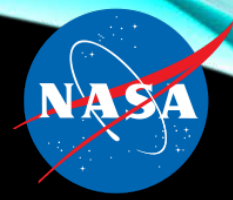


SPACE WEATHER FORECASTING CAPABILITIES AT THE COMMUNITY COORDINATED MODELING CENTER (CCMC)

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*

R

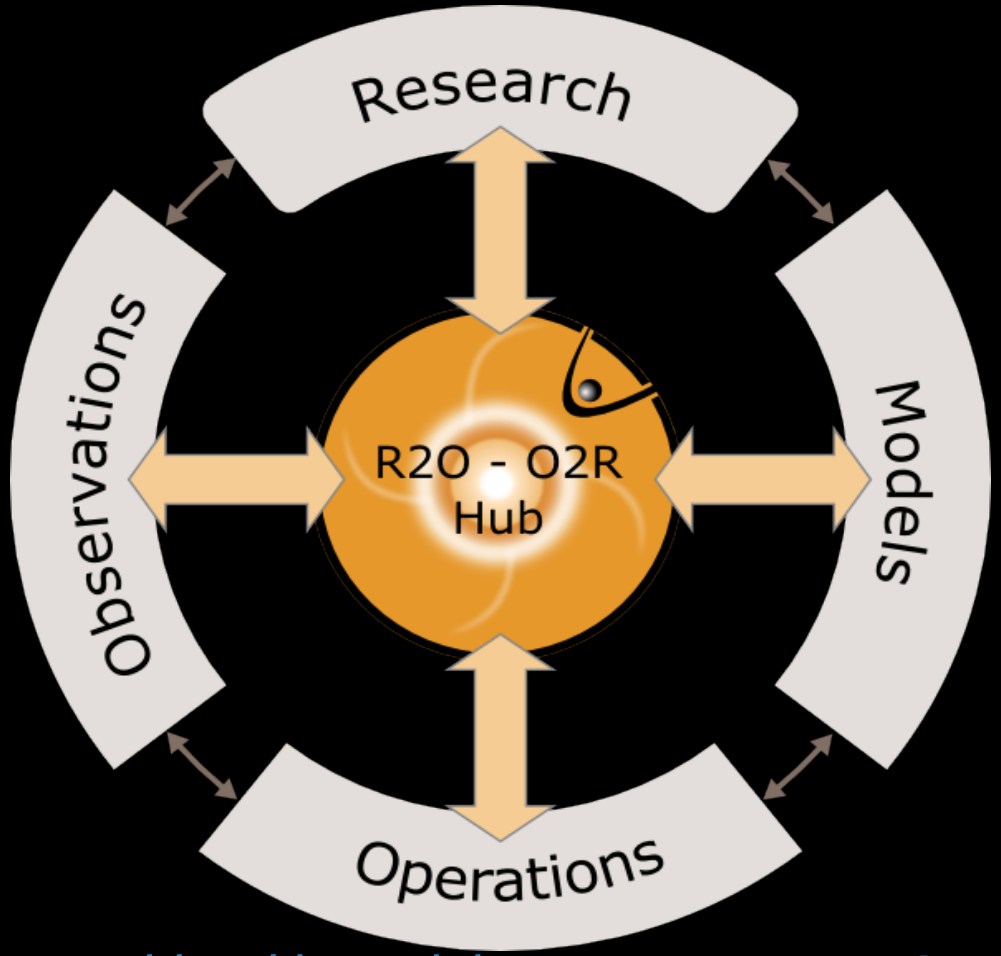
Support deployment of new ***operational space weather capabilities***

O

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

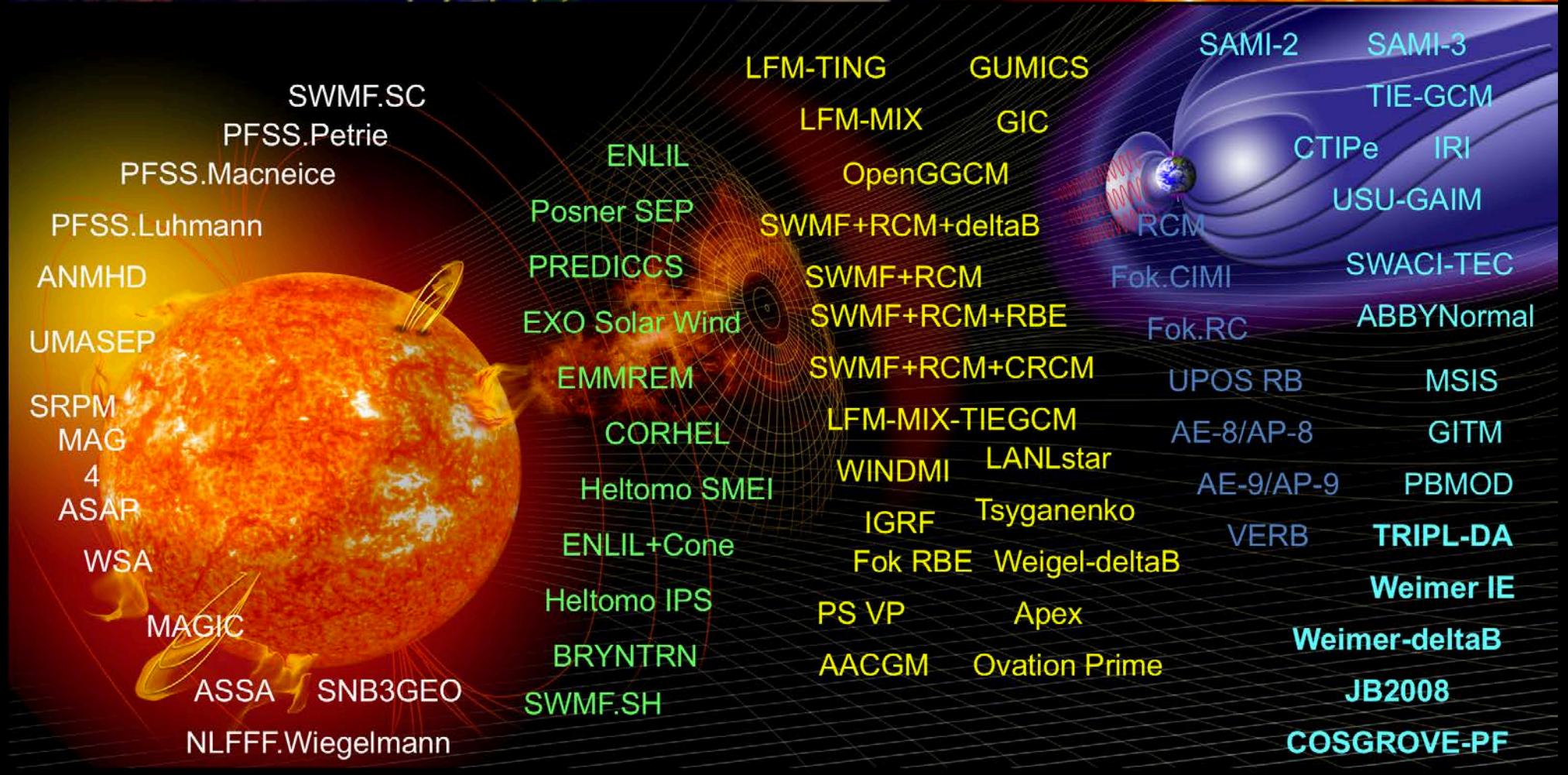
Dissemination

simulation services, web-based applications. actionable displays, interactive archives

Prototyping

services for NASA in-house users test-driving new techniques & procedures knowledge base building

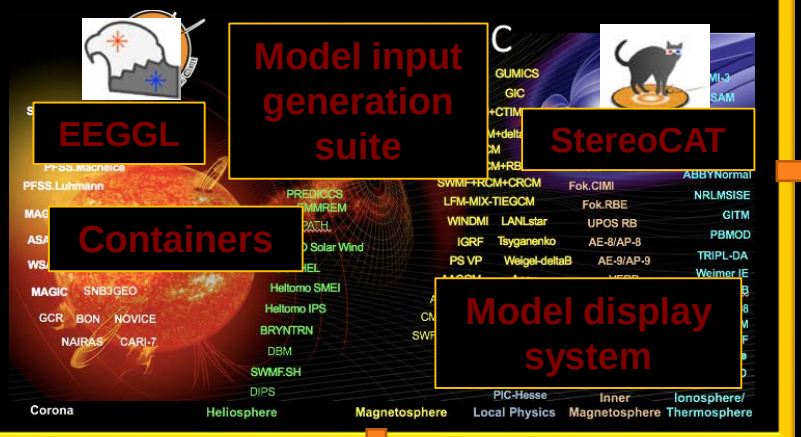
Comprehensive Collection Of Space Weather Models



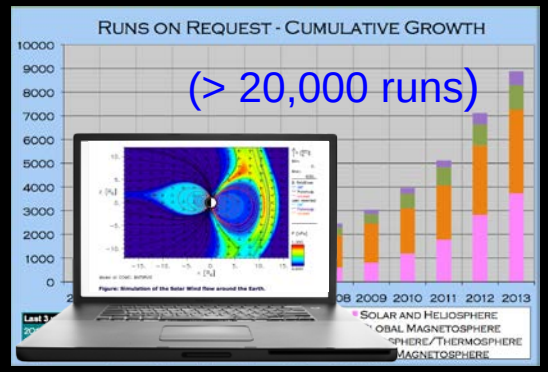
Corona **Heliosphere** **Magnetosphere** Inner Magnetosphere **Ionosphere/Thermosphere**

CCMC Functions

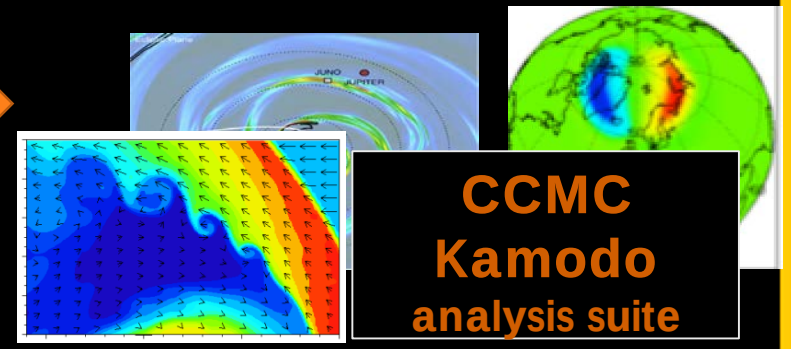
Models



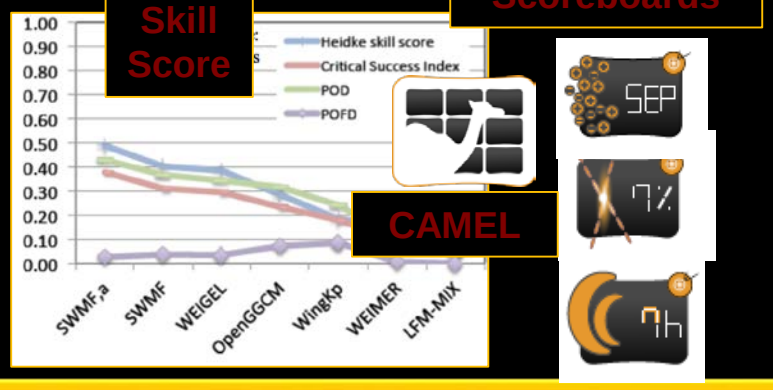
Simulation services



Visualization, dissemination

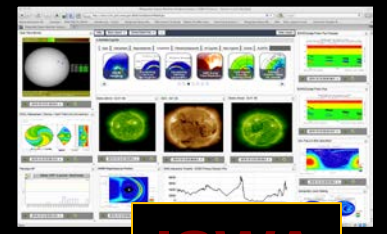


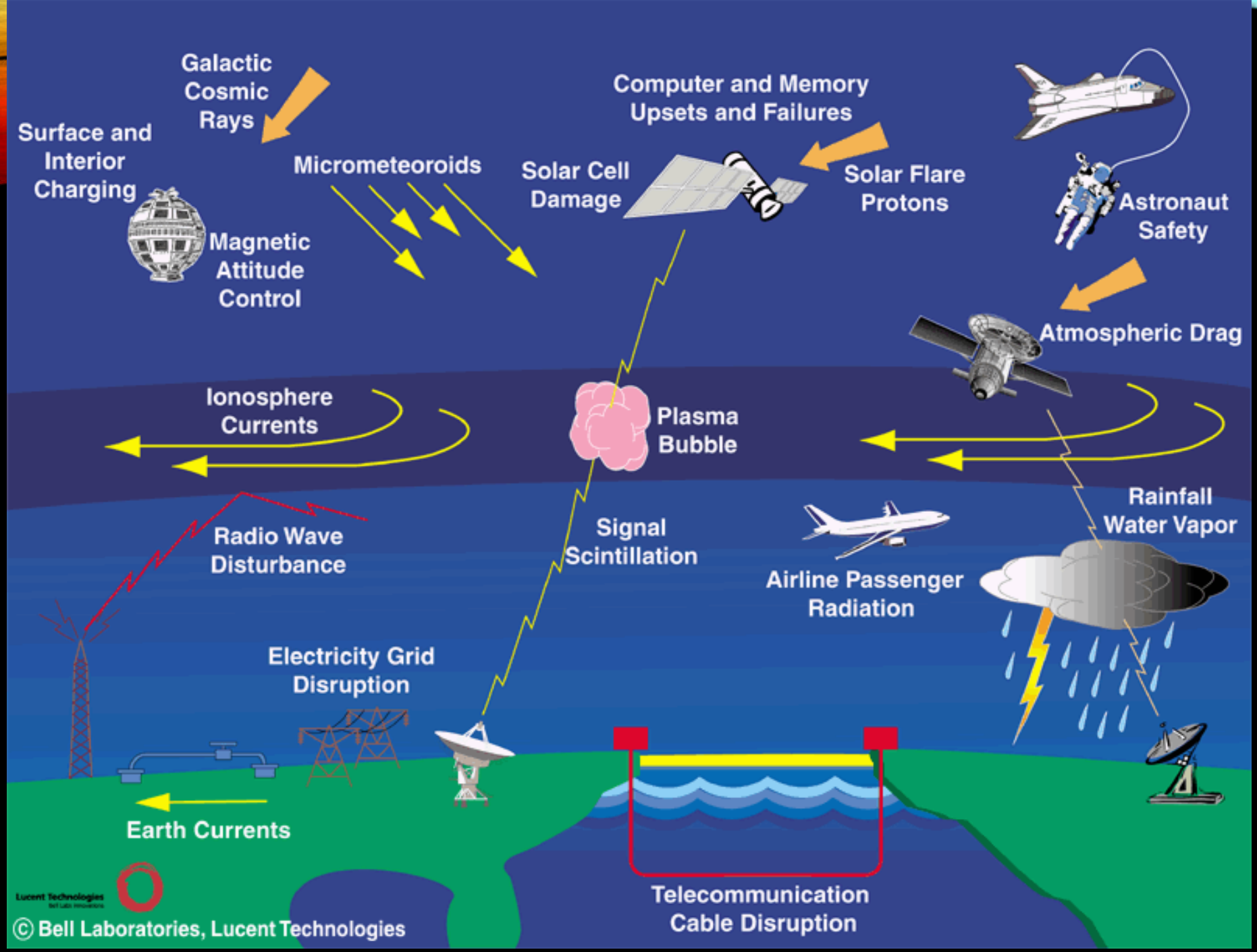
Evaluations, R2O



NASA missions & community Support

Information architecture: perpetual archive




Galactic Cosmic Rays
Surface and Interior Charging
Micrometeoroids
Computer and Memory Upsets and Failures
Solar Cell Damage
Solar Flare Protons
Astronaut Safety
Magnetic Attitude Control
Atmospheric Drag
Ionosphere Currents
Plasma Bubble
Radio Wave Disturbance
Signal Scintillation
Airline Passenger Radiation
Rainfall Water Vapor
Electricity Grid Disruption
Earth Currents
Telecommunication Cable Disruption
Lucent Technologies
© Bell Laboratories, Lucent Technologies

Evaluation and R2O

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

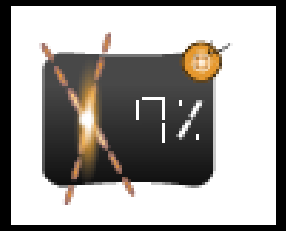
Evaluation of portability, quality of documentation.

Forecasting methods
Scoreboards

Testing predictive capability prior to event onset

CME Scoreboard

Flare Scoreboard



IMF Bz Scoreboard

SEP Scoreboard

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)**

HTTPS://CCMC.GSFC.NASA.GOV/TOOLS/

Run-On-Request System

integrated Space Weather Analysis (iSWA) system

Space Weather Database Of Notifications, Knowledge, Information (DONKI)

Kameleon Software Suite

Stereo CME Analysis Tool (StereoCat)

EEGGL tool: Eruptive Event Generator (Gibson and Low)

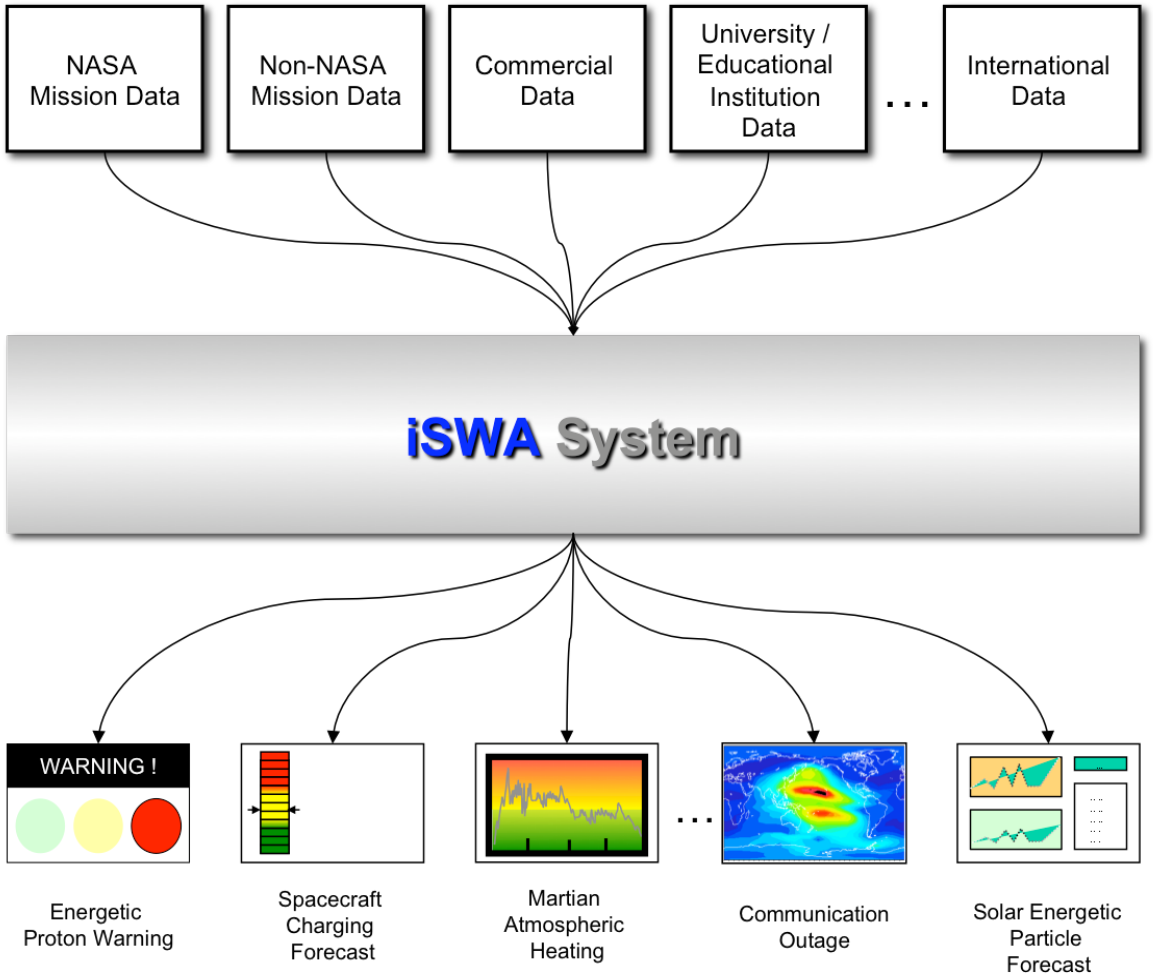
Space Environment Automated Alerts and Anomaly Analysis Assistant (SEA5)

CME Arrival Time Scoreboard

SEP Scoreboard

Flare Scoreboard

iNTEGRATED SPACE WEATHER ANALYSIS SYSTEM

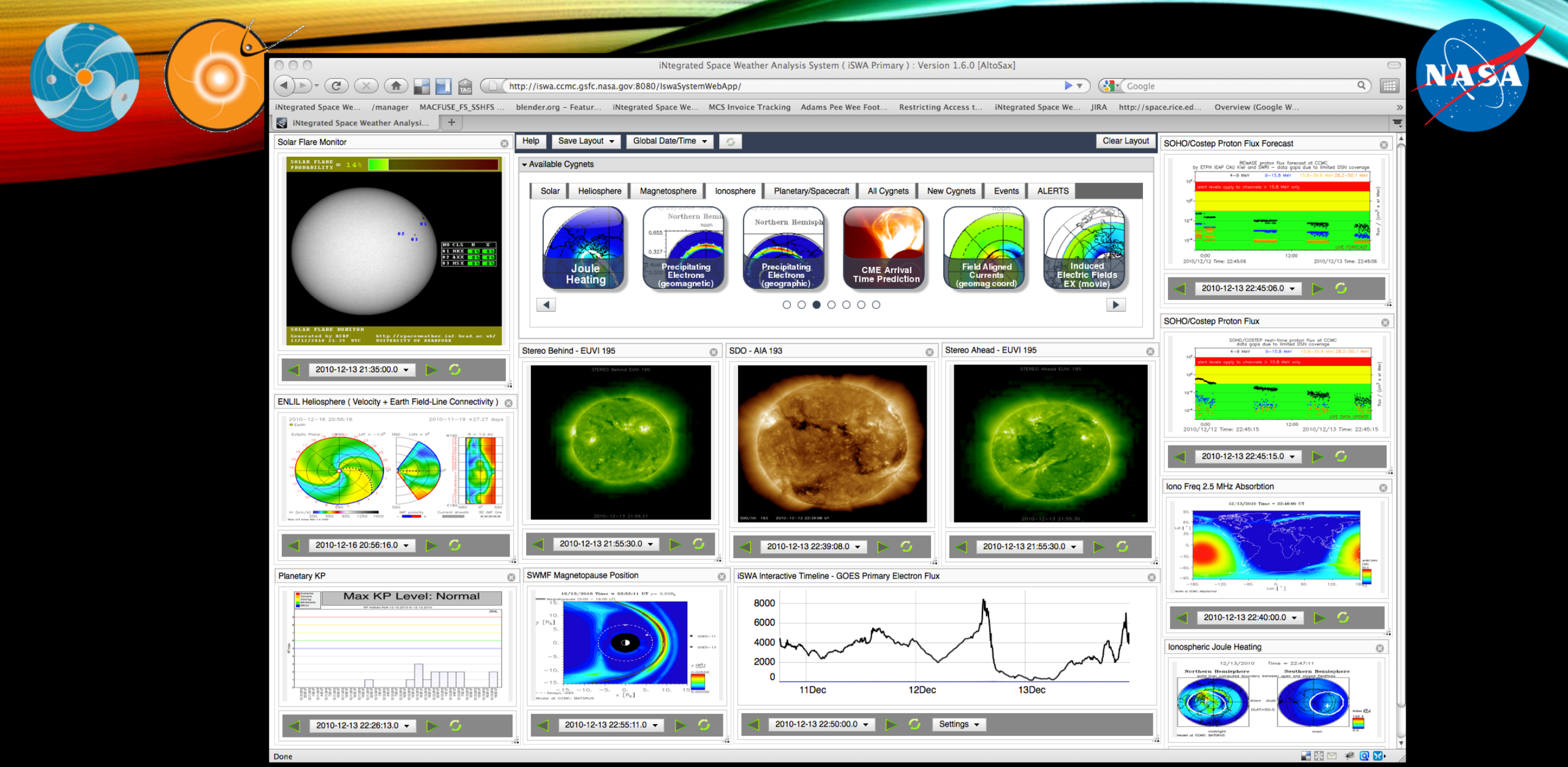


Highly diverse and distributed space weather data consisting of the latest observational data along with the most advanced space weather model simulation output.

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.

iNTEGRATED SPACE WEATHER ANALYSIS SYSTEM



http://iSWA.ccmc.gsfc.nasa.gov

https://ccmc.gsfc.nasa.gov/missionsupport/

Geocentric missions	Missions near-Earth	Heliospheric missions	Sounding Rockets	International
LEO: , RHESSI, IRIS, ISS, CALIPSO, Terra, AURA, AQUA, TRMM, FASTSAT, and NASA's EOS *GSO*: SDO *LEO/Highly Elliptical:* Chandra *Magnetosheric*: MMS, Van Allen Probes, THEMIS	ACE, SOHO, Wind, JWST	MESSENGER, STEREO, Spitzer Space Telescope, MAVEN, MSL, Dawn, Kepler, EPOXI, Juno, CASSINI, New Horizons, Voyager	Grand Challenge Sounding Rocket Campaign, STORM, VISIONS, VISIONS-2	SOTERIA, Venus

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 excepted. Team had to be assembled and kept the activities going for the time needed.

NASA SPACE EXPLORATION AND SPACE WEATHER WORKSHOP

- 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.

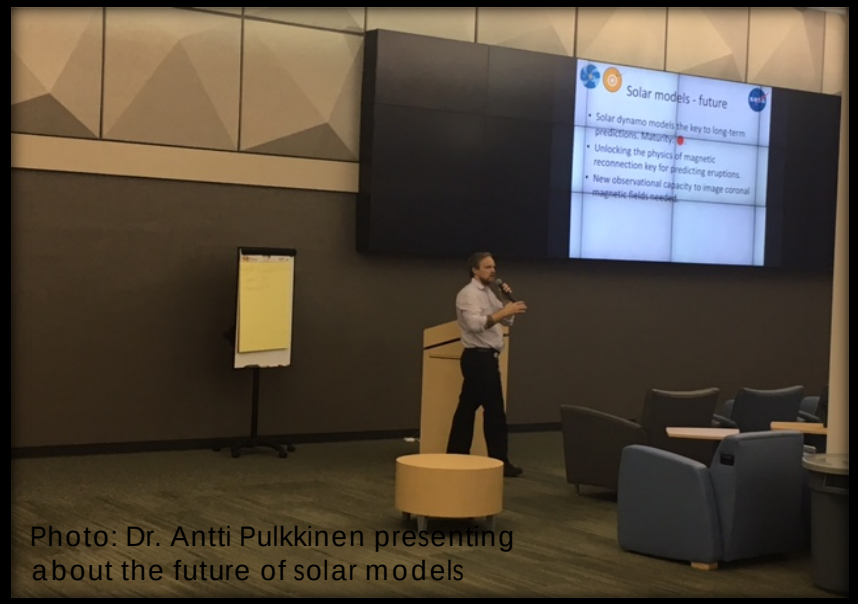
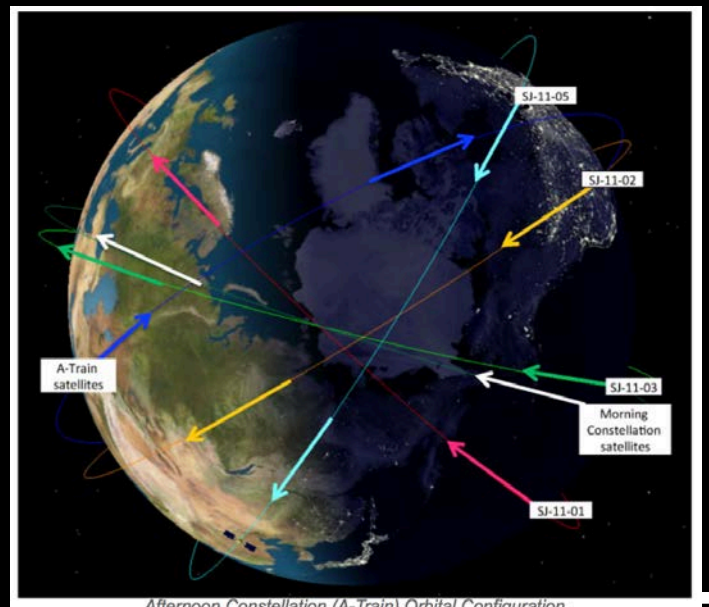


Photo: Dr. Antti Pulkkinen presenting about the future of solar models

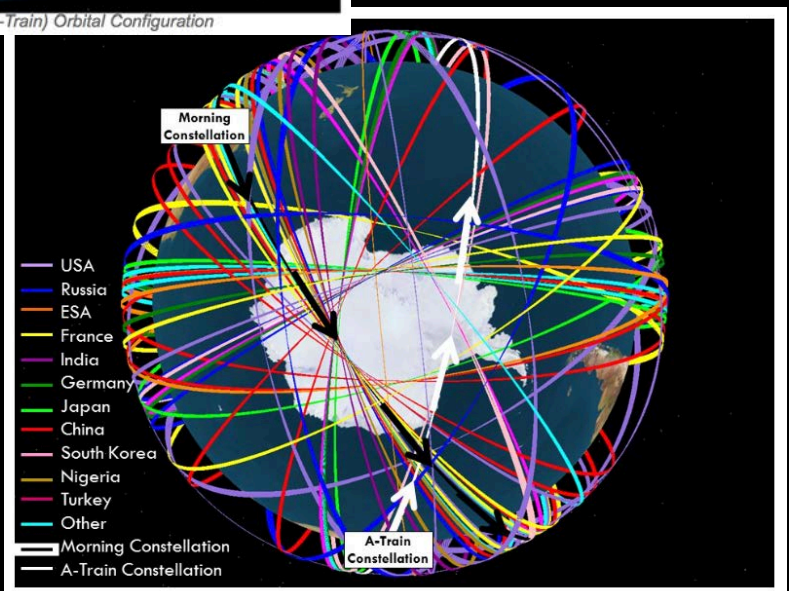
- Originally focused on NASA robotic missions’ needs, the workshops has evolved, through collaboration with Johnson Space Center Space Radiation Analysis Group (SRAG), to include human space exploration needs. During the last two workshops, emphasis has also been given to the operational implications 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.



Afternoon Constellation (A-Train) Orbital Configuration



Satellites near the 705 km Constellation orbit

DONKI

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

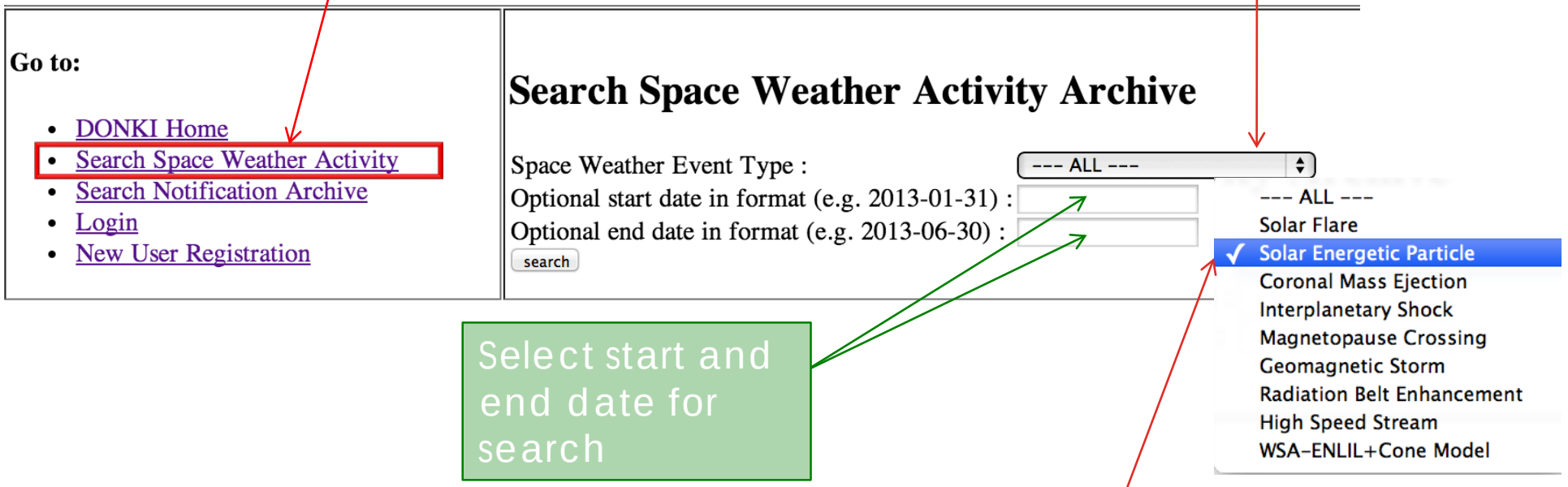
  Comprehensive search functionality to support **anomaly resolution** and **space science research**:

  - 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

DONKI

Search Space Weather Activity Archive

Space Weather Event Type : Solar Energetic Particle

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

Event Type	Activity ID	SEP Event Time	Associated Instrument
Solar Energetic Particle	2013-05-13T04:12:00-SEP-001	2013-05-13T04:12Z	STEREO B: IMPACT 13-100 MeV
Solar Energetic Particle	2013-05-13T18:02:00-SEP-001	2013-05-13T18:02Z	STEREO B: IMPACT 13-100 MeV
Solar Energetic Particle	2013-05-15T13:25:00-SEP-001	2013-05-15T13:25Z	GOES13: SEM/EPS >10 MeV
Solar Energetic Particle	2013-05-22T15:05:00-SEP-001	2013-05-22T15:05Z	GOES13: SEM/EPS >10 MeV
Solar Energetic Particle	2013-05-22T15:05:00-SEP-002	2013-05-22T15:05Z	GOES13: SEM/EPS >100 MeV
Solar Energetic Particle	2013-05-22T15:30:00-SEP-001	2013-05-22T15:30Z	SOHO: COSTEP 15.8-39.8 MeV

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

All columns are sortable! (click column headings)

Search Space Weather Activity Archive

Space Weather Event Type : WSA-ENLIL+Cone Model
Optional start date in format (e.g. 2013-01-31) : 2013-05-03
Optional end date in format (e.g. 2013-06-30) : 2013-05-31
search
Generate Report for WSA-ENLIL+Cone Inputs

Selecting "WSA-ENLIL+Cone Model" lists all CME simulations in a certain date range.

All columns are sortable! (click column headings)

Model Name	Model Completion Time	CME Input(s)	Predicted Earth Impact	Predicted Other Location(s) Impact
WSA-ENLIL+Cone	2013-05-03T09:33Z	• CME: 2013-05-02T14:36:00-CME-001(CME Analysis)	No or little impact to Earth.	
WSA-ENLIL+Cone	2013-05-03T18:07Z	• CME: 2013-05-03T18:00:00-CME-001(CME Analysis)	No or little impact to Earth.	Spitzer: 2013-05-06T14:32Z
WSA-ENLIL+Cone	2013-05-04T12:48Z	• CME: 2013-05-03T18:00:00-CME-001(CME Analysis) • CME: 2013-05-03T22:36:00-CME-001(CME Analysis)	No or little impact to Earth.	Spitzer: 2013-05-06T06:39Z STEREO B: 2013-05-06T16:39Z
WSA-ENLIL+Cone	2013-05-04T13:52Z	• CME: 2013-05-03T18:00:00-CME-001(CME Analysis) • CME: 2013-05-03T22:36:00-CME-001(CME Analysis)	No or little impact to Earth.	Spitzer: 2013-05-06T15:31Z
WSA-ENLIL+Cone	2013-05-05T11:58Z	• CME: 2011-05-24T11:24:00-CME-001(CME Analysis)	Earth Shock Arrival Time = 2011-06-01T02:38Z Duration of disturbance (hr) = Minimum magnetopause standoff distance: Rmin(Re) = 6.6 Possible Kp index: (kp)90=1 (kp)135= (kp)180=5	

Search Space Weather Activity Archive

Shows impact prediction summary for each simulation

Space Weather Event Type : WSA-ENLIL+Cone Model
Optional start date in format (e.g. 2013-01-31) : 2013-05-03
Optional end date in format (e.g. 2013-06-30) : 2013-05-31
search
Generate Report for WSA-ENLIL+Cone Inputs

Model Name	Model Completion Time	CME Input(s)	Predicted Earth Impact	Predicted Other Location(s) Impact
WSA-ENLIL+Cone	2013-05-03T09:33Z	• CME: 2013-05-02T14:36:00-CME-001(CME Analysis)	No or little impact to Earth.	
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WSA-ENLIL+Cone	2013-05-04T12:48Z	• CME: 2013-05-03T18:00:00-CME-001(CME Analysis) • CME: 2013-05-03T22:36:00-CME-001(CME Analysis)	No or little impact to Earth.	Spitzer: 2013-05-06T06:39Z STEREO B: 2013-05-06T16:39Z
WSA-ENLIL+Cone	2013-05-04T13:52Z	• CME: 2013-05-03T18:00:00-CME-001(CME Analysis) • CME: 2013-05-03T22:36:00-CME-001(CME Analysis)	No or little impact to Earth.	Spitzer: 2013-05-06T15:31Z
WSA-ENLIL+Cone	2013-05-05T11:58Z	• CME: 2011-05-24T11:24:00-CME-001(CME Analysis)	Earth Shock Arrival Time = 2011-06-01T02:38Z Duration of disturbance (hr) = Minimum magnetopause standoff distance: Rmin(Re) = 6.6 Possible Kp index: (kp)90=1 (kp)135= (kp)180=5	

Full simulation results for the selected run:

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

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

Impact prediction times

Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-den.gif
Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-vel.gif
Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-den-Stereo_A.gif
Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-den-Stereo_B.gif
Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-vel-Stereo_A.gif
Inner Planets Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_anim.tim-vel-Stereo_B.gif
Timelines Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_ENLIL_CONE_timeline.gif
Timelines Link = http://iswa.gsfc.nasa.gov/downloads/20130503_223000_ENLIL_CONE_Kp_timeline.gif

Links to simulation movies and plots

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

- Repository and dissemination of achievements in space science modeling.
- Hub for collaborative development. Resource for community-wide campaigns.
- Center for R2O transition.
- Provides accurate real-time experimental research forecasting of space environments - and their probable impacts for missions.