SPACE WEATHER FORECASTING CAPABILITIES AT THE COMMUNITY COORDINATED MODELING CENTER (CCMC)

Dr. Yaireska (Yari) Collado-Vega et al.
NASA GSFC, HSD, Space Weather Lab
The CCMC was established in 2000 as a multi-agency strategic investment in US space weather program.

**CCMC Goals**

- **Facilitate space weather research & model development** to advance understanding and to improve forecasting.
- **Support deployment of new operational space weather capabilities**

A long-term and flexible solution to the R2O transition.

*In partnership with international research and operational communities.*
CCMC is a Hub for Collaborative Development and Deployment of New Operational Space Weather Capabilities

Partnership with model owners, users or SW products & services, research, engineering & operational communities world-wide

**Ingestion**
- models & data products

**Evaluation**
- robustness, performance skill
- progress over time

**Improvement**
- simulation services,
- web-based applications,
- actionable displays,
- interactive archives

**Dissemination**

**Prototyping**
- services for NASA in-house
- users test-driving new techniques
- & procedures knowledge base building
Comprehensive Collection Of Space Weather Models

SWMF.SC
PFSS.Petrie
PFSS.Macneice
PFSS.Luhmann
ANMHD
UMASEP
SRPM
MAG
4
ASAP
WSA
MAGIC
ASSA
SNB3GEO
NLFFF.Wiegelmann
ENLIL
Posner SEP
PREDICCS
EXO Solar Wind
EMMREM
CORHEL
Heltomo SMEI
ENLIL+Cone
Heltomo IPS
BRYNTRN
SWMF.SH
LFM-TING
LFM-MIX
OpenGGCM
GUMICS
GIC
SMF+RCM+deltaB
SMF+RCM
SMF+RCM+RBE
SMF+RCM+CRM
LFM-MIX-TIEGCM
WINDMI
IGRF
Fok.RC
UPOS RB
AE-8/AP-8
AE-9/AP-9
VERB
Fok.CIMI
RCM
Fok.deltaB
PS VP
AAPGM
Apex
Ovation Prime
SAMI-2
SAMI-3
TIE-GCM
CTIPe
IRI
USU-GAIM
SWACI-TEC
ABBYNormal
MSIS
GITM
PBMOD
TRIPL-DA
Weimer IE
Weimer-deltaB
JB2008
COSGROVE-PF

Corona  Heliosphere  Magnetosphere  Inner Magnetosphere  Ionosphere/Thermosphere
CCMC Functions

Models
- EEGGL
- Containers
- StereoCAT
- Model input generation suite
- Model display system

Simulation services
- Simulation (RUNS ON REQUEST - CUMULATIVE GROWTH)
- (> 20,000 runs)

Visualization, dissemination
- CCMC Kamodo analysis suite (open source)

Evaluations, R2O
- Skill Score
- Scoreboards
- CAMEL

NASA missions & community support
- Support

Information architecture: perpetual archive
- ISWA
- DONKI
- CAMEL
Assessment of model output quality and reliability based on historic time intervals (events)

- Tracking progress vs. established metrics and benchmarks relevant to specific applications.
- Testing sensitivity to external drivers and internal assumptions

Evaluations for R2O transition readiness

- Real-time prototyping: tests for robustness and long-term performance, building knowledgebase.
- Correlate forecasts with impacts

Evaluation of portability, quality of documentation.

Forecasting methods Scoreboards

Testing predictive capability prior to event onset

- CME Scoreboard
- IMF Bz Scoreboard
- SEP Scoreboard
- Hare Scoreboard

Real-time prototyping: tests for robustness and long-term performance, building knowledgebase.

Correlate forecasts with impacts

Evaluation of portability, quality of documentation.
Space Weather Forecasting Team:
- 6 Senior Forecasters, 8 Student Forecasters + International Collaborators

Regular Activities:
- Monitor models and activity 8am-8pm daily
- Notifications are sent out to users when thresholds are exceeded
- 10am video and in person “tag-up” meetings each work day
- “International” tag-ups with international/external partners
- Weekly Space Weather Reports
- Assistance in spacecraft anomaly resolution

Previous Annual Events:
- Student Intern Program (June - August)
- 2-Week Space Weather Summer School (June)
- Space Weather/Robotic Missions Workshop (September)
iSWA System

Highly diverse and distributed space weather data consisting of the latest observational data along with the most advanced space weather model simulation output.

iSWA system collects data from a large and evolving list of sources. Data is sorted, characterized, and processed into ‘mission decision supporting’ products in response to individual user queries.

iSWA generates and provides a user-configurable display panel that can be accessed from a standard web browser. The end user can then customize their display to focus on specific products of interest.
http://iSWA.ccmc.gsfc.nasa.gov
CCMC provides vital science and space weather support to ongoing and future science missions in various capacities and during different phases:

- mission planning/building
- operation/prime and extended science stages.

Support is provided through CCMC services:
- Runs on Request service
- Real-time runs and data viewable via webpages and iSWA
- DONKI, a searchable database of space weather events, simulations, and notifications
- Anomaly resolution
Anomaly Analysis Support for NASA Robotic Mission

- Anomaly Analysis are requested by NASA missions several times a month.
- An assessment is prepared and sent to the mission team for their evaluation and decision.
- Sometimes face to face meetings are required when an evaluation board is conducted and the space weather environment is presented by our team.
- Critical decisions are made that take into account the space weather assessment.

We also work closely with the Space Asset Protection Program (SAPP) and we are part of their procedures for mission anomalies.

The support has been very important for the development of new missions.

During Shutdown:

Space weather forecasting services were critical and expected. Team had to be assembled and kept the activities going for the time needed.
The “NASA Space Exploration & Space Weather Workshops”, have been held annually since 2009. It enables the SWRC team to communicate to the end-users the latest space weather capabilities and to update our understanding of the current end-users’ space weather needs.

Originally focused on NASA robotic missions’ needs, the workshops have evolved, through collaboration with Johnson Space Center Space Radiation Analysis Group (SRAG), to include human space exploration needs. During the last two workshops, emphasis has also been given to the operational implications and future development of space weather capabilities for both human and robotic deep space exploration.
Space Weather Needs for NASA Missions

- NASA has a very unique space weather need with missions operating across the solar system. We are in the need of off Sun-Earth line imaging, in-situ observations.

- SEP characterization is a robotic mission need that it is shared with the human exploration activities.

- Collision avoidance activities need for development of long lead-time atmospheric drag predictions.
DO NKI

Database of Notifications, Knowledge, and Information

Catalog of space weather phenomena.
Chronicles the daily interpretations of space weather observations, simulation results, forecasting analysis, and notifications.
Key component of the forecaster tool suite, developed to address space weather needs of NASA missions.
Online tool for dissemination of forecasts, notifications, and archiving event-focused information

• Intelligent linkages, relationships, cause-and-effects between space weather activities

Comprehensive search functionality to support anomaly resolution and space science research:

- Space weather activity archive (flares, CME parameters and simulation results, SEPs, geomagnetic storms, radiation belt enhancements) with links between activities
- GSFC space weather notification and weekly report archive

• Enables remote participation by students, world-wide partners, model and forecasting technique developers
Click here to get started searching the database by space weather activity type and date.

Choose event type

Select start and end date for search

For example, Solar Energetic Particle (SEP), to see all SEP events above threshold values.
## Search Space Weather Activity Archive

**Space Weather Event Type:**

Optional start date in format (e.g. 2013-01-31): 2013-05-01
Optional end date in format (e.g. 2013-06-30): 2013-05-31

![Search Interface](image)

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Activity ID</th>
<th>SEP Event Time</th>
<th>Associated Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Energetic Particle</td>
<td>2013-05-13T04:12:00-SEP-001</td>
<td>2013-05-13T04:12Z</td>
<td>STEREO B: IMPACT 13-100 MeV</td>
</tr>
<tr>
<td>Solar Energetic Particle</td>
<td>2013-05-13T18:02:00-SEP-001</td>
<td>2013-05-13T18:02Z</td>
<td>STEREO B: IMPACT 13-100 MeV</td>
</tr>
</tbody>
</table>

For example, Solar Energetic Particle (SEP) lists all SEP events above threshold values at various locations.

All columns are sortable! (click column headings)
Selecting “WSA-ENLIL+Cone Model” lists all CME simulations in a certain date range.

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Model Completion Time</th>
<th>CME Input(s)</th>
<th>Predicted Earth Impact</th>
<th>Predicted Other Location(s) Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-03T09:33Z</td>
<td>CME: 2013-05-02T14:36:00-CME-001(CME Analysis)</td>
<td>No or little impact to Earth.</td>
<td></td>
</tr>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-03T18:07Z</td>
<td>CME: 2013-05-03T18:00:00-CME-001(CME Analysis)</td>
<td>No or little impact to Earth.</td>
<td>Spitzer: 2013-05-06T14:32Z</td>
</tr>
<tr>
<td>Model Name</td>
<td>Model Completion Time</td>
<td>CME Input(s)</td>
<td>Predicted Earth Impact</td>
<td>Predicted Other Location(s) Impact</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-03T09:33Z</td>
<td>• CME: 2013-05-02T14:36:00-CME-001( CME Analysis )</td>
<td>No or little impact to Earth.</td>
<td>Spitzer: 2013-05-06T14:32Z</td>
</tr>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-03T18:07Z</td>
<td>• CME: 2013-05-03T18:00:00-CME-001( CME Analysis )</td>
<td>No or little impact to Earth.</td>
<td>Spitzer: 2013-05-06T06:39Z</td>
</tr>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-04T12:48Z</td>
<td>• CME: 2013-05-03T18:00:00-CME-001( CME Analysis )</td>
<td>No or little impact to Earth.</td>
<td>STEREO B: 2013-05-06T16:39Z</td>
</tr>
<tr>
<td>WSA-ENLIL+Cone</td>
<td>2013-05-04T13:52Z</td>
<td>• CME: 2013-05-03T18:00:00-CME-001( CME Analysis )</td>
<td>No or little impact to Earth.</td>
<td>Spitzer: 2013-05-06T15:31Z</td>
</tr>
</tbody>
</table>

- Duration of disturbance (hr) = 38
- Minimum magnetopause standoff distance: Rmin(Re) = 6.6
- Possible Kp index:
  - (kp)90=1
  - (kp)135=
  - (kp)180=5

DONKI
Full simulation results for the selected run:

**WSA-ENLIL+Cone Model with Completion Time: 2013-05-04T12:48Z**

**Model Inputs:**
- 2013-05-03T18:00:00-CME-001 with **CME Analysis**: Lon.= -89.0, Lat.= 18.0, Speed= 760.0, HalfAngle= 60.0, Time21.5= 2013-05-03T22:30Z
- 2013-05-03T22:36:00-CME-001 with **CME Analysis**: Lon.= -86.0, Lat.= 18.0, Speed= 520.0, HalfAngle= 22.0, Time21.5= 2013-05-04T05:37Z

**Model Outputs:**
- **Earth Impact:** No or little impact to Earth.
- **Other Location(s) Impact:**
  - Spitzer with estimated shock arrival time 2013-05-06T06:39Z
  - STEREO B with estimated shock arrival time 2013-05-06T16:39Z

**Links to simulation movies and plots:**

CME input parameters are listed for each activity ID (click ID for more CME information)

Impact prediction times
CCMC is an Asset of NASA Heliophysics and the Entire Space Weather Community

- Repository and dissemination of achievements in space science modeling.
- Center for R2O transition.
- Provides accurate real-time experimental research forecasting of space environments - and their probable impacts for missions.