National Aeronautics and Space Administration

8 September 2017

CCMC Tools and Resources in the context of SEESAW

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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 analysi
- Online tool for dissemination of forecasts, notifications, & archiving event-focused information

Space Weather Scoreboards

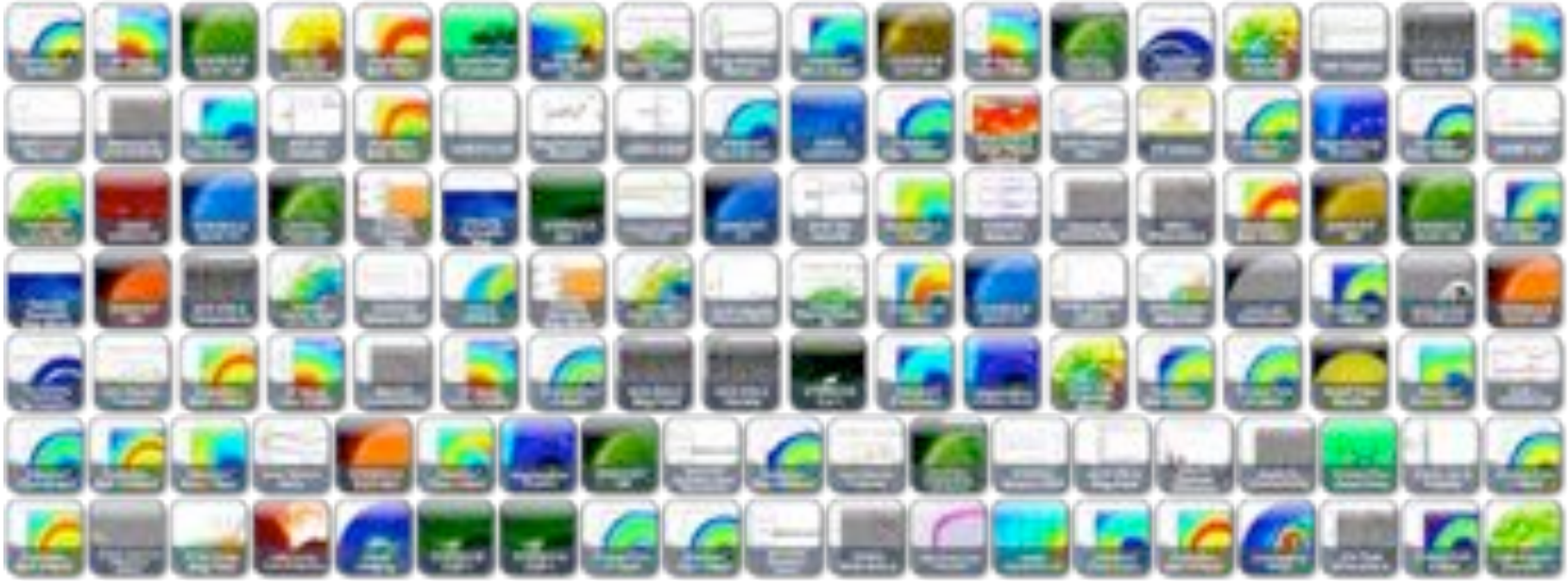
- Research-based forecasting methods validation
- Scientific community submits forecasts in real-time
- View and Compare all forecasting methods

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

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

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)

> 20 participating models / expert groups world-wide

Flare Scoreboard

Leads**: ROB** (J. Adries)
Trinity College Dublin (S. Murray)

SEP Scoreboard

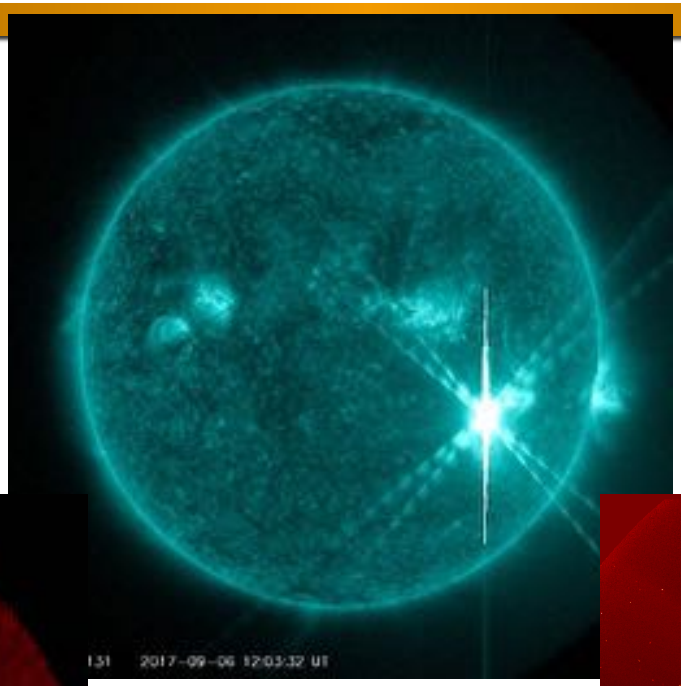
Leads: **BIRA-IASB**(M. Dierckxsens, N. Crosby)
UK Met Office (M. Marsh)

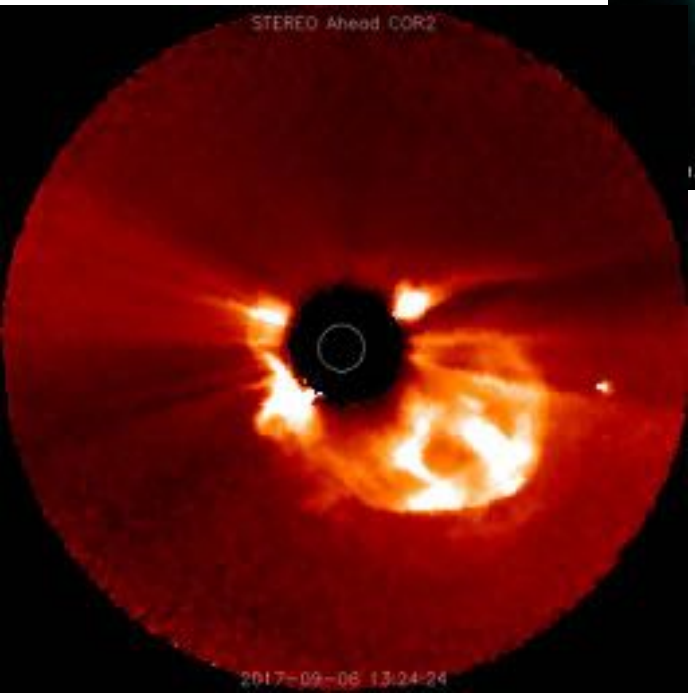
Engaging the whole community in forecasting CME arrival

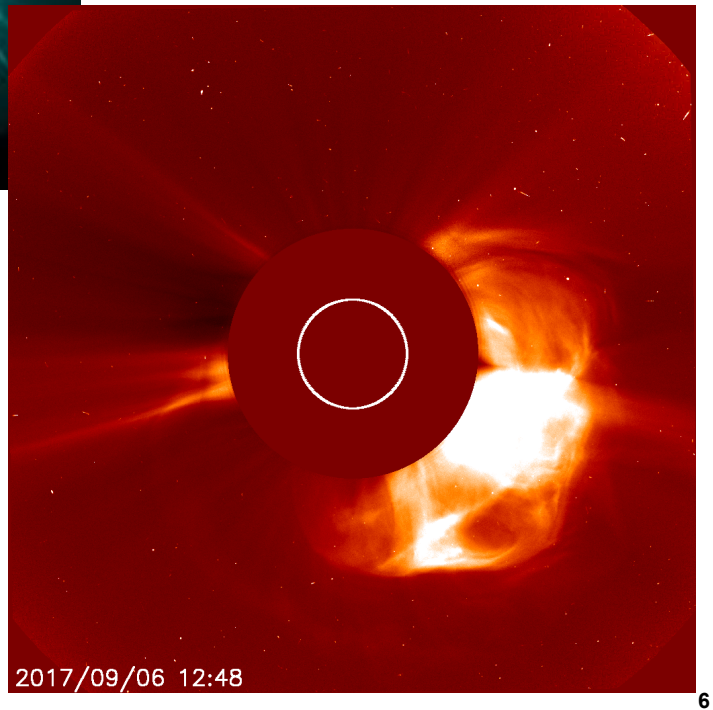
Community Ensemble (from different CME models)

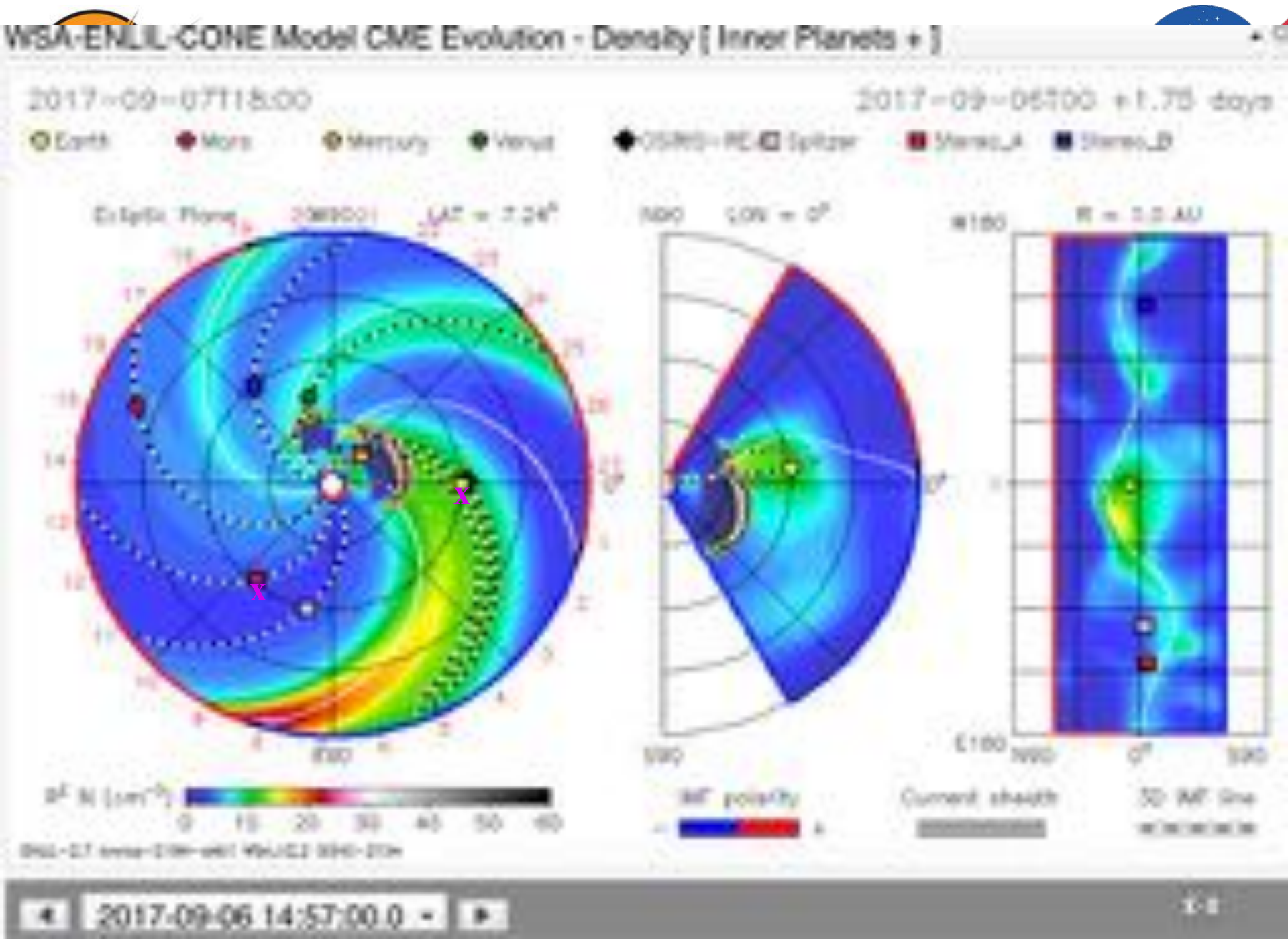
Community-wide space weather forecasting validation activity – Since 2013

The X9.3 flare and associated CME

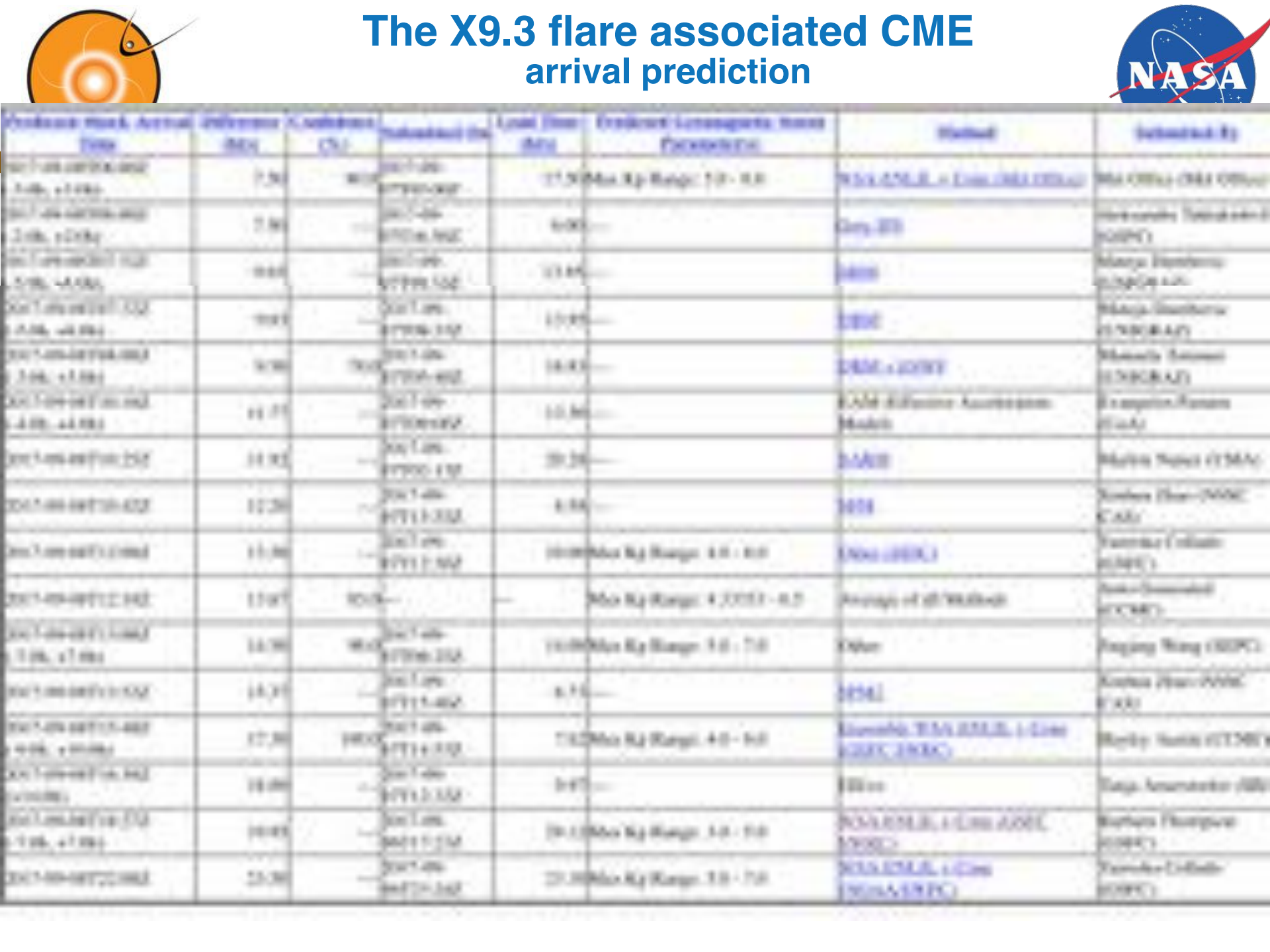







WSA-ENLIL-CONE Model CME Evolution - Density [Inner Planets +]
2017-09-07T18:00
2017-09-06T00 +1.75 days
Earth
Mars
Mercury
Venus
Spitzer
Stereo_A
Stereo_B
Ecliptic Plane
IMF polarity
Current sheet/s
2017-09-06 14:57:00.0

The X9.3 flare associated CME
arrival prediction

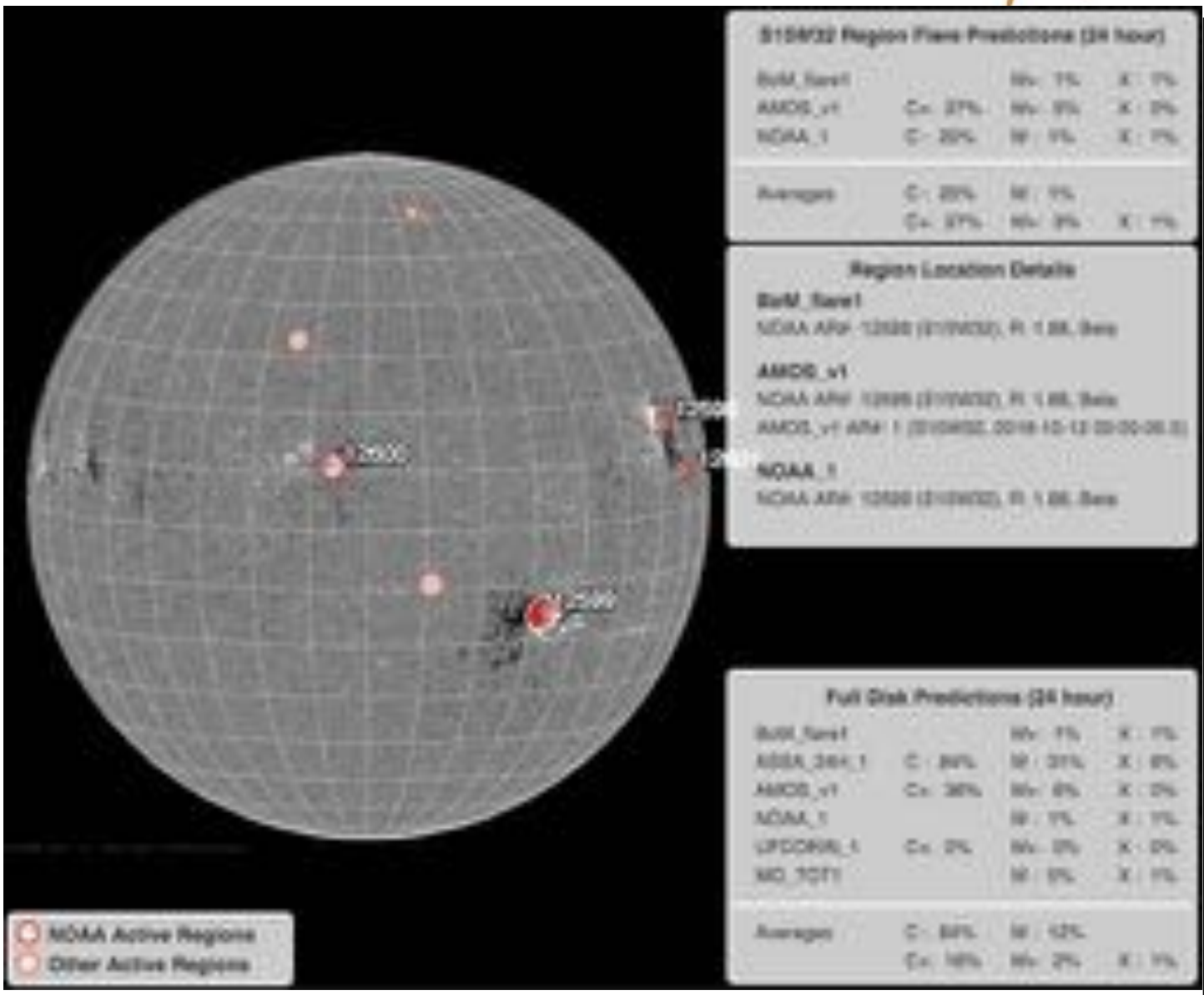


The 2017 Labor Day CME(s)
Arrival prediction

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…

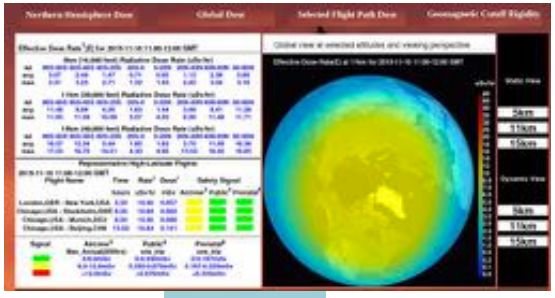
http://kauai.ccmc.gsfc.nasa.gov/DONKI/

Anomaly Database in DONKI

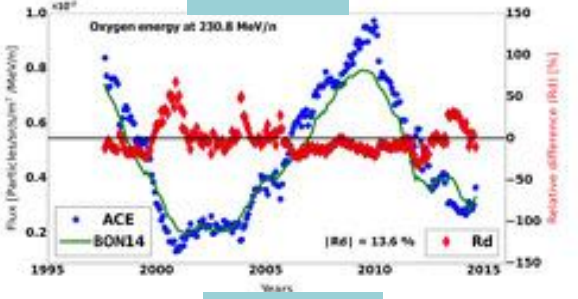
Connecting Space Environment to Space Weather Impacts: Radiation Effects

- 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

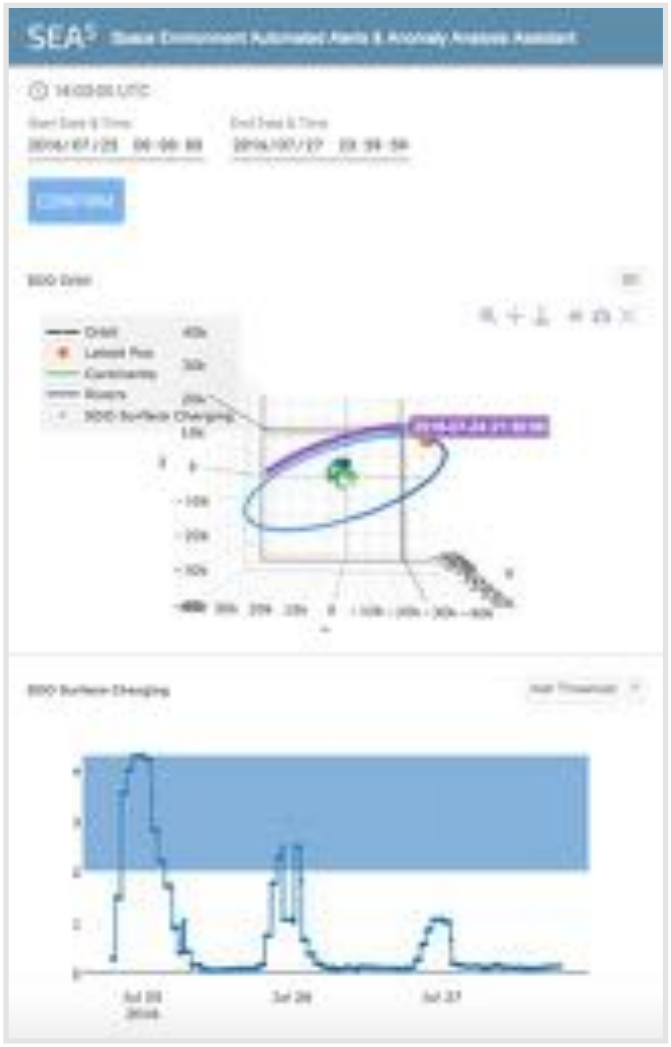
Space Environment Automated Alerts and Anomaly Analysis Assistant

- **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

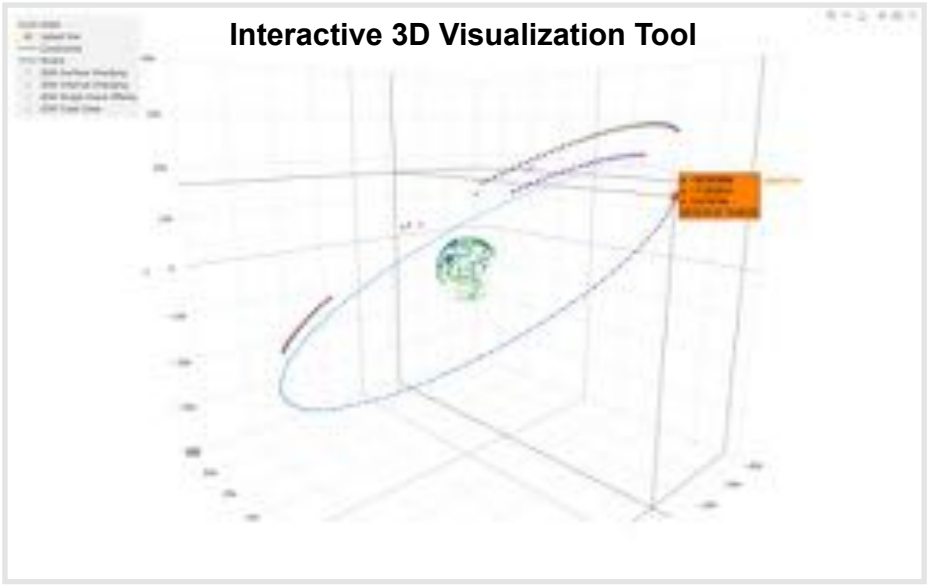
Mission specific dashboard for selected time range

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



O'Brien, 2009 SEAES-GEO

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 Magntosphere-Ionosphere) model update (the Comprehensive Inner Magntosphere-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