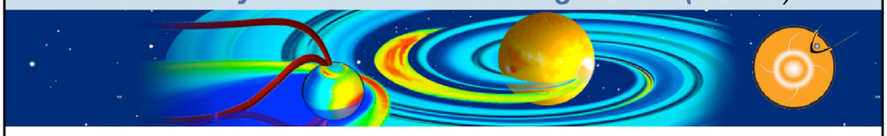
Community Coordinated Modeling Center (CCMC)



Introduction to Space Weather: Tools and Concepts

Space Weather Tools/Products

Yihua Zheng & the CCMC team

Science for Space Weather, Jan 24 – 29, 2016, Goa, India

Outline

- Tools available at CCMC
  - Stereo CAT
  - Coned tool
  - Space Weather scoreboard
    - CME scoreboard
    - Flare scoreboard
    - SEP scoreboard
  - DONKI
  - SEA^5
- Others
  - ISES (International Space Environment Services)
    - NOAA/SWPC
    - Belgium/SIDC
    - Japan/NICT
    - Australia/BoM
    - …
  - ESA/SPENVIS
  - Other space weather prediction/operation centers

Multipurpose Tools, Systems, Databases, Interfaces

Data Management, Metadata, Standardization, Access

KAMELEON

- Science Data Formats, Metadata
- Data Conversion
- Access & Interpolation Library
- Reusable Data Model/Framework

FlexDIT — Flexible Data Ingestion Tool

- Designed to facilitate ingestion of disparate time series data from a variety of sources into CCMC's existing infrastructure
- Describe input data via XML for efficient dataset imports
- Generalized parser works with a variety of formats

Integrated Space Weather Analysis System

- Web-Based Space Weather Dissemination System
- User Configurable, Interactive Products
- Web Services
- Real-Time & Historical Model + Observational Data

StereoCAT CME Analysis Tool

- Determine CME kinematic parameters
- Create CME height-time measurements
- Create an ensemble of CME measurements
- Save and share measurement sessions

Database Of Notifications, Knowledge, Information

- Catalog of space weather phenomena
- Knowledgebase of interpretations, simulation results, and forecasting analysis
- Online tool for dissemination of forecasts, notifications, & archiving event-focused information

EEGGL Eruption Event Generator (Gibson & Low)

- Use observations defining the CME source region (location and flux rope orientation,
- Generate Gibson-Low flux rope parameters for the flux rope emergence models.

Space Weather Scoreboard

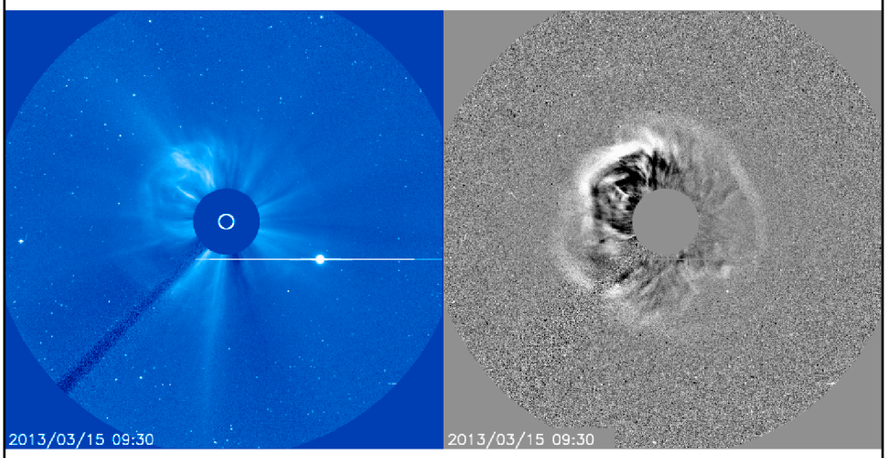
- Research-based forecasting methods validation
- Scientific community submits forecasts in real-time
- View and Compare all forecasting methods

Space Environment Automated Alerts, Anomaly Analysis Assistant (SEA^5)

- Mission/Location Specific Space Environment Tool
- Automated/Custom Alerts & Notifications
- Assimilate & Display Anomaly Information

STEREO CAT

Halo CMEs are CMEs that appear to surround the occulting disk of the coronagraph. The CME can originate from the front or back side of the Sun, and therefore are travelling either towards or away from the observer.



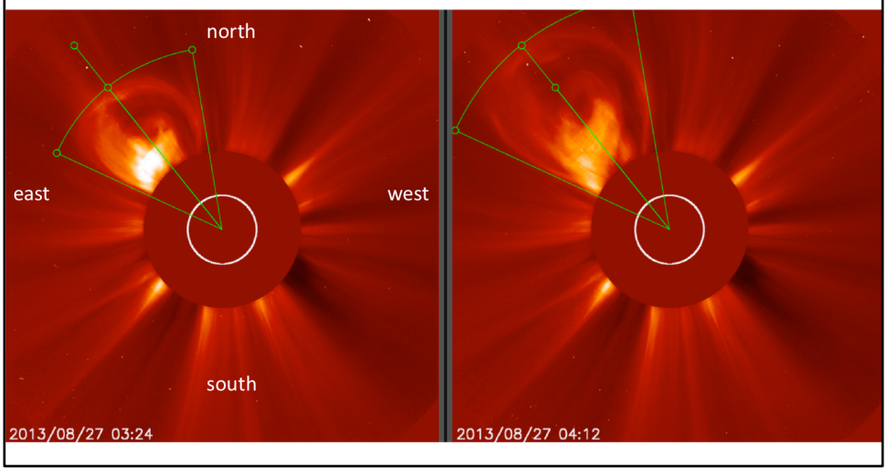
Due to scattering and projection, the CME sides or flanks are detected in these images

Halo CMEs are CMEs that appear to surround the occulting disk of the coronagraph. The CME can originate from the front or back side of the Sun, and therefore are travelling either towards or away from the observer.

Here is an example of a halo CME in SOHO LASCO C3, direct image on the left, difference image on the right. The difference image was created by subtracted the previous frame from the current frame. Some differences are subtracted from a "base" frame a few hours prior to the event.

Due to scattering and projection, the CME sides or flanks are detected in these images, not the leading edge (nose) of the CME.

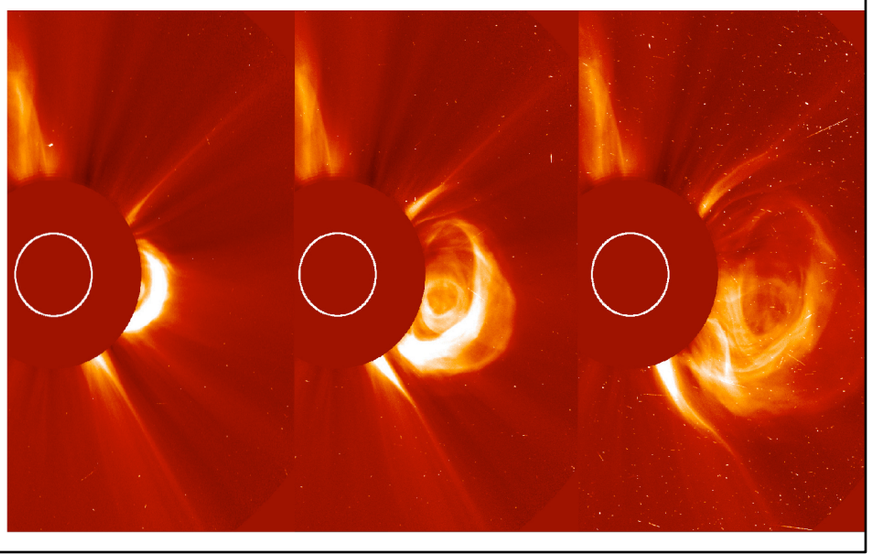
With **coronagraph** data you can measure the leading of the CME at different times. From this you can determine the "**plane-of-sky**" speed by measuring the position of the **leading edge** of the CME at two times. By using **coronagraphs** on various spacecraft, you can get a measurements of this projected speed from various viewpoints.



With **coronagraph** data you can measure the leading of the CME at different times. From this you can determine the "**plane-of-sky**" speed by measuring the position of the **leading edge** of the CME at two times. By using **coronagraphs** on various spacecraft, you can get a measurements of this projected speed from various angles.

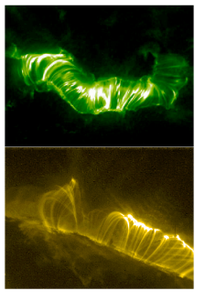
Here are coronagraph images from STEREO Ahead COR2, at two different times. You can the leading edge has been marked in each image. By knowing the height of the CME leading edge at two times, the speed in the plane of the image can be determined.

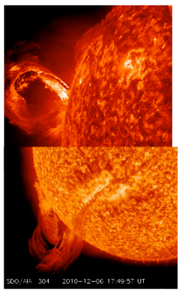
Time progression -> plane-of-sky speed

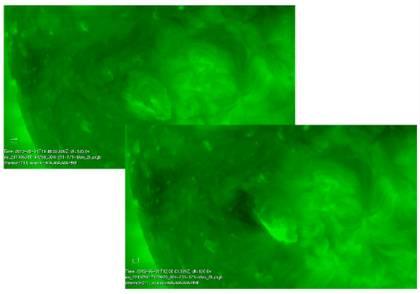


CME source locations/EUV lower coronal signatures of CMEs

* CMEs can originate from active regions and/or from filament eruptions.
* Some CMEs are associated with flares.
* EUV signatures include post eruption arcades, rising loops, coronal dimming, and prominence eruptions (click for example movies).







post eruption arcade prominence eruption coronal dimmings.

filament eruption

Important! Always determine the source location of every CME you analyze.
This can help you decide which coronagraph combinations to choose, and assess the accuracy of the CME parameters you obtain.

Sun Primer: Why NASA Scientists Observe the Sun in Different Wavelengths

More on this topic next Thursday!

CME source locations/EUV lower coronal signatures of CMEs
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EUV lower coronal signatures of CMEs movies

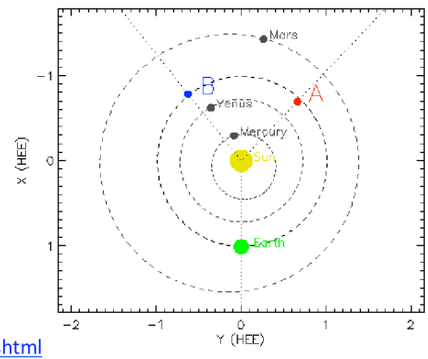
post eruption arcadehttp://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?img1=sta_e195&img2=sta_cor2&stime=20130526_1500&etime=20130527_0000

prominence eruptions http://go.nasa.gov/19Dni3v
http://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?img1=lasc2rdf&img2=sdo_a304&stime=20130430_2200&etime=20130501_0800

filament eruptions http://go.nasa.gov/12qcWDO
http://www.lmsal.com/hek/gallery/podimages/2013/06/01/pod_malanushenko_anna_2013-06-01T02:24:03.851/anny_AIA-304_20130531T113203-20130531T185203_120s_made_20130601T022253_720p.mpg

coronal dimmingshttp://www.lmsal.com/hek/gallery/podimages/2013/06/01/pod_malanushenko_anna_2013-06-01T00:52:07.870/anny_AIA-211_20130531T094003-20130531T145203_120s_made_20130601T005102_720p.mpg
http://cdaw.gsfc.nasa.gov/movie/make_javamovie.php?img1=stb_cor2&img2=stb_e195&stime=20120527_0300&etime=20120527_1600

Know where the coronagraph images are made/location of the spacecraft



http://stereo-ssc.nascom.nasa.gov/where.shtml
Click "STEREO Orbit Tool"

May 14, 2013

Longitude is measured
0 to 180˚ counterclockwise
0 to -180˚ clockwise

HEEQ:
Heliocentric Earth Equatorial
Z=North pole of solar rotation axis
X=intersection between solar equator and solar central meridian as seen from Earth

Use there STEREO website orbit tool (http://stereo-ssc.nascom.nasa.gov/where.shtml) to find the HEEQ coordinates of the STEREO spacecraft and see a graph. This will help you determine which quadrants the CME longitude could be in just by looking at the geometry.

HEEQ coordinates is defined as:
X=intersection between solar equator and solar central meridian as seen from Earth
Z= North Pole of the solar rotation axis.

Earth is at 0 degrees longtiude in this coordinate system. Longitude is measure from 0 to 180 degrees counterclockwise and 0 to -180 degrees clockwise.

For example, on this date (14 May 2013) STEREO A is at 136 degrees longitude. A CME seen going to the right (west) in a SOHO LASCO image which is seen going to the left (east) in a STEREO COR2A image, must have a longitude between these two spacecraft, so between 0 and 136 longitude. If this CME is also observed by STEREO COR2B as moving to the left (east), this further constrains the longitude to be the eastern side of STEREO B's view. STEREO B is at -141 degrees longitude on this date, so the eastern quadrant is between 39 degrees and -141 degrees. So putting this all together, the CME longitude must be between 39 and 136 degrees longitude.

Example 2: (On this date) if you view a full symmetric halo in SOHO LASCO and the source location is on the backside of the Sun, the longitude is likely near 180 degrees. If you view a full symmetric halo in STEREO A, but the source is on the front side of the sun (visible in SDO), the the longitude is likely near the opposite of STEREO A (located at 136 deg), so about -44 degrees.

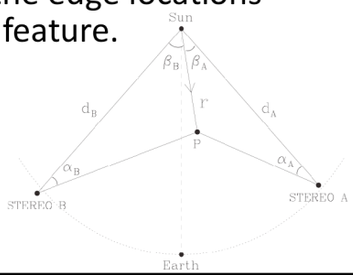
Geometric Triangulation

- Measuring the **same feature** (assumption) in two coronagraphs and using simple geometric relations to derive CME position and speed
- Observations are integrated line-of sight information through a 3D structure – projection effects, and scattering amplitudes impact the feature being measured!
- Note: StereoCAT does not use the edge locations (width) when triangulating the feature.

$$\frac{r\sin(\alpha_A+\beta_A)}{\sin\alpha_A}=d_A,$$

$$\frac{r\sin(\alpha_B+\beta_B)}{\sin\alpha_B}=d_B,$$

$$\beta_A+\beta_B=\gamma,$$



Very important! The main assumption of geometric triangulation is that you are measuring the **same feature** (assumption) in two coronagraphs and using simple geometric relations to derive CME position and speed. But remember observations are integrated line-of sight information through a 3D structure – projection effects, and scattering amplitudes impact the feature being measured!

CME analysis Procedure with StereoCAT

* Identify the CME and the start time. (The CME start time is the time it is first observed by any of the four coronagraphs)
* Observe all available coronagraph images in motion. Look for the same CME leading edge feature in various spacecraft.
* Look at EUV images in motion near the CME start time and identify the source location and any lower coronal signatures (post eruption arcade, dimming, rising loops, filament eruption).

Go to StereoCAT: http://ccmc.gsfc.nasa.gov/analysis/stereo/

* Select two overlapping times for each spacecraft pair available. Times should be around 45-75 minutes apart, and try to choose times just before the CME leading edge has left the field of view. It is useful to refer back to the CME movies while selecting images.
* Perform plane of sky measurements CME leading edge and obtain triangulation results if appropriate. Determine final CME parameters (radial speed, half width, longitude, latitude, and time at 21.5 Rs (solar radii)).

Resources & iSWA layouts
** StereoCAT: http://ccmc.gsfc.nasa.gov/analysis/stereo/*
** 40 Frame coronagraph and EUV movies http://go.nasa.gov/16bTvzK*
** Where is STEREO? http://stereo-ssc.nascom.nasa.gov/where.shtml*
and http://stereo-ssc.nascom.nasa.gov/cgi-bin/make_where_gif
** Solar Images with grid overlays http://www.solarmonitor.org/*

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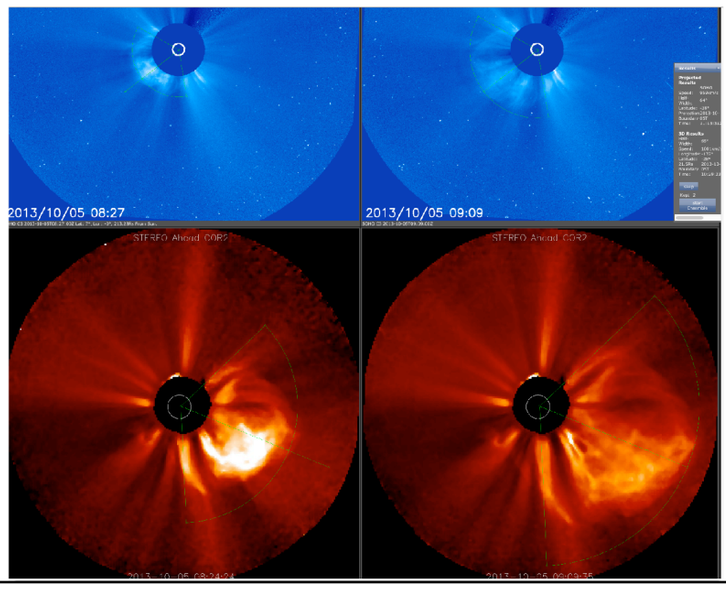
StereoCAT example



Oct 5, 2013 CME

http://ccmc.gsfc.nasa.gov/analysis/stereo/?s=iswa.ccmc.gsfc.nasa.gov&v=3&c=_2__t_t_OJNbhwI_OJNpIZO_0_1rLi_0_2Vvq_0_1rLi_0_-M1a_0_-V86_0_-M1a__5_UY_WC_5rFM_3nb_5rFM_4s9_5rFM_2d6_UY_WC_8Urj_3nb_8Urj_4s9_8Urj_2d6_V0_V0_7WDA_5tI_7WDA_lR_7WDA_4kr_V0_V0_AIe7_5tI_AIe7_lR_AIe7_4kr_t____t_t_OJNbhwI_OJNpIZO_0_1rLi_0_2Vvq_0_1rLi_0_-M1a_0_-V86_0_-M1a__5_UY_WC_5kJH_3oP_5kJH_4uB_5kJH_2d6_UY_WC_8Sw1_3oP_8Sw1_4uB_8Sw1_2d6_V0_V0_78xa_61Q_78xa_h3_78xa_5Ac_V0_V0_AK9F_61Q_AK9F_h3_AK9F_5Ac_t___0_0_0_--__t_t_OJNbhwI_OJNpIZO_0_1rLi_0_2Vvq_0_1rLi_0_-M1a_0_-V86_0_-M1a__5_--___2__t_

CME Scoreboard

CME Arrival Time Scoreboard

developed at the CCMC

The CME scoreboard is a research-based forecasting methods validation activity which provides a central location for the community to:

- submit their forecast in real-time
- quickly view all forecasts at once in real-time
- compare forecasting methods when the event has arrived

http://swrc.gsfc.nasa.gov/main/cmemodels
http://kauai.ccmc.gsfc.nasa.gov/SWScoreBoard

Currently registered models include:
Anemomilos, ESA Model, H3DMHD (HAFv.3 +3DMHD), HAFv.3, STOA, WSA-Enlil + Cone Model, BHV Model, DBM, ECA Model, HelTomo, HI J-map technique, TH Model

The scoreboard also includes predictions from the SWRC (Space Weather Research Center) which is a CCMC branch carrying out in-house research-based space weather ops team

http://kauai.ccmc.gsfc.nasa.gov/SWScoreBoard
Anyone can view predictions, please register to submit predictions.

Login

Space Weather ScoreBoard

Using this system, if you are a registered user, you can enter in your CME shock arrival time forecast. Begin by clicking "Add Prediction" under the "Active CMEs" section and select your forecasting "Method Type" from the list. Click here to see a list of registered methods. If you would like to register your prediction method, please send an email to M. Leila Mays or Yihua Zheng with your model/technique details.

Active CMEs

No Active CME

Past CMEs

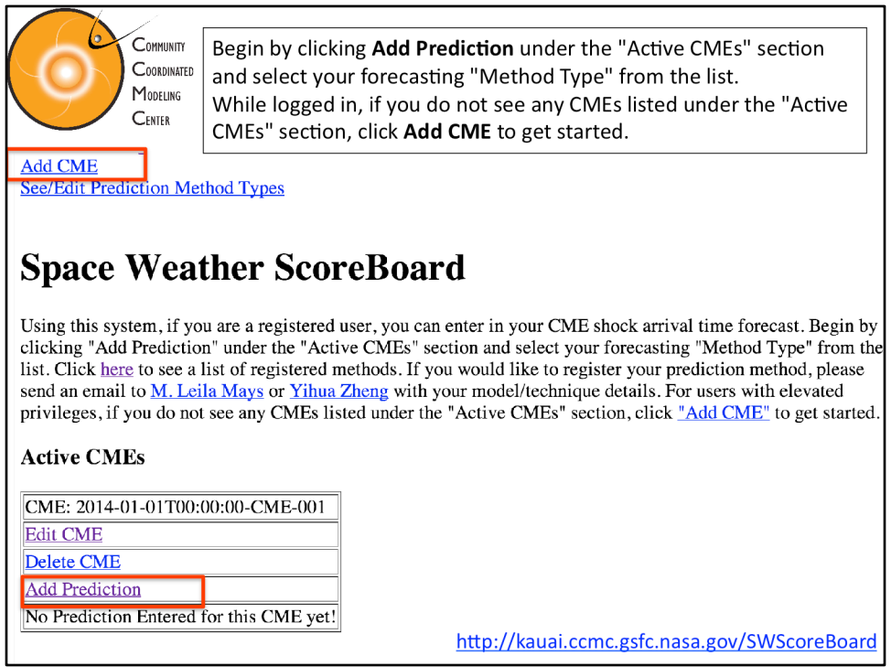
CME: 2013-03-15T06:54:00-CME-001 (SWA Layout URL)

Actual Shock Arrival Time: 2013-03-17T05:28Z

Observed Geomagnetic Storm Parameters:
Max Kp: 6.33
Dst min. in nT: -132
Dst min. time: 2013-03-17T21:00Z

Predicted Shock Arrival Time	Difference (hrs)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By	
2013-03-17T09:00Z	3.53	2013-03-16T01:26Z	31.57	----	ESA	Leila Mays (GSFC)	Detail
2013-03-17T01:00Z	-4.47	2013-03-15T13:00Z	36.00	Dst min. in nT: -139 Dst min. time: 2013-03-17T11:00Z	Anemomilos	Leila Mays (GSFC)	Detail
2013-03-17T10:46Z	5.30	2013-03-16T10:41Z	24.08	----	DBM	Leila Mays (GSFC)	Detail
2013-03-17T00:00Z	-5.47	2013-03-15T23:30Z	24.50	----	Other (ips.gov.au)	Leila Mays (GSFC)	Detail
2013-03-17T00:00Z	-5.47	2013-03-16T00:39Z	23.35	----	H3DMHD (HAFv.3+3DMHD)	Leila Mays (GSFC)	Detail
2013-03-16T20:00Z	-9.47	2013-03-15T11:43Z	32.28	Max Kp Range: 5.0 - 6.0	WSA-Enlil + Cone (NOAA/SWPC)	Leila Mays (GSFC)	Detail
2013-03-17T15:00Z	9.53	2013-03-16T12:29Z	26.52	Max Kp Range: 7.0 - 7.0	BHV	Leila Mays (GSFC)	Detail
2013-03-16T16:59Z (-7.0h, +7.0h)	-12.48	2013-03-15T14:04Z	26.92	Max Kp Range: 6.0 - 8.0	WSA-Enlil + Cone (GSFC SWRC)	Leila Mays (GSFC)	Detail
2013-03-18T13:00Z	31.53	2013-03-15T13:19Z	71.68	----	Other (SIDC)	Leila Mays (GSFC)	Detail

Columns are sortable


Community Coordinated Modeling Center
Begin by clicking **Add Prediction** under the "Active CMEs" section and select your forecasting "Method Type" from the list.
While logged in, if you do not see any CMEs listed under the "Active CMEs" section, click **Add CME** to get started.
Add CME
See/Edit Prediction Method Types
Space Weather ScoreBoard
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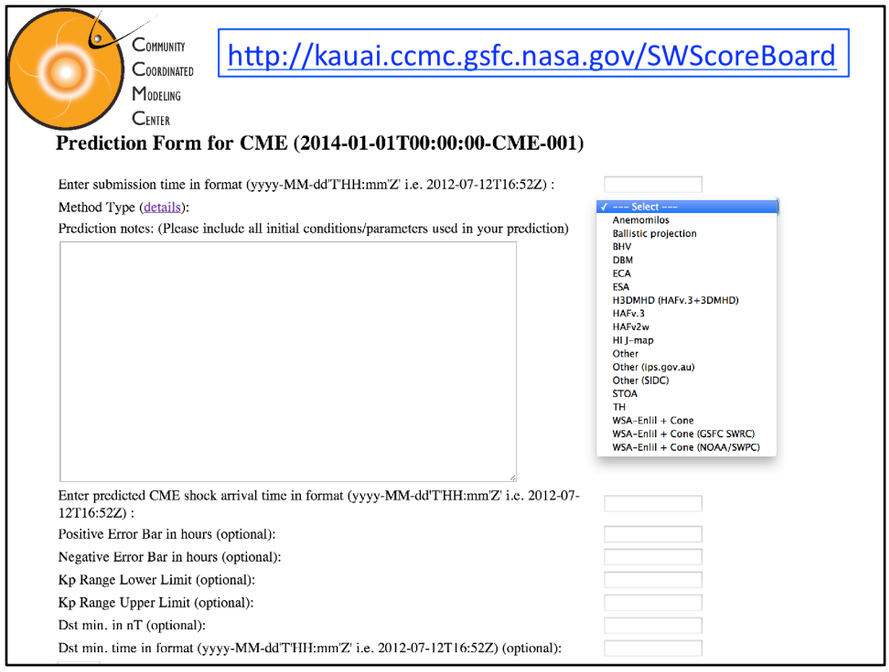
Active CMEs
CME: 2014-01-01T00:00:00-CME-001
Edit CME
Delete CME
Add Prediction
No Prediction Entered for this CME yet!
http://kauai.ccmc.gsfc.nasa.gov/SWScoreBoard


COMMUNITY
COORDINATED
MODELING
CENTER
http://kauai.ccmc.gsfc.nasa.gov/SWScoreBoard
Prediction Form for CME (2014-01-01T00:00:00-CME-001)
Enter submission time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) :
Method Type (details):
Prediction notes: (Please include all initial conditions/parameters used in your prediction)
--- Select ---
Anemomilos
Ballistic projection
BHV
DBM
ECA
ESA
H3DMHD (HAFv.3+3DMHD)
HAFv.3
HAFv2w
HI J-map
Other
Other (ips.gov.au)
Other (SIDC)
STOA
TH
WSA-Enlil + Cone
WSA-Enlil + Cone (GSFC SWRC)
WSA-Enlil + Cone (NOAA/SWPC)
Enter predicted CME shock arrival time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) :
Positive Error Bar in hours (optional):
Negative Error Bar in hours (optional):
Kp Range Lower Limit (optional):
Kp Range Upper Limit (optional):
Dst min. in nT (optional):
Dst min. time in format (yyyy-MM-dd'T'HH:mm'Z' i.e. 2012-07-12T16:52Z) (optional):

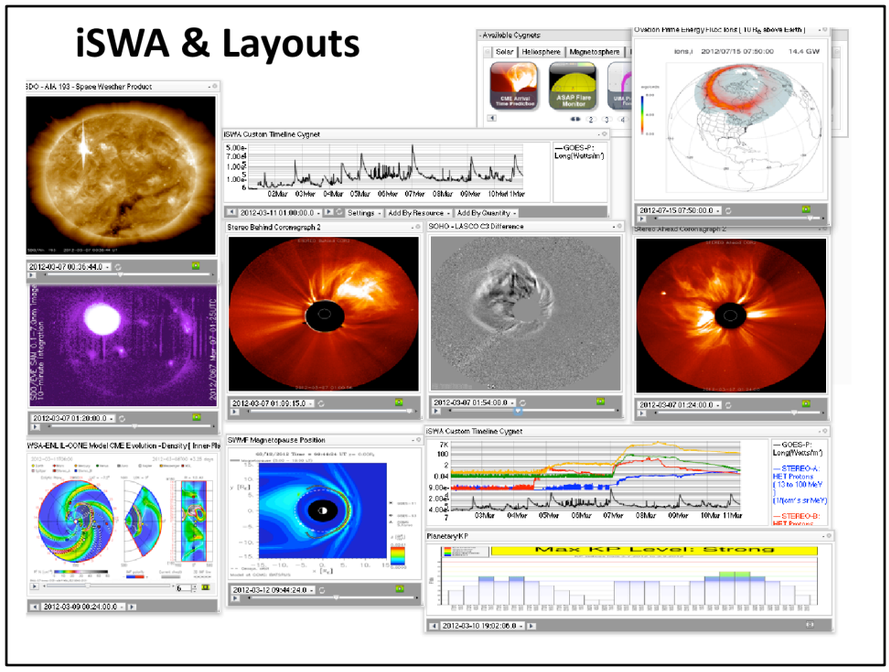
DONKI (Database of Notifications, Knowledge, Information)

facilitate connecting space weather phenomena to satellite effects

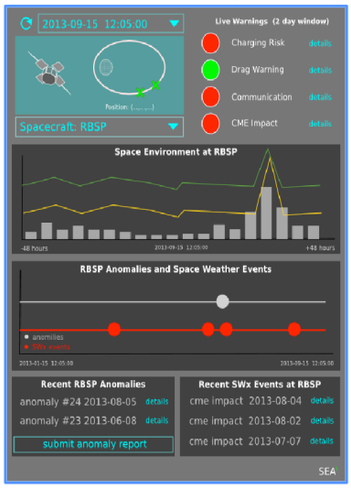
- Catalog of space weather phenomena.
- Chronicles the daily interpretations of space weather observations, simulation results, forecasting analysis, and notifications.
- Intelligent linkages, relationships, cause-and-effects between space weather activities (will add spacecraft anomaly/interesting spacecraft event info)
- 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
  - SWRC's space weather notification and weekly report archive
- …

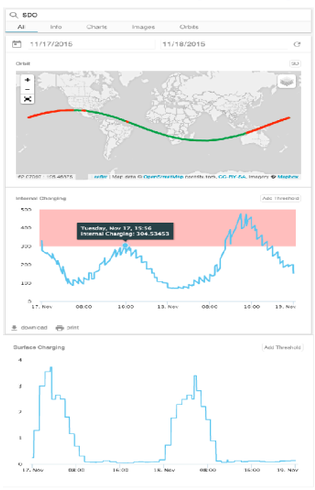
http://kauai.ccmc.gsfc.nasa.gov/DONKI/

iSWA & Layouts



The Space Environment Automated Alerts Anomaly Analysis Assistant (SEA5)

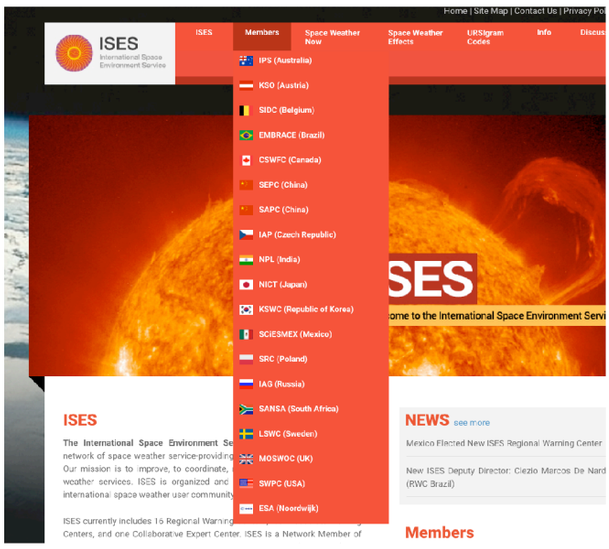




Non CCMC Tools
From the international community

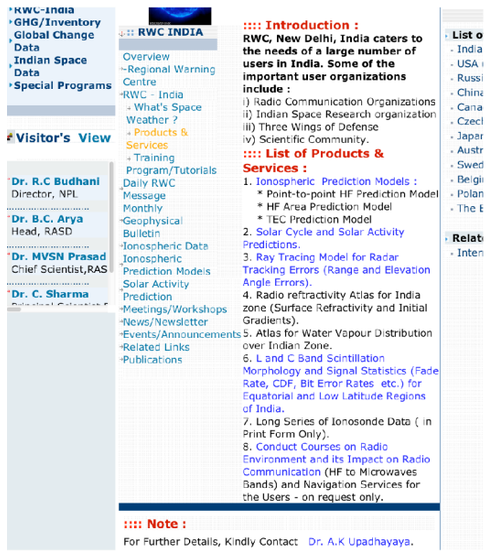
By no means an exhaustive list

International Space Environment Service



http://www.spaceweather.org/index.jsp

RWC in India



National Physical Laboratory, New Delhi

http://cgc.nplindia.org/atul/cgc/rwc/product.htm

Highlights of Space Weather Service Products

- NOAA SWPC
  - http://www.swpc.noaa.gov/
- SIDC
  - http://sidc.oma.be/
- Japan/NICT
  - http://swc.nict.go.jp/contents/index_e.php

SPENVIS
The SPace ENVironment Information System

- coordinate generators
- radiation sources and effects
- spacecraft charging
- atmosphere and ionosphere
- magnetic field
- meteroroids and debris
- data base queries
- Miscellaneous
- Geant4 tools
- ECSS space environment standard
  - http://space-env.esa.int/ECSS/ecss_10_04.html
- Planetary environment

SPENVIS
The Space Environment Information System

Particularly popular for engineers

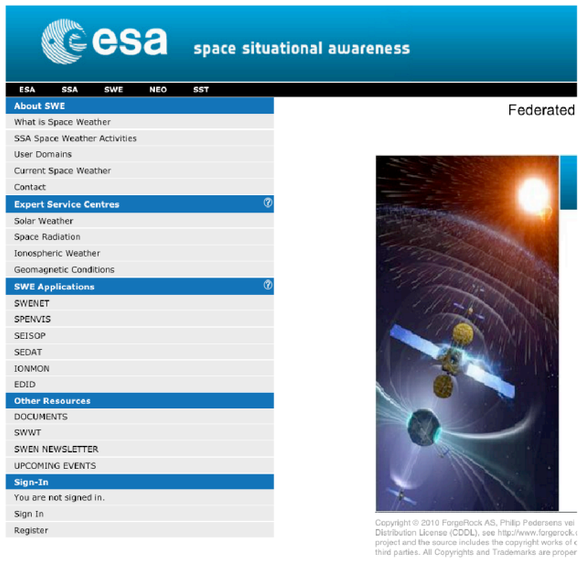
https://www.spenvis.oma.be/models.php

http://space-env.esa.int/ECSS/ecss_10_04.html

The European Co-operation for Space Standardization

http://www.spaceweather.eu/sl/model_access_interface

ESA's space weather portal



SWE applications

- The Space Weather European Network
  - http://www.spaceweather.eu/sl/node/234
- SEISOP (Space environment information system for opearations)
  - http://www.esa.int/Our_Activities/Space_Engineering_Technology/SEISOP_Space_Environment_Information_System_for_Ope
  - SEDAT (space environment data system)
  - IONMON(the IONosphere MONitoring facility)
  - EDID (European Debris Impact Database)

Space weather related applications

Space Radiation Products/sites

- AVIDOS (radiation dosimetry for aviation)
- ANeMOS (Ground Level Enhancement (GLE) event alert – using multistation neutron monitor data)
- SEPsFLAREs (*García-rigo, A et al.)*
- FORSPEF (*Anastasiadis, A et al.)*
- KREAM *(Korean Radiation Exposure Assessment Model for Aviation, Huang 2014*)
- WASAVIES (Kataoka et al., 2014)
- PANDOCA (Matthia et al., 2014)
- SEPEM (Crosby et al, 2015)
- Solar Particle Radiation SWx (SPARX)

Hwang, J., K. Dokgo, E. Choi, K.-C. Kin, H.-P. Kim, and K.-S. Cho (2014), Korean Radiation Exposure Assessment Model for aviation route dose: KREAM, KSS Fall meeting, Jeju, Korea, 29–31 Oct.

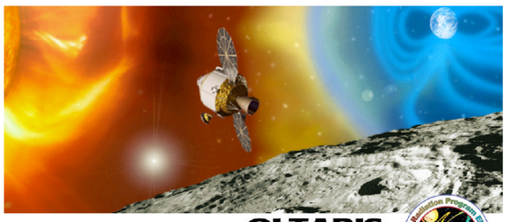
Tobiska, W. K., et al. (2015), Advances in Atmospheric Radiation Measurements and Modeling Needed to Improve Air Safety, Space Weather, 13, 202–210, doi: 10.1002/2015SW001169.

Matthiä, D., M. M. Meier, and G. Reitz (2014), Numerical calculation of the radiation exposure from galactic cosmic rays at aviation altitudes with the PANDOCA core model, Space Weather, 12, 161–171, doi: 10.1002/2013SW001022.

Crosby, N., D. Heynderickx, P. Jiggens, A. Aran, B. Sanahuja, P. Truscott, F. Lei, C. Jacobs, S. Poedts, S. Gabriel, et al. (2015), SEPEM: A tool for statistical modeling the solar energetic particle environment, Space Weather, 13, 406–426, doi: 10.1002/2013SW001008.

Marsh, M. S., S. Dalla, M. Dierckxsens, T. Laitinen, and N. B. Crosby (2015), SPARX: A modeling system for Solar Energetic Particle Radiation Space Weather forecasting, Space Weather, 13, 386–394. doi:10.1002/2014SW001120.

OLTARIS: On-Line Tool for the Assessment of Radiation in Space



User Name
Password
Sign in

OLTARIS
On-Line Tool for the Assessment of Radiation In Space

Space Radiation Program Element
NASA

+ Sign up | + Forgot your password?

+ Documentation and Links

Welcome to OLTARIS, the **O**n- **L**ine **T**ool for the **A**ssessment of **R**adiation in **S**pace. OLTARIS is an integrated tool set utilizing HZETRN (High Charge and Energy Transport). These tools are intended to help scientists and engineers study the effects of space radiation on shielding materials, electronics, and biological systems. This site is intended for users knowledgeable about space radiation and shielding concepts. A users guide and some reference documentation can be found under the *Documentation and Links* page linked above.

New Features

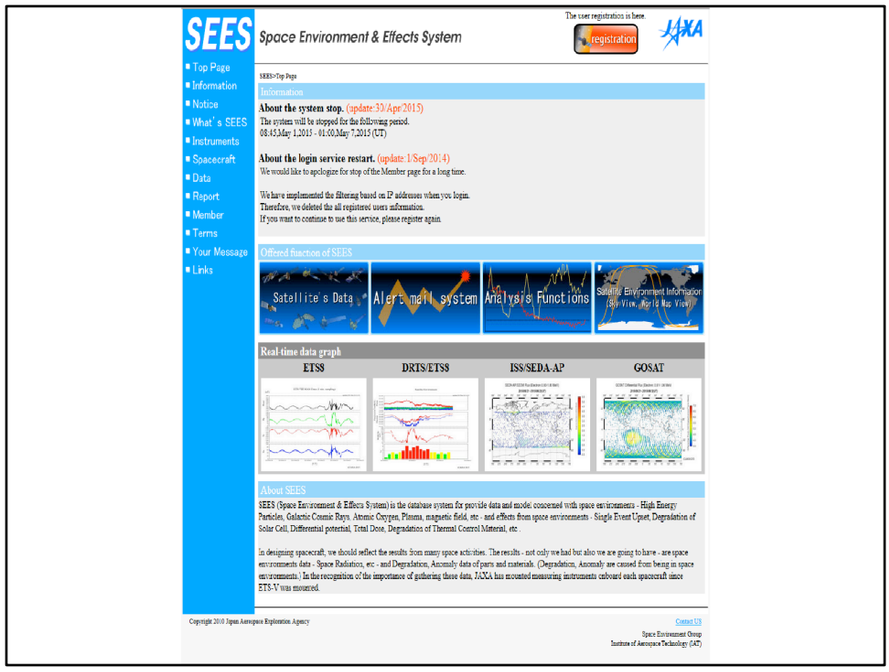
- Added the Matthiä 2013 GCR model.
- Added the option to use the Mars Climate Database (MCD) as the atmospheric model for Mars surface environments.
- Add LET response for slab and sphere geometries plus ray-by-ray transport jobs.
- The Badhwar-O'Neill 2010 GCR model has been added and is now the default. The 2004 model is also still available.
- Lunar albedo neitrons have been added to the Lunar surface environments for both interpolation-based and ray-by-ray based jobs.

Registration

There are no charges associated with the use of OLTARIS, but users must register and get approval from the site administrators before accessing the site contents. New users should click the *Sign up* link above and complete the *OLTARIS Sign Up* page. After registration is complete, one of the site administrators will activate your account when approved, and confirmation will be sent to the supplied email address.

System Requirements

OLTARIS requires a standard browser with JavaScript and Adobe Flash support.


SEES
Space Environment & Effects System
The user registration is here.
registration
JAXA
Top Page
Information
Notice
What's SEES
Instruments
Spacecraft
Data
Report
Member
Terms
Your Message
Links
SEES>Top Page
Information
About the system stop. (update:30/Apr/2015)
The system will be stopped for the following period.
08:45,May 1,2015 - 01:00,May 7,2015 (UT)
About the login service restart. (update:1/Sep/2014)
We would like to apologize for stop of the Member page for a long time.
We have implemented the filtering based on IP addresses when you login.
Therefore, we deleted the all registered users information.
If you want to continue to use this service, please register again.
Offered function of SEES
Satellite's Data
Alert mail System
Analysis Functions
Satellite Environment Information (3D View, World Map View)
Real-time data graph
ETS8
DRTS/ETS8
ISS/SEDA-AP
GOSAT
About SEES
SEES (Space Environment & Effects System) is the database system for provide data and model concerned with space environments - High Energy Particles, Galactic Cosmic Rays, Atomic Oxygen, Plasma, magnetic field, etc. - and effects from space environments - Single Event Upset, Degradation of Solar Cell, Differential potential, Total Dose, Degradation of Thermal Control Material, etc.
In designing spacecraft, we should reflect the results from many space activities. The results - not only we had but also we are going to have - are space environments data - Space Radiation, etc - and Degradation, Anomaly data of parts and materials. (Degradation, Anomaly are caused from being in space environments.) In the recognition of the importance of gathering these data, JAXA has mounted measuring instruments onboard each spacecraft since ETS-V was mounted.
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