Community Coordinated Modeling Center:  
Addressing Needs of Operational Space Weather Forecasting

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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

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

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

Flexible to adapt to changing model (and data) environment.
Innovative dissemination
One-stop shop for state-of-the-art information

> 300 SWx Tools

iswa.ccmc.gsfc.nasa.gov

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

- 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°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

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

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

<table>
<thead>
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<th>Model Setting</th>
<th>PredEff</th>
<th>N_region</th>
<th>N_finite</th>
<th>PredYield</th>
<th>MinTimingError</th>
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PredEff: Prediction Efficiency metric
N_region: the number of samples in the selected time window
N_finite: the number of points that were used for comparison (i.e., 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 nearest)
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.
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Space Weather Alerts, Reports & Forecasts

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Integrated Space Weather Analysis system

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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 en las pasadas dos semanas. Hubo un destello clase-M, dos CMEs clase-3 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...

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 ap...

CME SCORE Scale: Typification System...

NASASpaceWeather 426 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 1425, which was responsible for almost ...
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.