

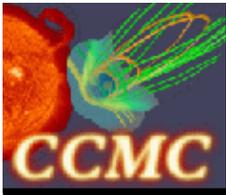
Director's Report

Michael Hesse

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

NASA Goddard Space Flight Center



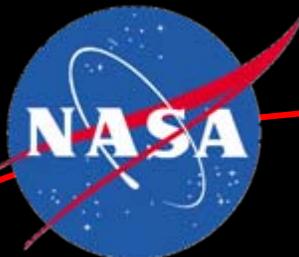


Workshop Purpose

- Assess (evolution to) CCMC state-of-affairs
 - What went well
 - What could have gone better
- Obtain input for future directions
 - Science service
 - Operations service
 - Collaborations with modelers
- Discuss other topics of interest

Our job is to listen to you...

... begin by summary of current status



NASA



NSF



AFRL

“A US multi-agency partnership to enable, support, and perform the research and development for next generation space science and space weather models”



AF/XOW - AFWA



AF SMC/CI



AFOSR



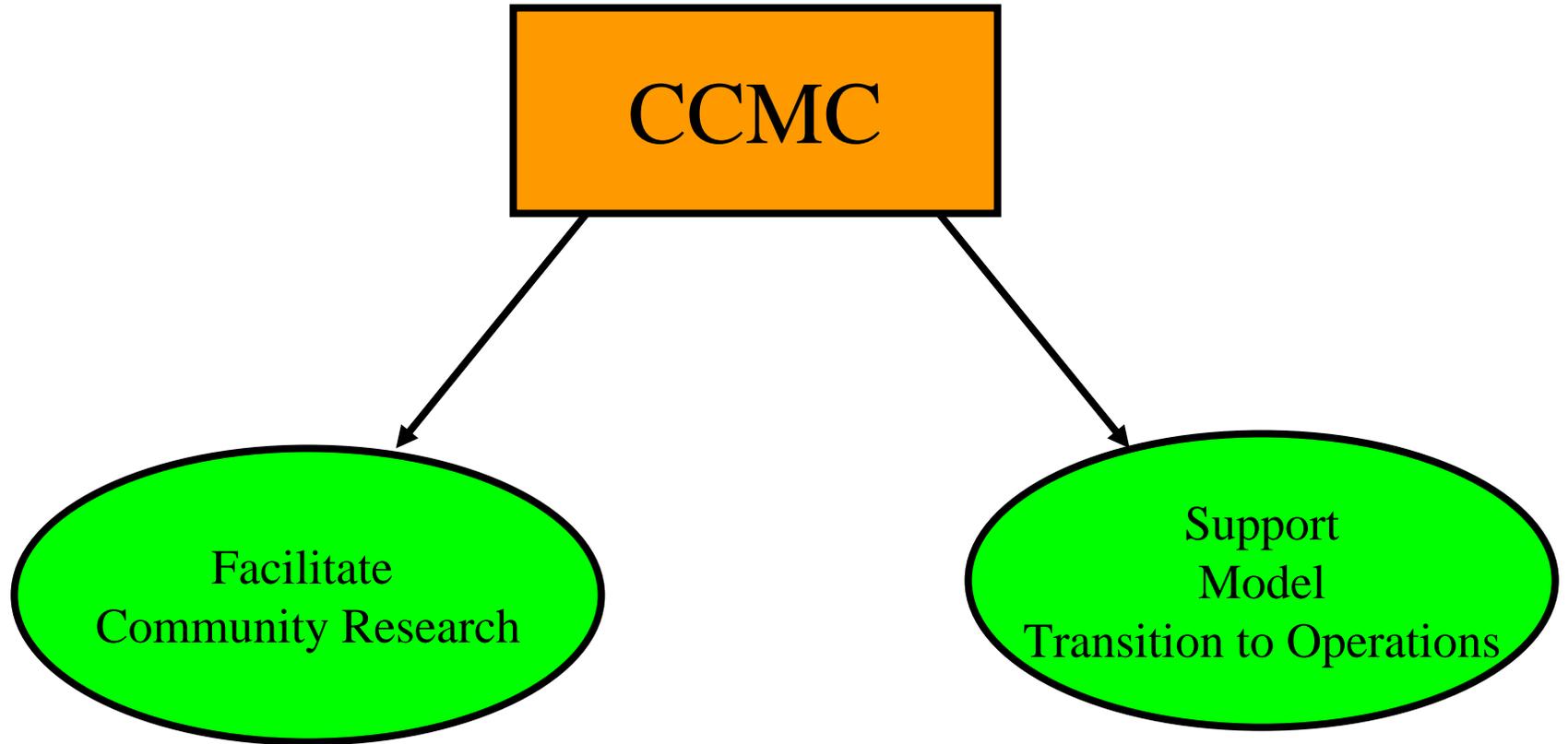
ONR



NOAA/SEC



CCMC Goals



International Research Community

DoD and NOAA Space Weather needs



CCMC Goals

- Employ scientific research models to address National Space Weather needs
- Generate, with the research community, a flexible model chain, which addresses solar atmosphere to Earth's upper atmosphere
- Serve the research community through access to scientific model results (“open model policy”)
- Perform broad-based testing and metrics-based evaluation of research models
- Make available science- and metrics-tested models to operational National Space Weather Agencies



Decision Flow

US National Space Weather Program Council

US Committee for Space Weather



recommendations,
needs

needs
requirements

directs

informs

Research Community

Operations Community

Science and Operations
Advisory Committees





CCMC Steering Committee

Members:

NASA Headquarters

Dr. Chuck Holmes

(Co-Chair)

NSF

Dr. Paul Bellaire

(Co-Chair)

AF/XOW

Maj. Mark Adair

AFOSR

Maj. David Byers

AFRL

Dr. Nick Arge

NASA GSFC

Dr. Michael Hesse

NASA Headquarters

Dr. Madhulika Guhathakurta

NOAA/SEC

Dr. Terry Onsager

NSF

Dr. Bob Robinson

ONR

Dr. Bob McCoy

SMC/CI

Mr. Kevin Scro

(Facilitator)

Technical Advisors:

AFIT

Maj. Chris Smithro

AFSPC

Mr. Kelly Hand



The CCMC Staff

Staff member

Dr. Michael Hesse

Dr. Masha Kuznetsova

Dr. Joel Allred

Mr. Sarabjit Bakshi

Mr. David Berrios

Ms. Anna Chulaki

Ms. Mary Goldfarb

Dr. Peter MacNeice

Mr. Marlo Maddox

Mr. Kiran Patel

Dr. Lutz Rastaetter

Dr. Aleksandre Taktakishvili

Function

Director

Models, Deputy Director

Postdoctoral fellow

Sysadmin.

Visualization

ROR system, metrics studies

WWW management

Models, model coupling, frameworks

Data Formats, visualization

Sysadmin., comp. resources

Models, V&V, visualization, frameworks

Postdoctoral fellow

Associate

Dr. Mei-Ching Fok

RC and rad. belt models



CCMC Facility

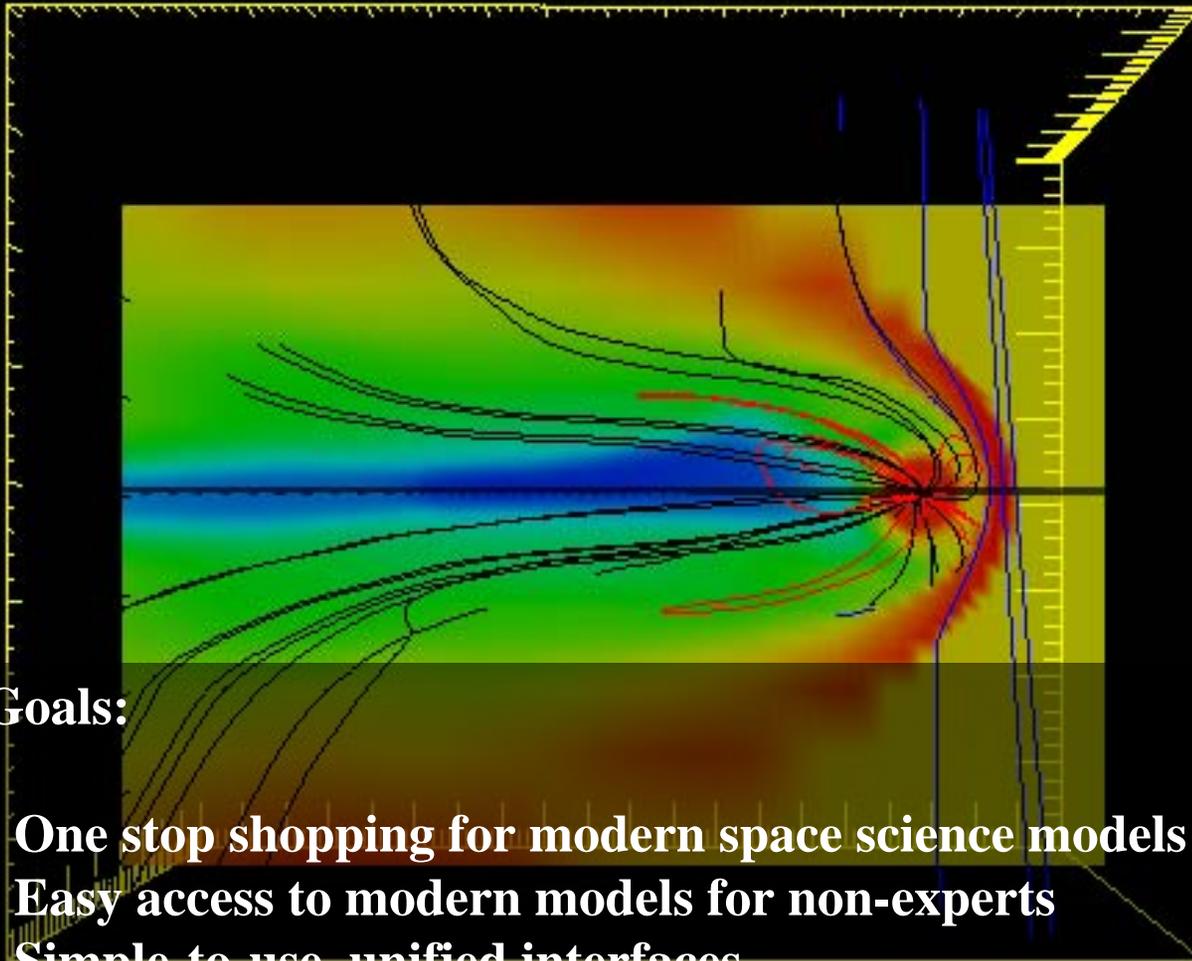


Located at
NASA GSFC



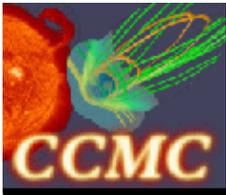
~200 node Beowulf system,
sponsored by **AF/XOW,**
NSF, AFOSR,
tech refresh sponsored by
NASA

CCMC Functions: Research Support



Goals:

- One stop shopping for modern space science models
- Easy access to modern models for non-experts
- Simple-to-use, unified interfaces
- Advanced, tailored visualization tools
- Continuous improvements through user feedback



Service

To track usage for our government sponsors, we ask that you notify ccmc.gsfc.nasa.gov whenever you use CCMC results in a scientific publication or presentation. Thank you.

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.

Exclude region around the Sun up to R_S

Choose data time:
 - or -
 Change time by moving output steps

Image magnification (all images; use ≥ 1.25 for 3D flowlines):

Allow variable plot image size (2D plots, aspect ratio (ratio dx/dy of plot) between 0.3 and 4)

Show simulation grid (disabled with 3D-Surface)

Interpolate data onto equidistant grid (available with 3D-Surface and Vector; recommended for plots with Vector)

Choose **Plot Mode**: Choose **quantity** to be displayed (some **Plot Modes** require up to three choices)

Color+Vector+B-Fieldlines q 1: q 2: q 3:

Plot Options for selected Plot Modes:

3D-Surface, 3D-Flowlines View angles: AX [-90..90]: AZ [-180..180]:

Color Contour: Use Grayscale
 Lock color range: (Log scale: use original values > 0)
 Min.: Max.:
 Log scale (N/Rho, En, P, most fluxes F...)

Contour: show values with contour levels

Vector: length of arrows:

3D-Flowlines: flowline start positions
 Choose **Flowline Setup Mode**:
 user-defined flowline start positions:
 Radius r:
 Lon. p:
 Lat. t:

Choose Plot Area:
 All **Plot Modes** except **Line Plot**: Select lower left corner of plot area on the left, and the upper right corner on the right.
Line Plot: Select start point of line on the left, the end point on the right.

Choose Cut Plane:

Radius r_1 : Radius r_2 : Range: 1 ... 20 R_S Radius r =constant:

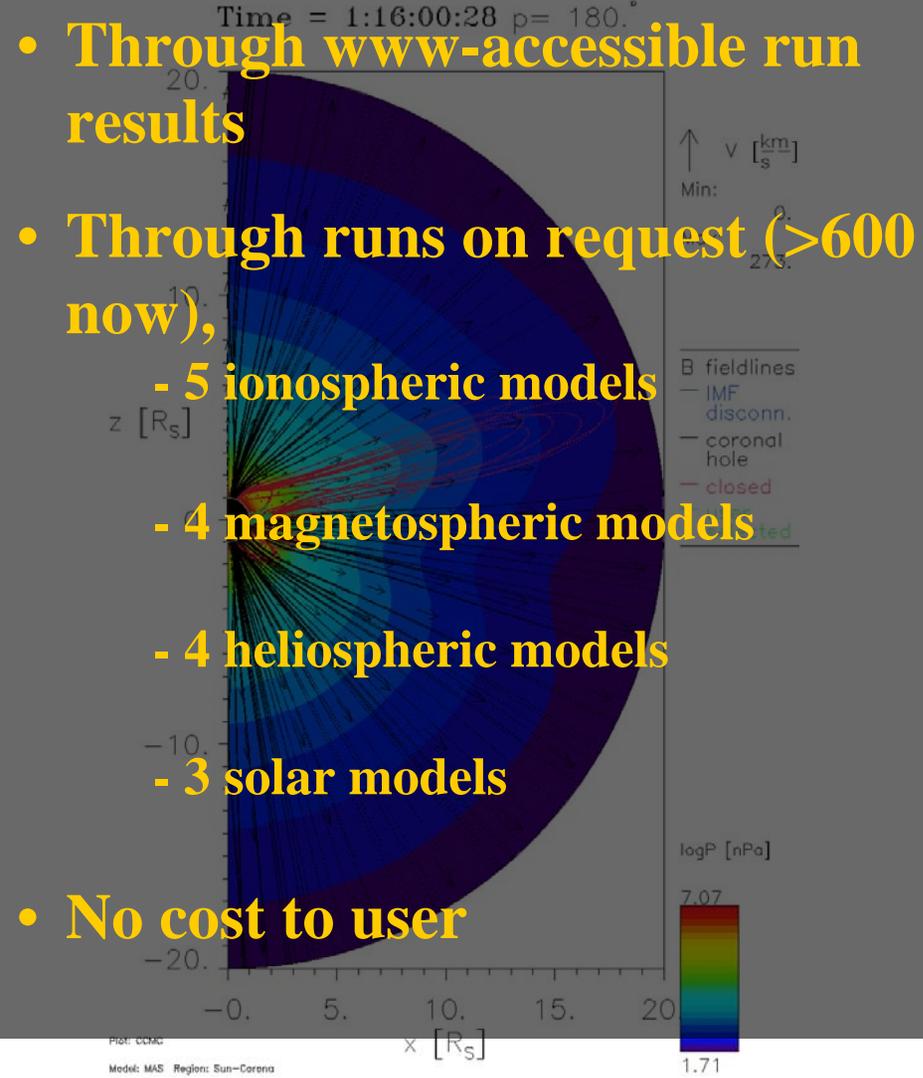
Lon. p_1 : Lon. p_2 : Range: 0 ... 360 deg. Lon. p =constant:

Lat. t_1 : Lat. t_2 : Range: -90 ... 90 deg. Lat. t =constant:

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.

List Data (check to get any of the following outputs):
 At positions specified: enter positions in Radius r , Lon. p , Lat. t , (within the allowed range) as comma-separated lists.
 Radius r positions:
 Lon. p positions:
 Lat. t positions:

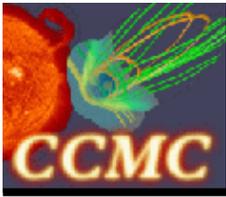
List Data From Plot:
 2D plots (Contour, Vector, ...):
 equidistant 61x61-element grid in cut plane (**Interpolate data onto equidistant grid** selected)



- Through **www-accessible run results**
- Through runs on request (>600 now),
 - 5 ionospheric models
 - 4 magnetospheric models
 - 4 heliospheric models
 - 3 solar models
- **No cost to user**

→ *Demos on Thursday*

A. Chulaki, L. Rastaetter, M. Goldfarb



Service Improvements

Comprehensive interface that allows:

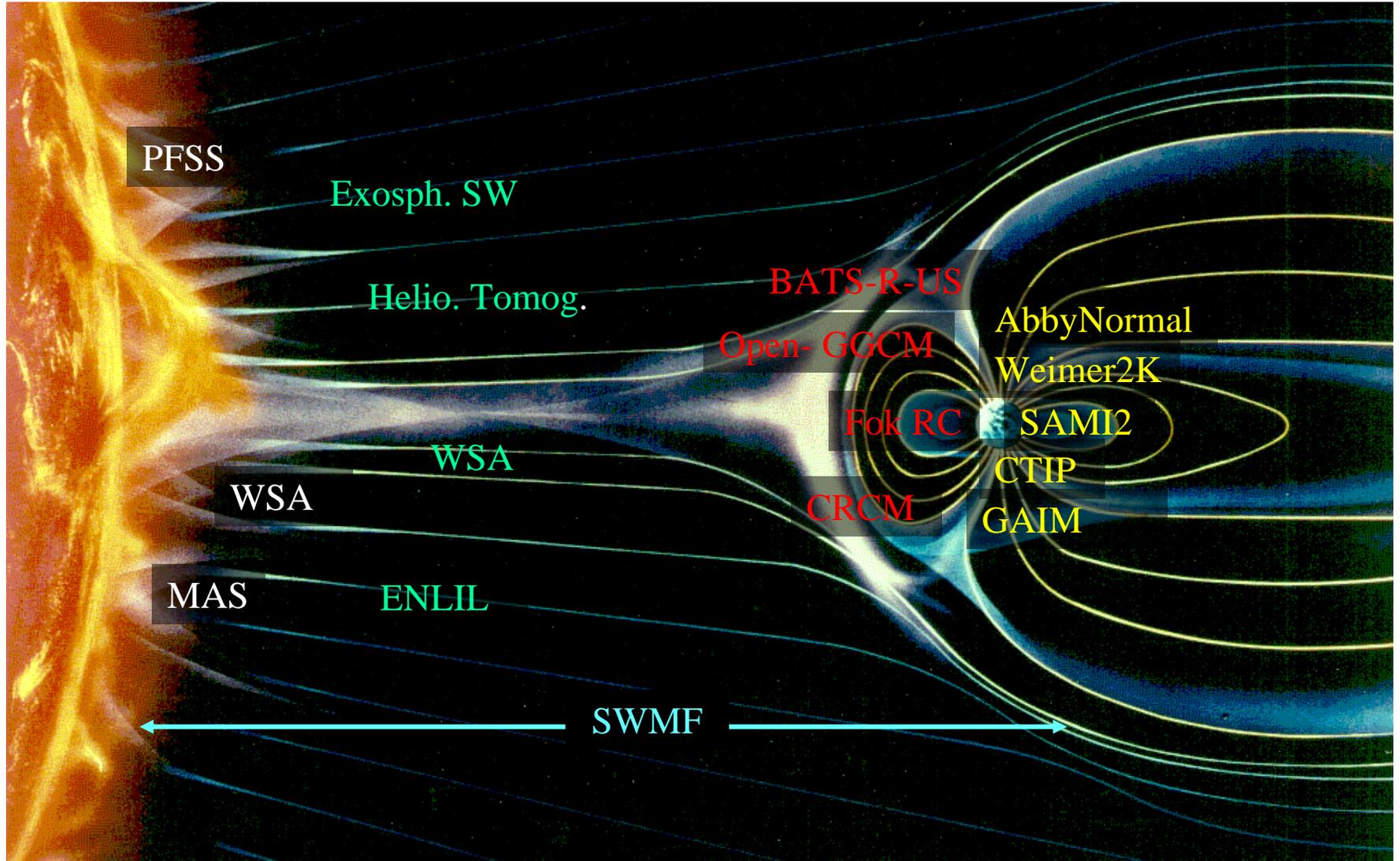
- Requesting and displaying satellite trajectories
- Line, surface, volume, and VRML plotting capabilities
- Various grid selections
- Output in standardized form with access libraries

More models:

- WSA
- ENLIL
- GAIM
- Eccles HF Absorption
- SWMF Solar and Heliospheric elements
- SWMF Magnetosphere/RCM
- Exospheric heliospheric model
- Fok CRCM

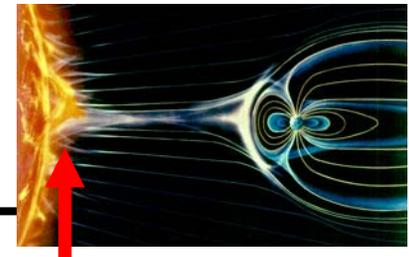


Models: Overview

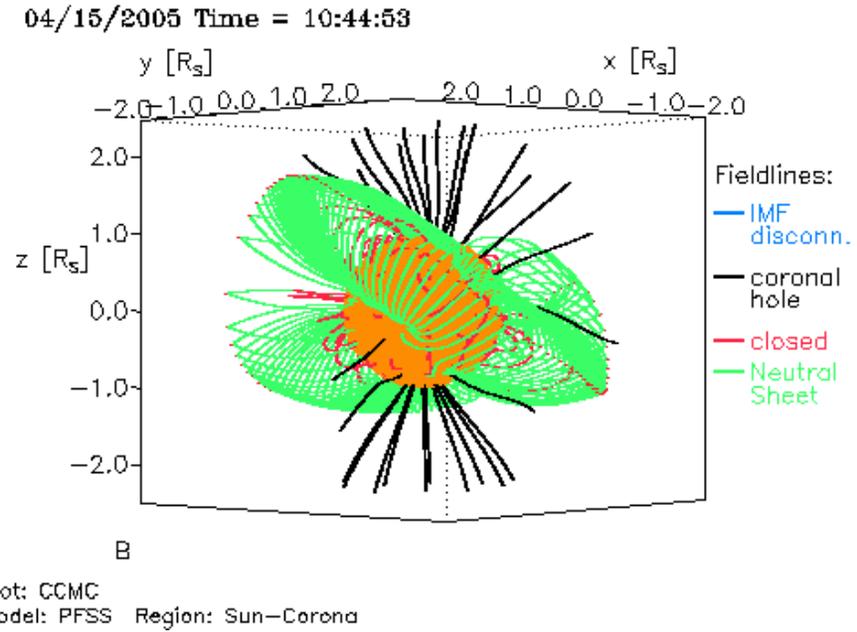
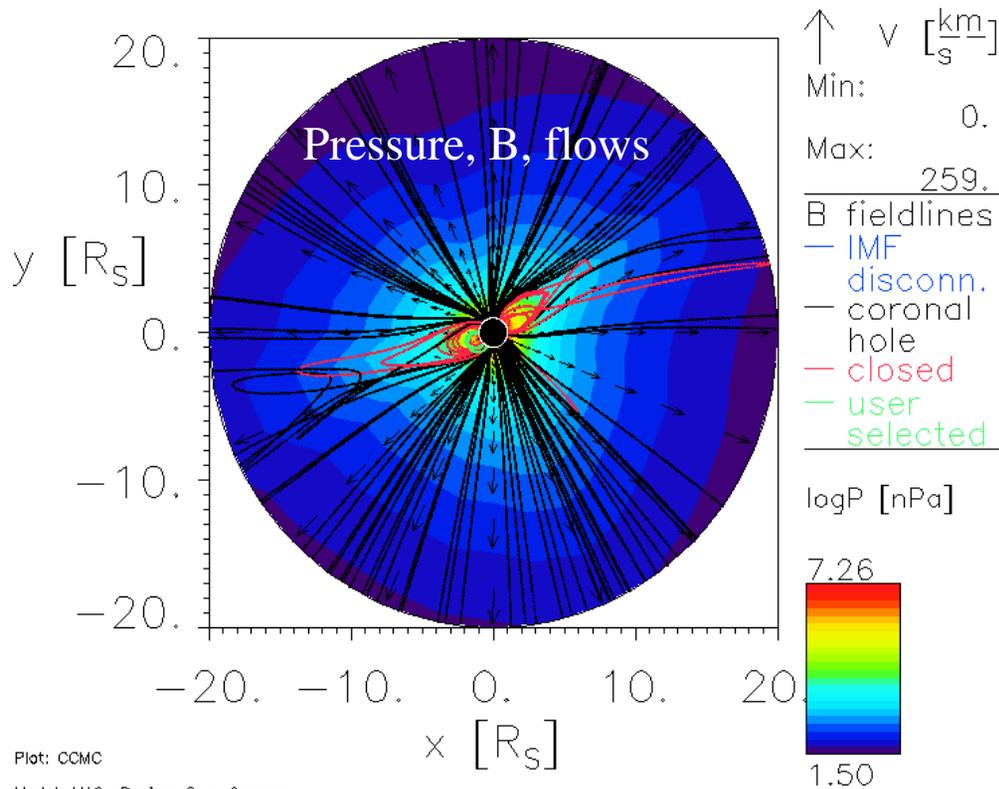




Solar Models



Time = 1:16:00:28 $t = 0.00^\circ$

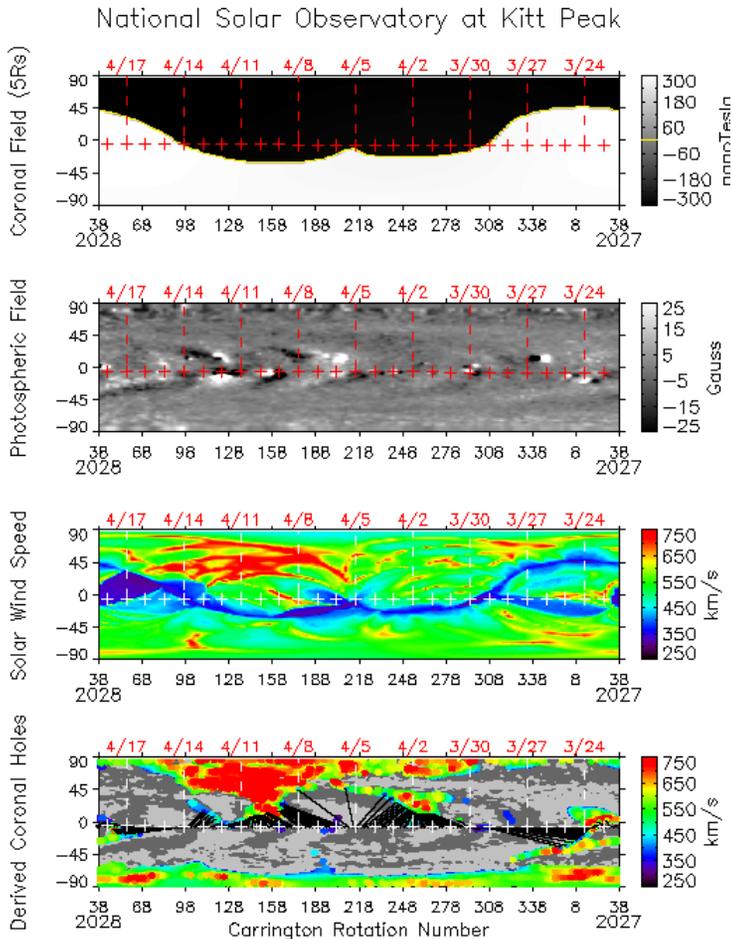
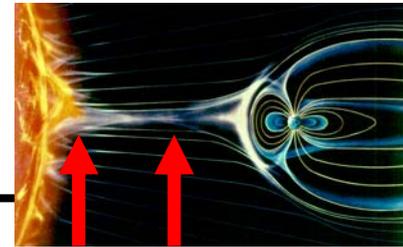


- **MAS** (Linker et al – SAIC) – Global solar magnetic field and plasma structure

- **Potential Field Source Surface** (Luhmann, UCB) - Global solar magnetic field structure

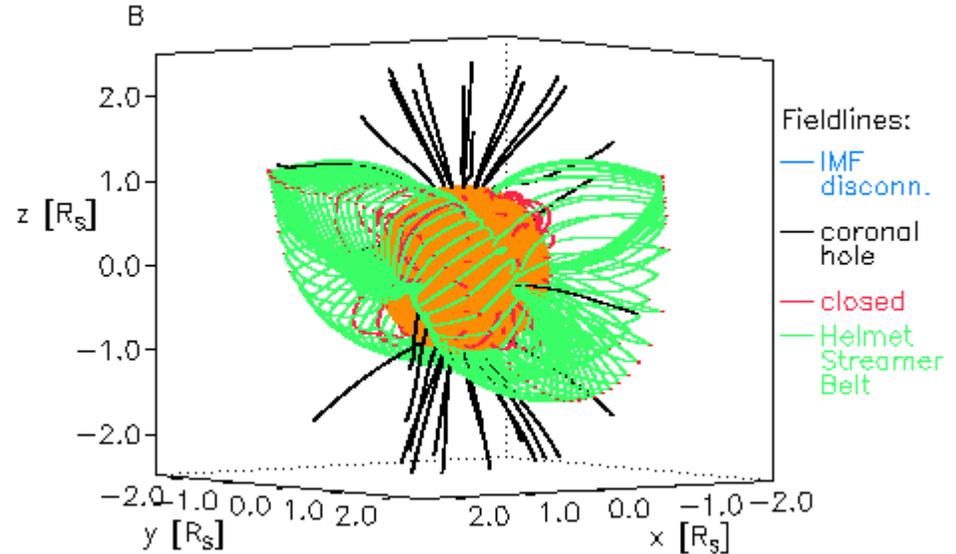


Solar/Heliospheric Models



WSA (Wang-Sheeley-Argé) – PFSS
 corona + ‘potential’ current sheet +
 empirical kinematic solar wind

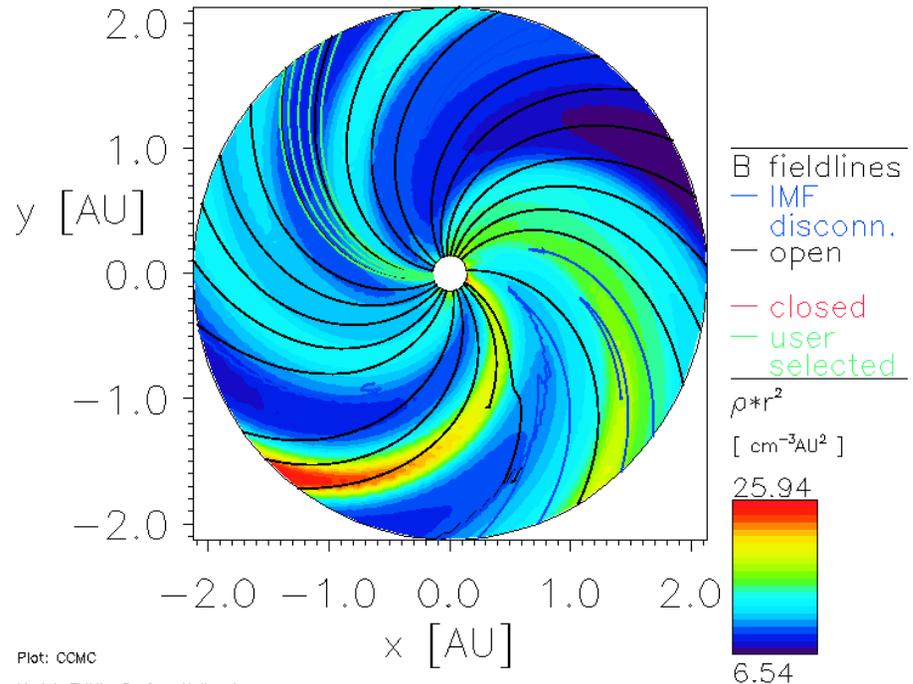
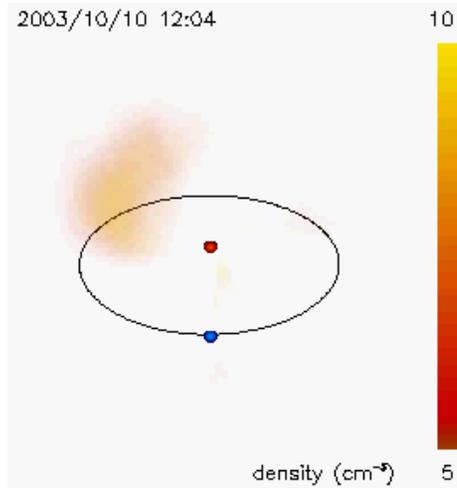
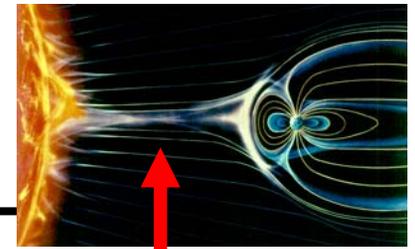
07/29/2005 Time = 10:38:09



Plot: CCMC
 Model: PFSS Region: Sun–Corona



Heliospheric Models

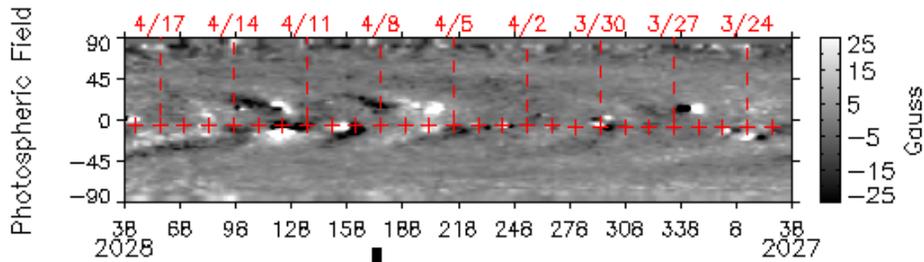


- **Heliospheric Tomography (Jackson, Hick – UCSD)** – Constructs global mass and velocity distribution from a simple kinematic model and assimilation of radio scintillation data.
- **Exospheric Solar Wind Model (Lamy/Pierrard)** – 1D kinetic model of solar wind solution along a coronal hole fieldline.

- **ENLIL (Odstroicil – NOAA)** – 3D MHD model of inner heliosphere ($30r_s - 2\text{AU}$).

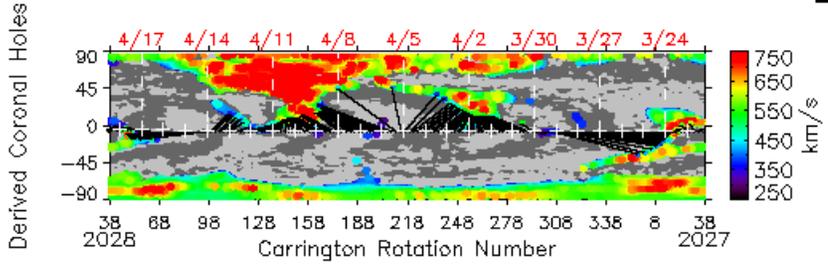
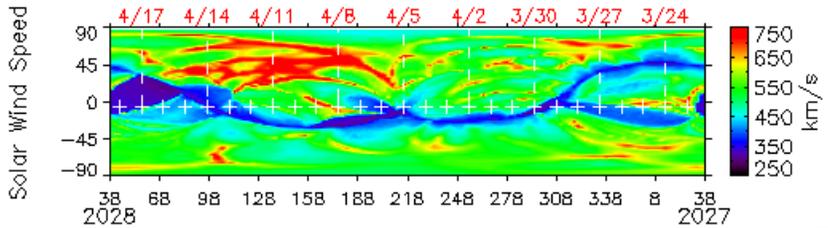


Forecasting : Sun to Earth



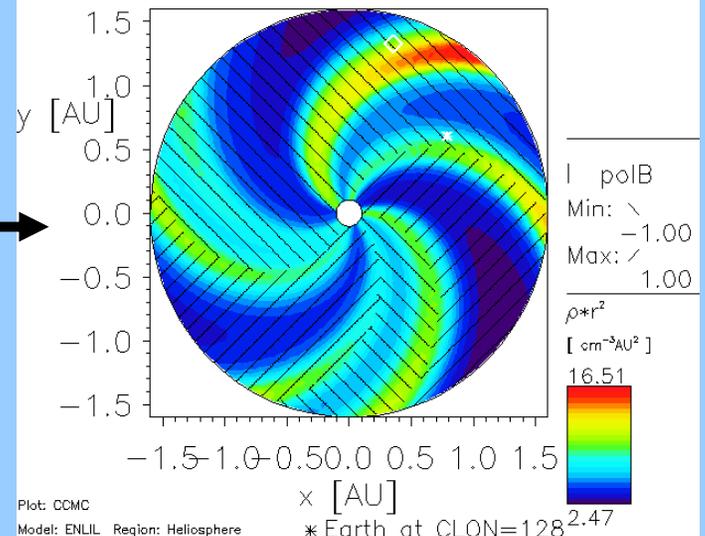
Photospheric Synoptic magnetograms

Running in realtime,
collab. With CISM
P. MacNeice, L. Rastaetter



WSA – potential field + equatorial current sheet model (1-21.5 r_s)

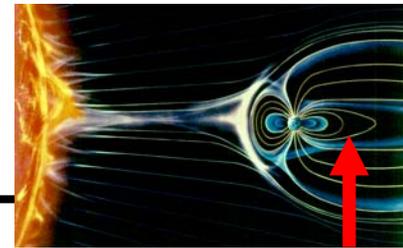
07/29/2005 Time = 10:33:12 lat= 0.00°
◊ Mars at r= 1.38 CLON= 75.



ENLIL - 3D MHD Heliosphere (21.5 r_s – 2AU)

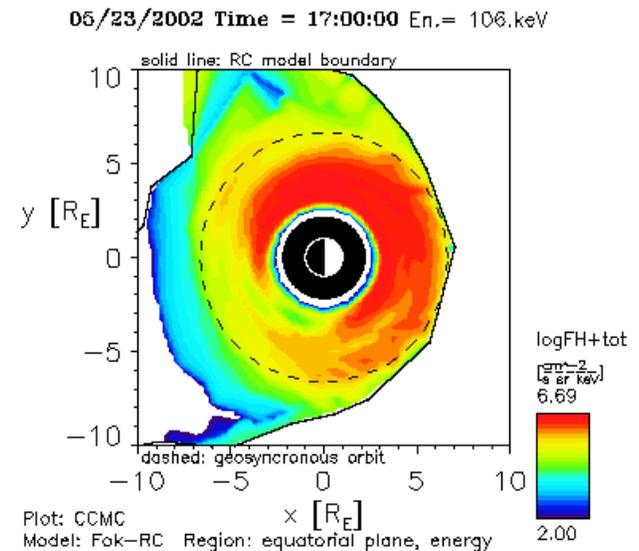
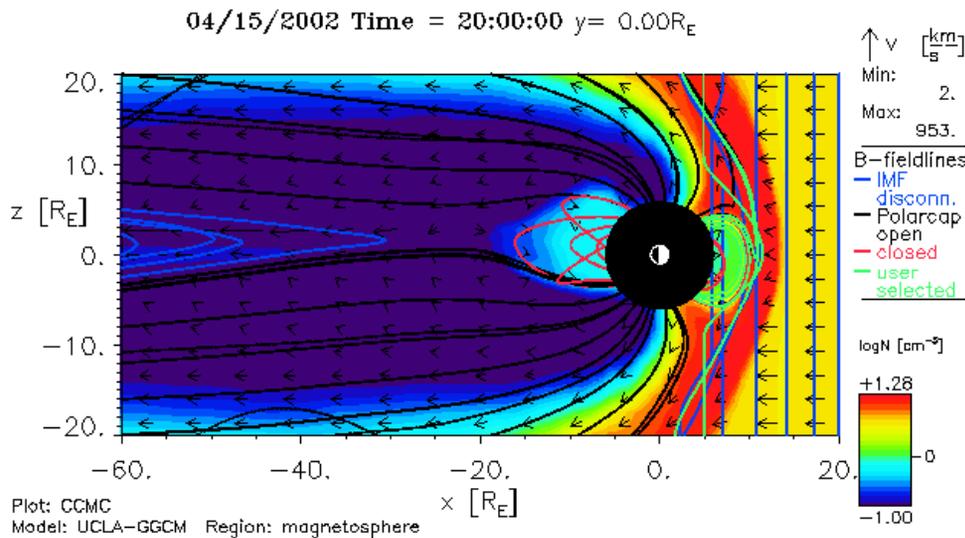


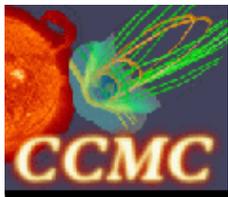
Magnetospheric Models



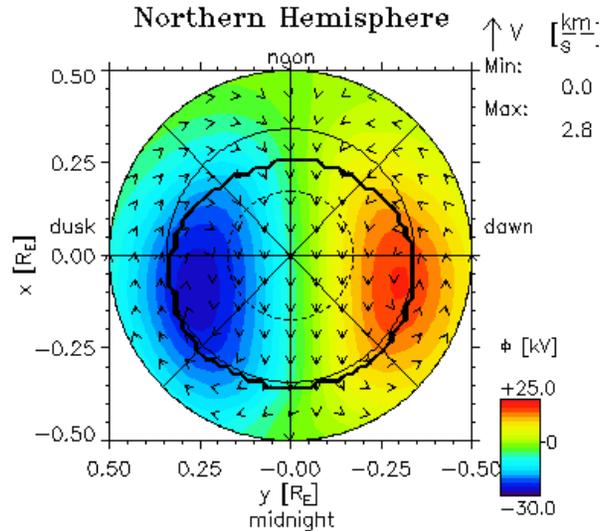
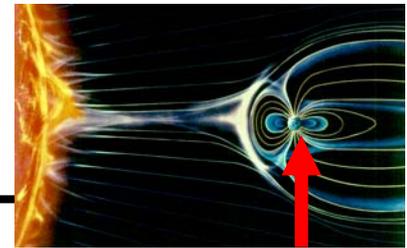
- OpenGGCM (UNH), BATSRUS (UMich) – 3D global MHD models of magnetosphere ($2R_E - 200R_E$).

- Fok kinetic Ring Current and Radiation Belt Models ($2R_E - 6R_E$).

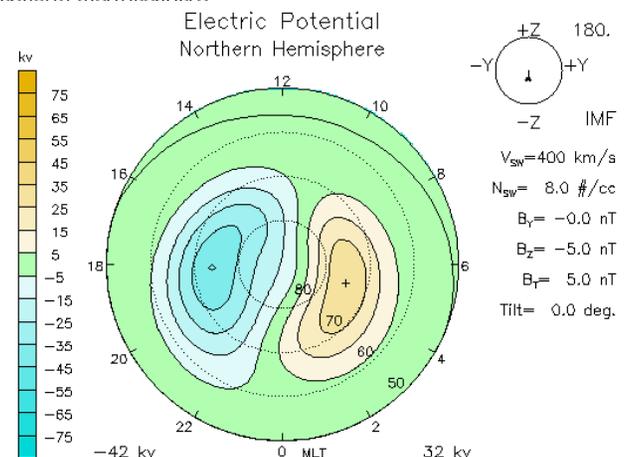
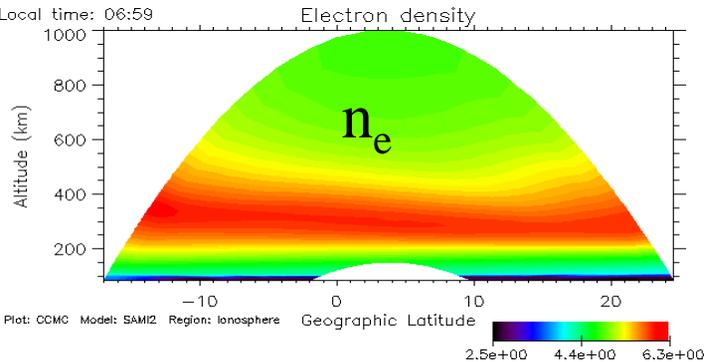
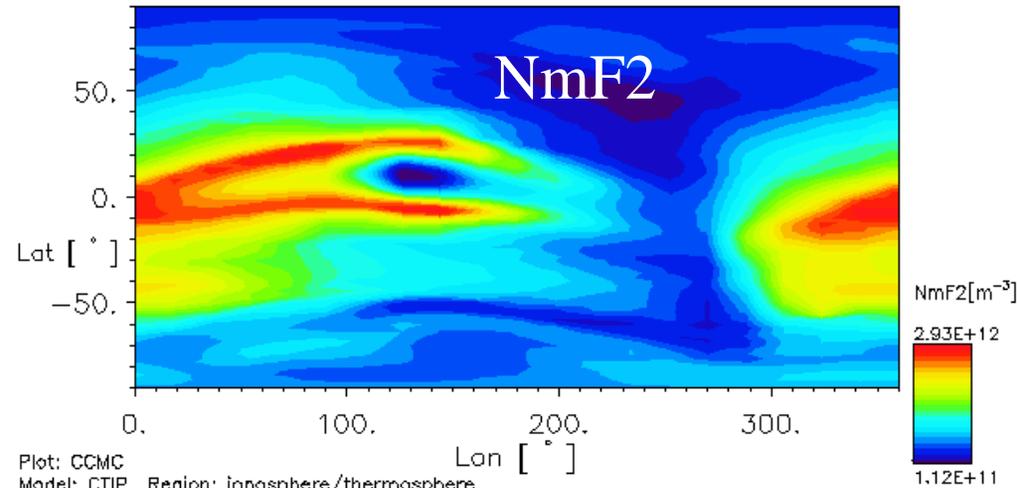




Ionospheric Models



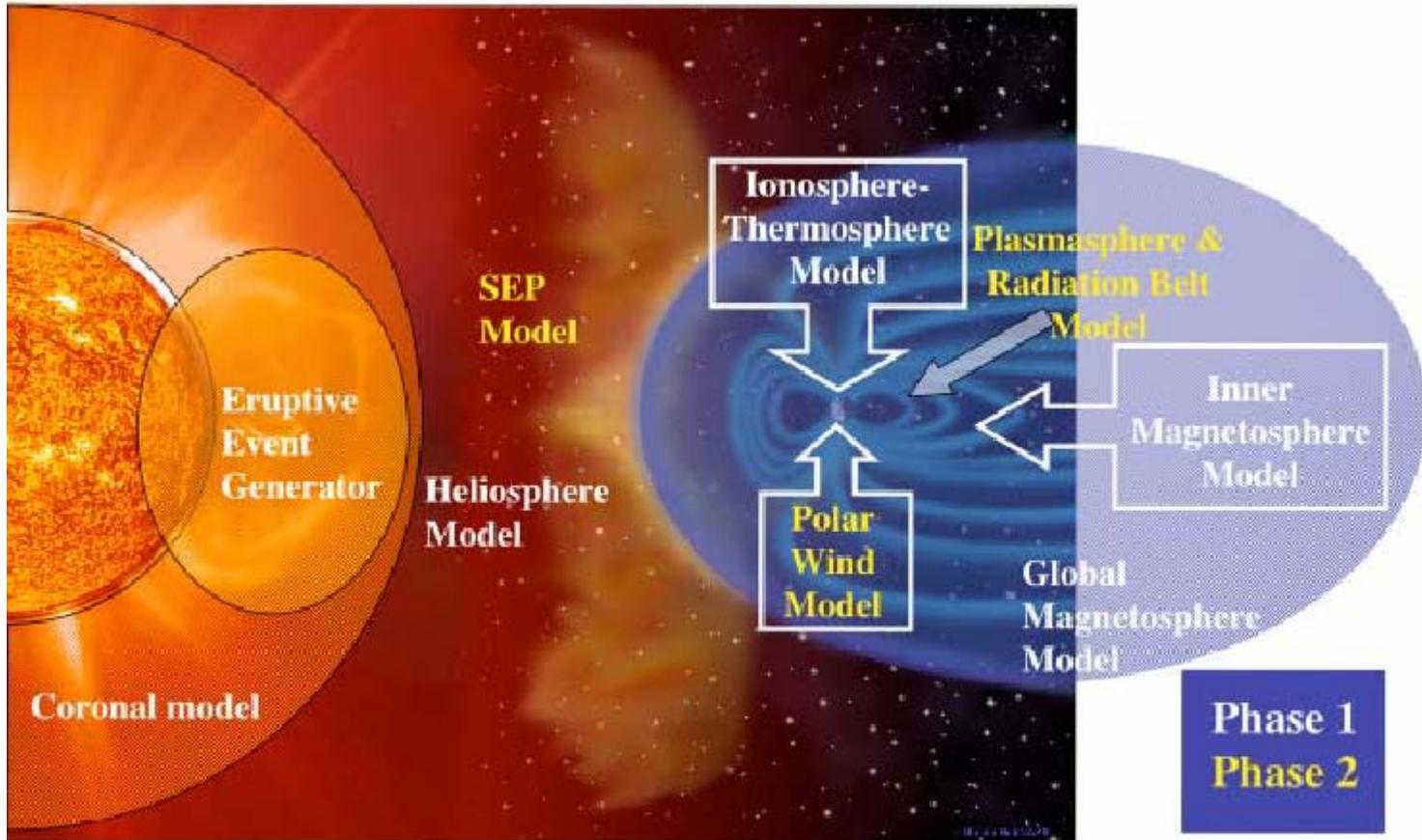
04/20/2000 Time = 12:00:00 IP= 8.00



- Electrodynamic (MHD ionospheric modules)
- Empirical (Weimer statistical)
- SAMI 2 meridional ionospheric (Huba, NRL)
- CTIP global ionospheric (Fuller-Rowell et al, NOAA)



Space Weather Modeling Framework



Entire framework incl. models at CCMC

CCMC will support incorporation of additional models

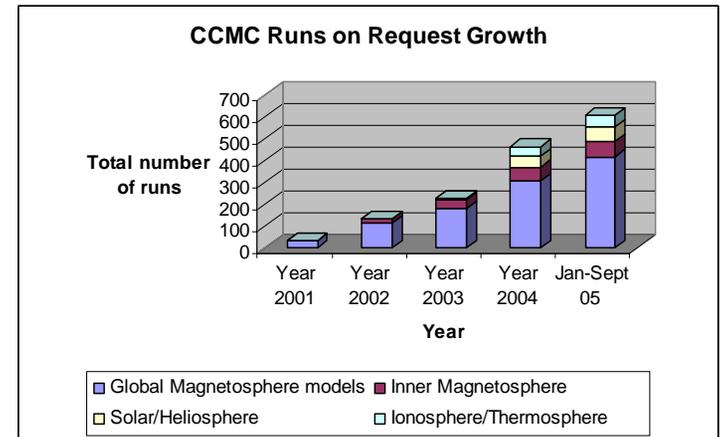
—————→ *Presentation by Peter MacNeice*

L. Rastaetter, P. MacNeice

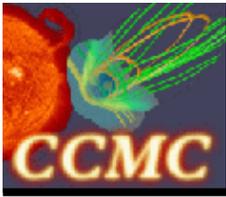


Key Usage Statistics

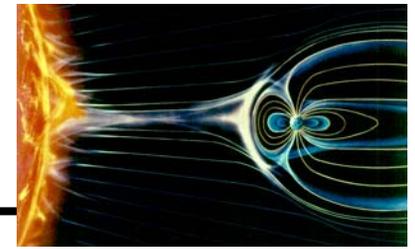
- Total executed model runs:
Over 600 runs executed so far
- Monthly website stats '05:
 - 17,900 website hits/month
 - 600 unique visitors/month
 - 1350 visualization requests/month
- International resource
- Responding to user feedback:
 - interface streamlining underway



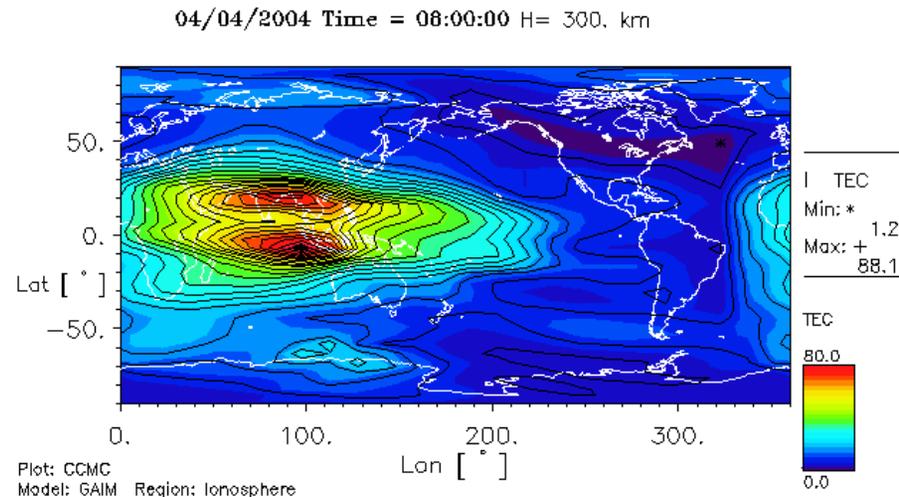
Visitors domains/countries				
	Domains/Countries		Pages	Hits
🇺🇸	USA Educational	edu	1000	1716
🇺🇸	USA Government	gov	529	801
🇨🇪	Czech Republic	cz	493	917
🌐	Network	net	491	855
🌐	Commercial	com	348	405
🇩🇰	Denmark	dk	193	274
🇺🇸	USA Military	mil	192	264
🇬🇧	United Kingdom	uk	40	60
🇧🇬	Bulgaria	bg	30	42
🇧🇪	Belgium	be	29	46
🌐	Non-Profit Organizations	org	22	29
🇦🇷	Argentina	ar	19	34
🇫🇮	Finland	fi	13	29
🇮🇹	Italy	it	12	21
🇯🇵	Japan	jp	10	20
🇩🇪	Germany	de	8	13



Models: Future



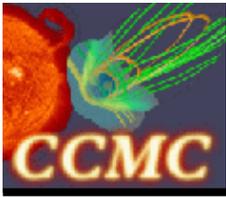
- Sun, Heliosphere, Magnetosphere and Ionosphere:
 - **SWMF (UMichigan)** includes 9 component models covering solar corona to upper atmosphere.
 - **CISM 1.0**: First version of CISM Sun-Earth model.
- Sun:
 - **Updated MAS** step toward eruption modeling
 - **New models**: UCB ANMHD model, DeVore ARMS, DeForest Fluxon
- Ionosphere:
 - **GAIM (USU)** installed (compiled code only)
 - CCMC will support GAIM V&V
 - **Eccles HF absorption model**
 - Installation completed
 - NASA/LWS supported
- Input from Science & Operations?





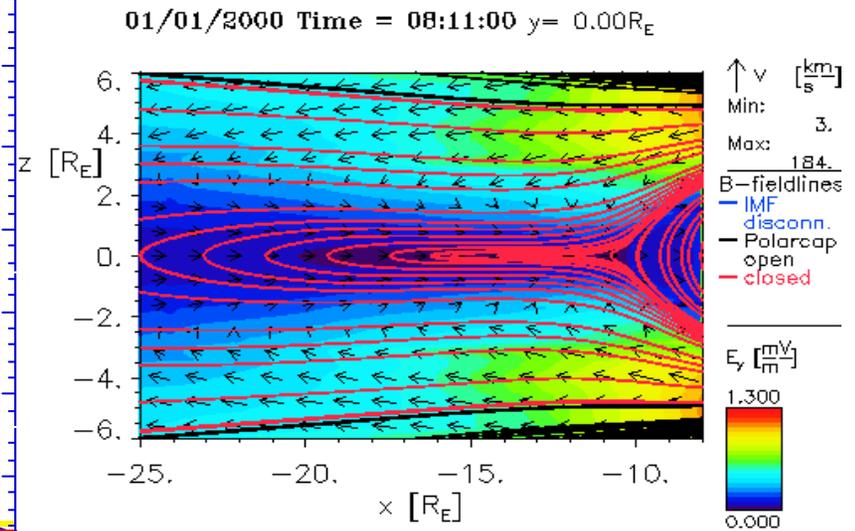
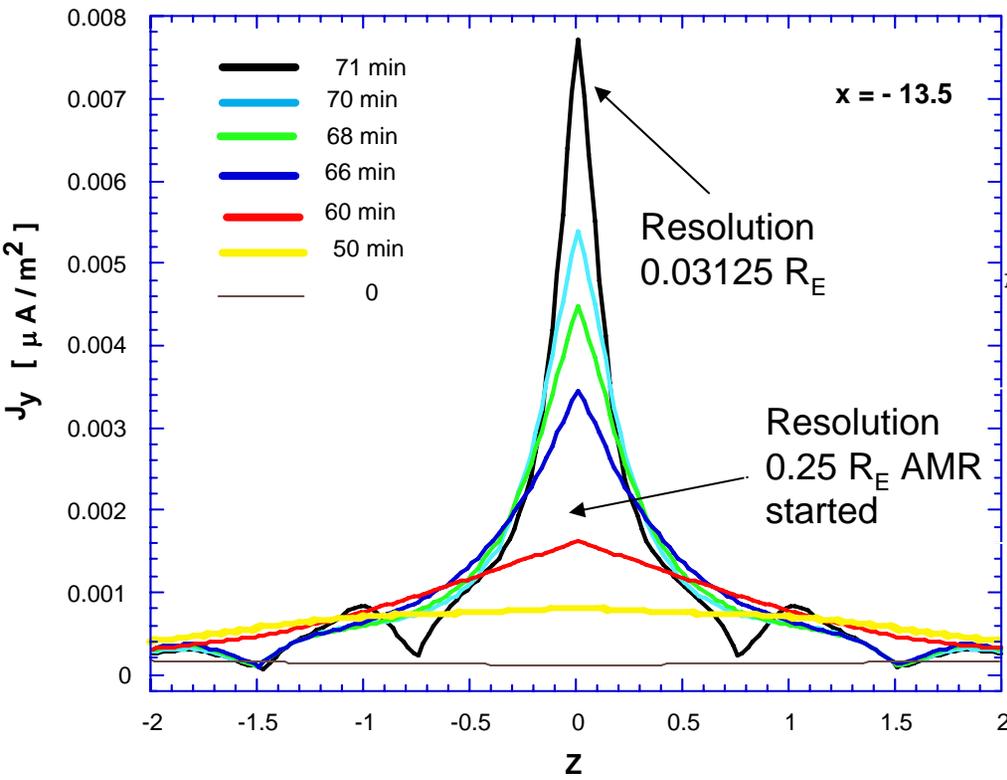
CCMC Transition Support Activities

- Evaluate scientific research models to address National Space Weather needs
 - Regarding validity
 - Regarding robustness, reliability
 - As unbiased evaluator
- Focus on research models with space weather operations benefits
- Develop real-time systems that apply to operations
- Participate in space weather education
- Transfer science- and metrics-tested models to operational National Space Weather Agencies



V&V Activity: Model Validity

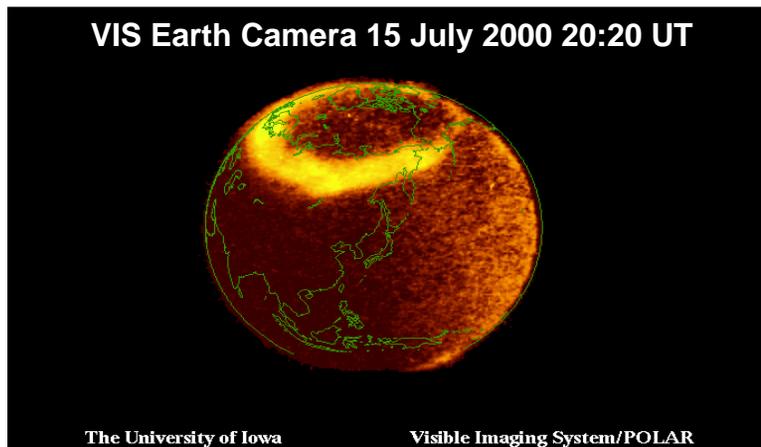
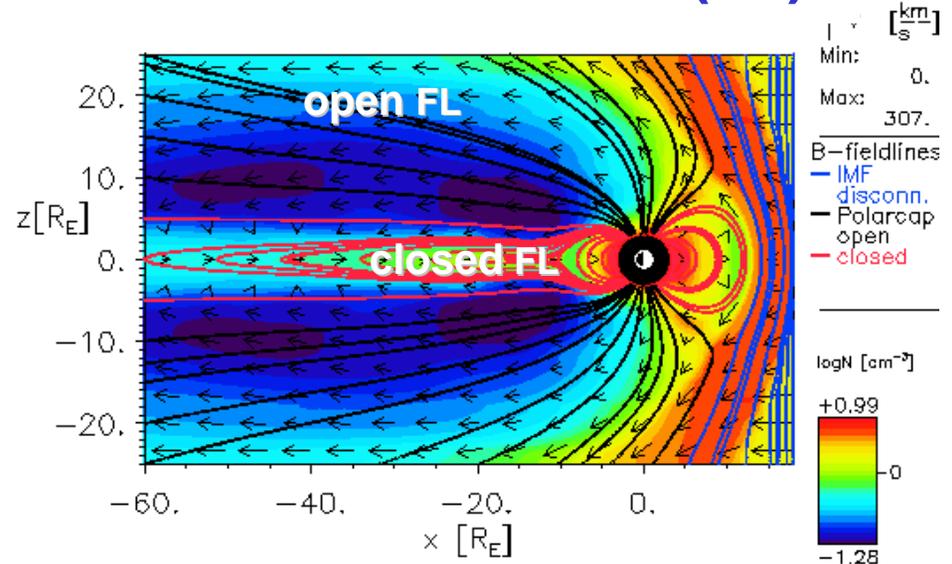
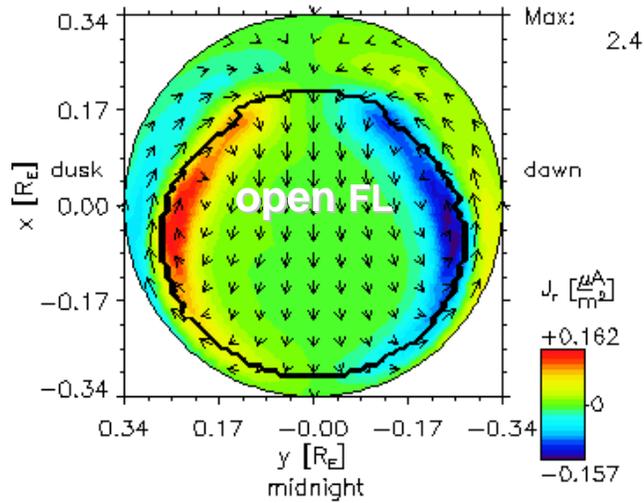
Current sheet fidelity as function of Numerical resolution





V&V: Simulate Polar Cap Size

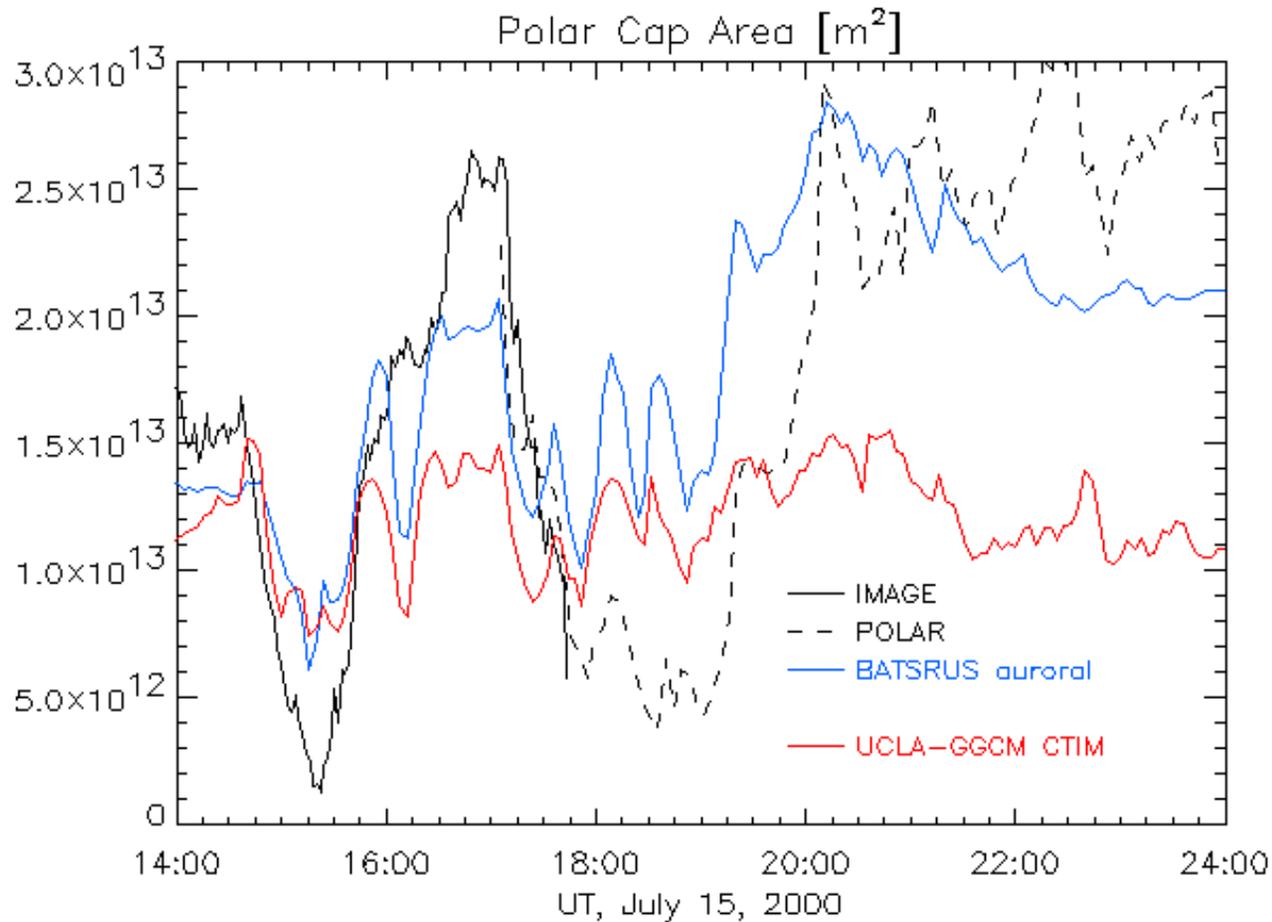
Boundary between open and closed field lines (FL)

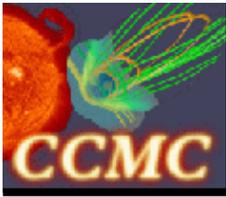


← Polar cap boundary observed by POLAR

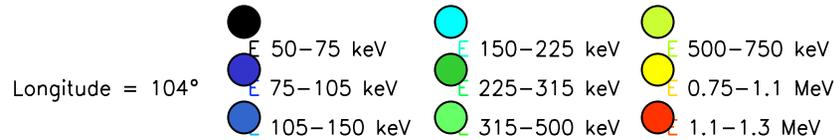


Reproduce Polar Cap Area: MHD models

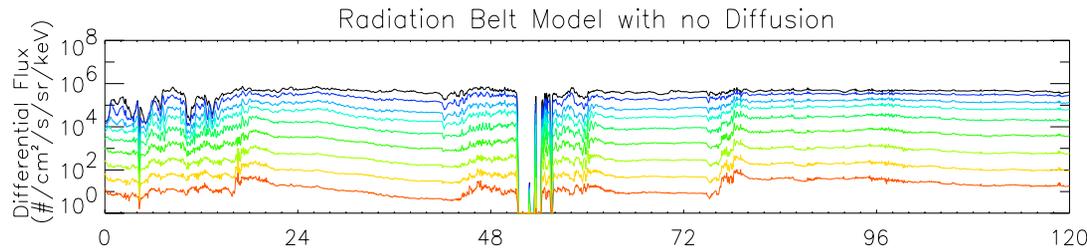




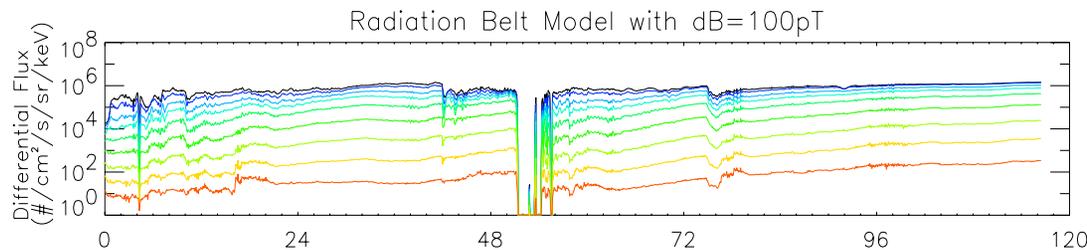
Science-Based Validation: Fok Radiation Belt Model



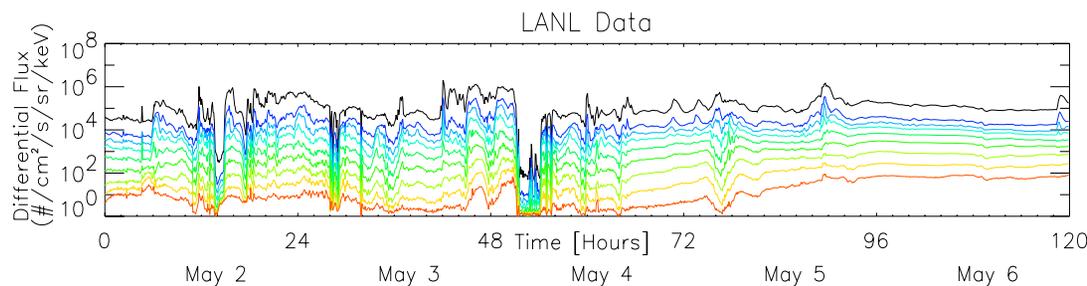
Fok radbelt model



Original
Model



Improved
Model



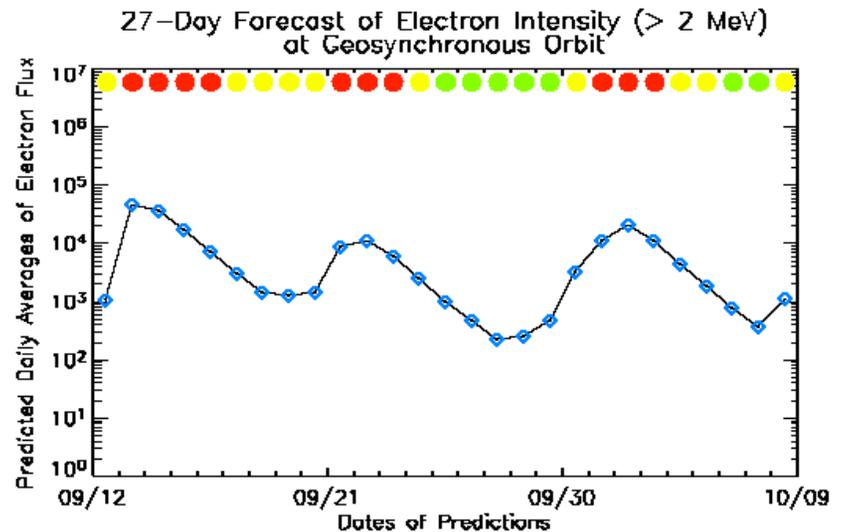
LANL Data



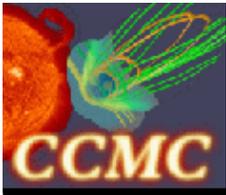
V&V: Radiation Belt

UPOS geo MeV electron forecasting model

- V&V activity requested by AFWA
- Installation completed
- Feedback to developers
- V&V activities ongoing
- First report to AFWA

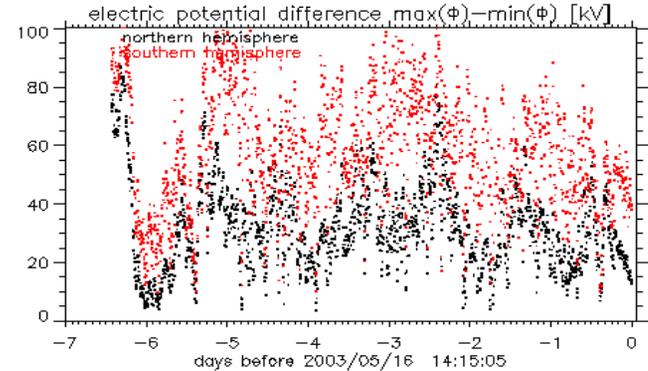
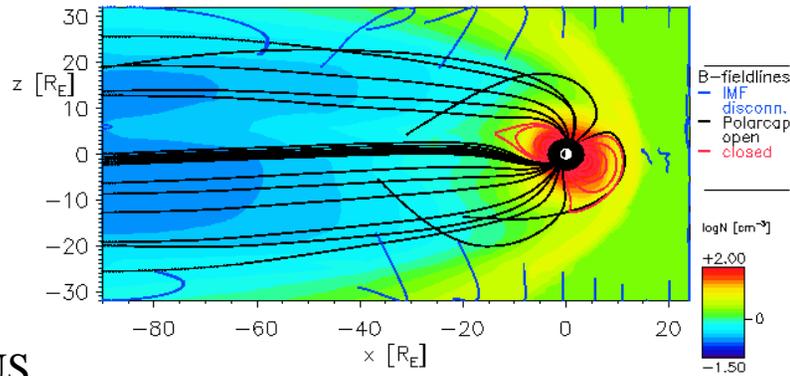


Prediction made on Sun Sep 11 20:29:59 2005



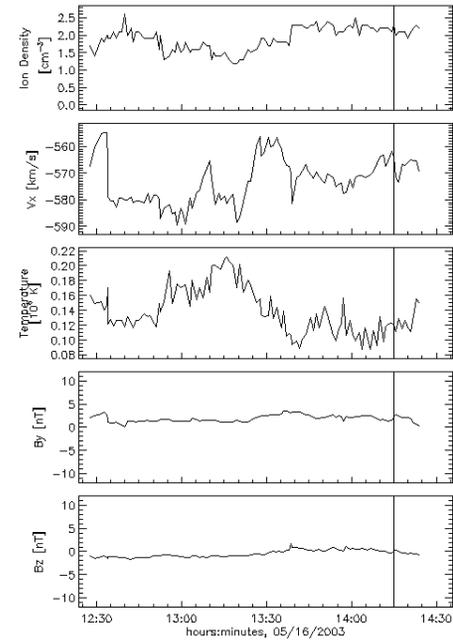
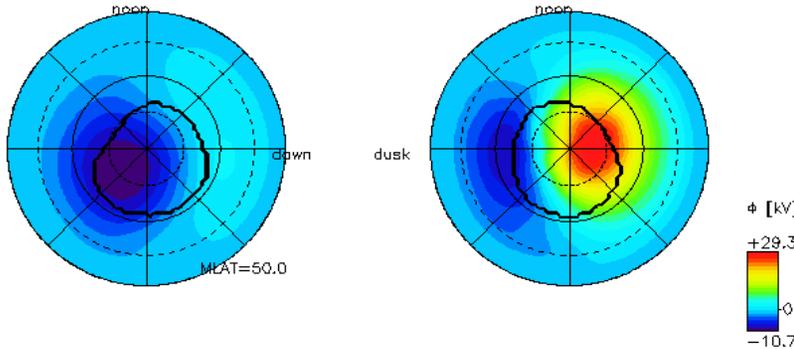
Experimental Real Time Page

05/16/2003 Time = 14:15:05 $y = 0.00R_E$

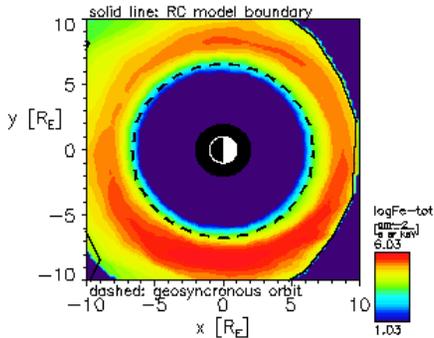


BATSRUS

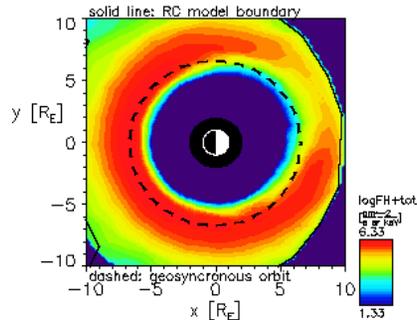
solid contour: polar cap boundary



06/16/2003 Time = 09:03:08 $E_n = 8.00\text{keV}$



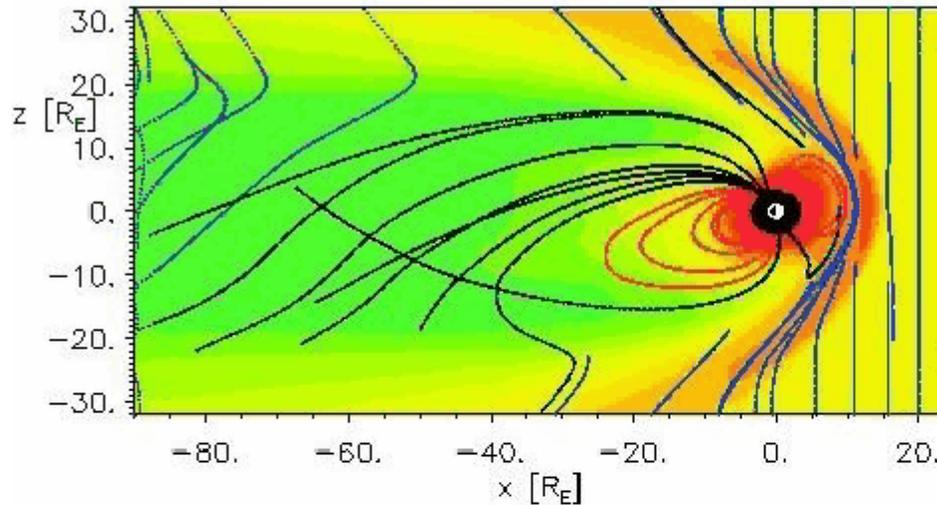
06/16/2003 Time = 09:03:08 $E_n = 8.00\text{keV}$





November 7, 2004 Storm

11/07/2004 Time = 09:34:46 $y = 0.00R_E$

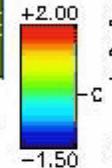


B-field lines
 - IMF
 - disconn.
 - Polar cap
 - open
 - closed

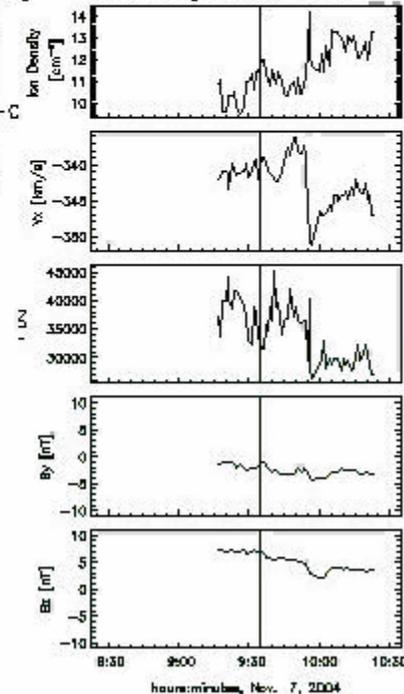


Model: **BATSRUS**
 Solar wind: **ACE**

$\log N$ [cm⁻³]



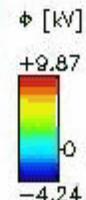
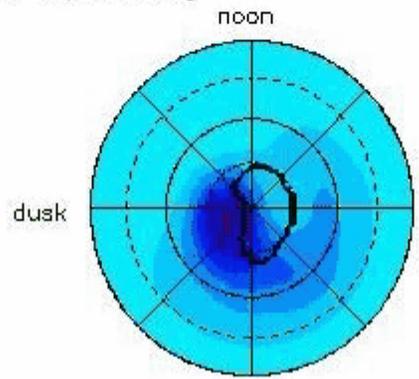
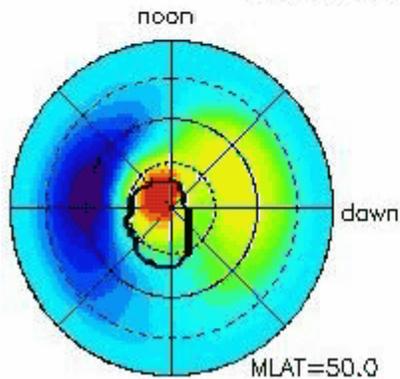
N, V_x, T, B_y, B_z ($X=33R_E$)



Northern Hemisphere

Southern Hemisphere

solid contour: polar cap boundary



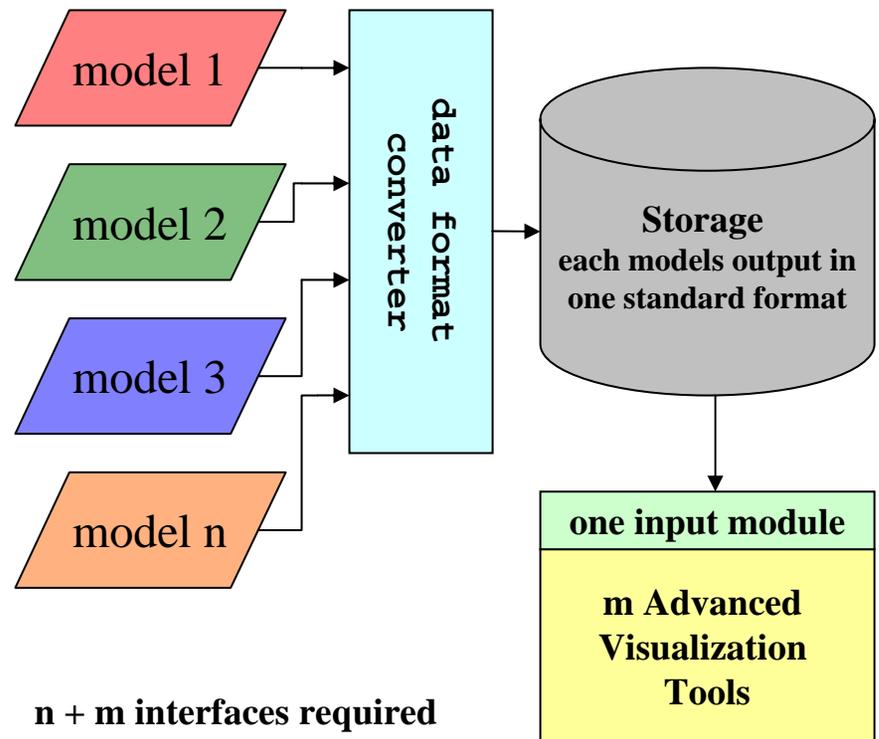
hours:minutes, Nov. 7, 2004



Data Standardization

Standardized Environment

- Standard format for storage, coupling, & visualization
- Ensures compatibility between models for coupling
- Resolves multiple-interface challenge
- Ground work for which standard, reusable interfaces and tools can be developed



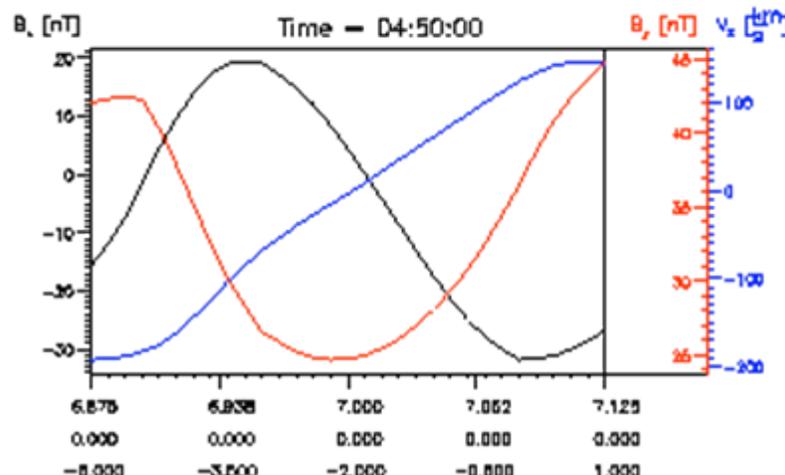
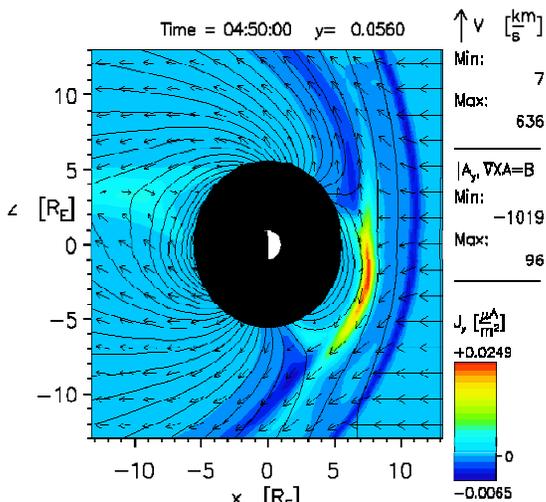
—————→ *Presentation by Marlo Maddox*

—————→ *Demo on Wednesday*



Data Standardization: Benefits

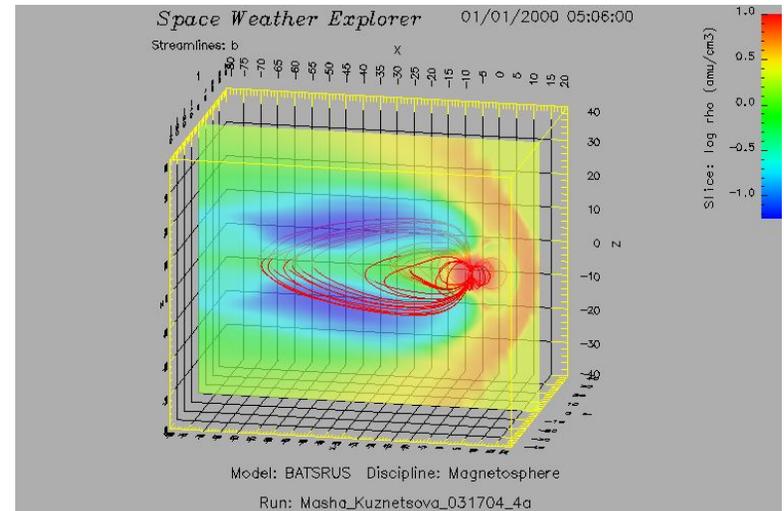
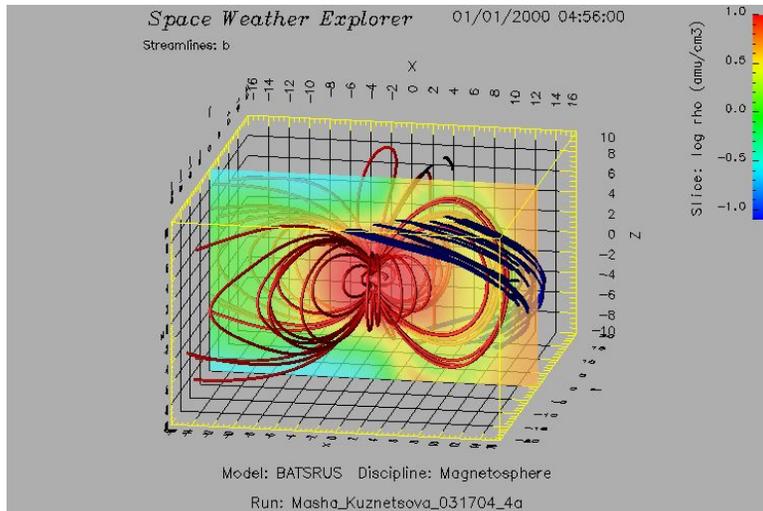
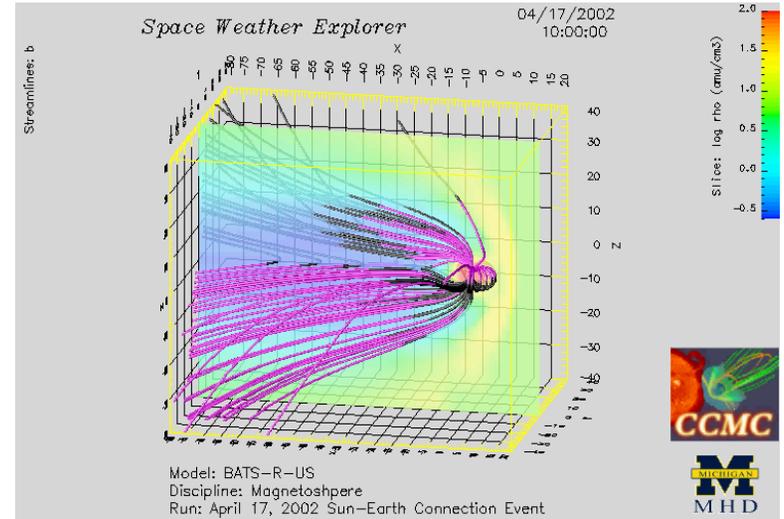
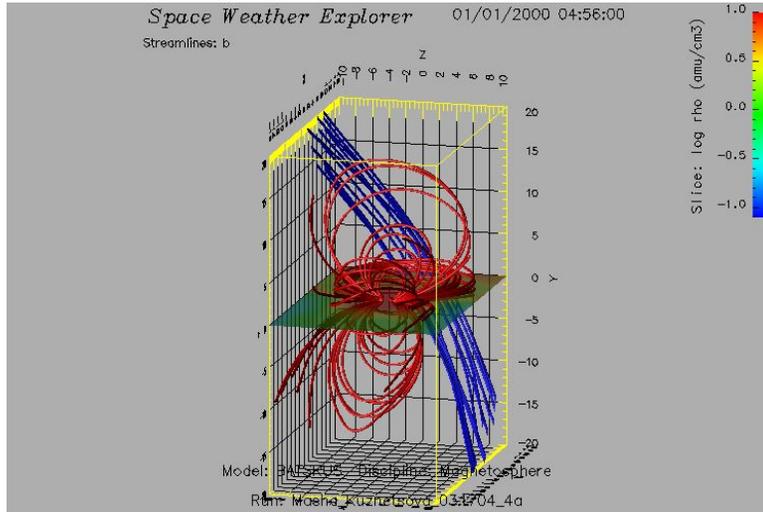
- Speed and efficiency of direct data access
 - Simple data access library
- Same interface regardless of model
- Platform independent
- Facilitates data & code reuse
- Permits rapid analysis of data sets from complex models
- Data format and access tools used by various customers
- Available to interested customers/libraries delivered to 2 modelers



Required
 v_x, B_x, B_y in
 Range of $\sim 10R_E$
 Reduced plot
 times from
15min to <5sec



Advanced Visualization: OpenDx



→ Demo on Wednesday

D. Berrios



Future Activities: Research Support

- Support the generation of advanced space science models
 - Address Space Weather-relevant processes
- Collaborate with related activities (CISM, CSEM, ILWS...)
- Expand strong service to (international) research community
 - Execute runs-on-request
 - Provide ready access to model output with enhanced tools
 - Includes mission support, e.g., STEREO
 - Includes campaign support, e.g., IHY
- Expand model base
 - UCB ANMHD model
 - DeVore ARMS
 - DeForest Fluxon model
 - Eruption modeling capability
 - GAIMs: USC/JPL
- Serve models developed under LWS and NASA/NSF partnership



Future Activities: Operations Support

- Provide tool by which science progress at NASA, NSF feeds into Space Weather operations
- Focus on science models with operational benefits
 - Operator input to identify model needs
- Address immediate payoffs as well as strategic value models (e.g., solar forecasting)
- Provide expanded, independent model evaluations
 - Obtain metrics, V&V procedures from operators
 - Support GAIM V&V
 - Perform priority evaluations for operations
 - Provide rapid response service in emergencies
- Other opportunities for closer collaborations/tailored support
 - Education: Coordination initiated with AFIT, USAFA
 - Interacting with AFWA (LtCol. Cade, Maj. Nobis)
 - Interacting with NOAA/SEC (J. Kunches, B. Murtagh)
 - Coordinating with AFSPC (K. Hand)
 - Implementation: Installation design and support possible
 - Tool development following operator needs