



CCMC Tools and Resources in the context of SEESAW

*Yihua Zheng, Masha Kuznetsova, Antti
Pulkkinen, M. Leila Mays, and the
CCMC/SWRC team*

NASA Goddard Space Flight Center



Space Environment Engineering and Science
Applications Workshop

Multipurpose Tools, Systems, Databases, Interfaces



Integrated Space Weather Analysis System


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

Database Of Notifications, Knowledge, Information (DONKI)



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

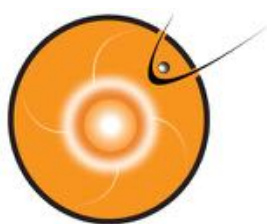
Space Weather Scoreboards

- 
- The icon for Space Weather Scoreboards shows a dark grey rectangular device with two digital displays showing the numbers '8' and '7'. Above the device are two small circular icons: one with a sun and one with a globe.
- Research-based forecasting methods validation
 - Scientific community submits forecasts in real-time
 - View and Compare all forecasting methods

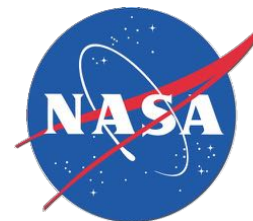
Space Environment Automated Alerts, Anomaly Analysis Assistant (SEA⁵)



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



Innovative Dissemination: iSWA



ISWA has >400 products including modeling results and comprehensive sets of observational data.



**Web-based. User configurable. Available world-wide.
One-stop shop for state-of-the-art information!
<http://iswa.gsfc.nasa.gov>**



SWRC Prompts the Development of Community Wide Ensemble Forecasting Via Scoreboards



- Collecting and displaying event forecasts from multiple models in **Forecasting Methods Scoreboards**
- Generate experimental international community-wide ensemble forecasts.
- Demonstrate operational potential to users.



CME Scoreboard

Leads: **CCMC** (L. Mays)



Flare Scoreboard

Leads: **ROB** (J. Adries)

Trinity College Dublin (S. Murray)



SEP Scoreboard

Leads: **BIRA-IASB**(M. Dierckxsens, N. Crosby)

UK Met Office (M. Marsh)

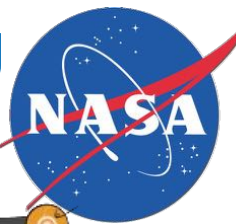
> 20 participating models / expert groups world-wide





Engaging the whole community in forecasting CME arrival

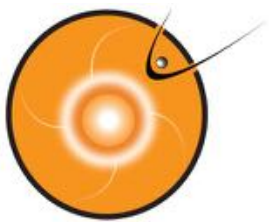
Community Ensemble (from different CME models)



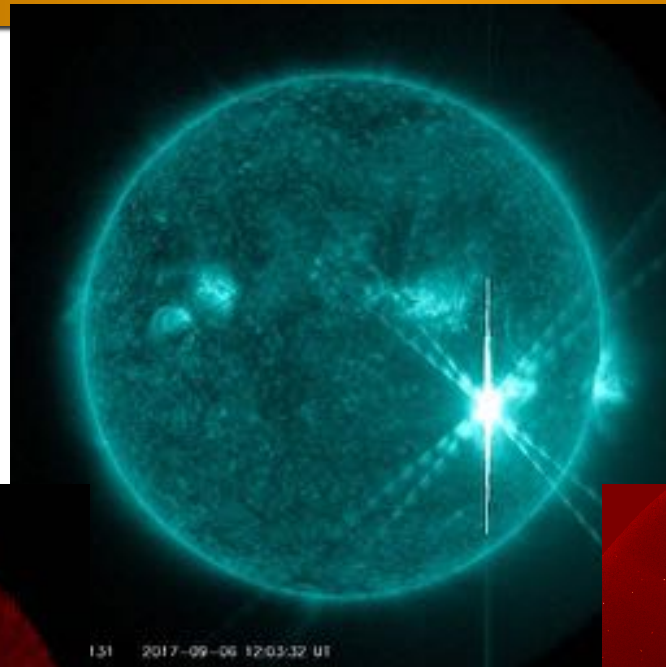
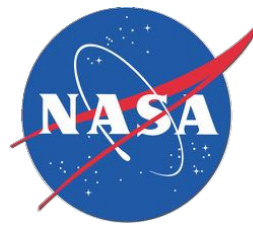
CME: 2014-01-07T08:24:00+00:00
 Actual Shock Arrival Time: 2014-01-07T19:12Z
 Observed Geomagnetic Storm Parameters
 Max Kp: 7.0

Forecast Shock Arrival Time	Inference Class	Submitted On	Lead Time (hrs)	Forecast Geomagnetic Storm Parameters	Method
2014-01-07T19:24Z (+10h, +10h)	4.00	2014-01-07T12:00Z	4.50	---	SWFA
2014-01-07T19:32Z (+7h, +7h)	10.00	2014-01-07T08:00Z	4.00	Max Kp Range: 4.0 - 4.0	SWFA ENLIL + Coas (GSEP SWBC)
2014-01-07T19:00Z	10.75	2014-01-07T08:00Z	4.00	Max Kp Range: 4.0 - 7.0	SWFA ENLIL + Coas (MAGSWBC)
2014-01-07T12:00Z	---	---	---	Obs min. Kp: 7.0	Assessment
2014-01-07T19:12Z (+4h, +4h)	---	---	---	---	Ensemble SWFA ENLIL + Coas (GSEP SWBC)
2014-01-07T19:30Z (+3h, +3h)	---	---	---	---	Obs (SEC)
2014-01-07T12:00Z	5.00	2014-01-07T08:00Z	3.00	---	LLS
2014-01-07T12:00Z (+7h, +7h)	7.50	2014-01-07T08:00Z	3.00	---	SWFA ENLIL + Coas
2014-01-07T19:00Z (+4h, +4h)	10.75	2014-01-07T08:00Z	3.00	---	ENSE
2014-01-07T19:00Z (+3h, +3h)	8.50	2014-01-07T14:00Z	2.00	Max Kp Range: 4.0 - 4.0 Obs min. Kp: 7.0	ENSELSE
2014-01-07T19:00Z	10.00	2014-01-07T16:00Z	2.00	---	Empirical Speed Prediction Model
2014-01-07T19:00Z	17.75	2014-01-07T12:00Z	2.00	Max Kp Range: 4.0 - 4.0	SWFA
2014-01-07T19:00Z	10.75	2014-01-07T12:00Z	2.00	Obs min. Kp: 7.0 Obs min. Kp: 2014-01-07T12:00Z	Assessment
2014-01-07T19:00Z (+7h, +7h)	10.00	2014-01-07T12:00Z	2.00	Max Kp Range: 4.0 - 4.0	SWFA ENLIL + Coas
2014-01-07T12:00Z (+3h, +3h)	8.00	2014-01-07T16:00Z	4.00	Max Kp Range: 1.0 - 1.0	Ensemble SWFA ENLIL + Coas (GSEP SWBC)
2014-01-07T19:00Z	12.00	---	---	Max Kp Range: 4.0 - 7.0	Average of all Methods

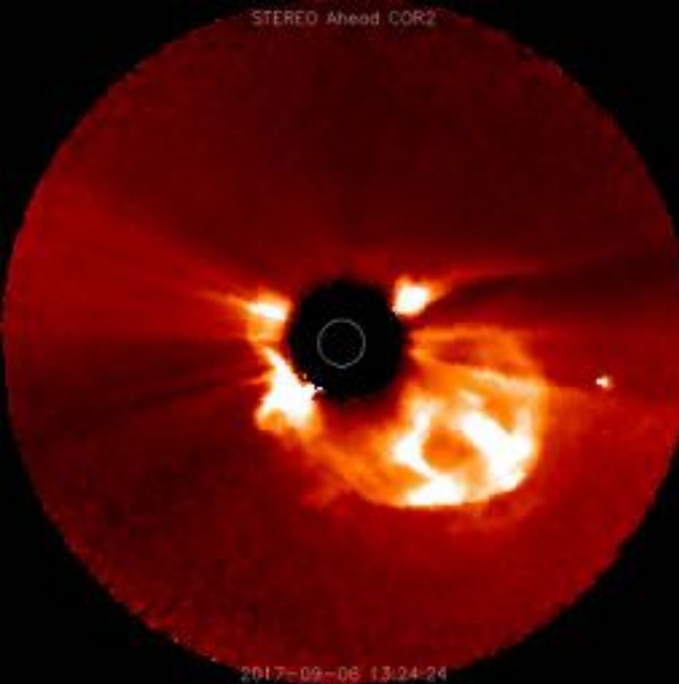
Community-wide space weather forecasting validation activity - Since 2013



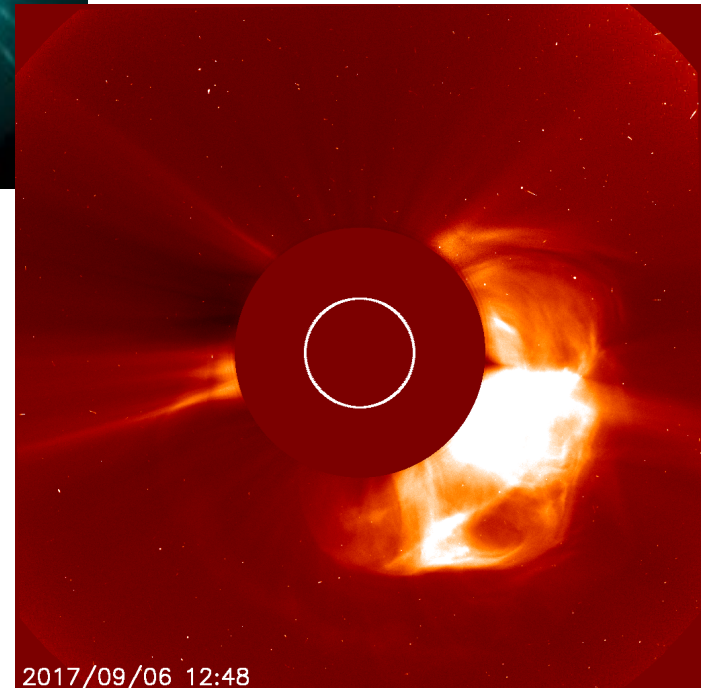
The X9.3 flare and associated CME



151 2017-09-06 12:03:32 UT



2017-09-06 13:24-24



2017/09/06 12:48

2017-09-07T18:00

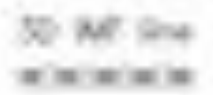
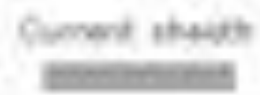
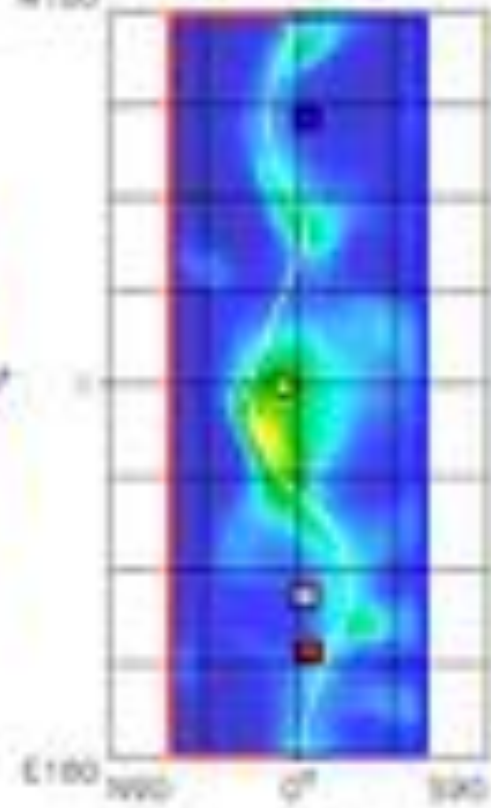
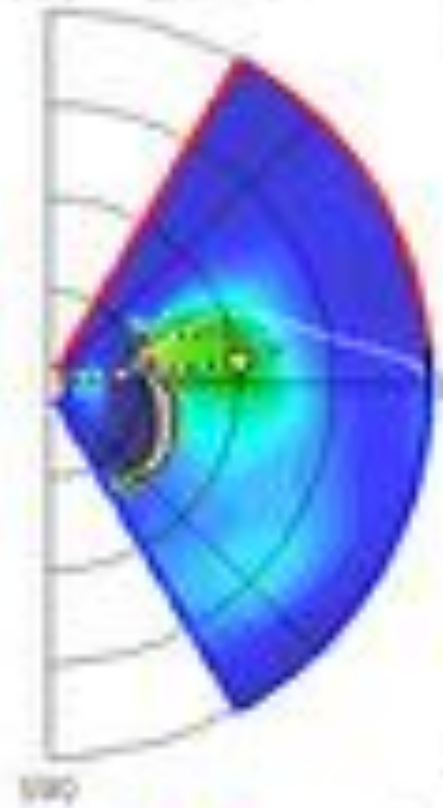
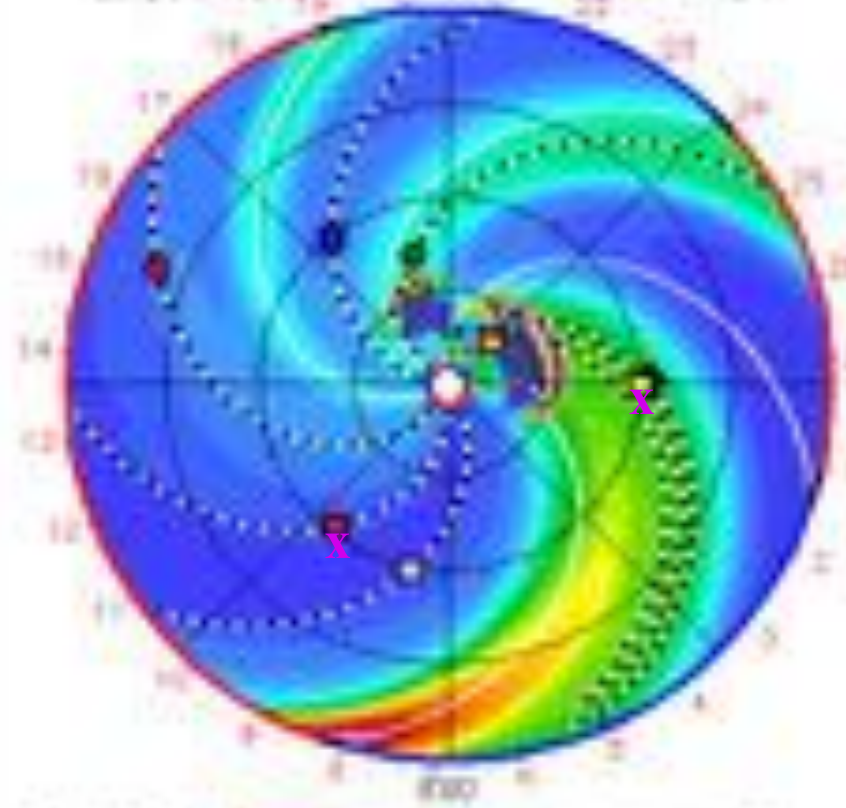
2017-09-06T00 + 1.75 days

- Earth
- Mars
- Mercury
- Venus
- ◆ OSRD-RE
- Spitzer
- Merco_A
- Merco_B

ExPlan Plane 2089001 LAT = 2.24°

NOO LOW = 0°

#160 R = 2.0 AU



ENLIL-2.7 Area-2.0M-461 461022 890-27m

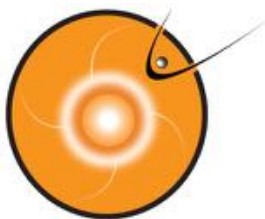
2017-09-06 14:57:00.0



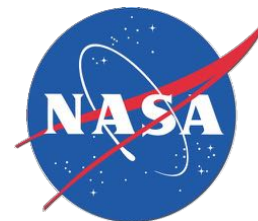
The X9.3 flare associated CME arrival prediction



Proton peak Arrival Reference Coordinates	Local Time	Predicted Longitude Range	Method	Detected by	
Time	(UT)	(deg)	(deg)		
06:14:00(04:00) 1.0E +1.0E	7.5E	W05	07:20 Max Rg Range: 70 - 80	NOVA EMU, + Univ. of Michigan	NOVA EMU (NOVA EMU)
07:14:00(05:00) 2.0E +2.0E	7.5E	---	6:00	None	NOVA EMU (NOVA EMU)
08:14:00(06:00) 3.0E +3.0E	8.0E	---	13.0E	None	NOVA EMU (NOVA EMU)
09:14:00(07:00) 4.0E +4.0E	8.0E	---	17.0E	None	NOVA EMU (NOVA EMU)
10:14:00(08:00) 5.0E +5.0E	8.5E	W05	14.0E	None + JAXA	NOVA EMU (NOVA EMU)
11:14:00(09:00) 6.0E +6.0E	11.7E	---	10.0E	None + JAXA Aurorascope	NOVA EMU (NOVA EMU)
12:14:00(10:00) 7.0E +7.0E	11.0E	---	20.2E	None	NOVA EMU (NOVA EMU)
13:14:00(11:00) 8.0E +8.0E	11.2E	---	4.0E	None	NOVA EMU (NOVA EMU)
14:14:00(12:00) 9.0E +9.0E	11.5E	---	10:00 Max Rg Range: 40 - 60	None (JAXA)	NOVA EMU (NOVA EMU)
15:14:00(13:00) 1.0E +1.0E	11.0E	W05	Max Rg Range: 4 2000 - 8.0	Average of all methods	NOVA EMU (NOVA EMU)
16:14:00(14:00) 2.0E +2.0E	14.5E	W05	10:00 Max Rg Range: 10 - 70	None	NOVA EMU (NOVA EMU)
17:14:00(15:00) 3.0E +3.0E	14.2E	---	4.1E	None	NOVA EMU (NOVA EMU)
18:14:00(16:00) 4.0E +4.0E	17.5E	W05	7:00 Max Rg Range: 40 - 60	None + JAXA EMU, + Univ. of Michigan	NOVA EMU (NOVA EMU)
19:14:00(17:00) 5.0E +5.0E	18.0E	---	5.0E	None	NOVA EMU (NOVA EMU)
20:14:00(18:00) 6.0E +6.0E	18.0E	---	19:00 Max Rg Range: 10 - 70	NOVA EMU, + Univ. of Michigan	NOVA EMU (NOVA EMU)
21:14:00(19:00) 7.0E +7.0E	23.5E	---	27:00 Max Rg Range: 10 - 70	NOVA EMU, + Univ. of Michigan	NOVA EMU (NOVA EMU)



The 2017 Labor Day CME(s) Arrival prediction



1. All: see Forecast/Updated/No-Data
 2. Arrival: Arrival Time: 2017-09-01T00:00:00Z
 3. Arrival: Geomagnetic Storm Prediction: ...
 4. Note: CME must have had to be updated from 2017-08-29T12:00Z

July 2017

Forecasted Shock Arrival Time	Minimum %	Confidence CSI	Forecasted ID	Lead Time (hr)	Forecasted Geomagnetic Storm Prediction	Method	Ref
2017-09-01T00:00:00Z 4.0h, 4.0h	11%	80%	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	11.5h	Max Kp Range: 10 - 10	NASA SML, 1 Case, M2, G1, G2	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z	10%	82.2%	---	---	Max Kp Range: 4-14/24 - 1-14/24	Average of all Methods	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 7.0h, 4.0h	8%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	21.5h	Max Kp Range: 4 - 10	NASA SML, 1 Case, M2, G1, G2	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z	11%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	16.5h	Max Kp Range: 4 - 10	NASA SML, 1 Case, M2, G1, G2	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z	4%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	44.5h	---	NASA	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z	8%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	16.5h	Max Kp Range: 4 - 10	Other	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 1.0h, 4.0h	8%	80%	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	16.5h	---	Other, NASA	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 7.0h, 4.0h	8.2%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	21.5h	Max Kp Range: 4 - 10	NASA SML, 1 Case, M2, G1, G2, G3	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 4.7h, 4.4.0h	9%	80%	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	20.5h	Max Kp Range: 4 - 10	Other, NASA SML, 1 Case, M2, G1, G2, G3	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 4.0h, 4.0h	11.1%	80%	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	16.5h	Max Kp Range: 4 - 10	Other (G1, G2)	2017-08-30T00:00:00Z
2017-09-01T00:00:00Z 4.0h, 4.0h	10.5%	---	2017-08-30T00:00:00Z 2017-08-30T00:00:00Z	17.0h	---	Other, Geomagnetic Storm Prediction	2017-08-30T00:00:00Z

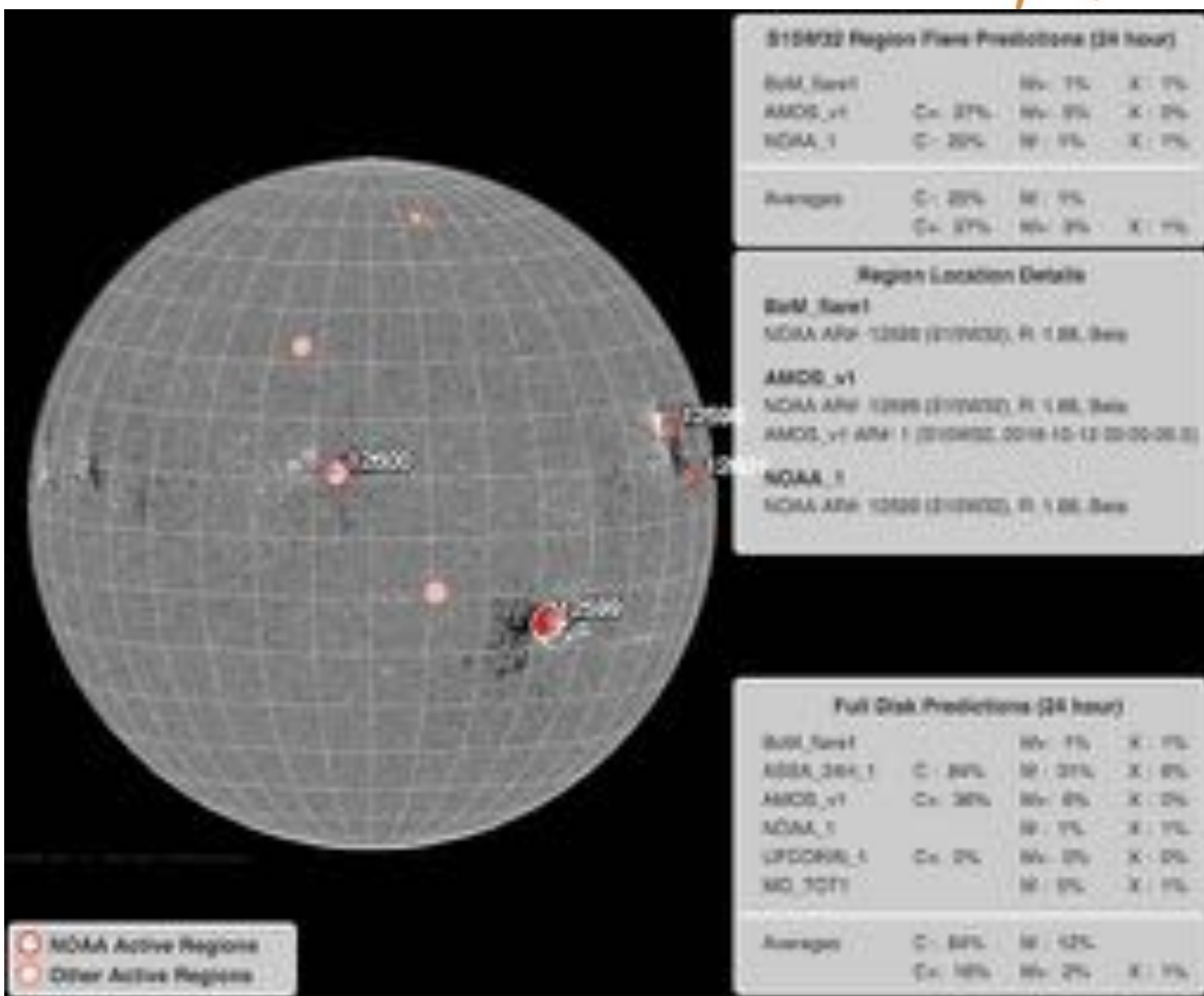


Flare Scoreboard



<https://ccmc.gsfc.nasa.gov/challenges/flare.php>

- Allows a consistent real-time comparison of various operational and research flare forecasts.
- Automated system; model developers can routinely upload their predictions to an anonymous ftp
- Forecast data is parsed and stored in a database which accessible to anyone via an API
- This project is led by Sophie Murray and the planning group includes expert scientists as well as operational space weather prediction centers.





SEP Scoreboard

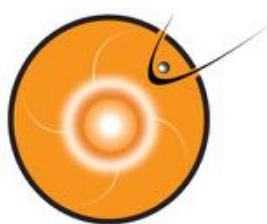


<https://ccmc.gsfc.nasa.gov/challenges/sep.php>

- Planning for the SEP Scoreboard has started (led by BIRA-IASB and the UK Met Office)
- Builds upon the flare scoreboard and CME arrival time scoreboard
- Automated system; model developers can routinely upload their predictions to an anonymous ftp. Forecast data will be parsed and stored in a database which accessible to anyone via an API
- SEP forecasts can be roughly divided into three categories:

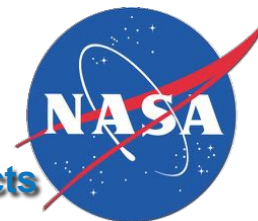


- The SEP scoreboard will focus on real-time forecasts (first and second categories) and will collect: proton flux profile, threshold crossing probability, onset time, and duration.
- The SEP scoreboard team will also coordinate with the SEP Working Team for historical comparisons, particularly for those physics-based models in the third category that are not ready or relevant for real-time modeling.

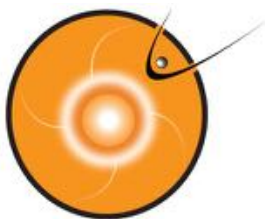


DONKI (Database of Notifications, Knowledge, Information)

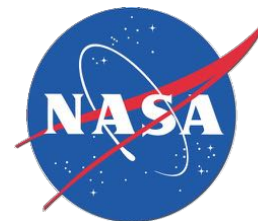
facilitate connecting space weather phenomena to satellite effects



- ❑ 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
- ❑ **API**... <http://kauai.ccmc.gsfc.nasa.gov/DONKI/>



Anomaly Database in DONKI



Space Weather Database Of Notifications Information (DONKI)

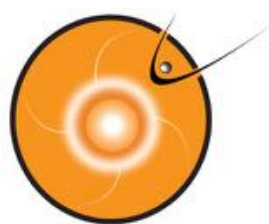
Go to:

- [About DONKI](#)
- [DONKI Home](#)
- [Enter Space Weather Activity](#)
- [Enter U.S.A. INTEL-Center Model Results](#)
- [Generate Search Reports/Logs](#)
- [Search Space Weather Activity](#)
- [Search Notifications Archive](#)
- [Space Environment Effects and Anomalies](#)
- [Logout](#)
- [Edit Personal Profile](#)
- [Change Password](#)

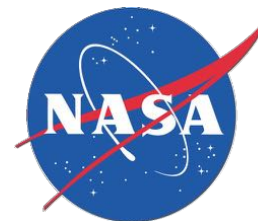
Space Environment Effect and Anomalies Archive

click on the link below to generate/search reports in the archive

- [Report Space Environment Effect](#)
- [Report Spacecraft Anomaly](#)
- [Search Archive](#)



Connecting Space Environment to Space Weather Impacts: Radiation Effects



❑ NOVICE

- ❑ Radiation effect code for spacecraft and/or component in complex geometries

❑ NAIRAS (Nowcast of Atmospheric Ionizing Radiation System)

- ❑ Models and assesses radiation exposure levels for aviation from GCRs and SEPs

❑ CARI-7

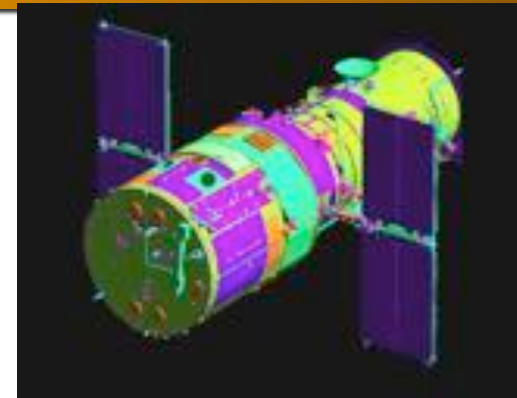
- ❑ Calculates radiation dose from GCRs received by airline passengers/crews

❑ Badhwar-O'Neill (BON) 2014 GCR model

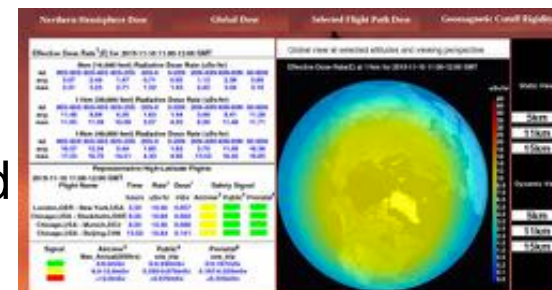
- ❑ Latest Badhwar-O'Neill model of Galactic Cosmic Rays

❑ Internal Charging code (Minow's, NUMIT)

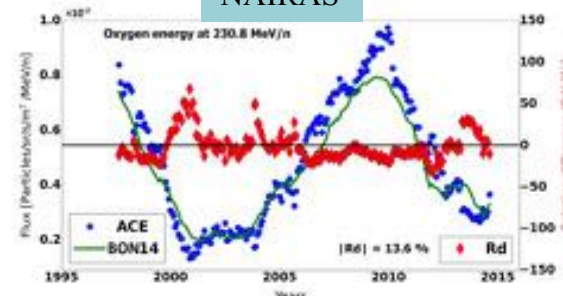
❑ PANDOCA



HST from NOVICE



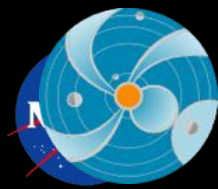
NAIRAS



BON 2014



Space Weather Bootcamps (2 week-long ones and 1-day ones)

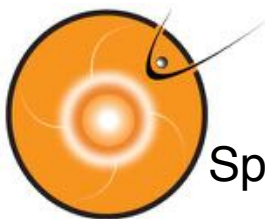


Summer Bootcamp: 6-16 June 2017 NASA/GSFC

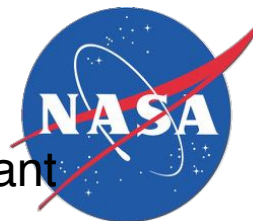
Space Weather School at VarSITI 2017 (Irkutsk, Russia)

*Anna Chulaki, Yaireska Collado-Vega, Marlo Maddox, Leila Mays, Karin Muglach, Antti Pulkkinen, Aleksandre Taktakishvili, Barbara Thompson, Chiu Wiegand and Yihua Zheng (lecturers)
Karen Catucci, Anna Chulaki, Yaireska Collado-Vega (additional support prior to and throughout the bootcamp)*

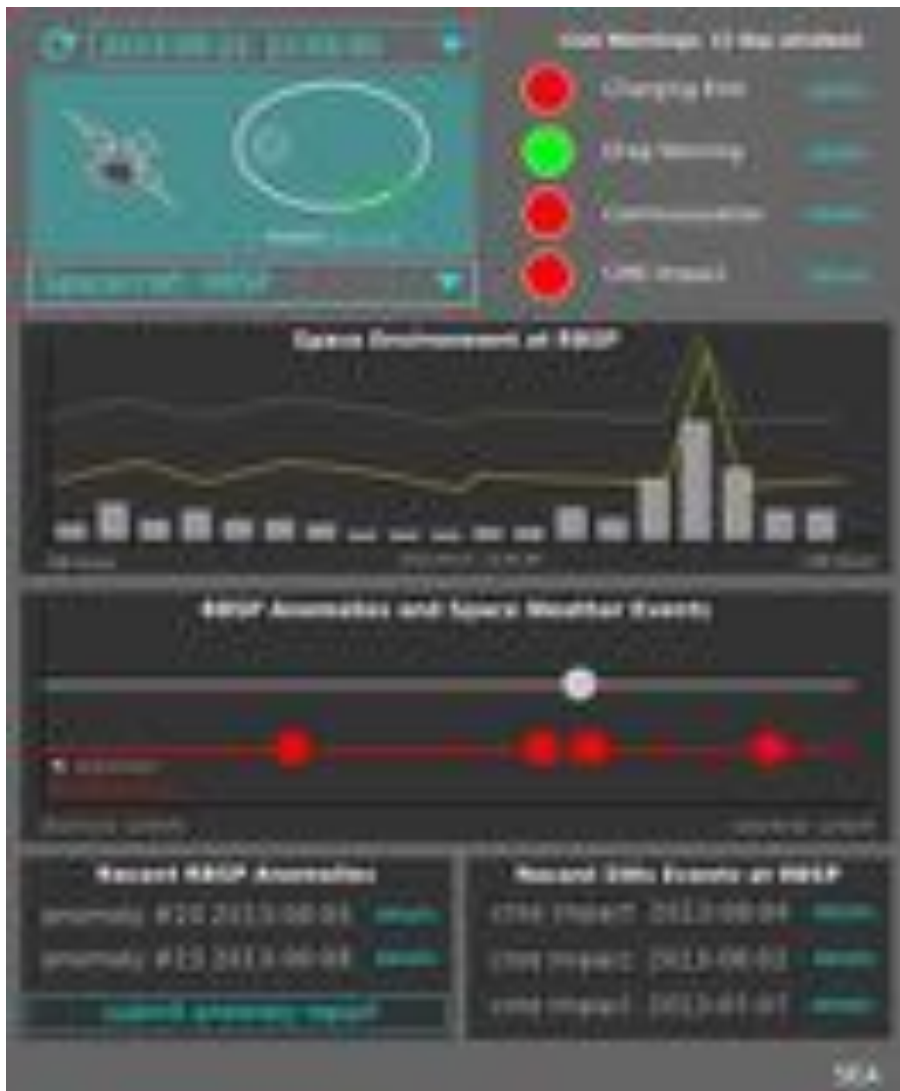




SEA5 Overview



Space Environment Automated Alerts and Anomaly Analysis Assistant

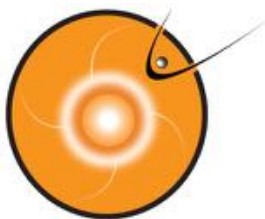


- **SEA5 Original Web Interface Mockup:**

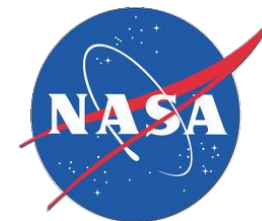
- Orbit information, current location, hazard assessment
- Impending solar storms, predicted levels of activity, and expected impacts
- Relevant space weather parameters
- Recent space weather events, spacecraft anomalies
- Real-time, automated and customizable alert functionality

Mission specific dashboard for selected time range

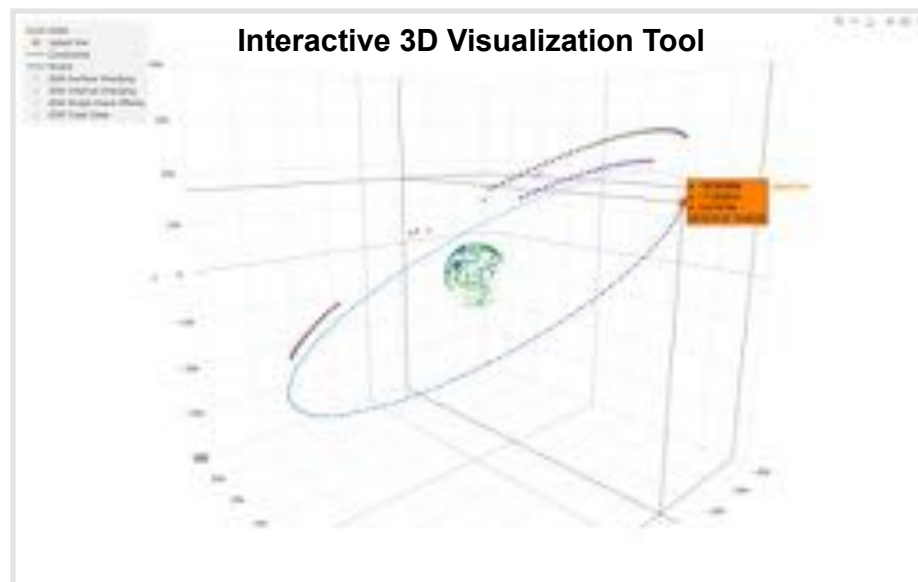
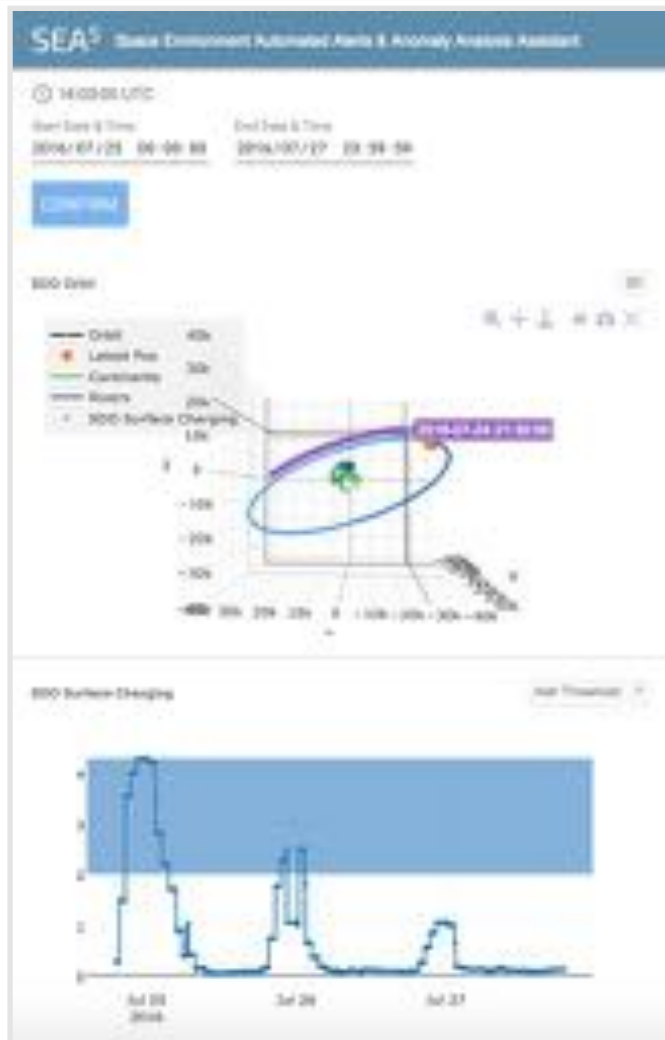
Justin Boblitt et al.

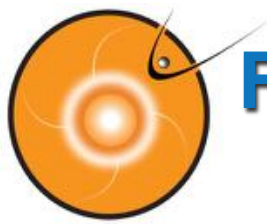


SEA5 Current Capability

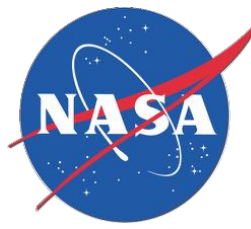


- SEA5 Geosynchronous Anomaly Analysis subsystem
 - Initial set of geosynchronous NASA satellites
 - Mission-specific dashboard of data products that represent the hazard level of its environment
 - User-defined thresholds to reveal positions and times of elevated hazardous environment
 - Custom time range analysis





Future models we would like to bring into CCMC and SEA5



- CCMC would like to run the following radiation and impact models for historical time periods and in realtime, with results disseminated through the SEA5 system
 - Inner magnetosphere models
 - VERB (Versatile Electron Radiation Belt) model
 - Relevant for internal charging analysis/products
 - CIMI (the Comprehensive Inner Magnetosphere-Ionosphere) model update (the Comprehensive Inner Magnetosphere-Ionosphere)
 - Relevant for internal charging and surface charging analysis/products
 - IMPTAM (Inner Magnetosphere Particle Transport and Acceleration Model)
 - Surface charging
 - NARMAX (Nonlinear Autoregressive Moving Average with eXogenous input) for radiation belt
 - Impact models
 - NOVICE (dose calculation for satellite impacts)
 - Radiation impact models on aviation
 - NAIRAS
 - CARI-7
 - PANDOCA
- Energetic electron fluence from GOES
Proton fluence from GOES