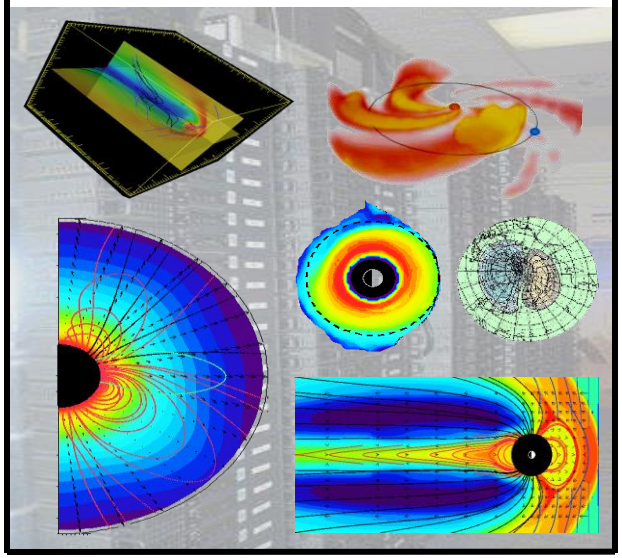
COMMUNITY COORDINATED MODELING CENTER



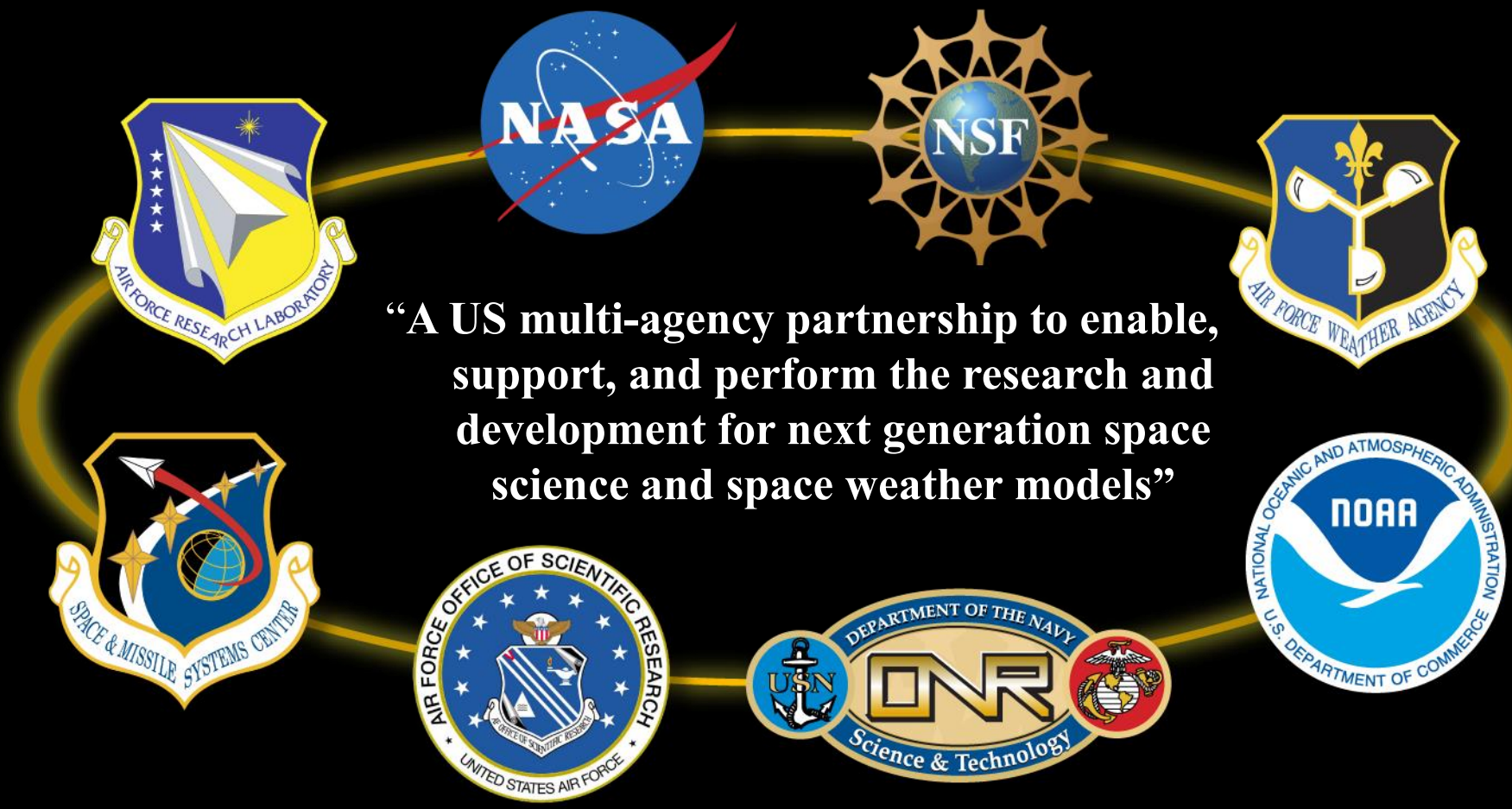
Extracting Space Weather Information from Research Models: Opportunities and Challenges

Michael Hesse
and the CCMC Team

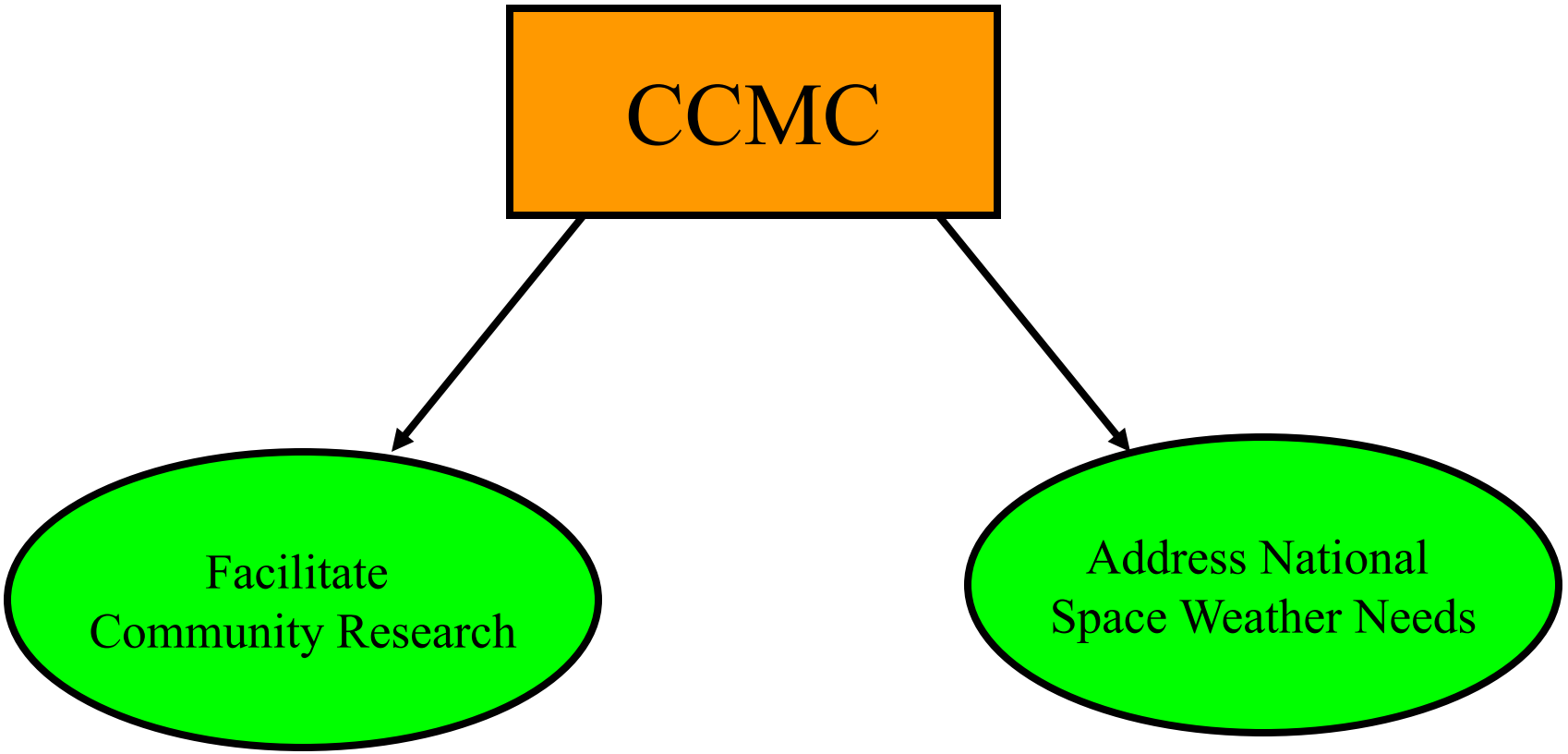
Space Weather Laboratory

http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center


NASA
NSF
AIR FORCE RESEARCH LABORATORY
AIR FORCE WEATHER AGENCY
"A US multi-agency partnership to enable, support, and perform the research and development for next generation space science and space weather models"
SPACE & MISSILE SYSTEMS CENTER
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
UNITED STATES AIR FORCE
DEPARTMENT OF THE NAVY
USN
ONR
Science & Technology
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

CCMC goals



NASA, DoD and NOAA

..through partnering with the international modeling community

SWx use of research models: opportunities

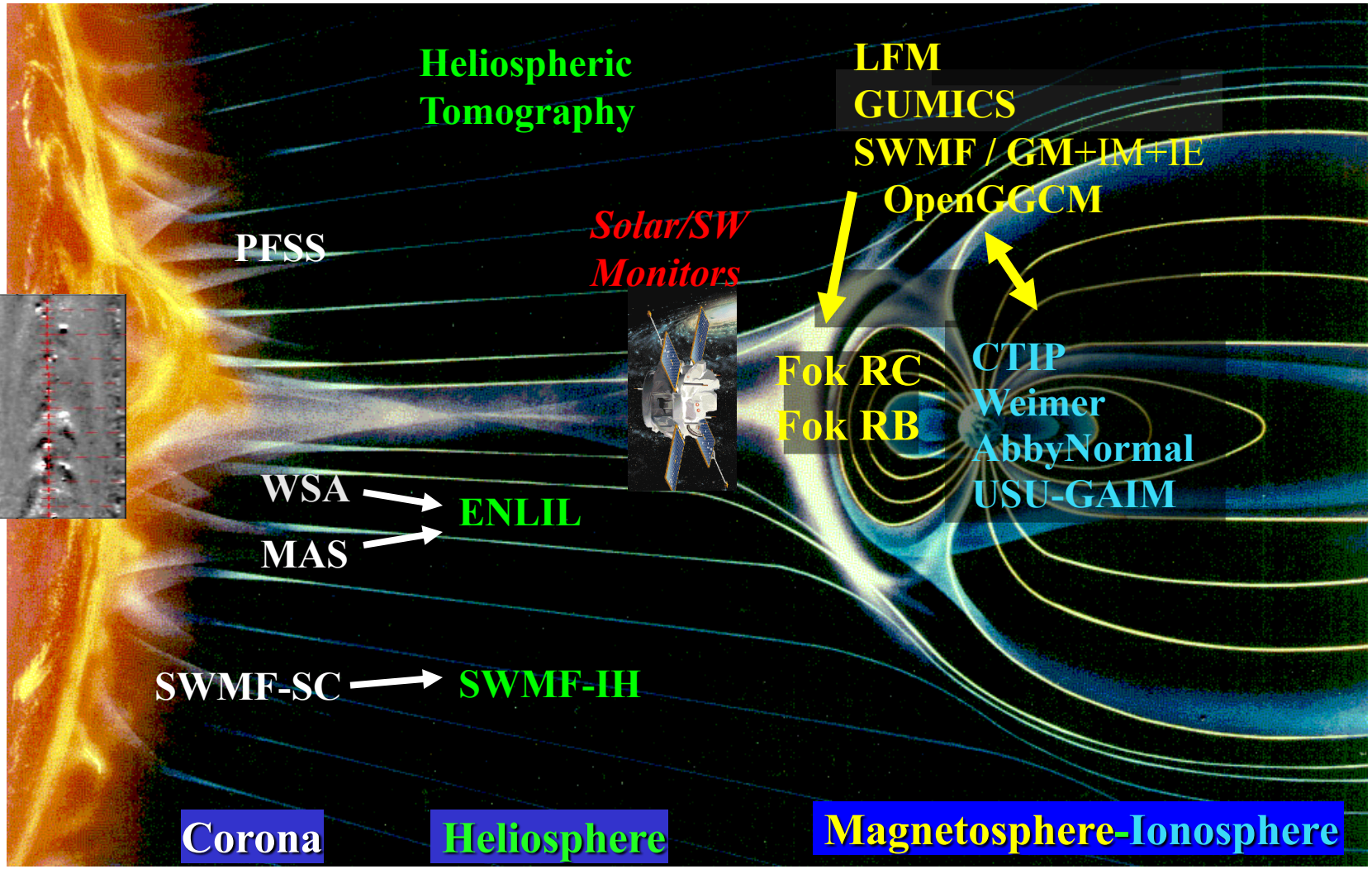
- Provide information which is state-of-the art
- Provide information which is otherwise unavailable
- Despite some issues, RT services can be set up
- Provides visibility to modeling community
- Is inclusive – many models/modelers can be featured

SWx use of research models: challenges

- Models are usually not black-boxed – often not easy to install and use
- Model results may not always be available – not “operational”
- RT services and model maintenance requires numerical expertise
- Scientific expertise is needed to interpret model results
- Flexibility required to adapt to changing information landscape

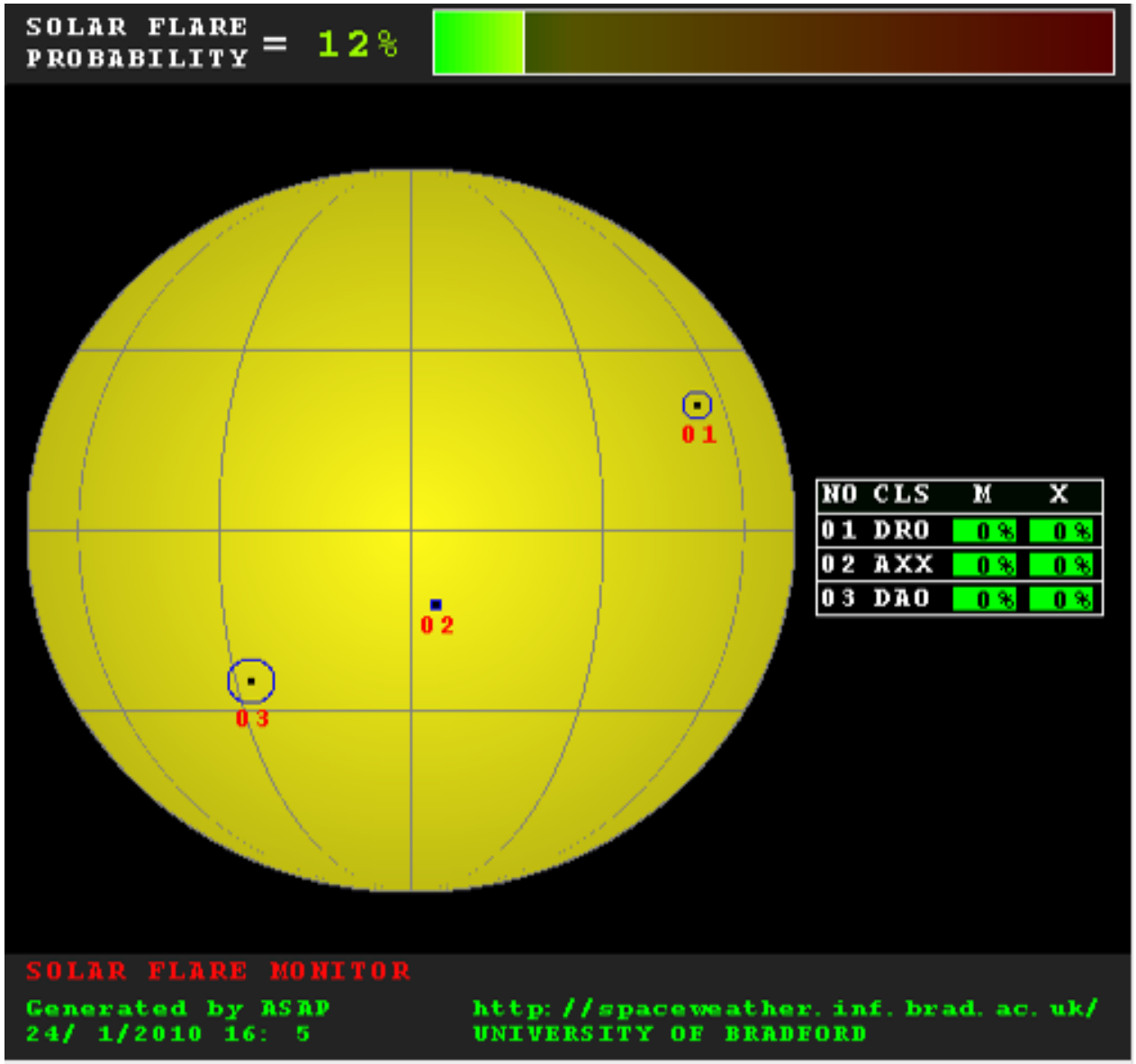
But: If a non-operational web cam shows an incoming tidal wave, would anyone ignore that information?

Models hosted by CCMC



Unique breadth

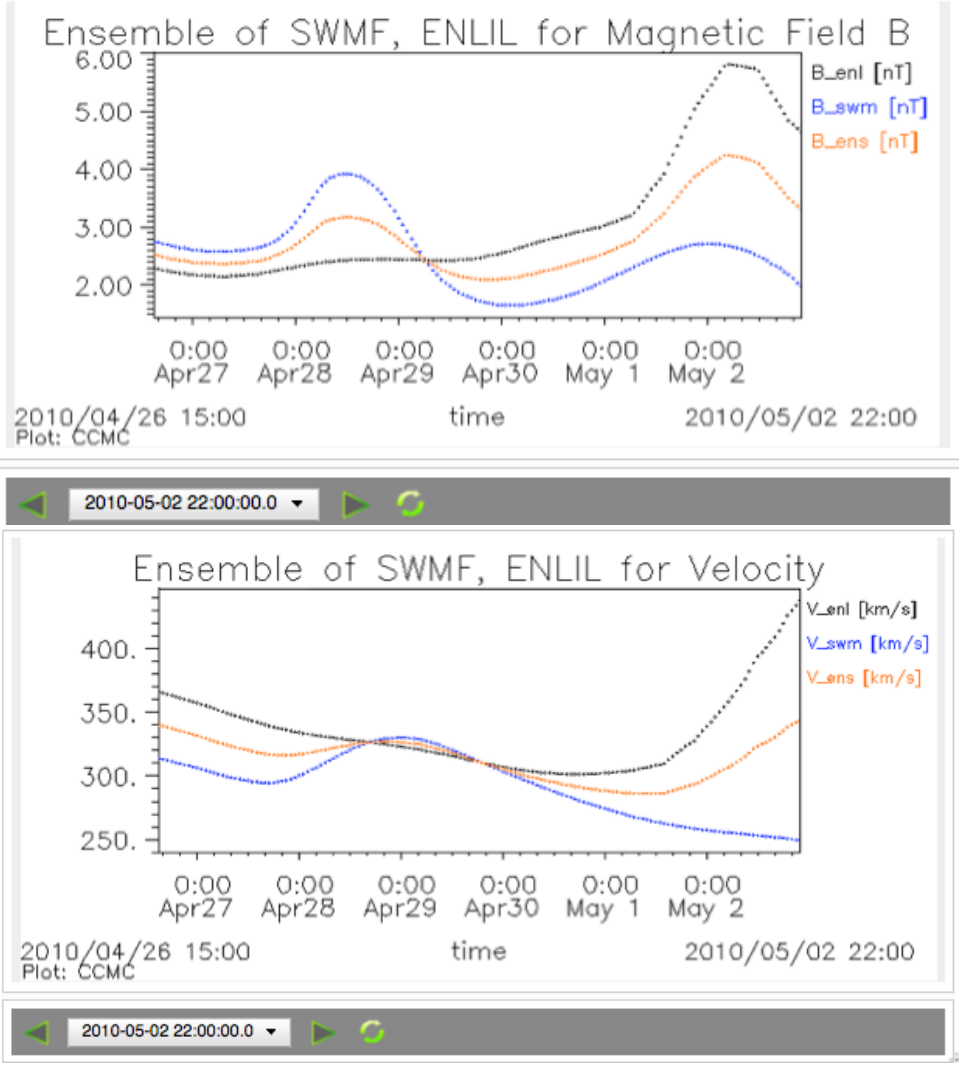
Flare monitoring product (U. Bradford, UK)



Solar wind forecasts

RT ops ongoing (available on iSWA), addition of WSA imminent

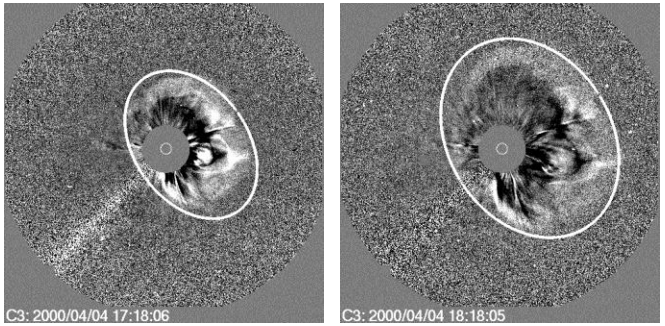
Models:
WSA/ENLIL (CISM),
SWMF (CSEM)



P. MacNeice, S. Taktakishvili

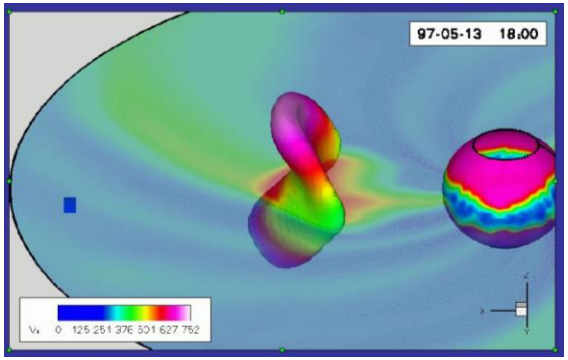
WSA/ENLIL cone model: CME prediction

SOHO LASCO C3 RD Images



Enlil Cone Model

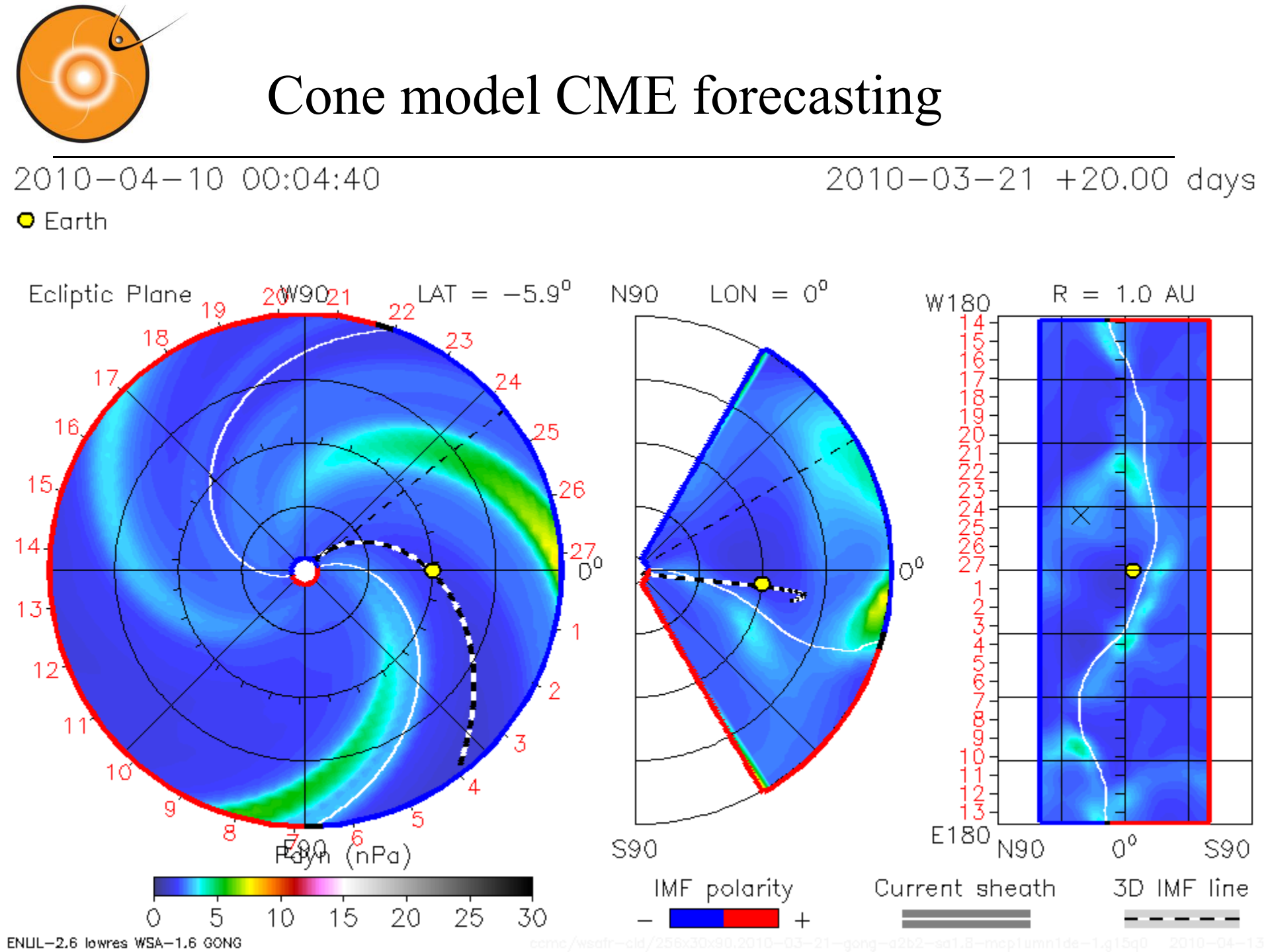
CME Arrival Prediction



- **Time** of CME Arrival
- Measure of **Uncertainty**
- **Magnitude** of Impact

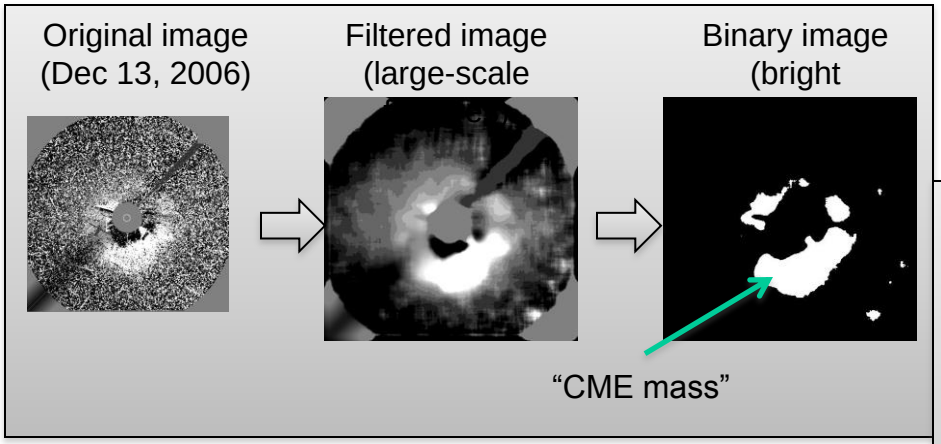
S. Taktakishvili, P. MacNeice

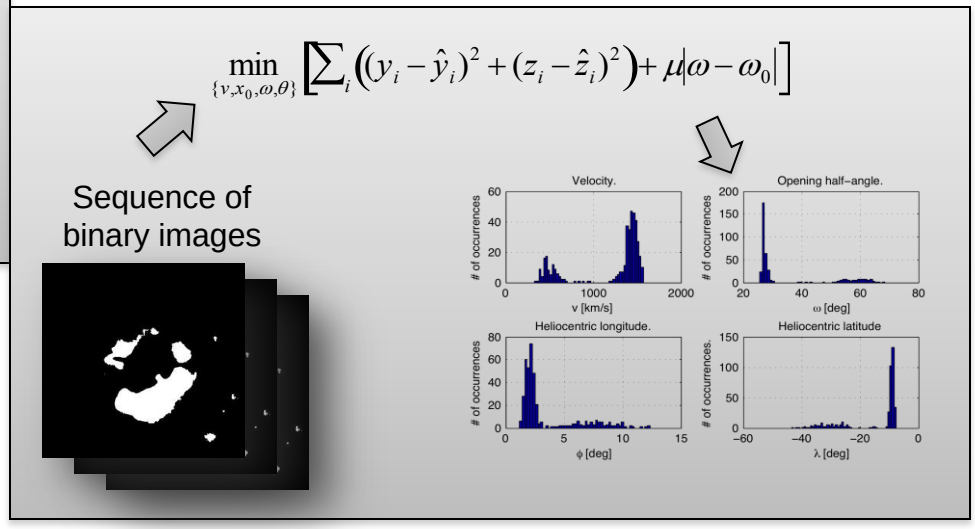
Cone model CME forecasting



Cone model forecasting: the next step

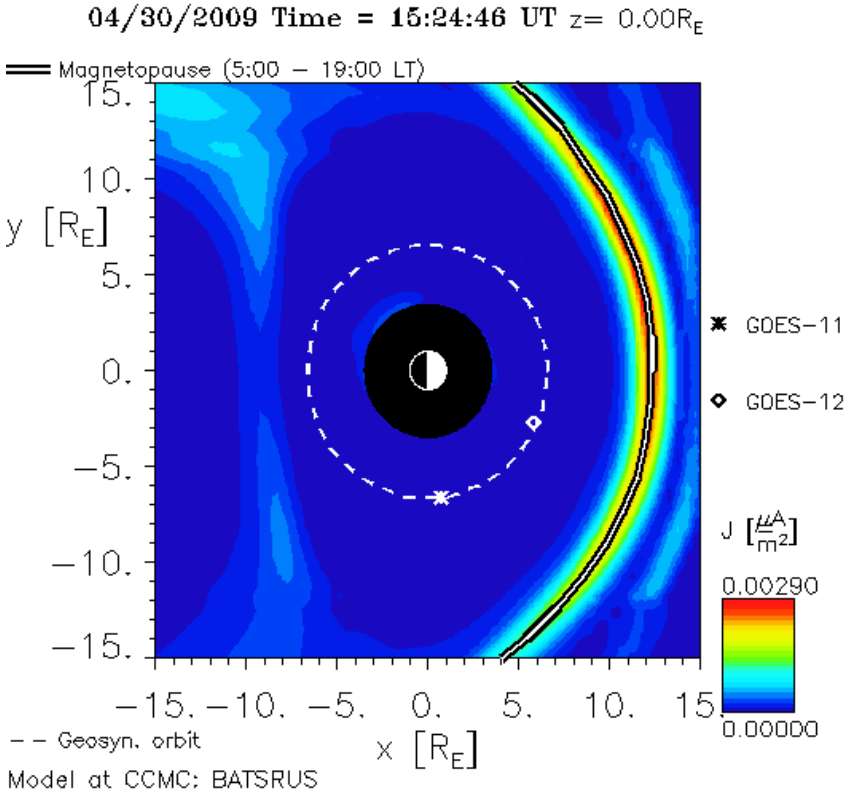
- Current Operational system
  - Manual generation of cone model parameters from LASCO difference images
- Automated system (paper published)*
  - Fit error estimates define ‘ensemble forecast’ parameter set

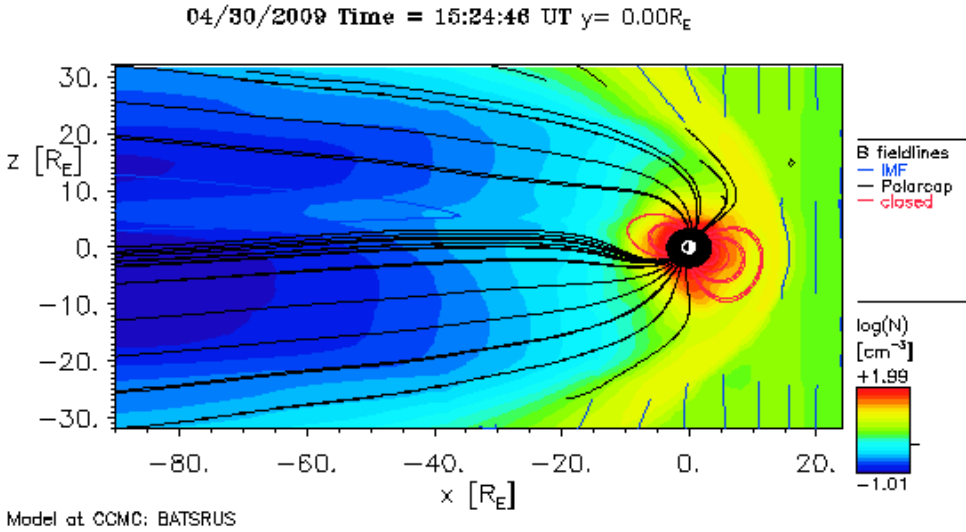




A. Pulkkinen, S. Taktakishvili, D. Berrios

Presently available tools





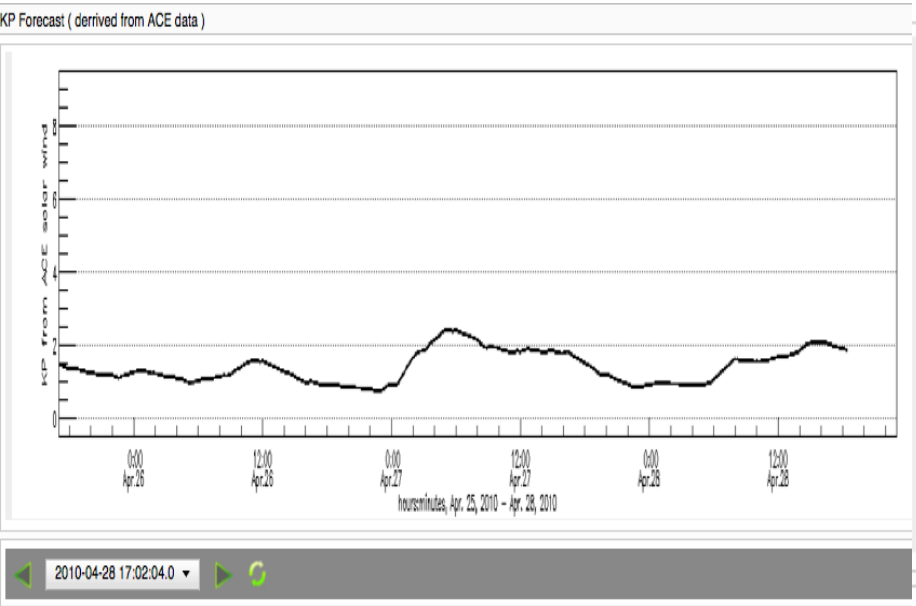
Magnetopause position:
S/C orientation
Updated every 4mins
~45min forecast

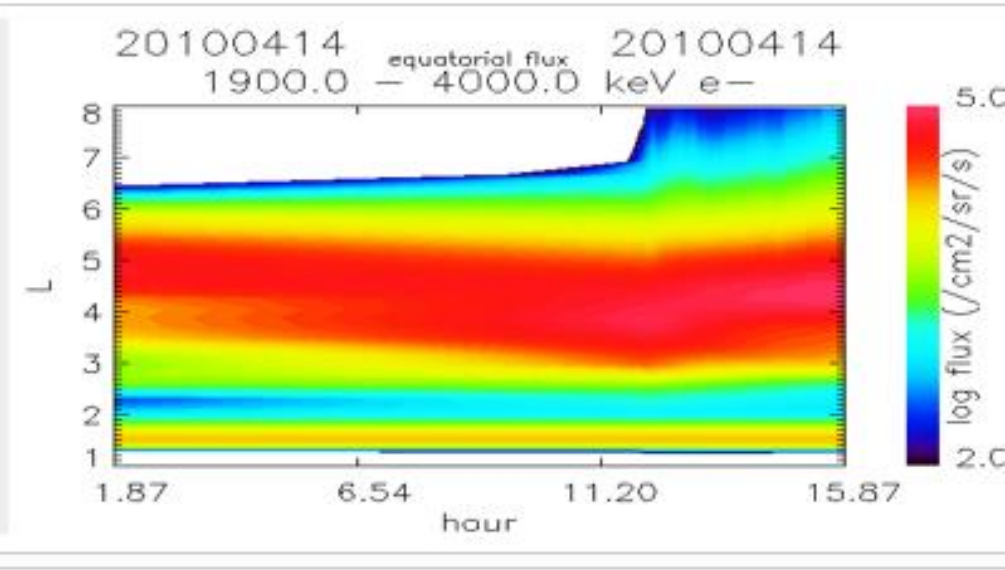
1-10keV plasma density:
S/C charging
Updated every 4mins
~45min forecast

Model: SWMF T. Gombosi et al. (CSEM)

L. Rastaetter, M. Kuznetsova

Presently available tools





Kp forecasts
Updated ~4mins
~45min forecast

Algorithm: P. Newell (APL)

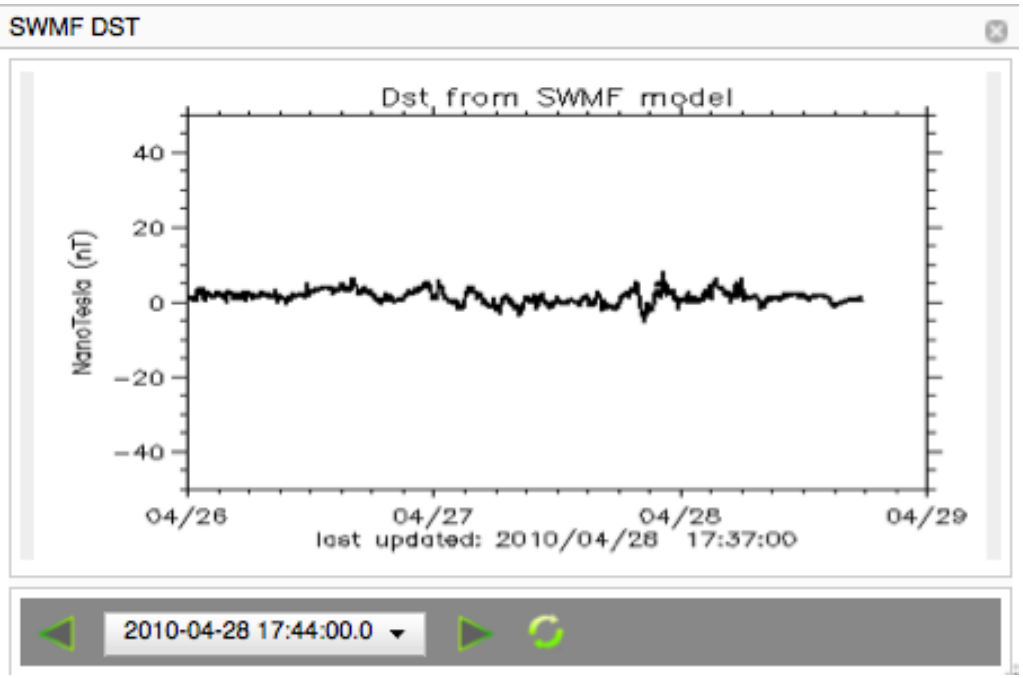
Y. Zheng, L. Rastaetter

1keV-10MeV electron fluxes:
S/C charging, SEU, radiation hazards
Updated every 4mins
~45min forecast

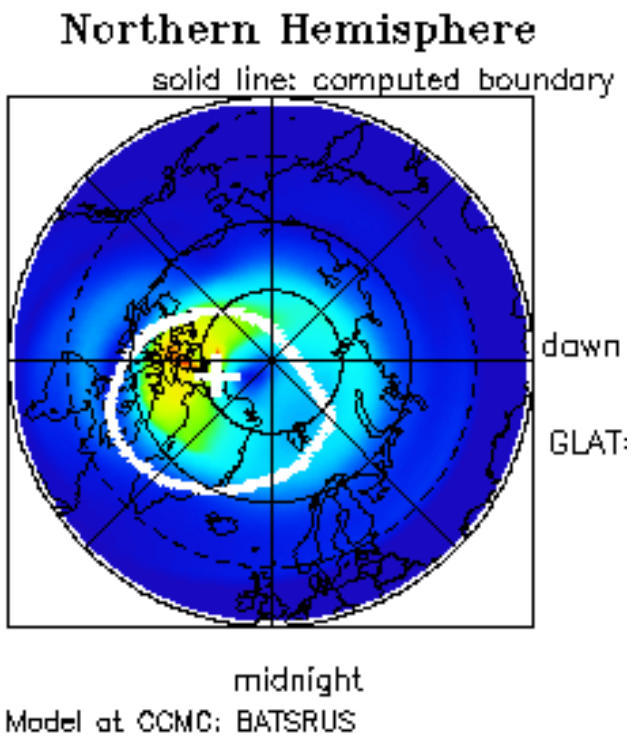
Model: RC/RB M-C Fok (GSFC)

L. Rastaetter, M. Kuznetsova

Presently available tools



Dst:
Input for various products
Updated ~4mins
~45min forecast

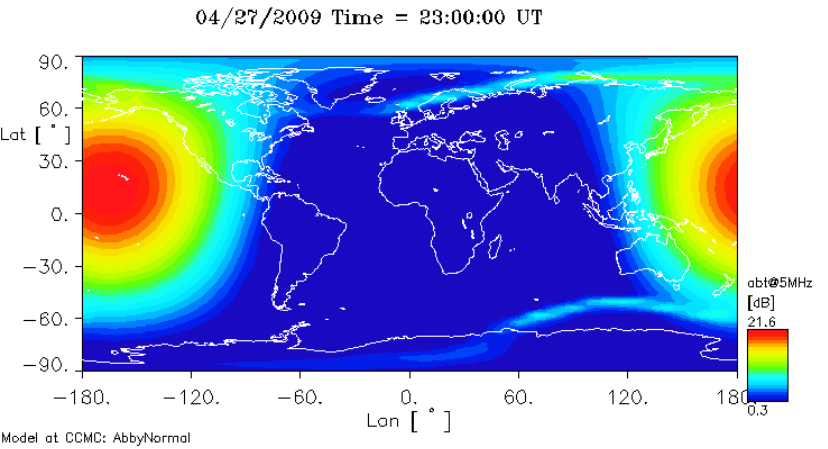


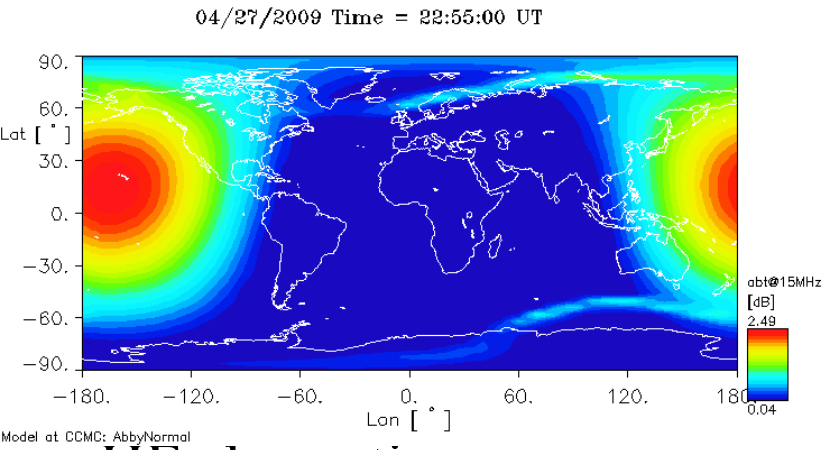
Atmospheric Joule heating:
Atmospheric drag
Updated ~4mins
~45min forecast

Model: SWMF T. Gombosi et al. (CSEM)

L. Rastaetter, M. Kuznetsova

Presently available tools



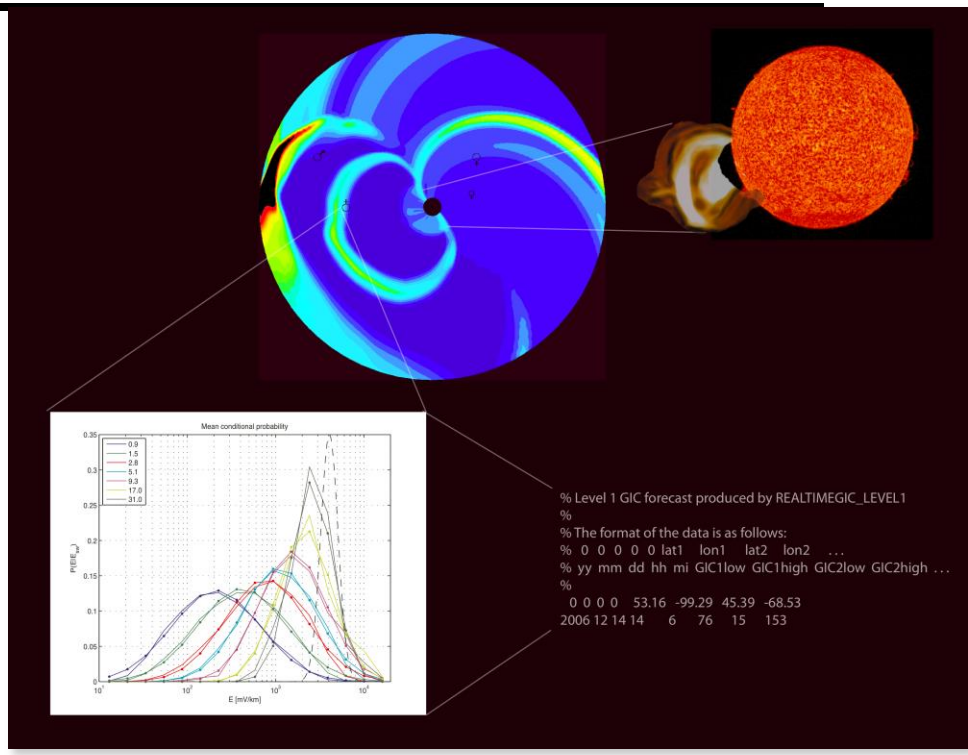


HF absorption:

Executing in real-time

Model: AbbyNormal V. Eccles (USU)

L. Rastaetter, M. Kuznetsova



GIC Warning:

Electric power grid safety

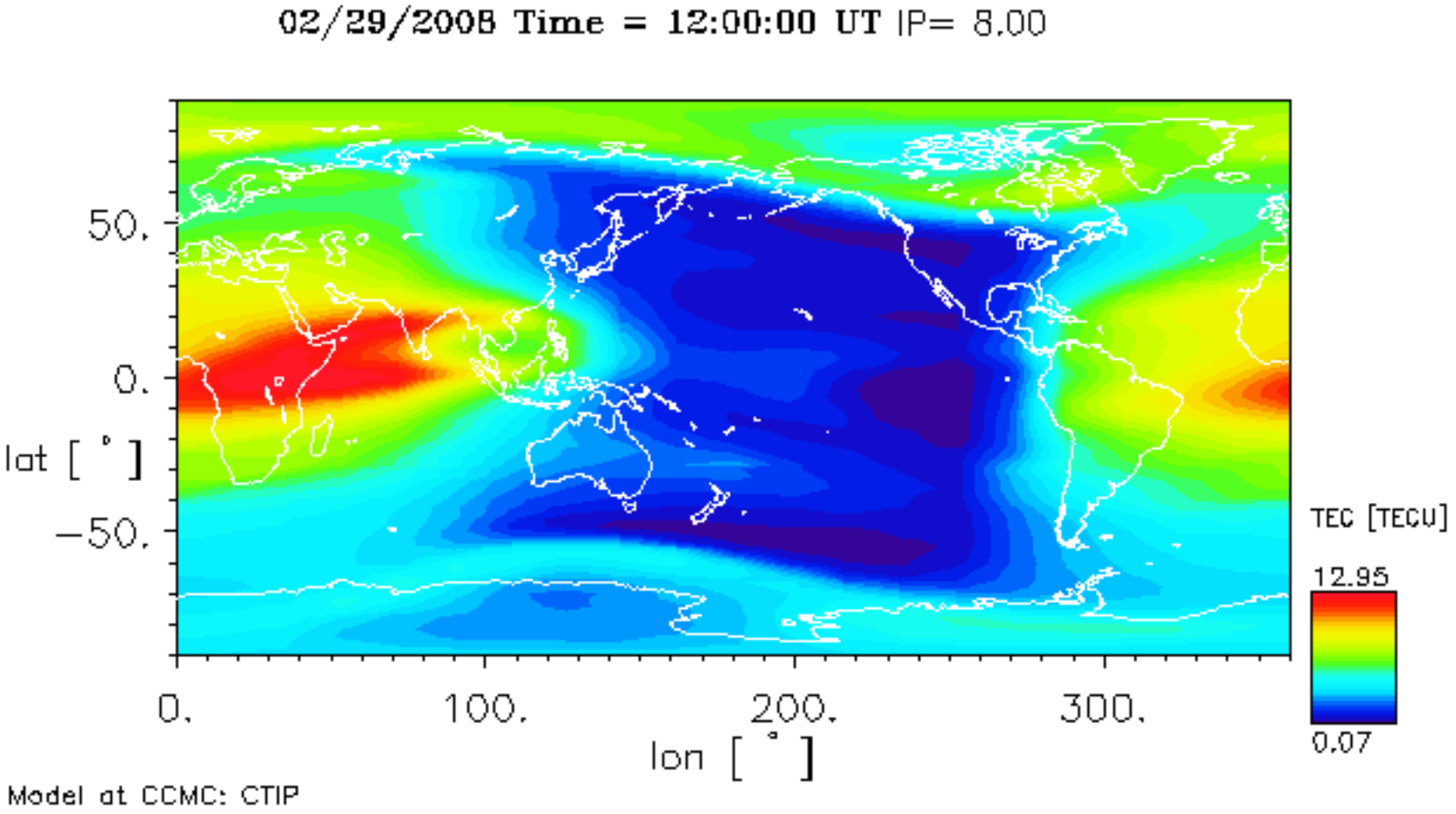
Updated every 4mins

~45min forecast

Different mode for CME events

Model: WSA/ENLIL, SWMF, A. Pulkkinen

Available soon

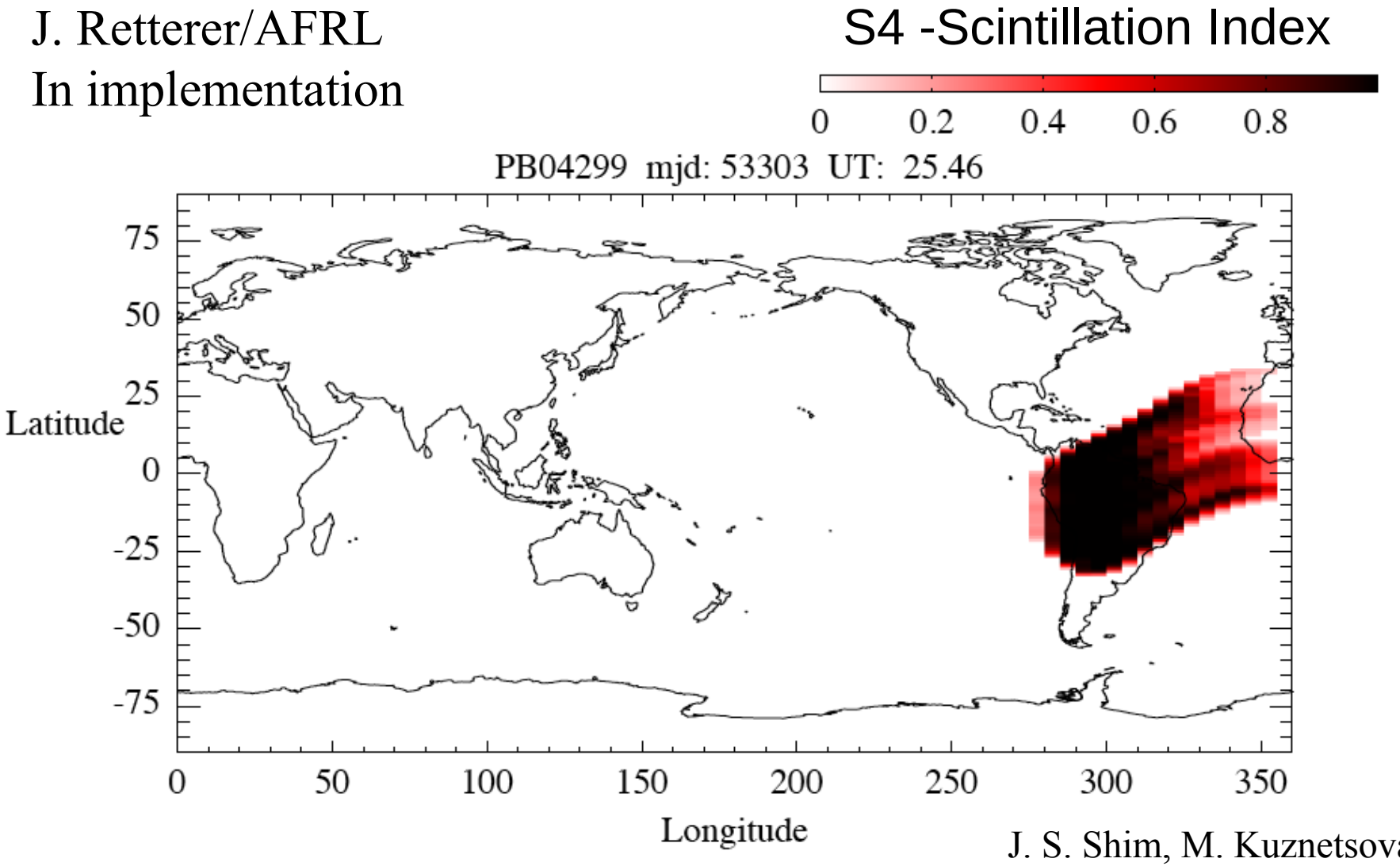


Various updates, RT runs imminent

J.-S. Shim, M. Kuznetsova

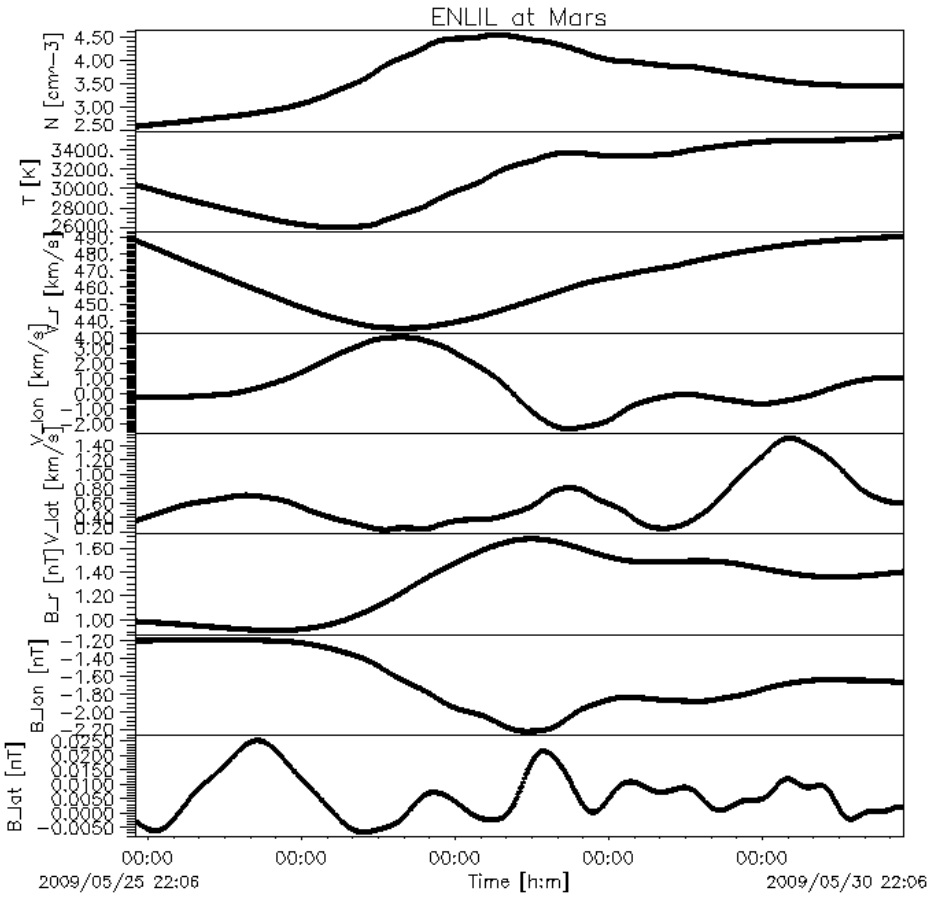
Available soon

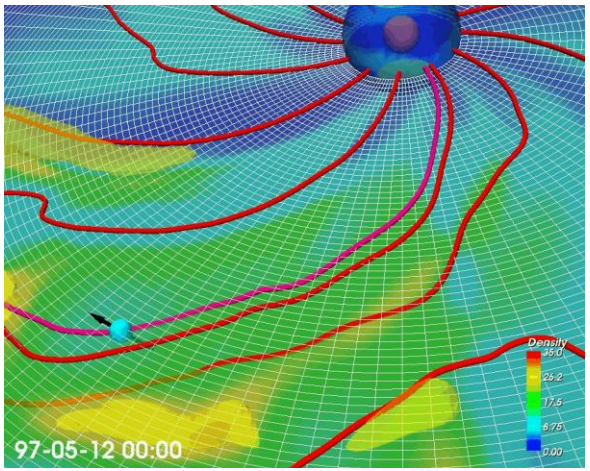
J. Retterer/AFRL
In implementation

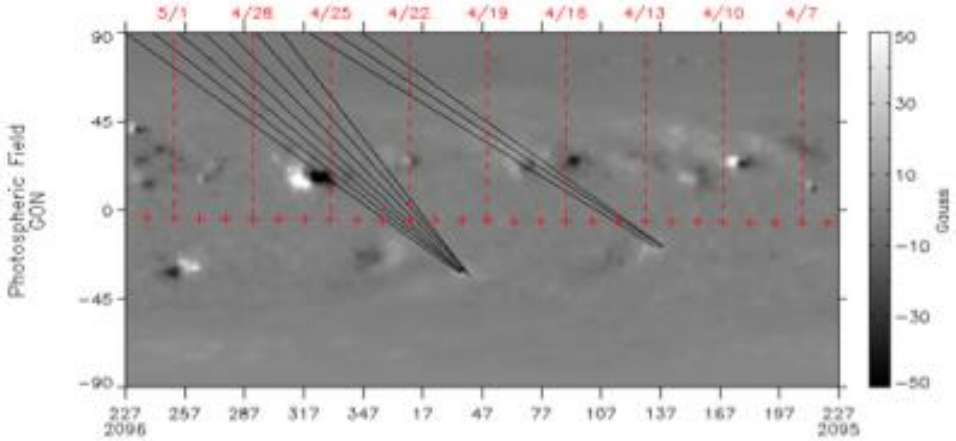


J. S. Shim, M. Kuznetsova

Planetary SWx pages: available now



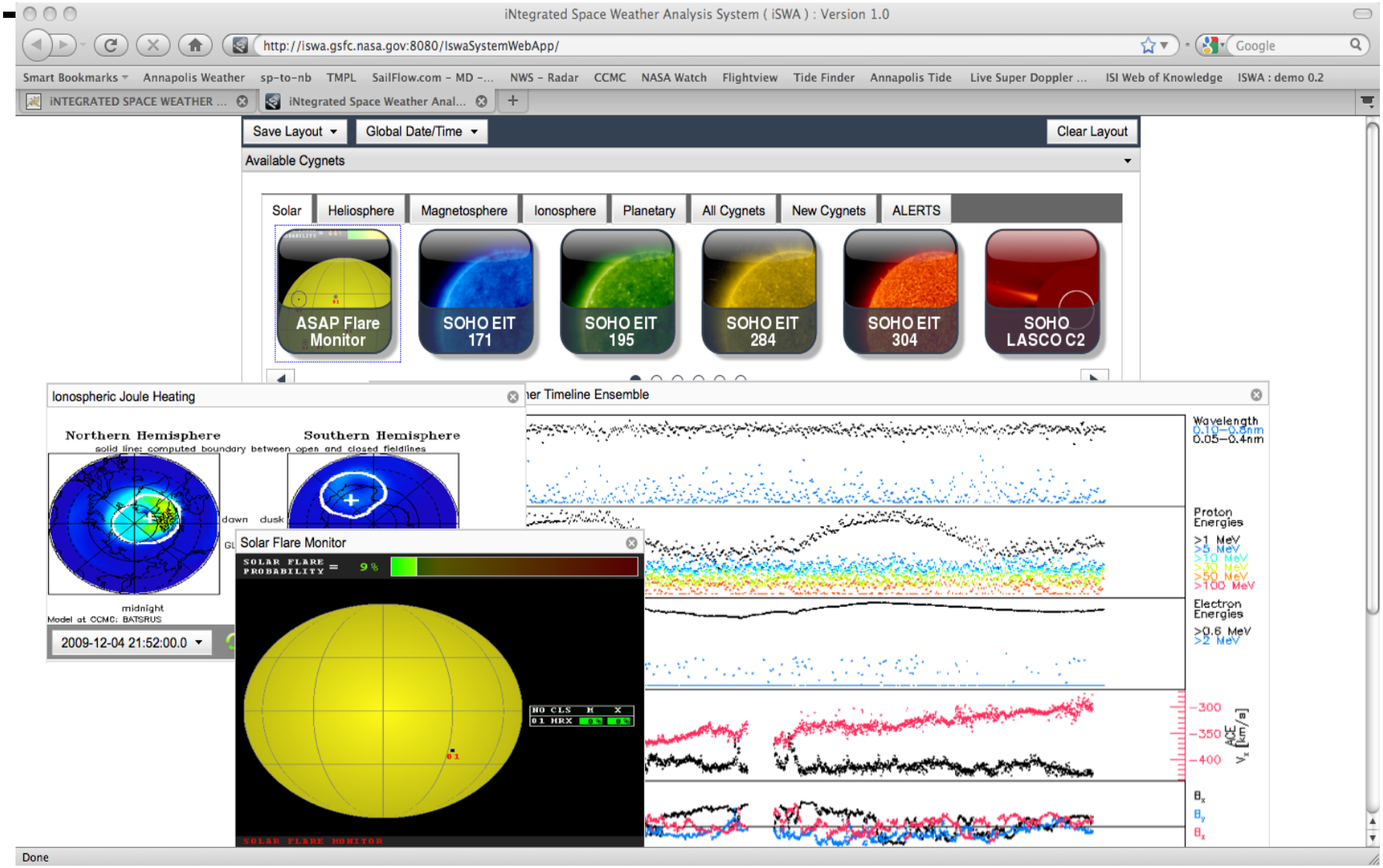




e.g., for Mars WSA/ENLIL

P. MacNeice, L. Rastaetter

Innovative dissemination: iSWA



iswa.gsfc.nasa.gov, >180 products

M. Maddox, D. Berrios, R. Mullinix, P. Jain

US Air Force Weather Agency partnering

Community V&V activities

COMMUNITY COORDINATED MODELING CENTER

GEM 2008/2009 Modeling Challenge

Metrics challenge home | Selected events/metric studies | Simula
CCMC home

Metrics Challenge Information

Presentations from 2009 Summer GEM workshop (Snowmass, CO) - *PDF format*:

- Introduction by Masha Kuznetsova
- SOPA Corrections to the MPA Measurements by Joe Borovsky
- GEM Challenge: Ground Magnetic Field Perturbations by Antti Pulkkinen
- Magnetic Fields at GOES Geosynchronous Satellites by Lutz Rastaetter
- Publication options
- Operational Metrics for Geospace Models by Howard Singer

CCMC Metrics Suite:

- **Simulation results submission interface**, including:
  - Submission procedure
  - Satellite trajectories
  - Groundbased stations
  - Model output file format
  - Solar wind input
- **Time series plotting tool**
- **Runs for metric studies performed at the CCMC**
- **Configurable table of metrics results**
- **Feedback Collection**

GEM Modeling Challenge update as of June 2009

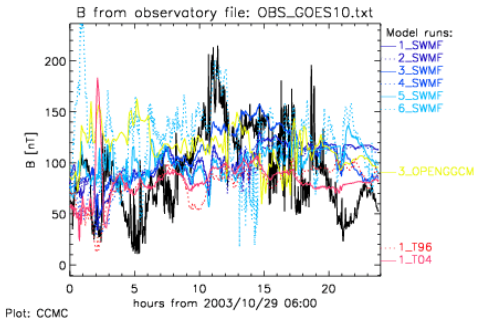


Figure: B from observatory GOES10 and model runs
Campaign: GEM2008 Metric study: 1 Event: 1

COMMUNITY COORDINATED MODELING CENTER

CETI Challenge

Simulation results submission interface

Challenge Status

CEDAR Electrodynamics Thermosphere Ionosphere (CETI) Challenge was in
current state of the ionosphere/thermosphere models, to track model improv
developing metrics for space weather model evaluations. The CEDAR commu
2008/03/31 (doy 091), and also signed on for nine events and five physical p

Three GEM Storms

Event 1: 2001/08/31(doy 243) 00:00 UT – 09/01 (doy 244) 00:00 UT
Event 2: 2005/08/31 (doy 243) 10:00 UT – 09/01 (doy 244) 12:00 UT
Event 3:2006/12/14 (doy 348) 12:00 UT – 12/16 (doy 350) 00:00 UT

Three Medium Storms

Event 4: 2007/04/01 (doy 091) 00:00 UT – 04/02 (doy 092) 12:00 UT
Event 5: 2007/05/22 (doy 142) 12:00 UT – 05/25 (doy 145) 00:00 UT
Event 6: 2008/02/28 (doy 059) 12:00 UT – 03/01 (doy 061) 12:00 UT

Three Quiet Periods

Event 7: 2007/03/20 (doy 079) 00:00 UT – 03/22 (doy 081) 00:00 UT
Event 8: 2007/07/09 (doy 190) 00:00 UT – 07/10 (doy 191) 00:00 UT
Event 9: 2007/12/07 (doy 341) 00:00 UT – 12/09 (doy 343) 00:00 UT

Metric Study 1: Vertical drifts at Jicamarca
Metric Study 2: Neutral density at CHAMP orbit
Metric Study 3: Electron density at CHAMP orbit
Metric Study 4: NmF2 (CHAMP IRO measurements)
Metric Study 5: hmF2 (CHAMP IRO measurements)

SHINE – SW forecasting in planning

J.-S. Shim, M. Kuznetsova, A. Pulkkinen, P. MacNeice

Space weather tools: benefits

- Facilitate model evaluation through a relevant product

- Support NASA robotic mission ops (direct) and human missions (through SRAG)

- Support bootstrapping of services at partners in government and industry

- Showcase value of space research and modeling at NASA, NSF, AFOSR, ONR… to interests in government as well as across society

Vice Admiral Horatio Nelson: The measure may be thought bold, but I am of the opinion the boldest are the safest

Admiral D. G. Farragut: Damn the torpedoes: Full speed ahead!

Future of CCMC SWx Support

- Provide tool by which science progress at NASA, NSF, AFOSR, ONR feeds into Space Weather operations
- CCMC has unique experience in RT modeling and a trusted relation with model owners
- Space Weather Desk services supporting NASA robotic missions
  - Integrating model output tailored to operator needs -> ISWA project
  - Quasi-operational model results/forecasts already existing
  - Unique scope and capabilities, also available to NASA's SRAG
- Close working relations with AFWA, SMC/AFSPC, AFIT, USAFA, AFRL, SWPC
- Partnering with EPRI, Space Environment Technologies, UStar, very interested in more (international) collaborations