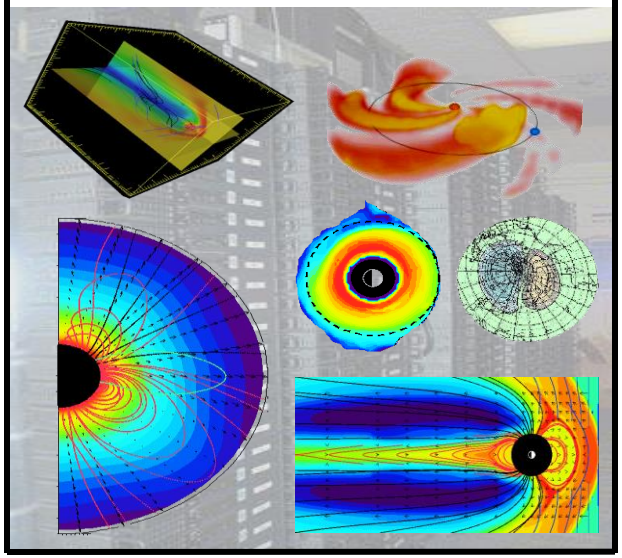
COMMUNITY COORDINATED MODELING CENTER



Community Coordinated Modeling Center:

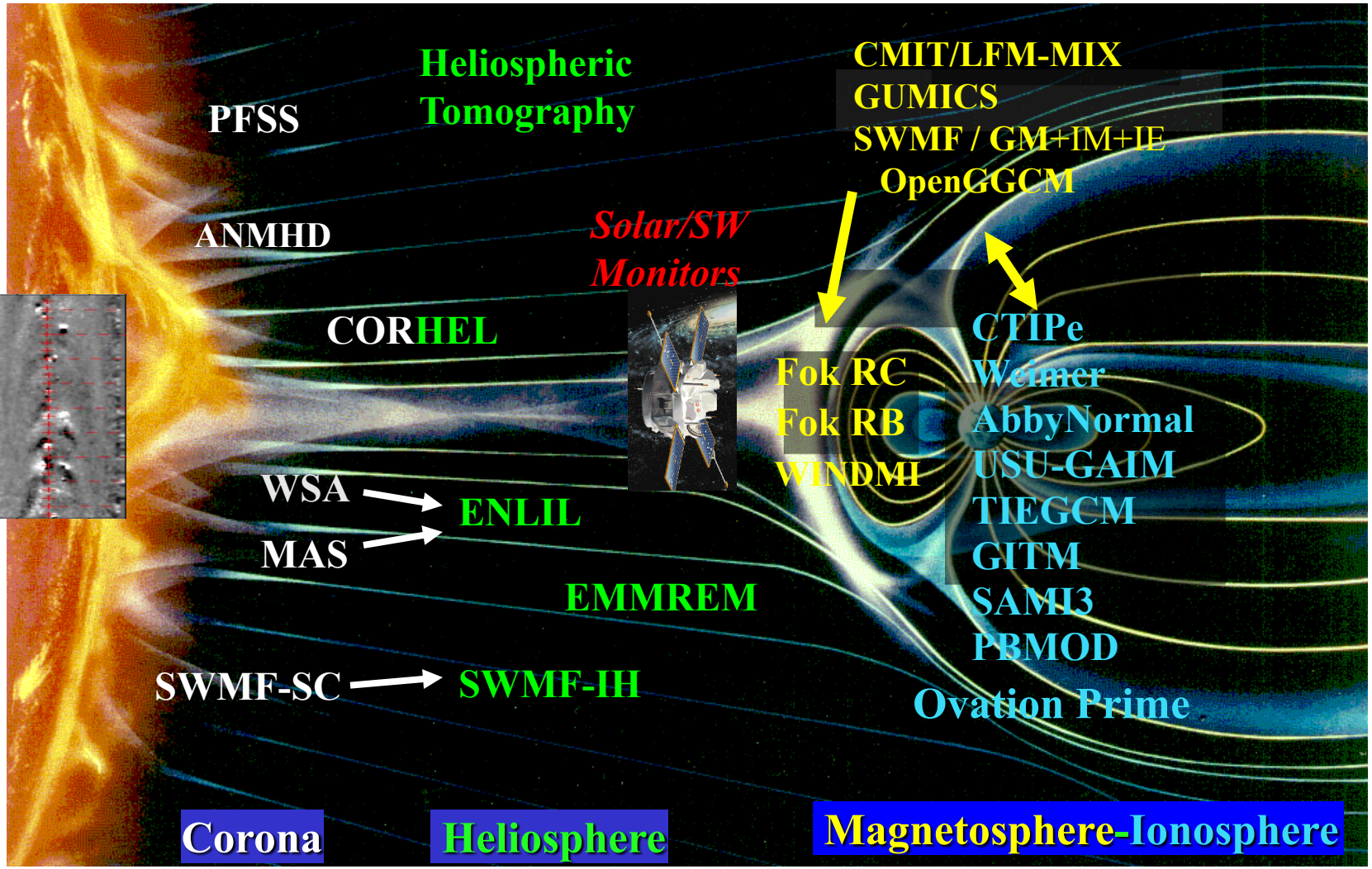
Addressing Needs of Operational Space Weather Forecasting

Masha Kuznetsova
and the CCMC Team

http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center

Model hosted by CCMC: Unique collection of state-of-the-art



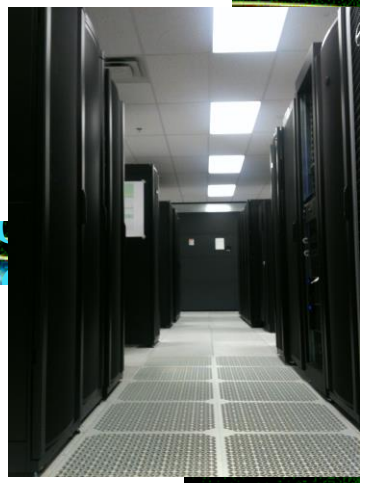
recipient of NASA Strategic Capability models

Web-based Runs-on-Request System

(in operations since 2001)

Research and education support:

- CCMC serves models to the international research community
- Access to models through the web-based runs-on-request system
- > 6000 runs
- Sophisticated on-line visualization and analysis tools,
- Maximize return on model development investment
- > 100 publications/presentations/reports
- Broad community feedback on model performance



Address operation's needs

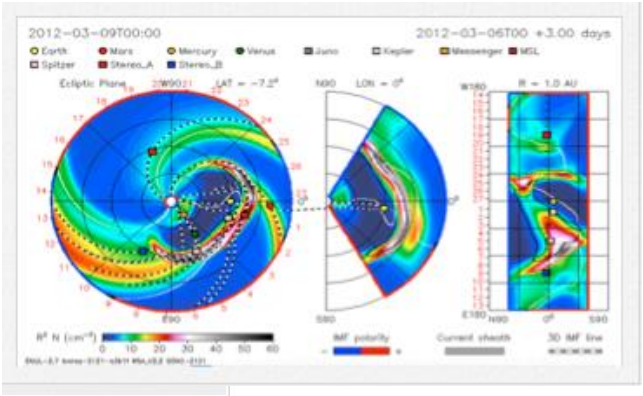
- Automated operational system
- About 40 major requests per week.
- Model-data comparisons (validation) by a large number of users

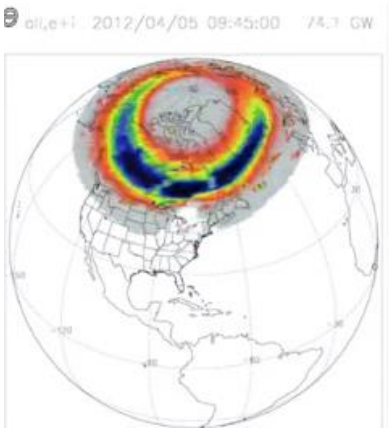
Real-Time Systems

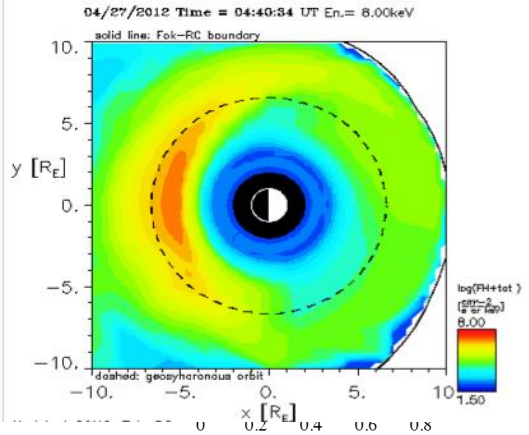
Running for years:

- SWMF/Magnetosphere (since 2002)
- WSA-Enlil background solar wind
- WSA-Enlil cone model (CME prediction)
- SWMF/Solar-Heliosphere
- Fok Ring Current
- Fok Radiation Belt
- AbbyNormal (HF signal loss)

+ statistical models (Dst, Kp, AL)

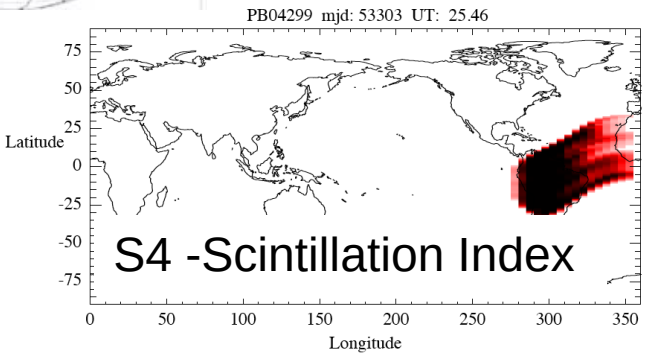






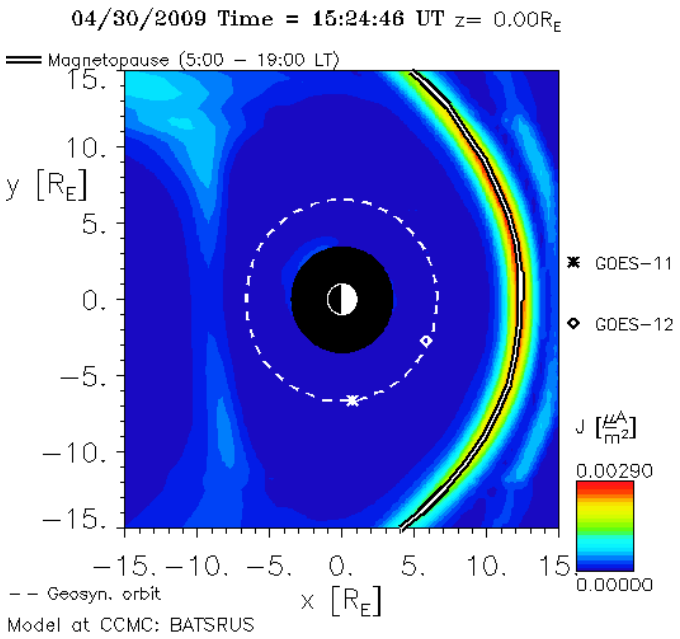
Recent additions/plans:

- CTIPe (2010)
- Ovation Prime (2011)
- PBMOD (scintillations) (2012)
- EMMREM (radiation exposure) (test mode)
- TRIPL-DA (ion. assimilation) (in progress)
- DREAM (with RBSP feeds) (planning)



Extracting SWx information from models

- Make complex models operationally useful.
- Products tailored for specific mission's needs.
- Certain products require outputs from several models + data
- Large number of tools from one model



Enlil Cone model:
CME arrival at L1
Range of Kp
Solar wind parameters at L1, planets, satellite locations

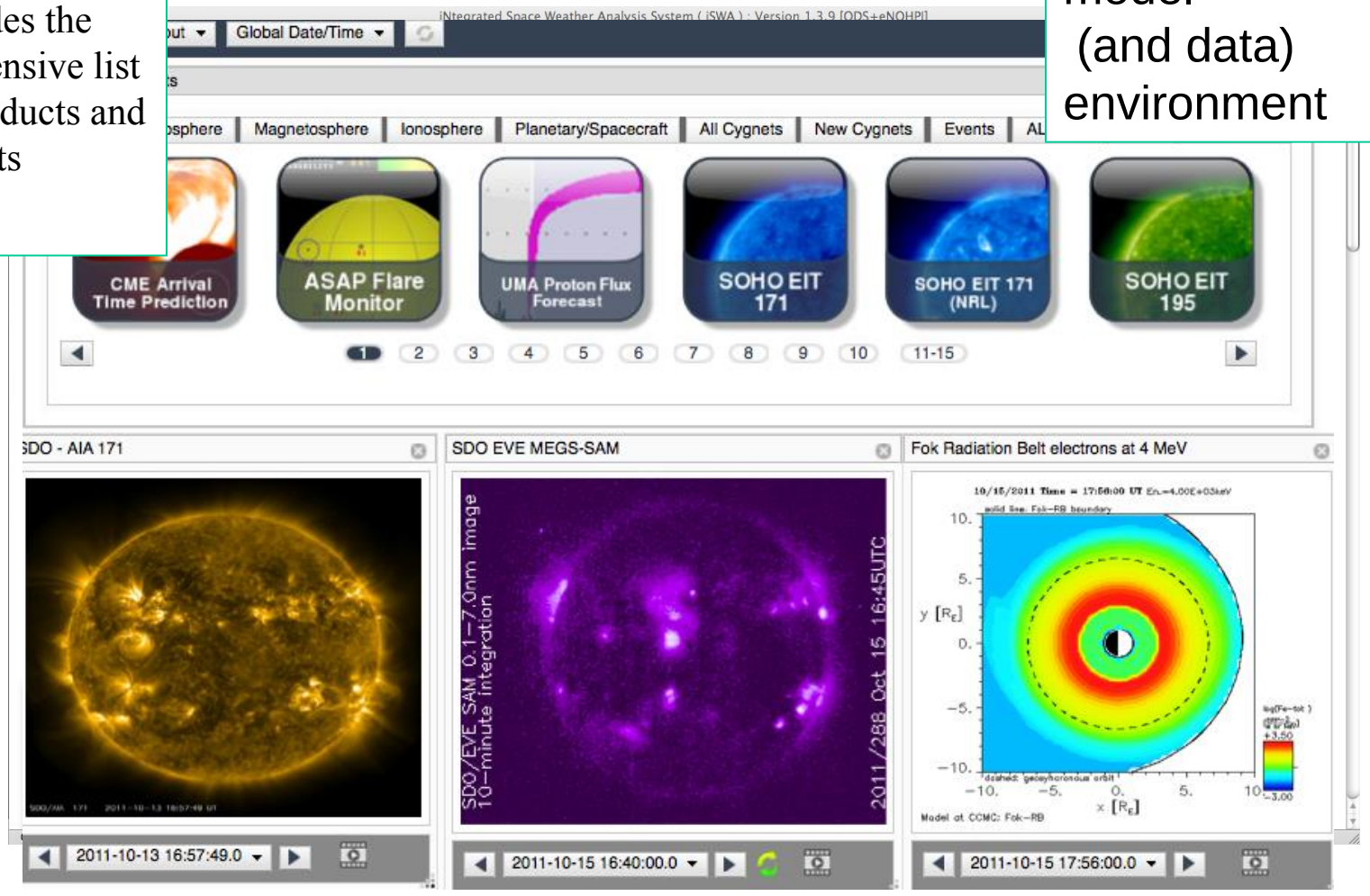
SWMF:
Magnetopause position
Joule heating
Polar cap position
dB/dt (ground mag. perturbations), Dst

Innovative dissemination
One-stop shop for state-of-the-art information

User-configurable web-based system for analyzing space weather. Includes the most comprehensive list of SW data products and modeling results

> 300 SWx Tools
iswa.ccmc.gsfc.nasa.gov

Flexible to adapt to changing model (and data) environment



Innovative dissemination
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> 300 SWx Tools

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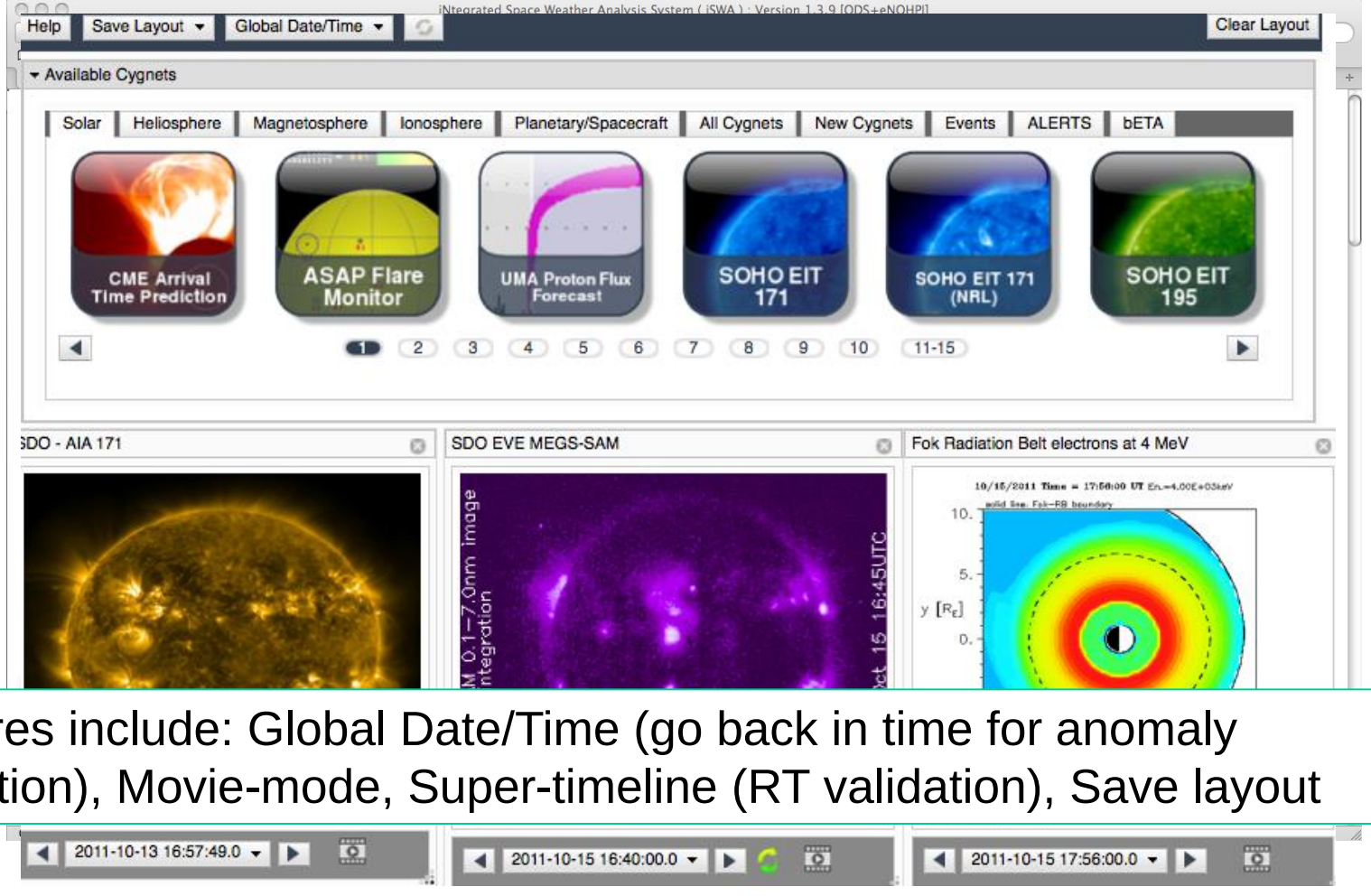
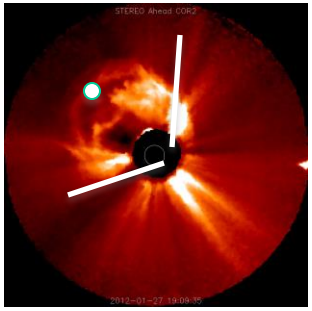
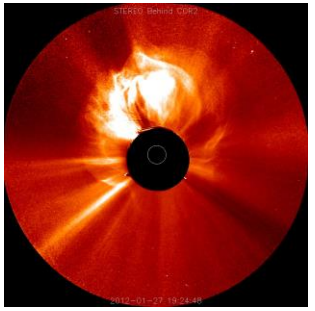


Features include: Global Date/Time (go back in time for anomaly resolution), Movie-mode, Super-timeline (RT validation), Save layout

Address challenges of input data uncertainty

- Uncertainties in Enlil Cone model input parameters derived from STEREO/SOHO images

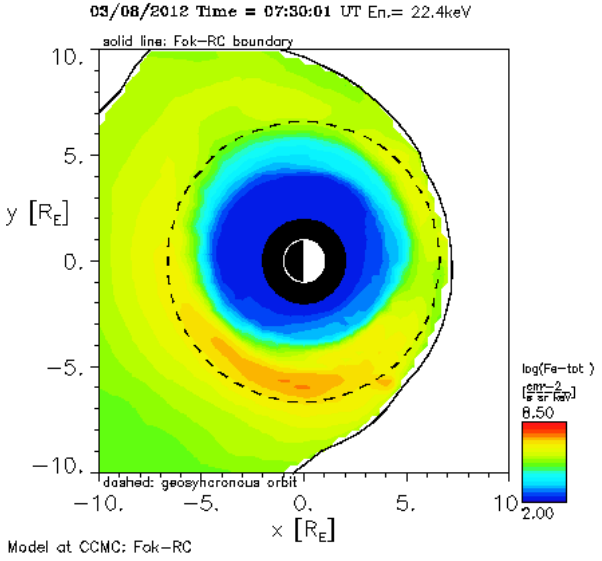




Approach: Ensemble modeling.
50 runs on dedicated cluster (2 hours)

- ACE plasma data quality for big events
- Enlil output IMF Bz uncertainty

Approach: SWMF (+FRC)
driven by Enlil Cone model
Ensemble of IMF clock angles (90 – 180)



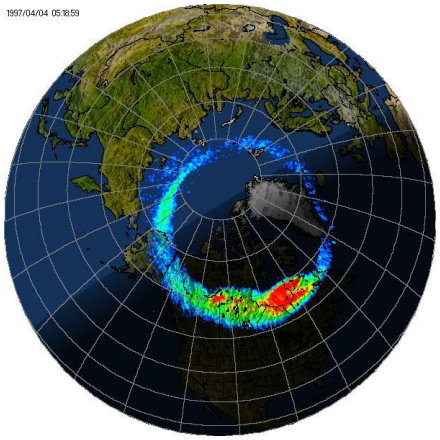
- Flexibility required to adapt to changing information landscape

Operational agencies need model validations

Independent Validation
- Evaluation of current state of sw modeling (reports)
- Trace model performance over time
- Archive metrics results (with open access)

Published
- Investigations of the sensitivity of ENLIL to solar input parameters
- Model Uncertainties in predictions of arrival of CMEs at earth orbit
- Tracing Field lines in Heliospheric models

Ongoing Studies
- UCSD Heliospheric Tomography – data collection phase
- ENLIL ambient model validation – data collection phase
- Realtime Cone Model – ‘manual’ and ‘ensemble’ modes
- Rad. Belt models validation (historic events and realtime)
  - RBE standalone, SWMF (with RBE-RCM)
- Auroral models validation (collaboration with AFIT)
  - Ovation Prime, New and Old Hardy, SWMF –Fok-RC, AMIE

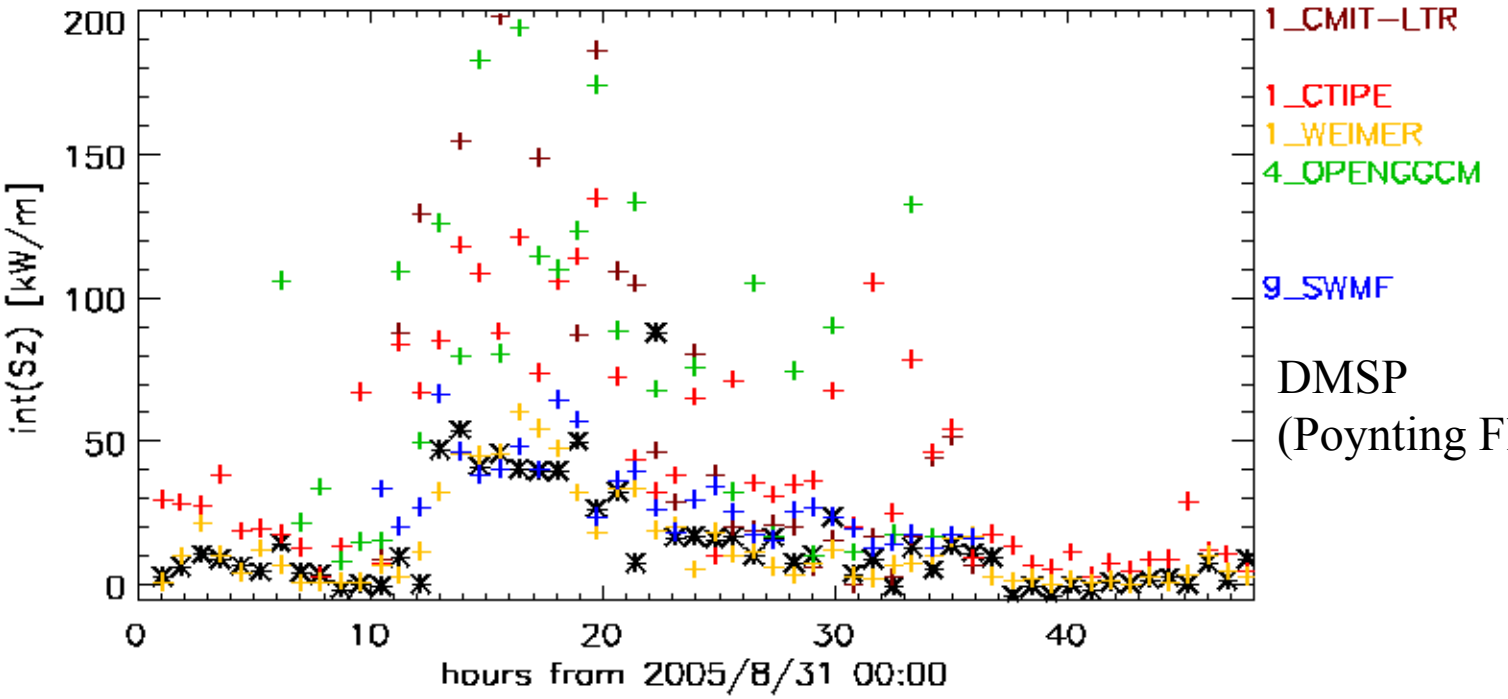


Leadership in community-wide model validation efforts

- Community-wide modeling Challenges
  - GEM (2008)
  - CEDAR (2009)
  - SHINE (2011)
- Facilitate a dialog between research and operational communities to define physical parameters and metrics formats relevant to SWx applications.
- Address uncertainties and challenges in model-data comparisons..
- The first GEM Metrics Challenge was initiated in 2008 (4 events)
  - Magnetic perturbations at ground stations and geosynch orbits
  - 3 publications (JGR and SWJ). Models: SWMF, OpenGGCM, Weimer
- In 2010-2012 added Dst Index, Joule Heating/Poynting Flux, auroral boundaries studies
  - > 10 participating models
  - 3 papers in preparation

Initiated GEM-CEDAR collaboration

Integrated Joule Heating vs. Poynting Flux



DMSP
(Poynting Flux)

- 2 joint sessions at GEM-CEDAR Summer workshop
- Joint session at GEM mini-workshop
- GEM-CEDAR Challenges (common time intervals and phys. parameters)
- Plan to address the role of magnetosphere drivers on metrics results.

CEDAR Modeling Challenges

- **CEDAR Electrodynamics Thermosphere Ionosphere (CETI) Challenge**
  Events : total of 9 events during different geomagnetic condition (include 3 GEM events)
  Physical Parameters : Vertical and horizontal drifts at Jicamarca, Electron density and Neutral density at CHAMP orbit, NmF2 and hmF2 from LEO satellites and ISRs

- **Global Electron Density Challenge (ongoing)**
  Eight 5^{o}geographic longitude sectors (36 latitude bins each)
  One of GEM Challenge events: 2006/12/13 - 2006/12/16
  Physical parameters : global • TEC from ground-based GPS, • NmF2 and hmF2 from COSMIC

- **Publications**:
  1 paper published, 2 papers in preparation

Web tools for model validation

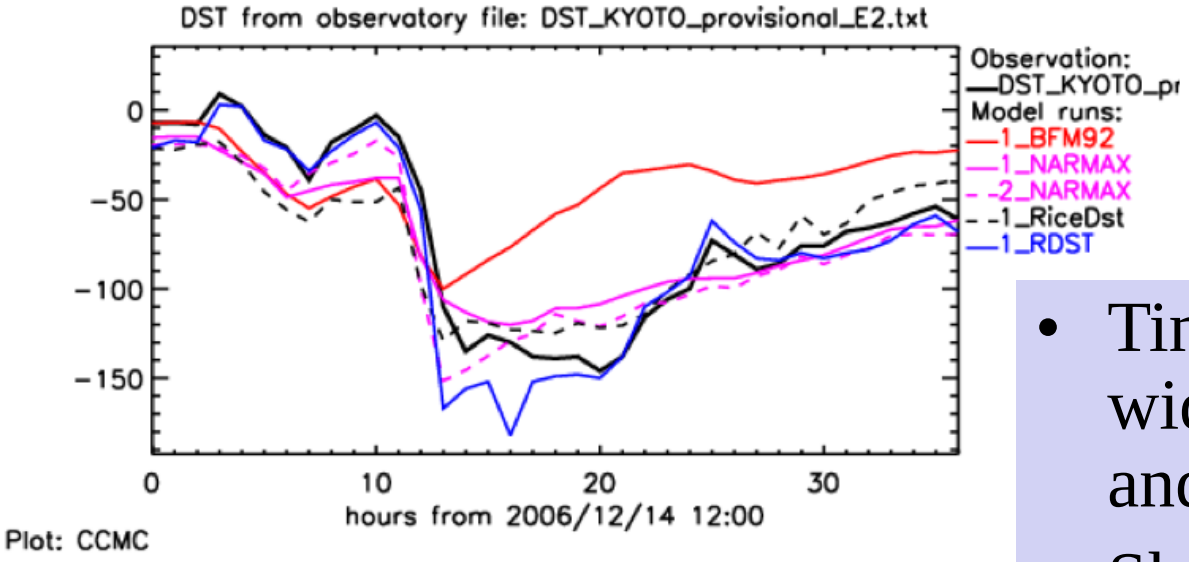


Figure: DST from observatory KYOTO and model runs
Campaign: GEM2008
Metric study: Dst
Event: December 14, 2006 12 00 UT - December 16, 00 00 UT

Observed Dst (black) and models (colors)

- Time series data from a wide variety of models and quantities.
- Skill scores computed with plots.

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)

Supporting Operational Geospace Model Selection

- Collaboration with NOAA/SWPC
- Build upon GEM 2008 Challenge (ground magnetic perturbations)
  - 4 GEM events + 2 new (surprise) events
  - same set of ground stations
  - dB/dt (vs dB)
- CCMC worked with code developers on new model versions installations
- All models were tested on the same set of nodes (should not run slower than 2 x real-time on 64 nodes at CCMC computer, should not crash).
- Lessons learned
  - Threshold-based metrics and set of skill scores were selected
  - Sensitivity study to station location
  - Sensitivity study to output frequency (10 vs 60 sec)
- CCMC (Lutz Rastaetter) developed tool to calculated dB/dt from magnetosphere and ionosphere model output (compared with on-the-fly SWMF calculations)
- All simulations have finished and skill scores calculated (Antti Pulkkinen). Results are presented to SWPC.
- Full model output, timelines, on-line analysis tools will appear at CCMC website.

http://swc.gsfc.nasa.gov

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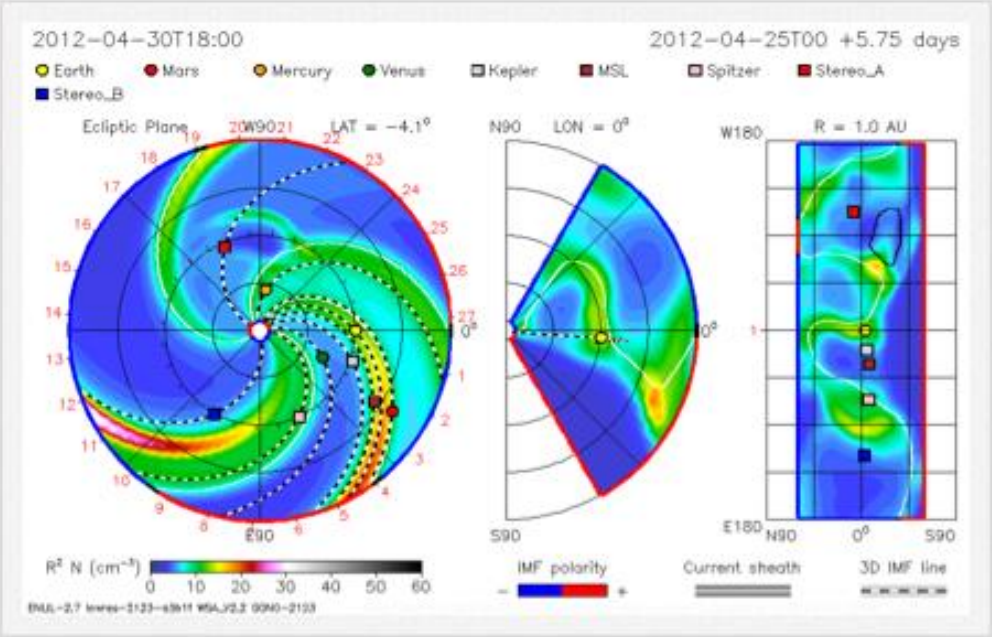

Latest Space Weather Storm

Forecasted CME Track

WSA-ENLIL Cone Model

The Space Weather Center at NASA GSFC routinley executes complex space weather model simulations to determine the path and impact of space weather storms through the heliosphere.

More

Address Space Weather needs of NASA's robotic missions.
Bring Space Weather knowledge to the public.

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Reporte Semanal del 11-17 Abril 2012 ...

NASASpaceWeather 129 views 3 days ago

http://swc.gsfc.nasa.gov - Esta semana experimentamos un poco más de actividad que en las pasadas dos semanas. Hubo un destello clase-M, dos CME's clase-O y cuatro

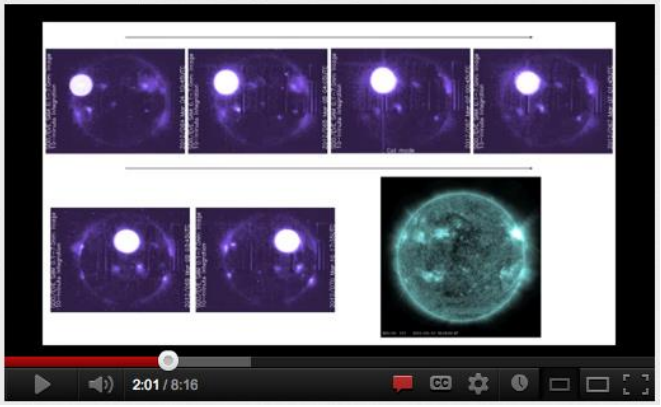
Weekly Report for April 11-17, 2012 - ...

NASASpaceWeather 446 views 3 days ago

http://swc.gsfc.nasa.gov - This week there was an increase in space weather activity over the last few weeks. There was one M-class flare, 4 Common-scored CMEs, and 2 Occas...

Incredible Active Region 1429: One for the Record Books (v1)

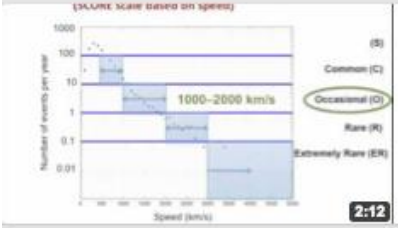
NASASpaceWeather | Subscribe | 10 videos



Weekly Report for April 4-10, 2012 - N...

NASASpaceWeather 835 views 1 week ago

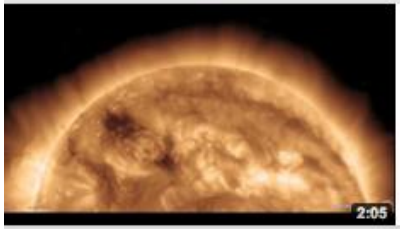
http://swc.gsfc.nasa.gov - The calm and quiet conditions we've seen recently continued throughout this week. None of the CMEs or flares from this week resulted in strong sp...



CME SCORE Scale: Typification Syste...

NASASpaceWeather 420 views 2 weeks ago

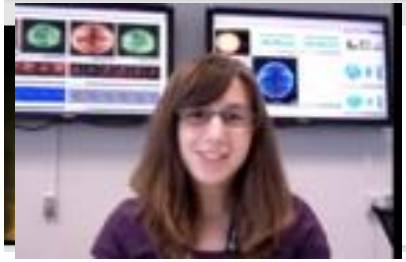
http://swc.gsfc.nasa.gov - We introduce our new coronal mass ejection (CME) classification/typification system called SCORE. SCORE indicates the type of the detected CME



Weekly Report for March 28, 2012 - Ap...

NASASpaceWeather 534 views 2 weeks ago

http://swc.gsfc.nasa.gov - The sun as a whole was pretty quiet this week. The active region previously referred to as Active Region 1429, which was responsible for almost ...



Incredible Active Region 1429: One fo...

NASASpaceWeather 356 views 3 weeks ago

http://swc.gsfc.nasa.gov - On March 2nd, 2012, active region 1429 rotated onto the Earth-facing solar disk. This region has dominated space weather conditions throughout ...

CCMC & SWC support Space Weather education.

- Educational material in support of Space Weather Education (collaboration with CUA, BU, GMU)
- Forecaster's training tools development (collaboration with AFWA)
- Interns (both at CCMC and SWC).
- CCMC scientists co-supervised three Air Force Institute of Technology graduate students 2010-2011. Models hosted at CCMC utilized extensively.
- Summer School Support
  - CCMC supported CISM and Heliophysics Summer Schools. Development of classroom materials and school labs.
- Student Research Contests
- Runs-on-request, iSWA and other tools are utilized

Outlook

- CCMC facilitate research and provide tool by which progress in space science modeling feeds into Space Weather operations
- *CCMC services are fast and flexible, facilitate science and operational space weather forecasting. CCMC is invaluable asset of space weather community* (user's feedback at the last CCMC Community Workshop)
- CCMC – NASA Goddard Space Weather Center consortium is an example of successful R2O. Proximity to scientific research.
- Great opportunities for Space Weather education.
- CCMC tools and Services are continuously evolving in response to customer needs.
- Partnering, e.g., with AFWA, NSF, FAA, DHS, NOAA, EPRI, Europe, Korea, Russia, commercial sector… is very important
- Addressing national space weather needs requires innovative, collaborative, and cost-effective ways.