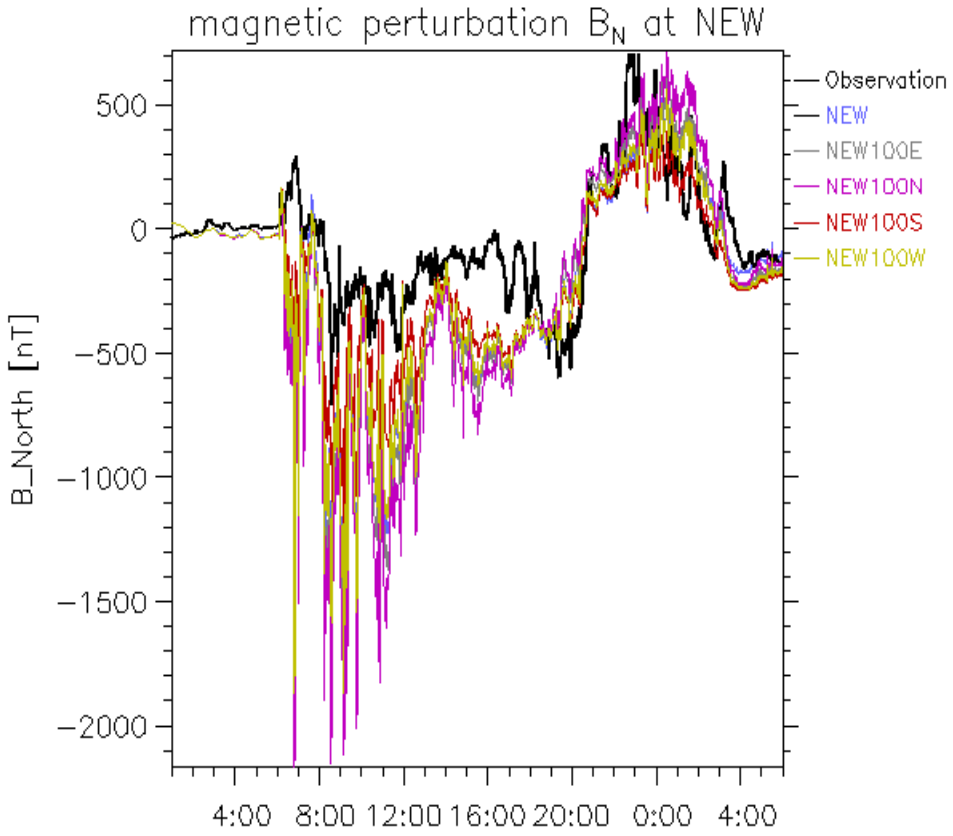


Virtual Magnetometers

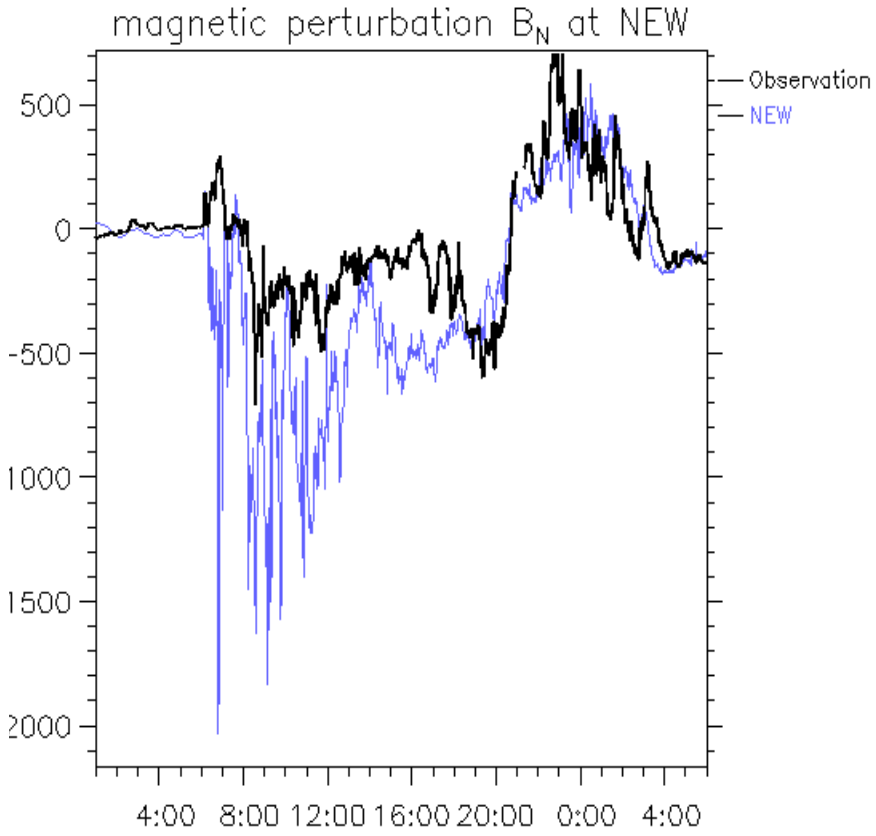
100 km	200 km
NEW100S	NEW200S
NEW100N	NEW200N
NEW100E	NEW200E
NEW100W	NEW200W

300 km
NEW300S
NEW300N
NEW300E
NEW300W

Ensemble of Virtual Magnetometers



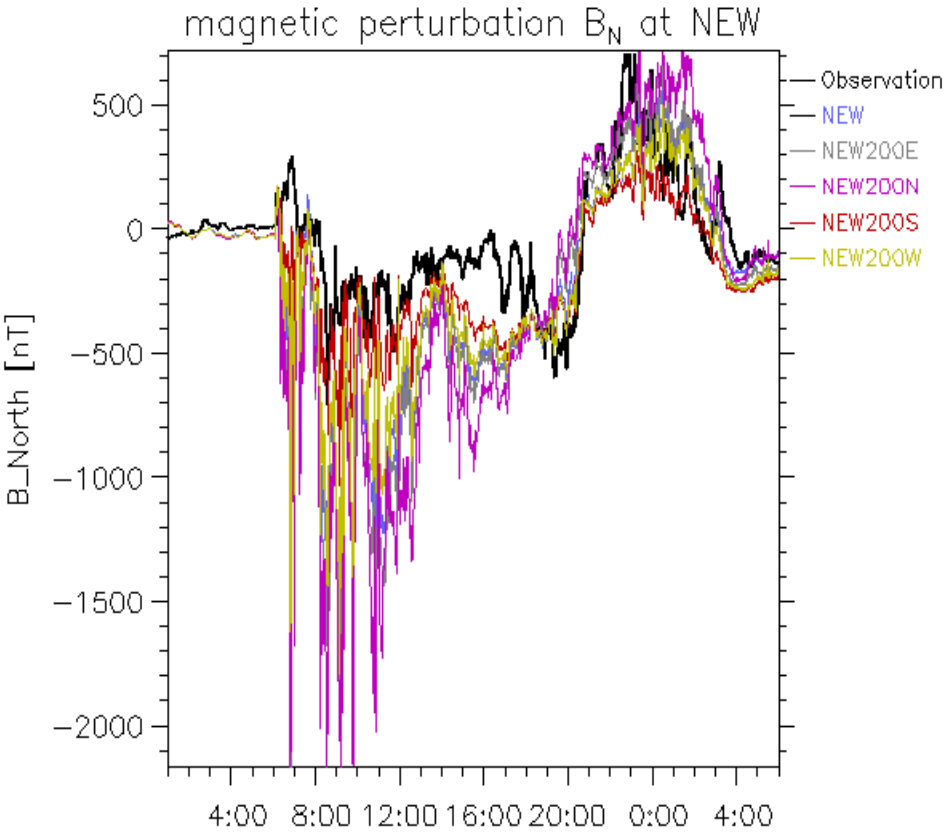
100 km distance



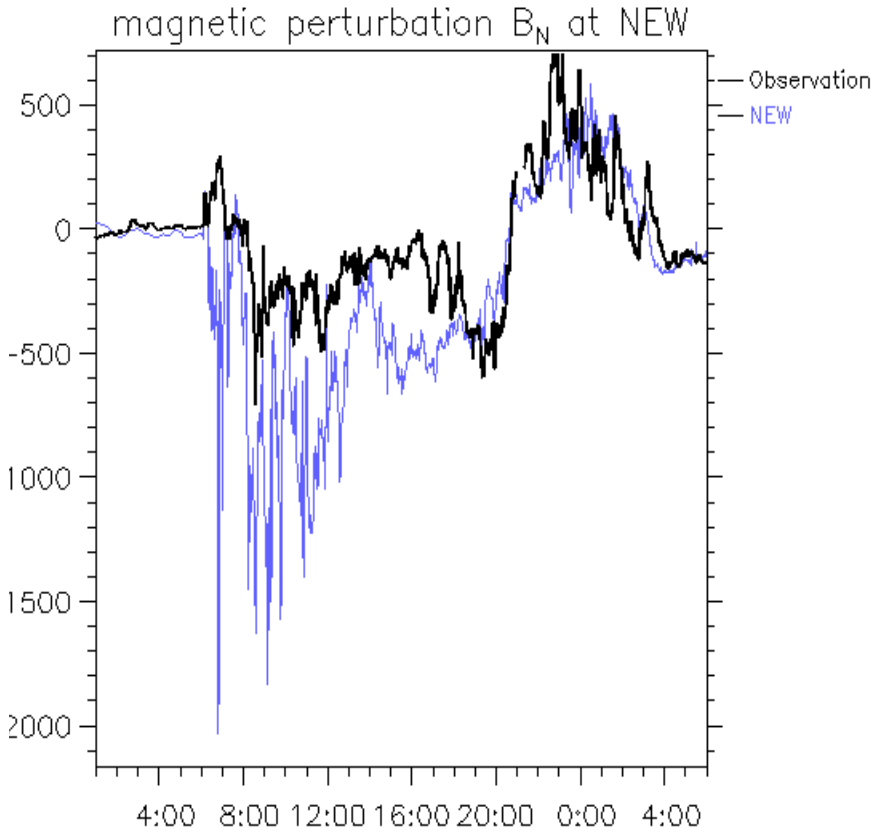
Oct. 29-30, 2003 (Halloween Storm)

Observation and **model** at NEW

Ensemble of Virtual Magnetometers



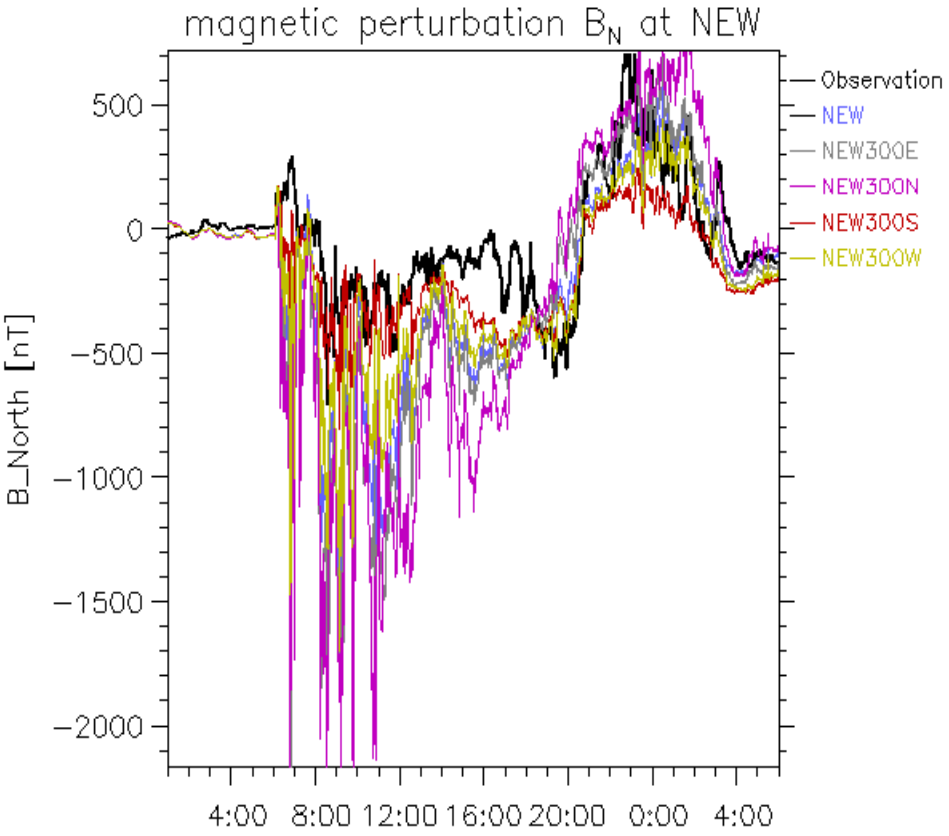
200 km distance



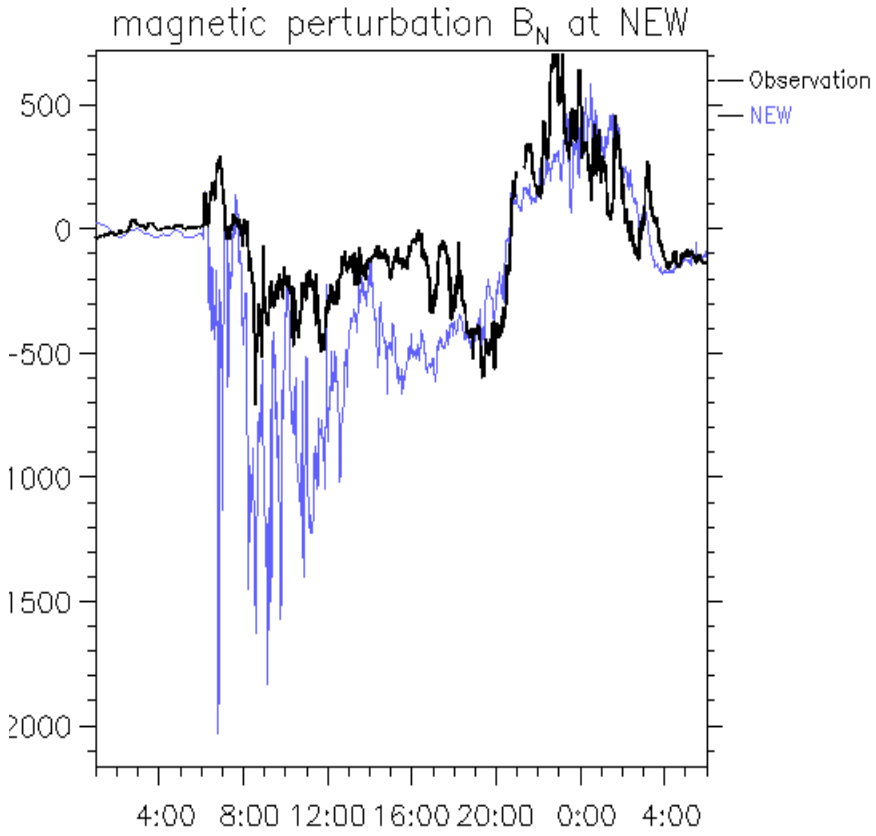
Oct. 29-30, 2003 (Halloween Storm)

Observation and **model** at NEW

Ensemble of Virtual Magnetometers



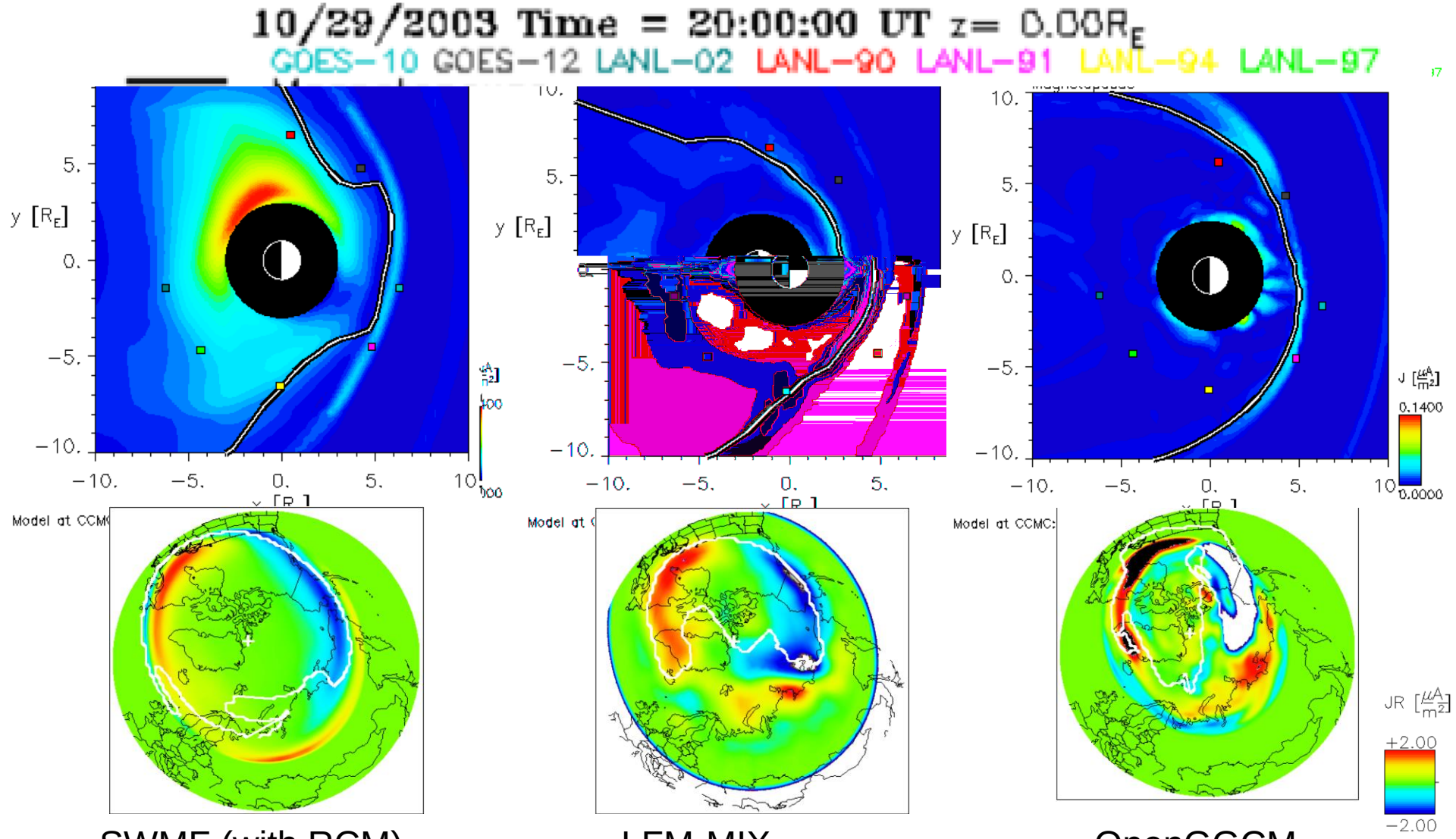
300 km distance



Oct. 29-30, 2003 (Halloween Storm)

Observation and **model** at NEW

Ensemble Displays (Event Simulations)

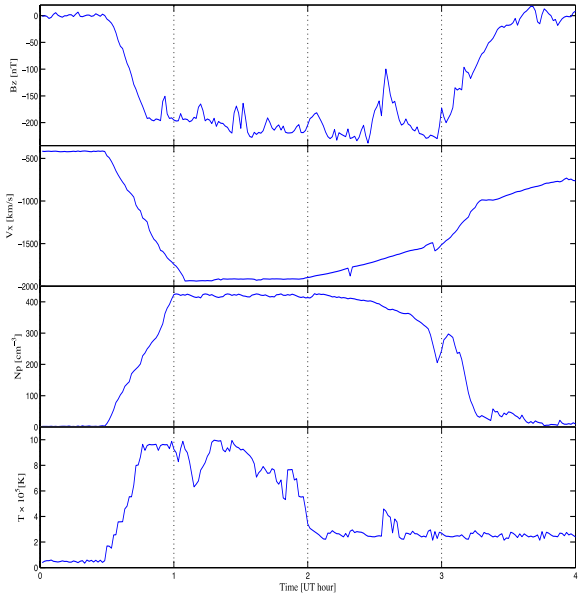


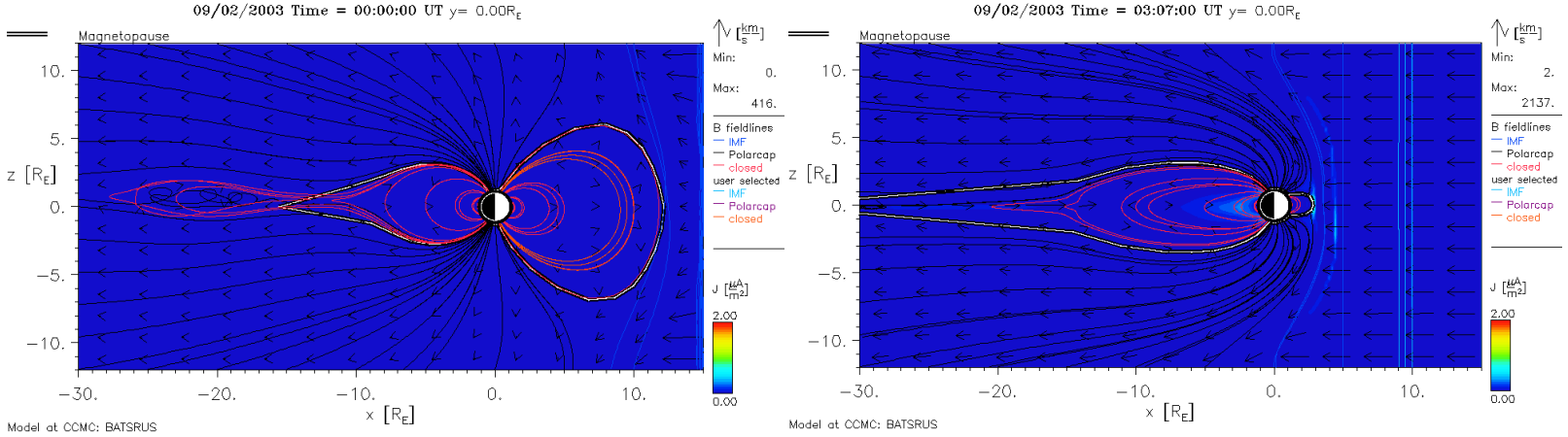
SWMF (with RCM) LFM-MIX OpenGGCM

FastTrack option with automated skill score calculation to trace model improvement over time – *coming soon.*

Pushing Models to the Limits: Modeling Extreme SW Event

- Artificially constructed solar wind driving conditions (consistent with available information on Carrington storm).
- Specially adapted version of the SWMF:
  - inner boundary at 1.25 Re vs 2.5 Re,
  - resolution at inner boundary 1/16 Re vs 1/4 Re.
- The inner boundary condition becomes extremely important during periods of strong driving.





Working with code developers to address the issue

C. Ngwira, A. Glocer, G. Toth

Partnership with NASA Users

Linking CCMC space environment modeling systems with models calculating impacts on systems in space

JSC/SRAG, D. Fry et al, Space radiation analysis

JPL, H. Garret et al., Surface charging modeling

MSFC, J. Minow et al., Internal charging

GSFC, K. Label et al., SEU modeling

GSFC, L. Newman, Satellite drag & conjunction assessment

A. Pulkkinen, Y. Zheng, M. Maddox, J-S Shim

Summary and Outlook

- CCMC is designed for rapid implementation and prototyping of advanced capabilities (including LWS deliverables).
- On-going activities in support of geospace model transition to NOAA/SWPC:
  - Continuous real-time SWMF runs with results dissemination through iSWA displays and Web services.
  - Event triggered simulations for SWMF and other global magnetosphere models (LFM, OpenGGCM).
  - Automated dB/dt and skill score calculations.
  - Push models to the limits. Sensitivity analysis.
- Operation agencies are invited to take advantage of iSWA.
  - ✓ Test-drive before investing.
  - ✓ Opportunity for collaborative tool development.
- Participation of users of space weather products in setting validation projects is a key.
- Much more is possible if we continue working together and expand collaboration.

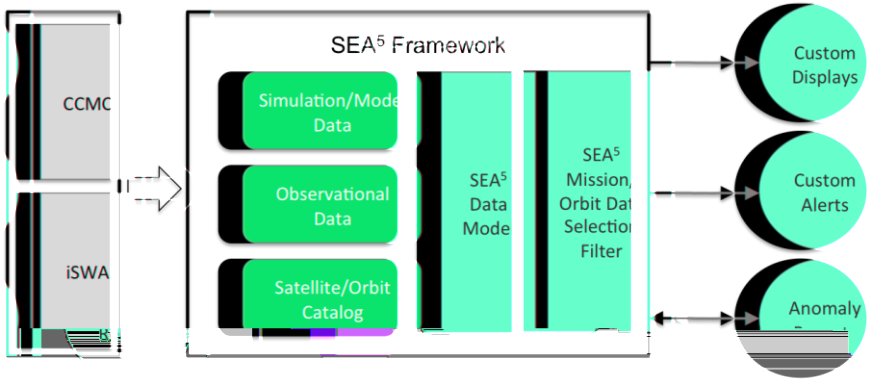

Research Education Development Initiative
Contact Yihua Zheng for more information
2nd Space Weather REDI Boot Boot Camp,

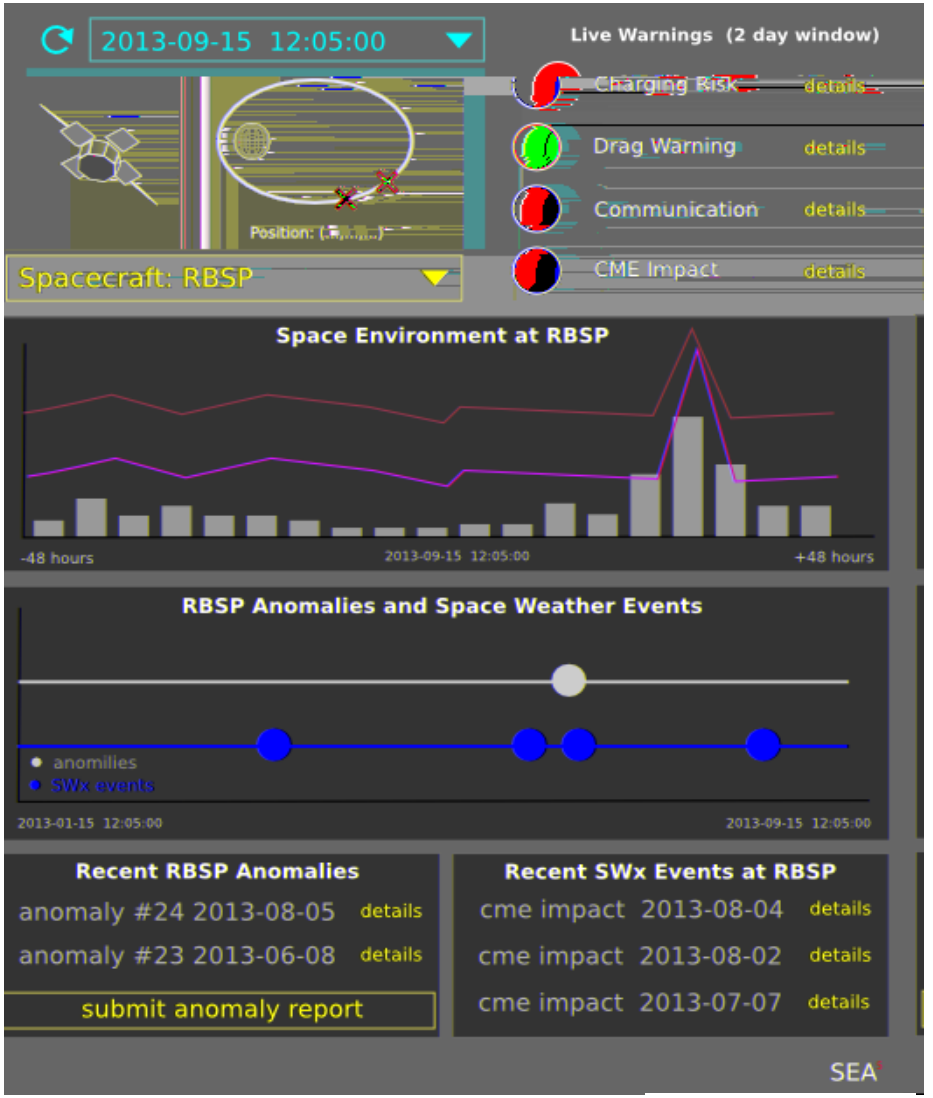
Supplementary Material

SEA^5 : Space Environment Automated Alerts & Anomaly Analysis Assistant

An extensible software system for NASA that provides an unprecedented capability for:

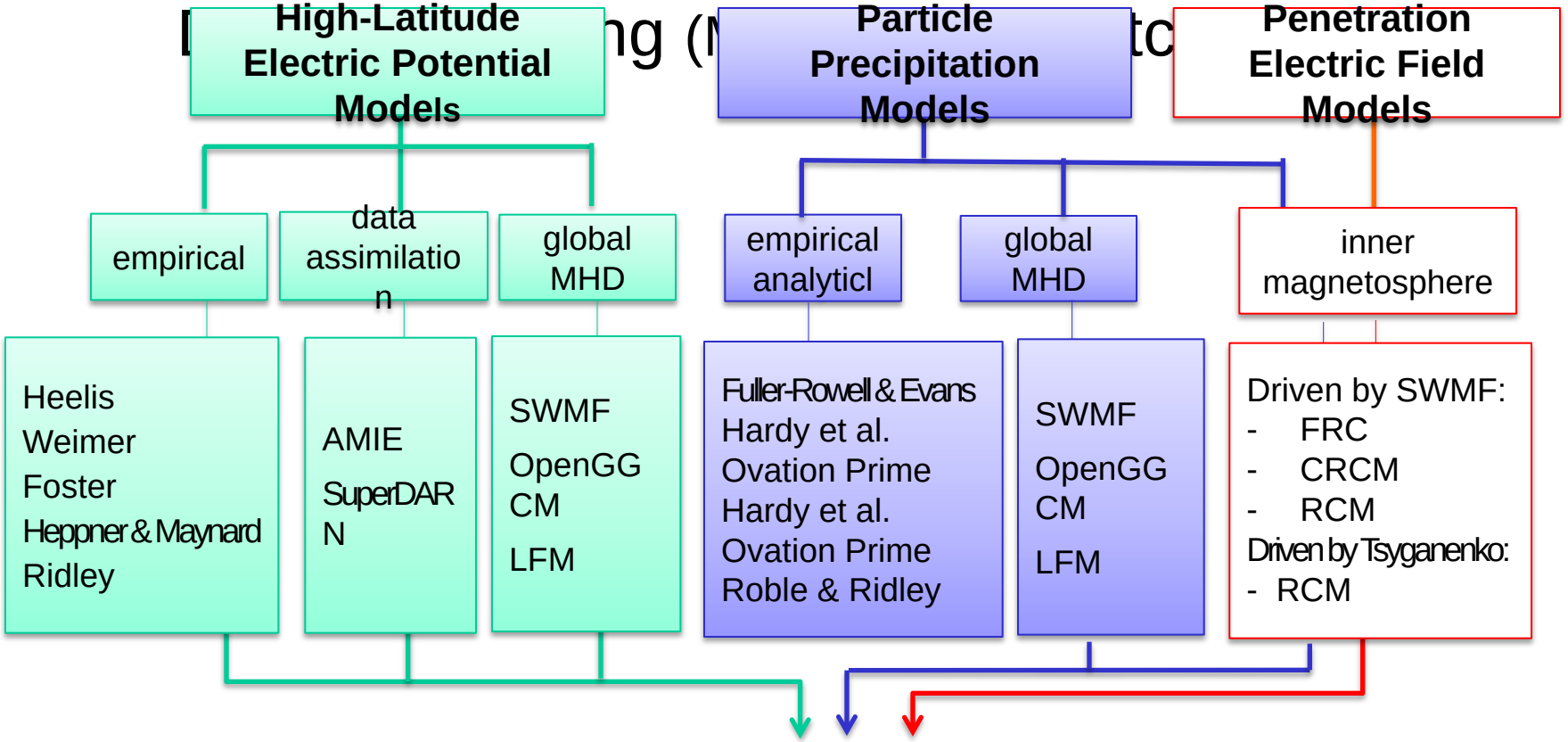
- viewing space environment conditions for specific missions/orbits
- providing automated SW alerts
- assimilating and displaying spacecraft anomaly information
- displaying spacecraft/mission data





M. Maddox

Collaborative Development with Model Owners



All drivers are converted to a common format.
The tool is called as a KAMELEON subroutine to provide values on the grid;

call kameleon (model, time, mlts, mlats, variables, values_output)

IT Models: CTIPe/TIE-GCM/GITM

J-S. Shim
M. Swindell