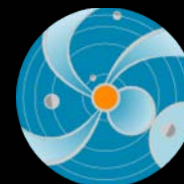




# Space Weather Forecasting at NASA GSFC Space Weather Research Center

*Yihua Zheng, Maria M. Kuznetsova, Antti Pulkkinen; Marlo M. Maddox; Aleksandre Taktakishvili; Mona L. Mays; Anna Chulaki; Hyesook Lee; Michael Hesse; Rebekah M. Evans; David Berrios; Richard Mullinix*

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



Fall 2012 AGU Meeting [IN31D-02]

# NASA GSFC Space Weather Research Center

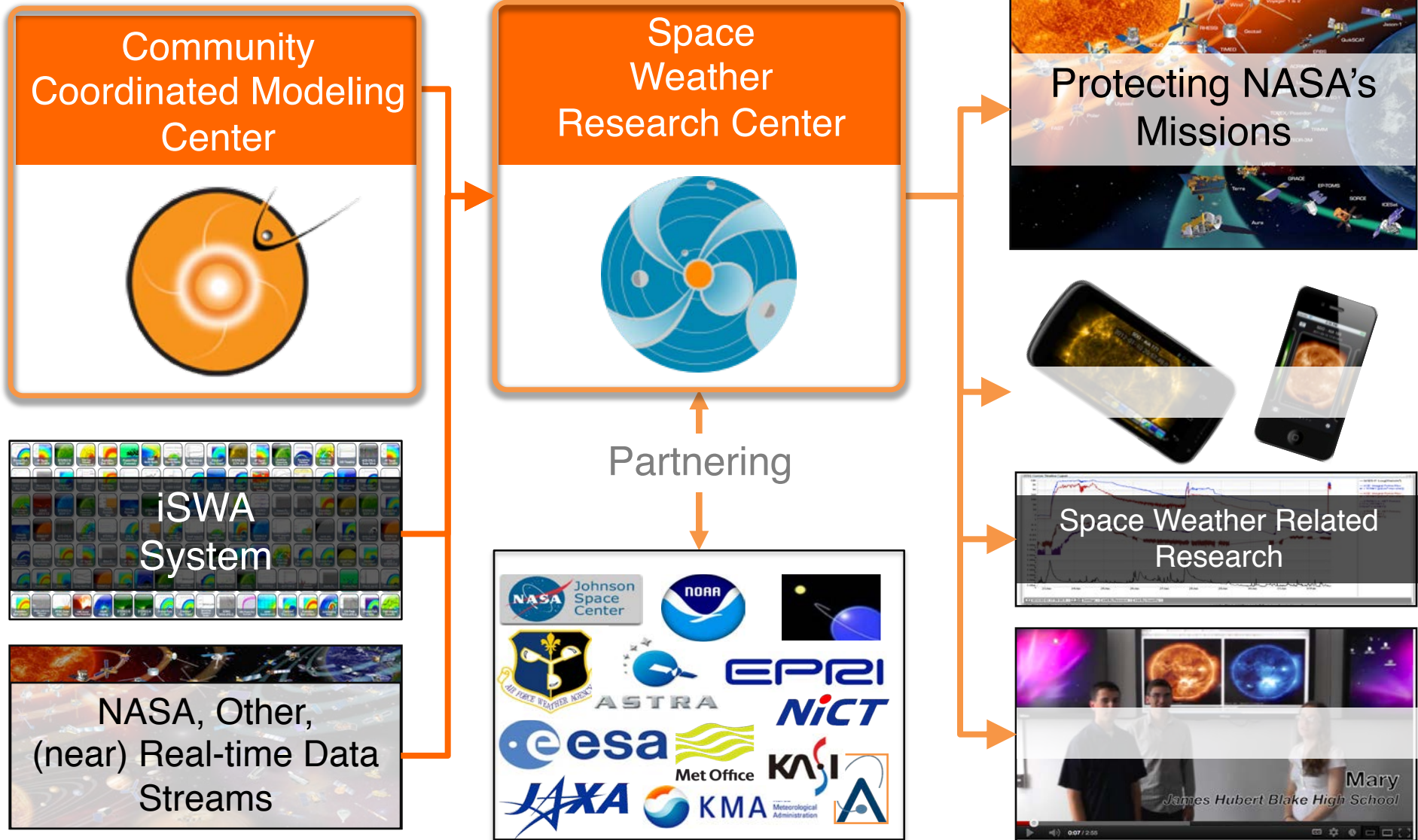


## Primary Objective:

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

since March 2010

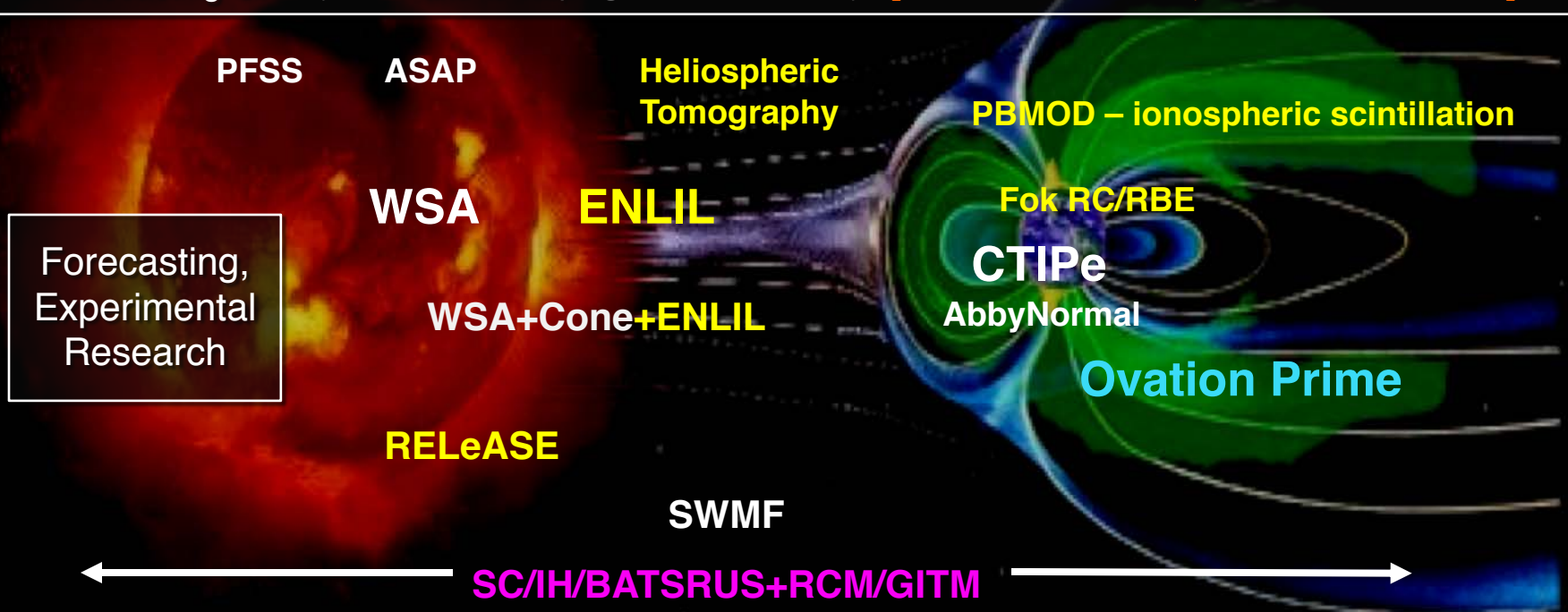
# Space Weather Forecasting @ NASA/SWRC



# Community Coordinated Modeling Center

## 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

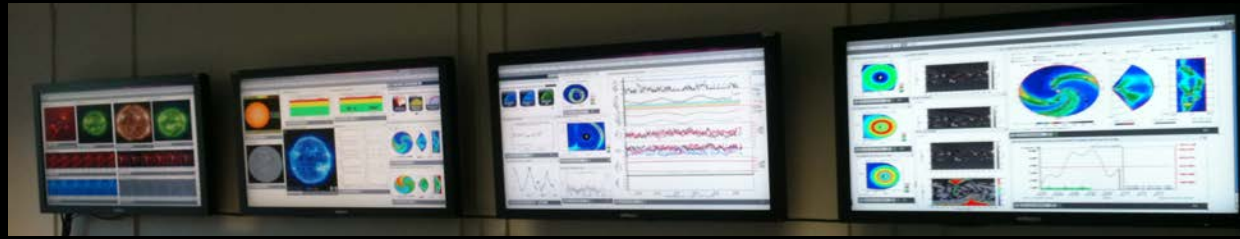
Super Computing Clusters  
( 1100 CPU's )

Dedicated Workstations

**CCMC**

.5 Peta-Byte of Data Storage

Online and Downloadable Analysis Tools

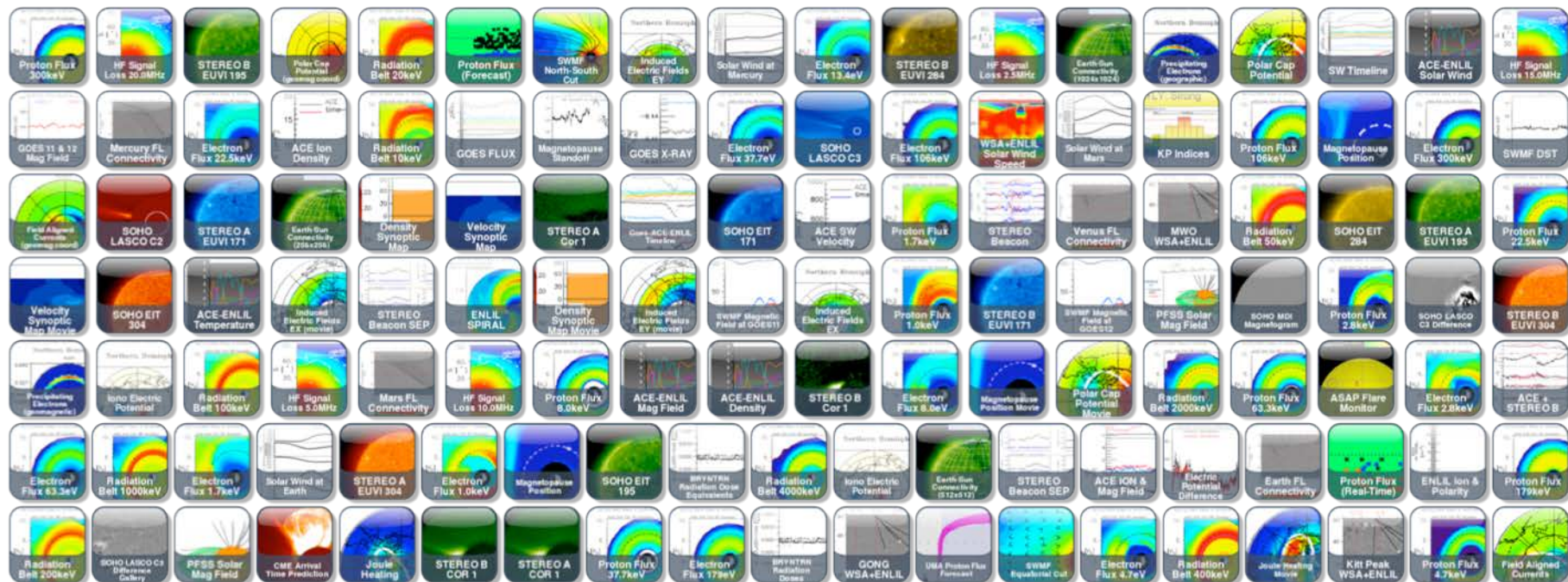




# Innovative Dissemination: iSWA

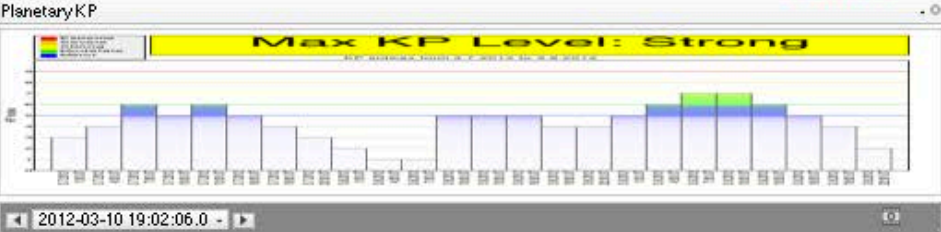
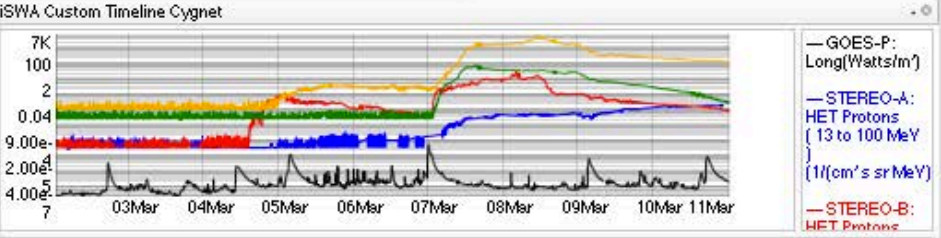
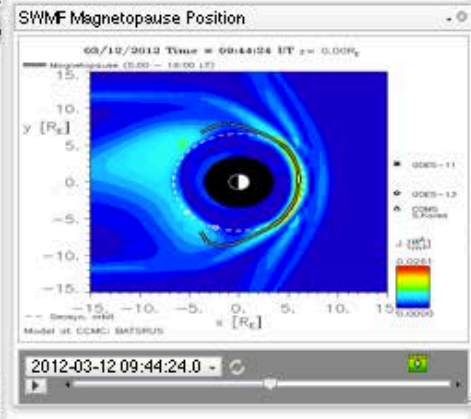
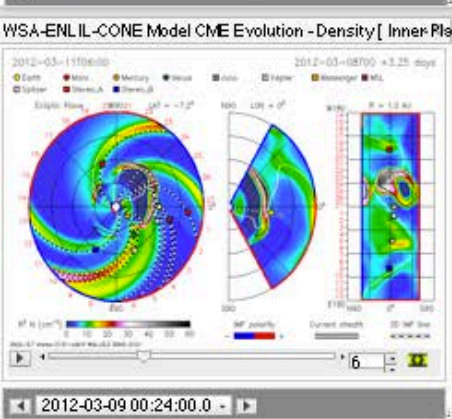
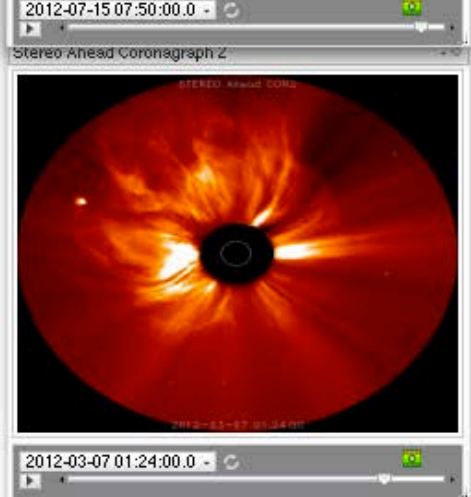
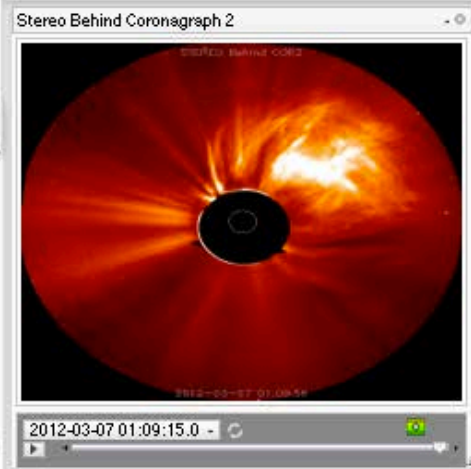
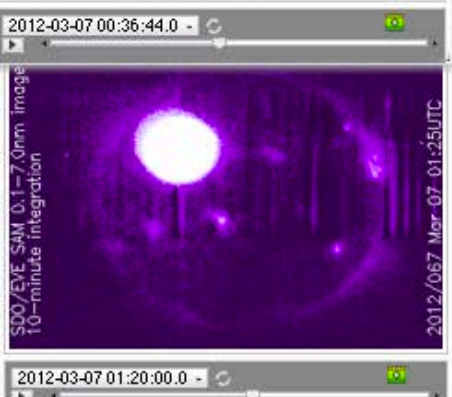
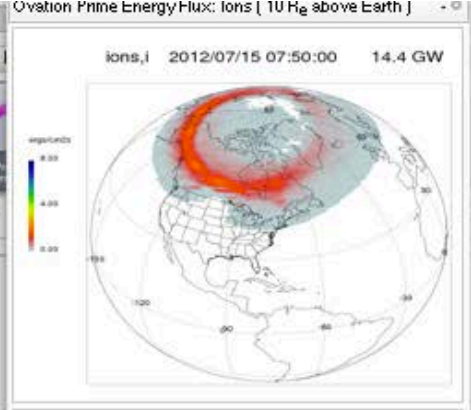
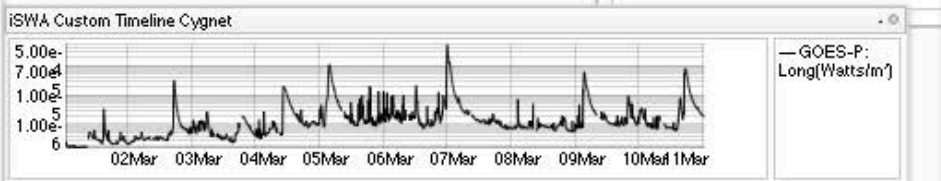
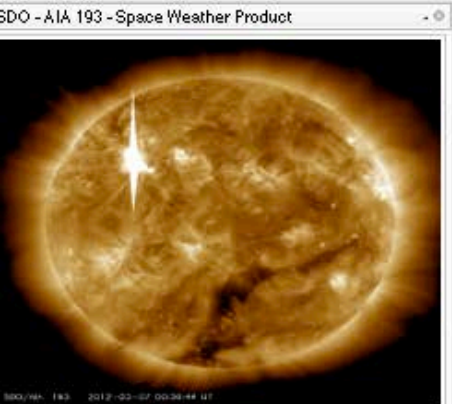


ISWA has ~300 products including modeling results and comprehensive sets of observational data.



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

# Configurable Layouts







# 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

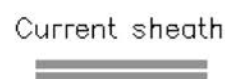
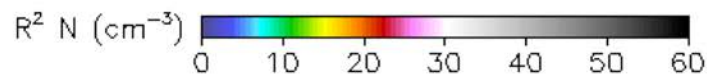
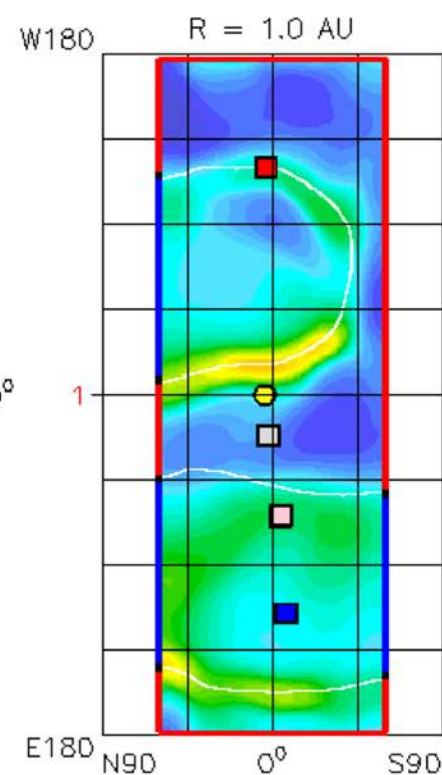
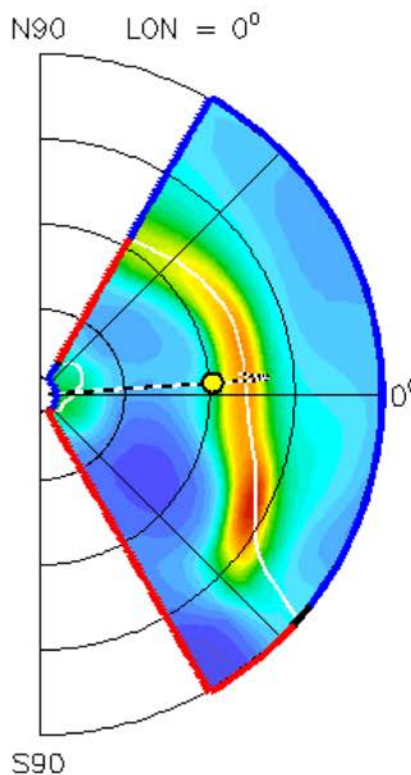
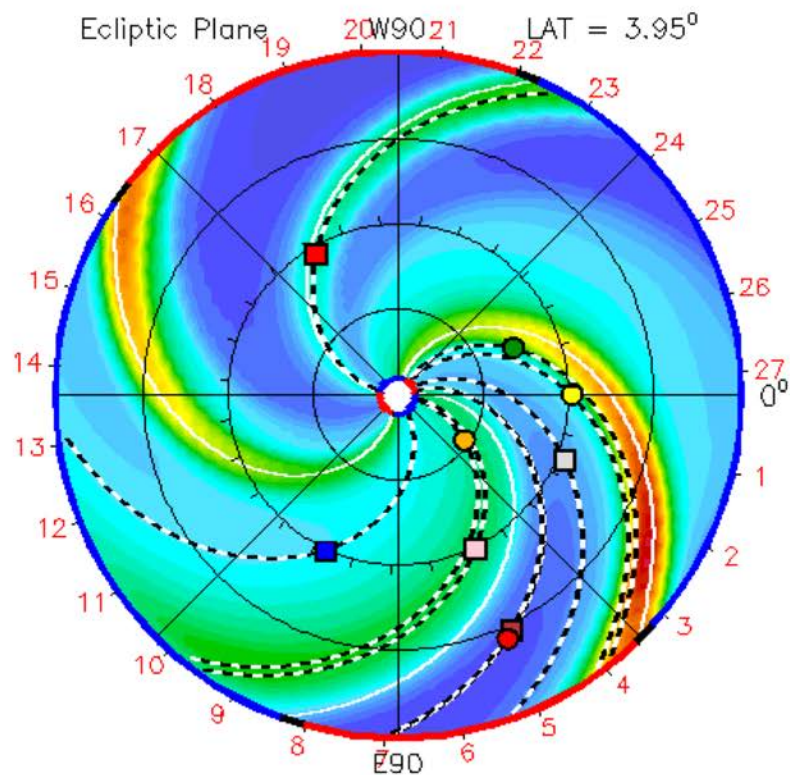


V=1400 km/s, associated with an X1.4 class solar flare

2012-07-11T00:00

2012-07-11T00 +0.00 day

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





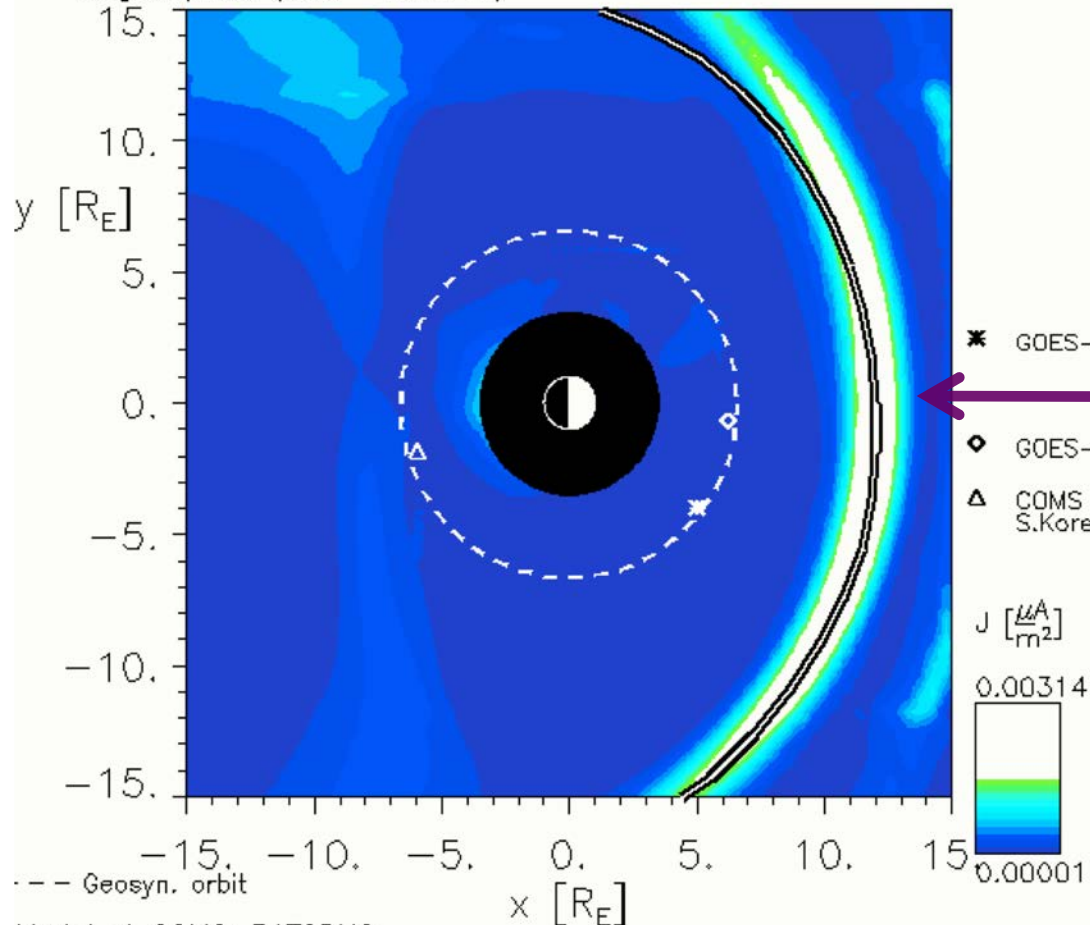


# Earth's Response to the CME's Arrival

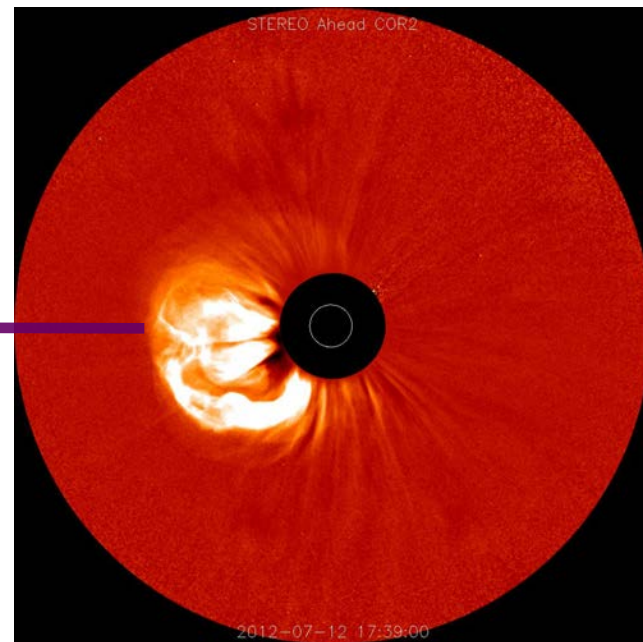


07/14/2012 Time = 16:35:10 UT  $z = 0.00R_E$

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



--- Geosyn. orbit  
Model at CCMC: BATSRUS

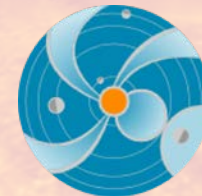


The CME seen by STEREO A

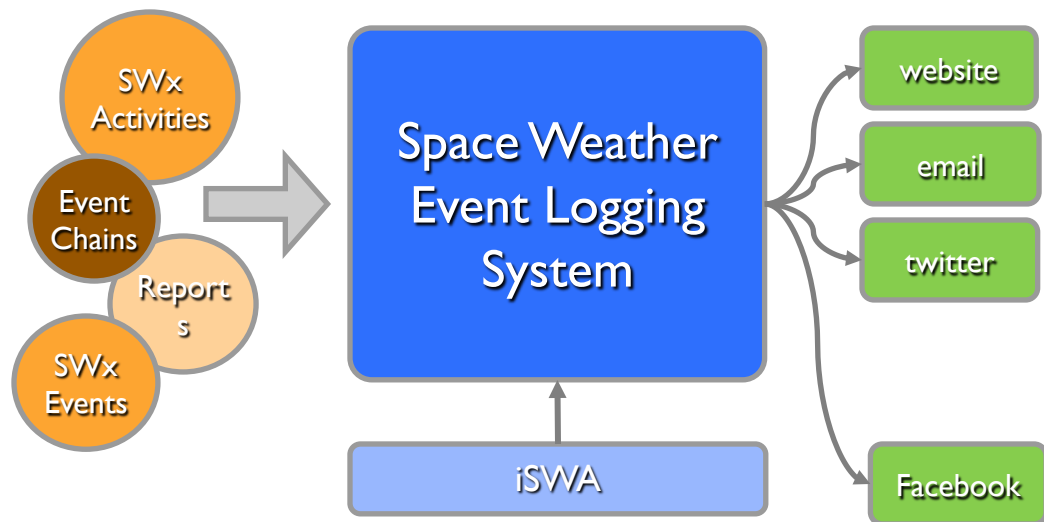
Resulting in a  $K_p = 7-$  on a scale from 0 – 9,  $K_p$ : a measure of geomagnetic disturbances



# 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



**Stream**

- 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
- Merge Nuggets
- Email Settings

iSWA  
CME TOOL  
Enlil 1-Click Submission

Logged in as - Rick Mullinix

!!

Reports: Weekly Daily  
View Activity: Flares CMEs Alerts Event Chains

! Date/Time of alert  
Information here  
Parameters here  
More parameters here  
View Data  
Nugget ID: Submitted automatically by Computer A  
Date/Time of submission  
Comments-0 Add Comment Edit

● Date/Time of Weekly Report  
Information here  
Parameters here  
Apart of Event Chain 124:  
Comments-0 Add Comment Edit

● Date/Time, Duration of Event Chain  
Information here  
Parameters here  
M Class Flare: 11-1-12 20:00:00  
CME: 11-1-12 24:00:00  
CME: 11-1-12 24:00:00  
Predicted Impact: 11-4-12  
Nugget ID: Created manually by Leila  
Date/Time of submission  
Comments-0 Add Comment Edit

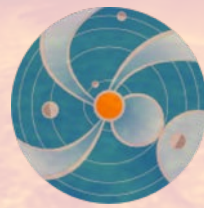
● Date/Time of CME  
Information here  
Parameters here  
View Data  
Apart of Event Chain 124:  
Leila - We might need to re-run this model.  
Nugget ID: Submitted automatically by Enlil Cone Model Run  
Date/Time of submission  
Comments-1 Add Comment Edit

● Date/Time of Flare  
Information here  
Parameters here  
View Data  
Apart of Event Chain 124:  
Comments-1 Add Comment Edit

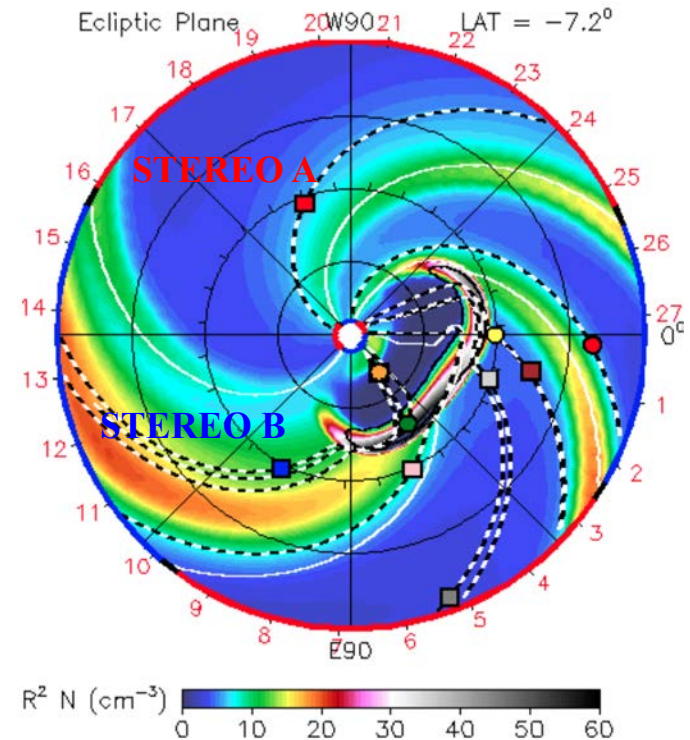
<-prev next->



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

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



# 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.***