



# Space Weather Forecasting at NASA GSFC Space Weather Research Center

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<http://swrc.gsfc.nasa.gov> <http://ccmc.gsfc.nasa.gov>



Fall 2012 AGU Meeting [IN31D-02]



# NASA GSFC Space Weather Research Center



## Primary Objective:

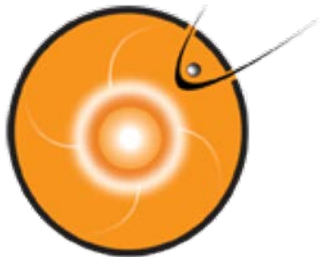
Provide the latest space weather information to NASA's robotic mission operators.

since March 2010



# Space Weather Forecasting @ NASA/SWRC

Community  
Coordinated Modeling  
Center



Space  
Weather  
Research Center



Partnering



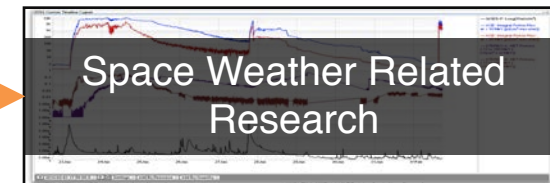
iSWA  
System

NASA, Other,  
(near) Real-time Data  
Streams

Protecting NASA's  
Missions



Space Weather Related  
Research

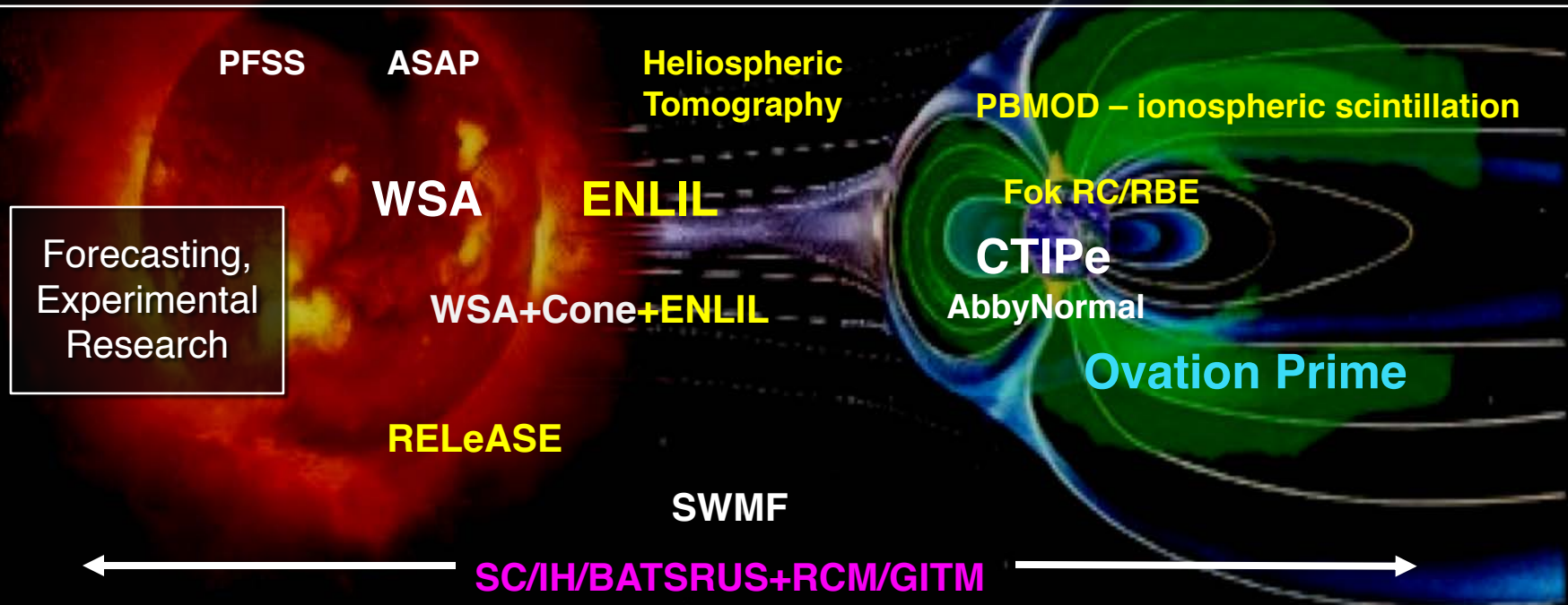


Mary  
James Hubert Blake High School

# Community Coordinated Modeling Center

## Comprehensive Collection Of Space Weather Models running in real-time

- ✓ CME Ensemble Forecasting – [ **SH41B-2112 Taktakishvili** ]
- ✓ CME & ambient solar wind forecasting (WSA+ENLIL+Cone, WSA+ENLIL, HELTOMO)
- ✓ Flare forecasting/monitoring (ASAP)
- ✓ Radiation (ions and e-) forecasting/now casting (RELeASE, RBE)
- ✓ 3-D States of the magnetosphere and ionosphere (SWMF, CTIPe, Fok RC, RBE) [ **SM23A-2294 Zheng, SM23B-2305 Rastaetter, SA33A-2183 Shim** ]
- ✓ Scintillation, HF absorption, drag effects, Aurora, etc (PBMOD, AbbyNormal, CTIPe, OP)
- ✓ Forecasting GICs (SWMF and its coupling with other models) - [ **SM21D-01 Pulkkinen; SM23B-2304 Ngwira** ]



...enabling the creation of next generation prediction systems



# Key Challenges in SWx Forecasting

knowledge/research, data/info, models, dissemination



- SWx research and models evolve at a rather rapid pace – advantage being embedded in a research organization
- Model identification, ingestion, and integration
- Model improvement and development
- Model validation
- Data Continuity
- Maintaining Dedicated Computational Infrastructure
- Data Formats
- Scientific Visualization - [ **SM43A-2235 Berrios** ]
- Data Archiving ( Large, Disparate Data Sets )
- Data Dissemination – [ **IN33C-152 Mullinix** ]





# Computational Resources



## Community Coordinated Modeling Center

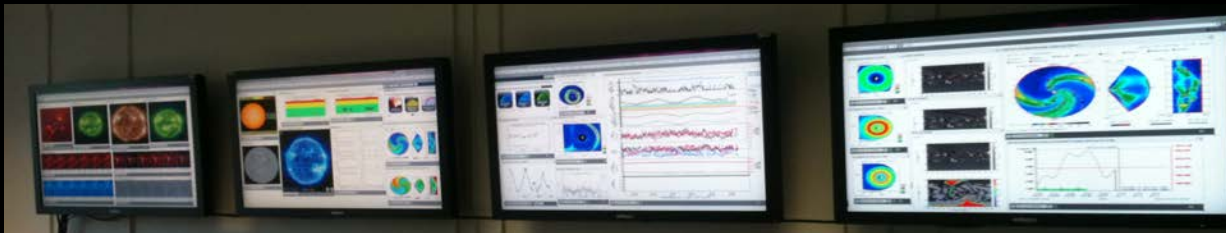
Super Computing  
Clusters  
( 1100 CPU's )

Dedicated  
Workstations

**CCMC**

.5 Peta-Byte of  
Data Storage

Online and  
Downloadable  
Analysis Tools

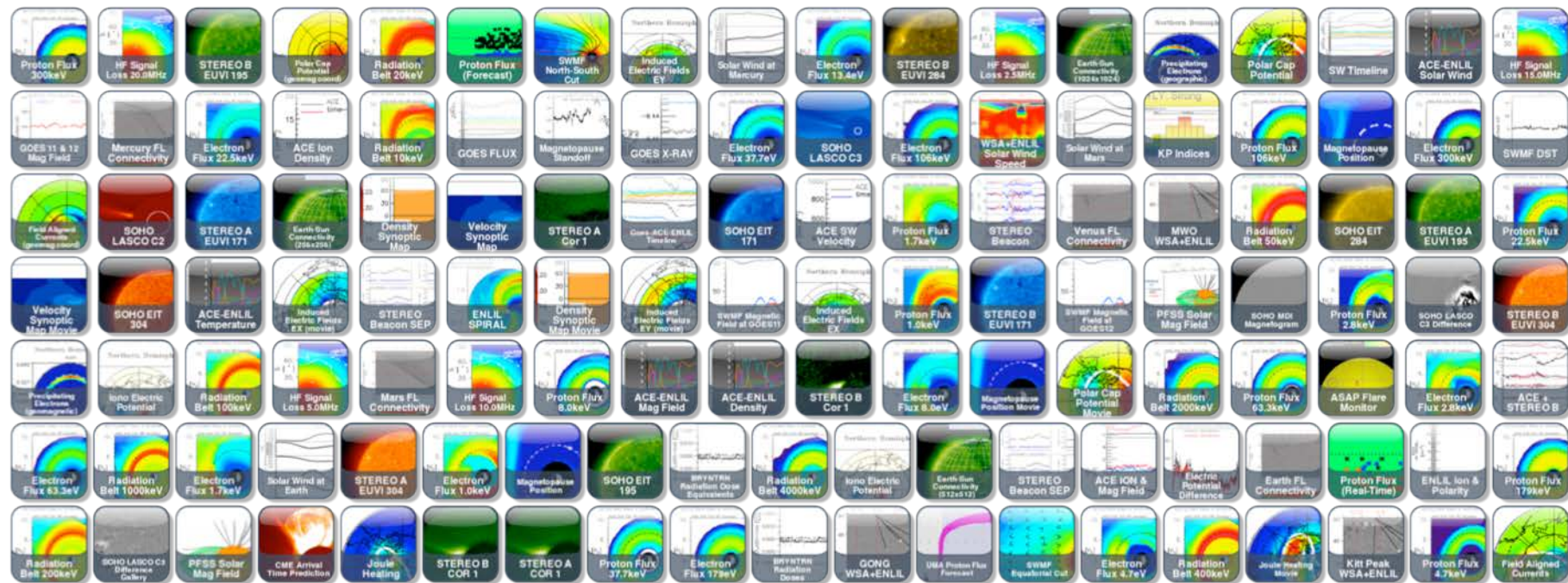




# Innovative Dissemination: iSWA



ISWA has ~300 products including modeling results and comprehensive sets of observational data.



**Web-based. User configurable. Available world-wide.**

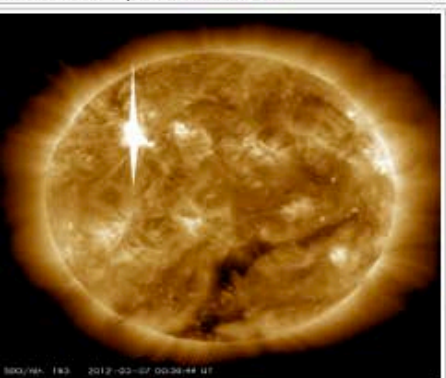
**One-stop shop for state-of-the-art information!**

**<http://iswa.gsfc.nasa.gov>**

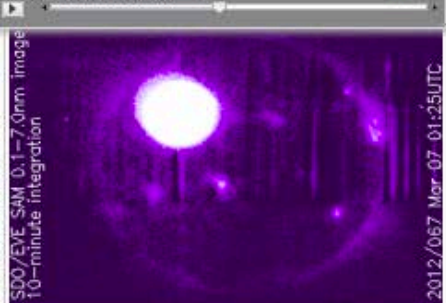


# Configurable Layouts

SDO - AIA 193 - Space Weather Product

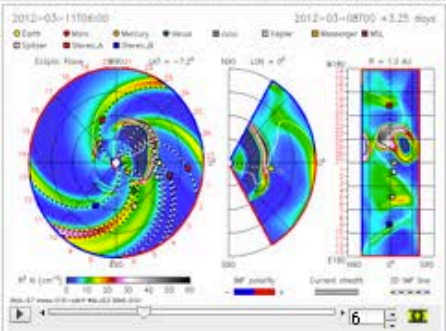


2012-03-07 00:36:44.0

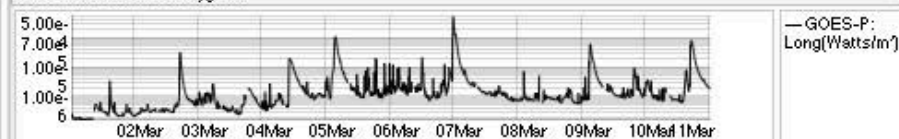


2012-03-07 01:20:00.0

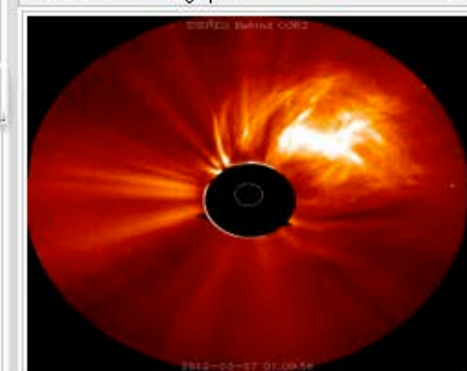
WSA-ENLIL-CONE Model CME Evolution - Density [ Inner Pls



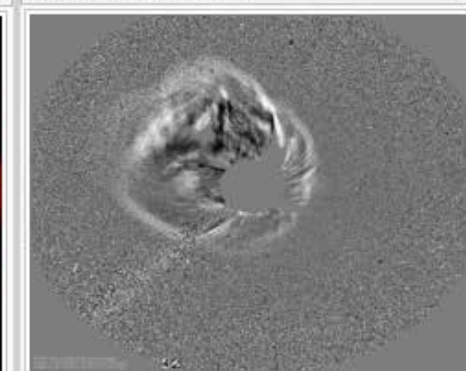
iSWA Custom Timeline Cygnet



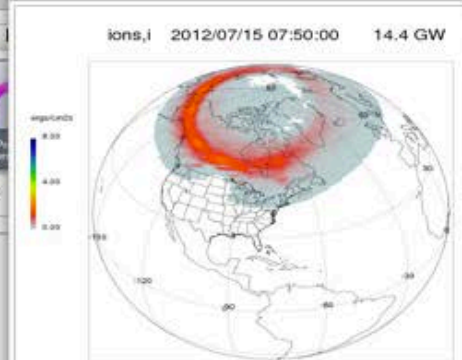
Stereo Behind Coronagraph 2



SOHO - LASCO C3 Difference

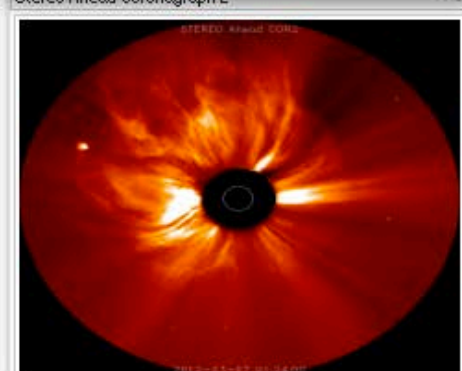


Ovation Prime Energy Flux: Ions [ 10 R<sub>E</sub> above Earth ]

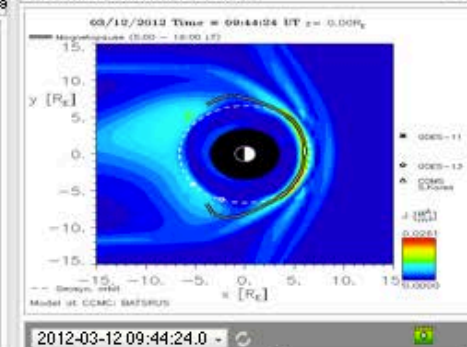


2012-07-15 07:50:00.0

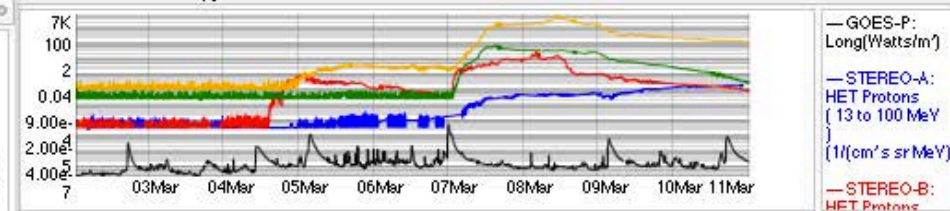
Stereo Ahead Coronagraph 2



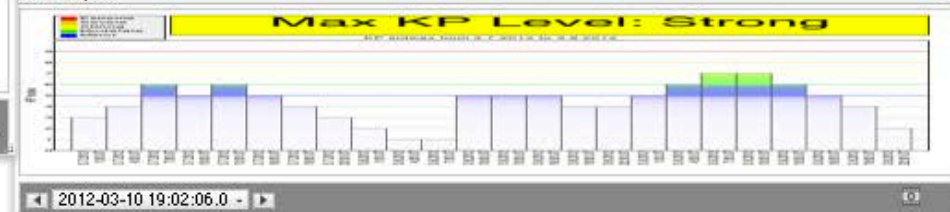
SWMF Magnetopause Position



iSWA Custom Timeline Cygnet



Planetary KP







# iSWA



**iSWA enables tracking space weather events in interplanetary space (throughout the solar system) and analyzing their expected impacts**

**One iSWA layout for the 12 July 2012 space weather event**

[http://bit.ly/July12\\_2012](http://bit.ly/July12_2012)

**This web link provides a dynamic (and rather comprehensive) view of this solar event**





# Highlights of Forecasting Capabilities



Enabled by real-time data streams and state-of-the-art modeling capabilities

## **Forecasting Earth-Directed CME and its impact the 12 July 2012 solar eruption**

a minor radiation storm (SEP)  
But a major geomagnetic storm





# Modeling of the 12 July 2012 CME

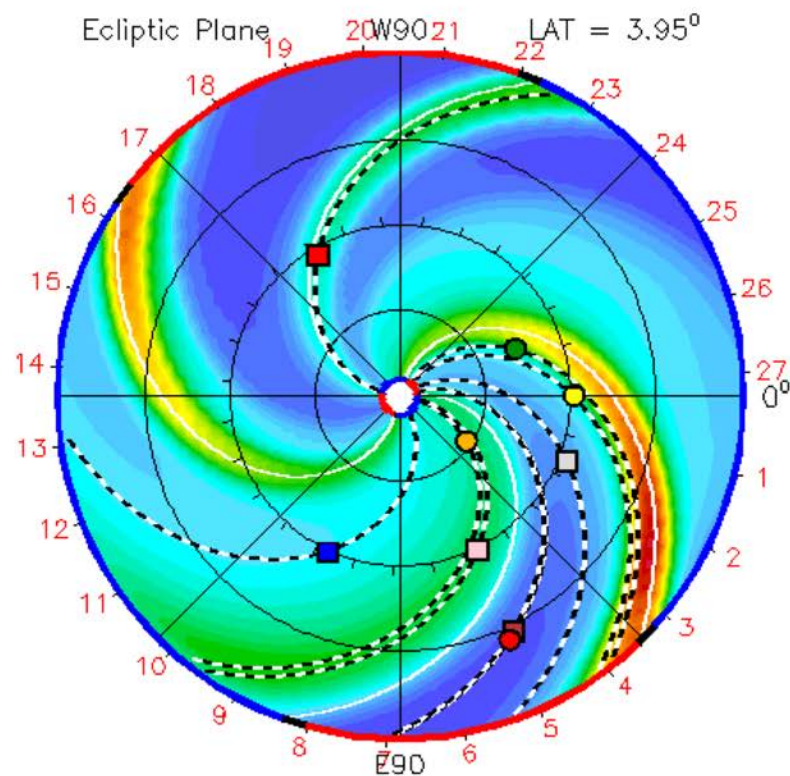


$V=1400$  km/s, associated with an X1.4 class solar flare

2012-07-11T00:00

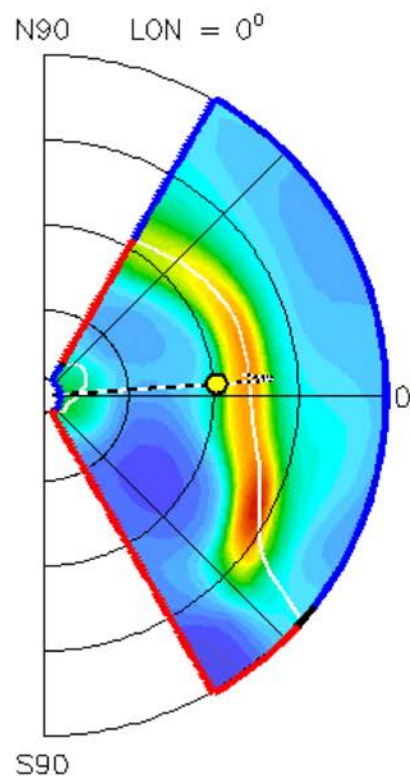
2012-07-11T00 +0.00 day

● Earth ● Mars ● Mercury ● Venus □ Kepler ■ MSL □ Spitzer ■ Stereo\_A  
■ Stereo\_B



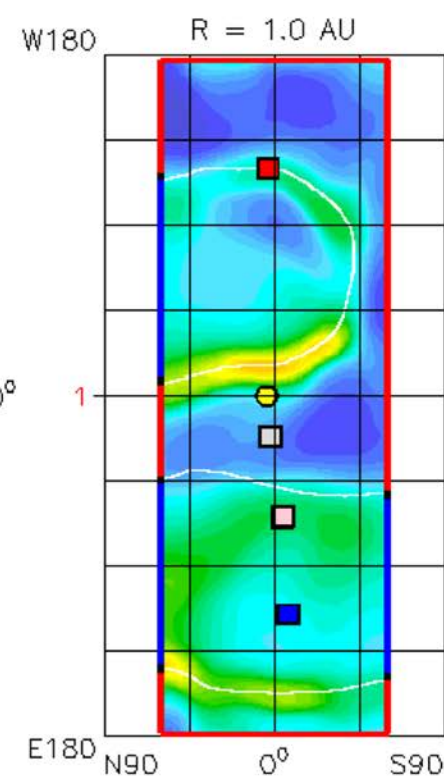
$R^2 N$  ( $\text{cm}^{-3}$ )

0 10 20 30 40 50 60



IMF polarity

- +



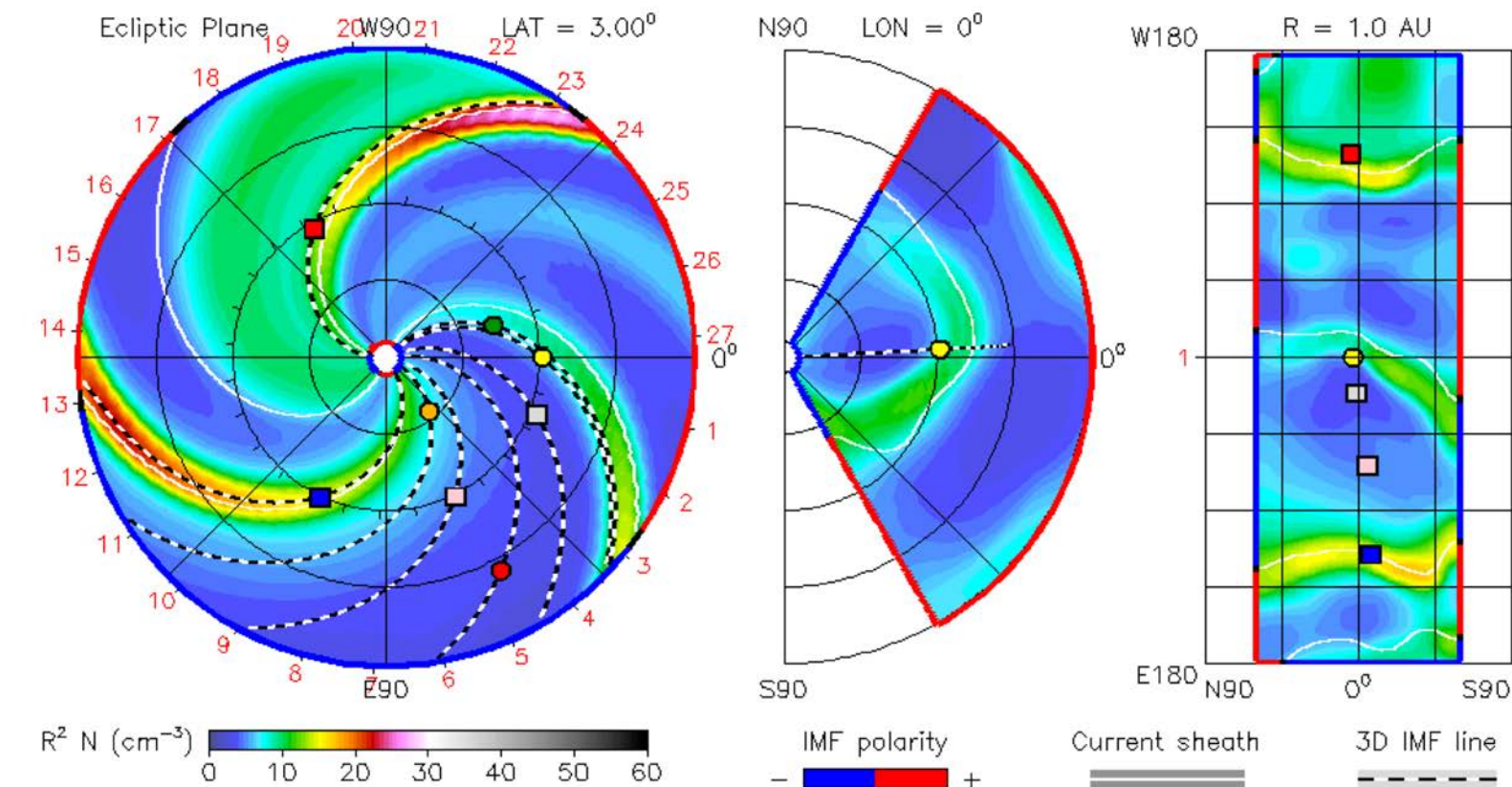
Current sheath

3D IMF line



2012-07-02T00 +0.00 day

■ Stereo\_B





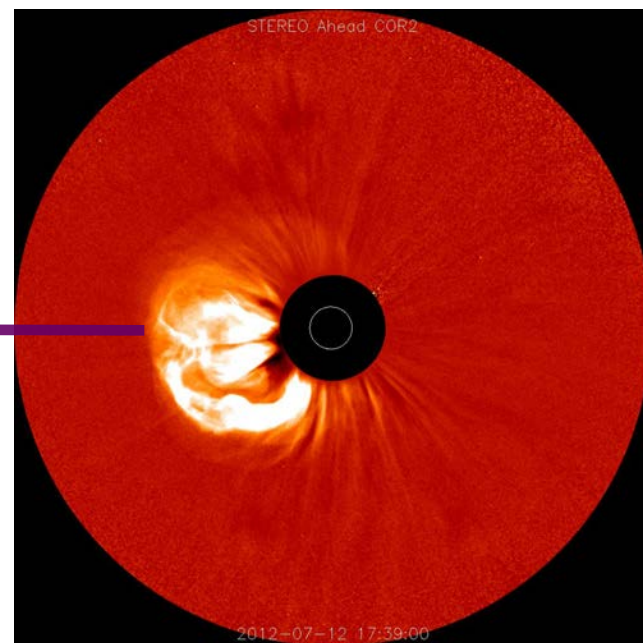
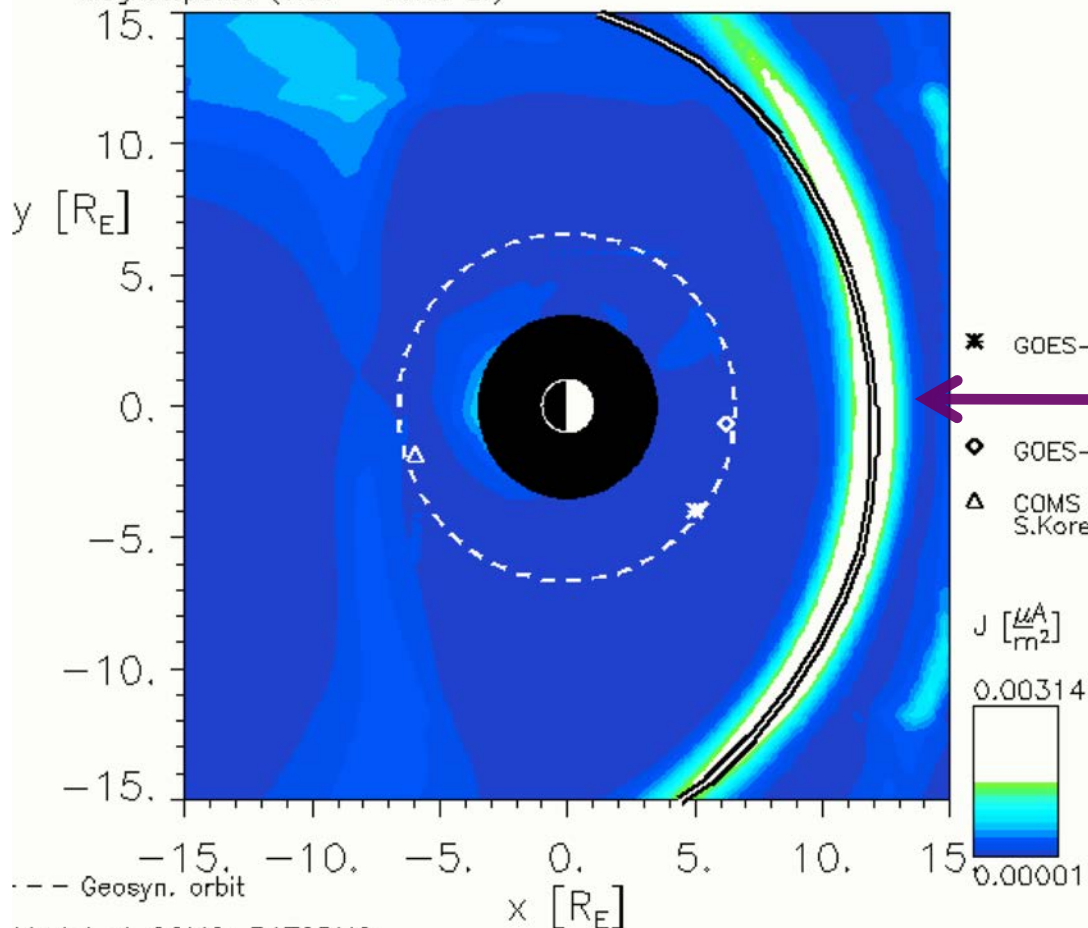


# Earth's Response to the CME's Arrival



07/14/2012 Time = 16:35:10 UT  $z = 0.00R_E$

== Magnetopause (5:00 - 19:00 LT)

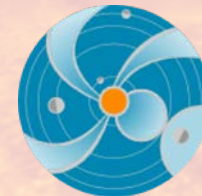


The CME seen by STEREO A

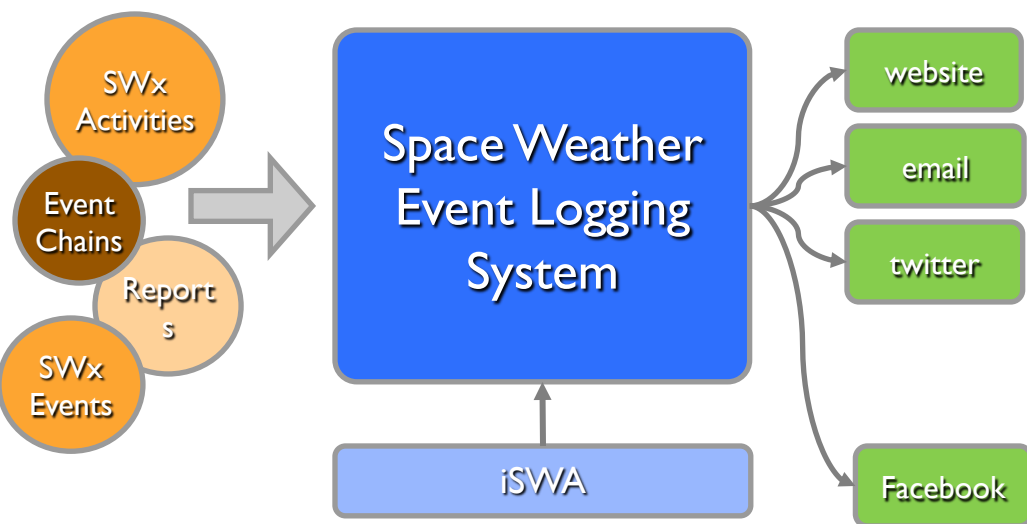
Resulting in a  $K_p = 7-$  on a scale from 0 – 9,  $K_p$ : a measure of geomagnetic disturbances



# Space Weather Event Logging System

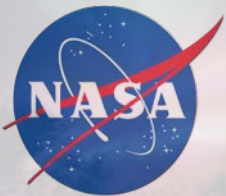


- Forecasters log space weather events and activities
- Allow events/activity chains, establish cause and effect relationships
- Multi user/forecaster system designed to promote community involvement
- Entry point for initiating alerts, cataloging events
- Knowledge management system for human generated logs, analysis

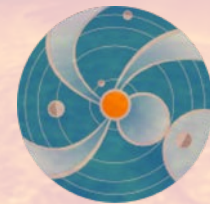


The screenshot shows the user interface of the Space Weather Event Logging System. At the top right, it says 'Logged in as - Rick Mullinix'. On the left is a sidebar menu with a 'Stream' section containing various event types (Add Event Chain, Add Flare, Add CME, Add SEP, Add GST, Add RBE, Add MPC, Add IPS, Add ENLIL, Add Generic Entry, Add Weekly Report, Add Daily Report) and other options like 'Merge Nuggets' and 'Email Settings'. The main content area displays a list of event entries. Each entry includes a timeline visualization, a title (e.g., 'Date/Time of alert', 'Date/Time of Weekly Report'), a description, a 'Nugget ID', and submission details. For example, one entry is 'Submitted automatically by Computer A' and another is 'Submitted manually by Leila'. Each entry has a 'Comments' section and an 'Edit' button. At the bottom right, there are navigation links '<-prev' and 'next->'.



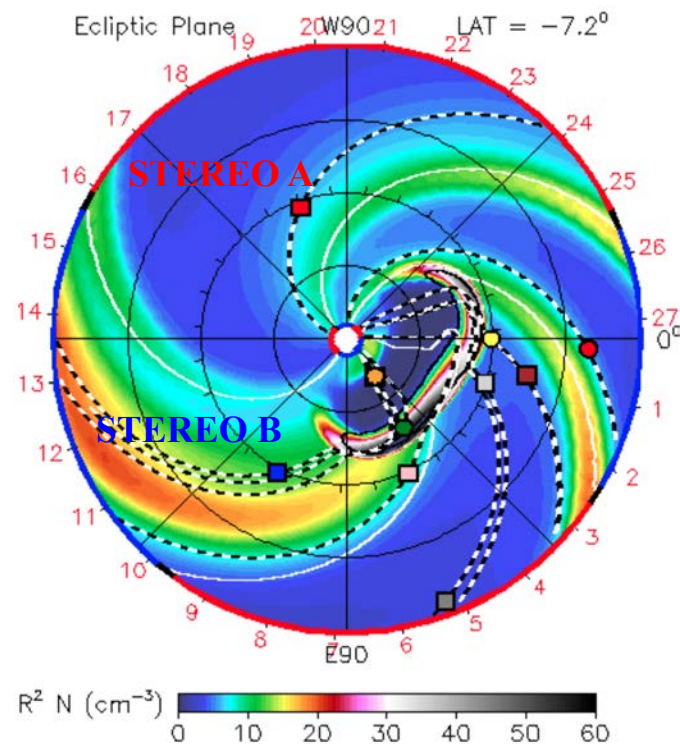


# Critical Data Streams For Space Weather Forecasting



- Solar activity monitor (SDO – Earth-facing disk, OK)
- Magnetograms of the sun (Ok)
- Real-time coronagraph images
  - with STEREOs drift further towards the farside of the sun (an issue)
  - SOHO (aging)
- L1 solar wind monitor (critical for all magnetosphere and ionosphere models) (ACE aging, DSCOVR 2014)

SOHO launched on December 2, 1995  
ACE launched on Aug 25, 1997



**SOHO/ACE (L1)**  
**SDO (GTO)**



# Summary



**NASA/GSFC Space Weather Research Center** combines:

- Forefront space weather science and models
- (Near) Real-Time Data from NASA and other missions
- Scientific expertise
- Innovative, configurable dissemination system accessible worldwide
- Domestic & international collaborations
- Strong potential for additional development

... to provide cutting-edge, cost-effective, space weather information/experimental **forecast products for NASA's robotic missions and partners**, to **conduct SWx related research**, and to **educate the public**.

***Community (World)-wide coordinated efforts be made to ensure the continuity of critical data streams that are vital for space weather.***