# The Integrated Space Weather Analysis System

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SW REDI Bootcamp 2014

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NASA Goddard Space Flight Center

Greenbelt, MD
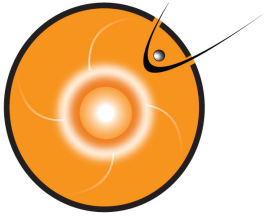
# http://ccmc.gsfc.nasa.gov

HSD
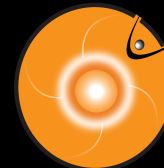
Space Weather LAB

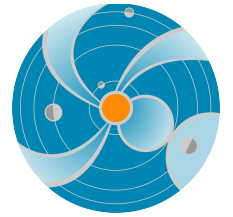# How Do You Quickly Determine Past, Present, & Expected Space Weather Impacts?

With so many NASA assets throughout the Heliosphere, the agency identified a critical need for the

# Integrated Space Weather Analysis System

# iSWA Project Overview

## OCE Technical Excellence Initiative Project

- Partnership between NASA HQ OCE, SWL, CCMC, & AETD
- Address technical challenges in acquiring space weather environment information
- Began March 2008
- Version 1.0 deployed November 2009
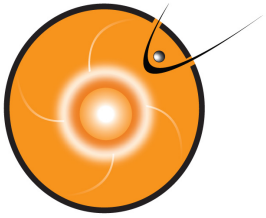
## Fundamental Challenges To Be Addressed

- Existing space weather resources are diverse and scattered
- Data accessibility
- Accurate real time  now-casting & forecasting of the space environment
- Historical space weather impact analysis
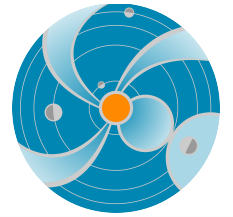
## Initial Requirements Gathering

- GSFC SSMO, JSFC SRAG

## Refined Requirements

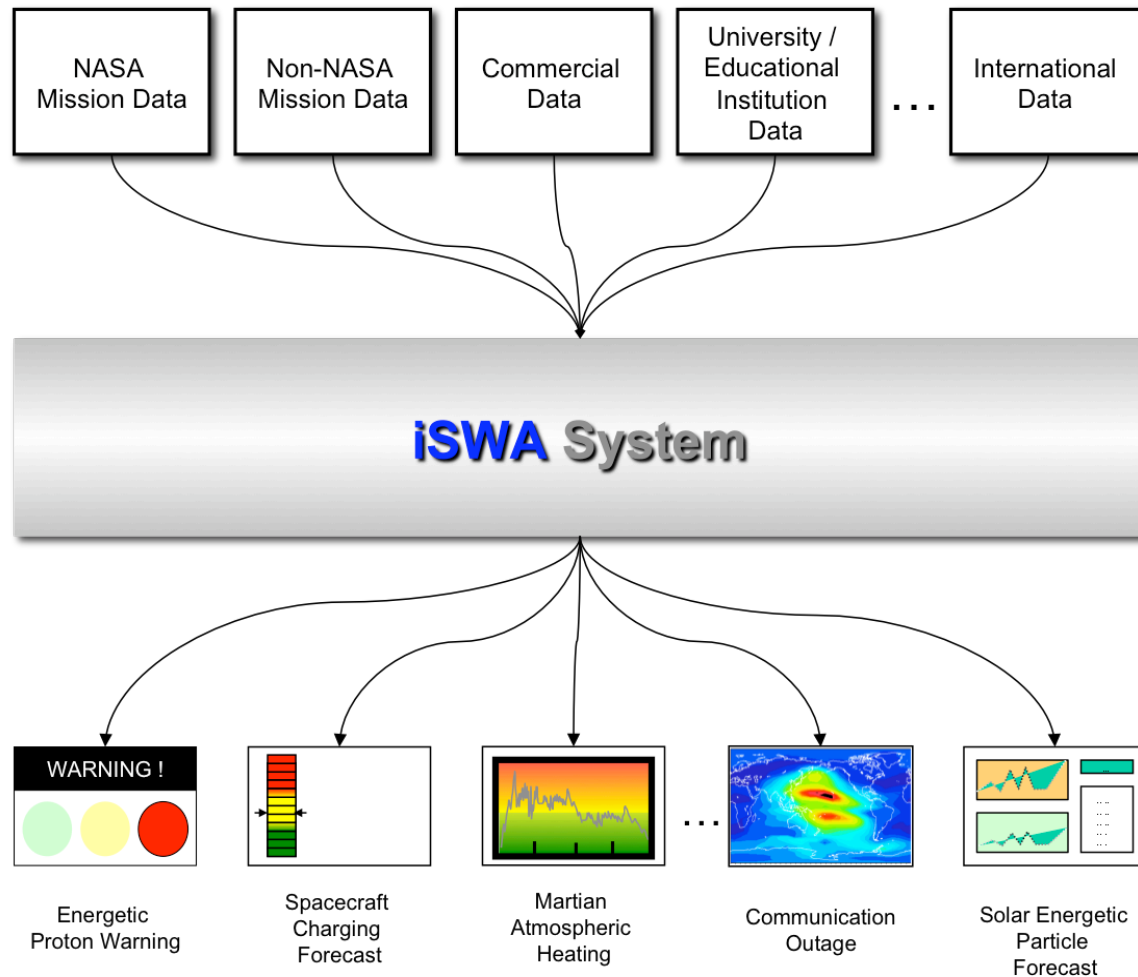- Space Weather Workshops for NASA Robotic Missions

# iSWA Solution & Deliverables

1.  Acquire, ingest, and produce NASA relevant space weather information

2.  Utilize both observational and simulation/model data

3.  Produce and provide real-time data streams

4.  Categorize and archive data for historical impact analysis

5.  Provide customizable and highly configurable displays

6.  Disseminate through the most widely deployed and accessible interface – the web

| NASA Mission Data | Non-NASA Mission Data | Commercial Data | University / Educational Institution Data | . . . | International Data |
|---|---|---|---|---|---|

**iSWA System**

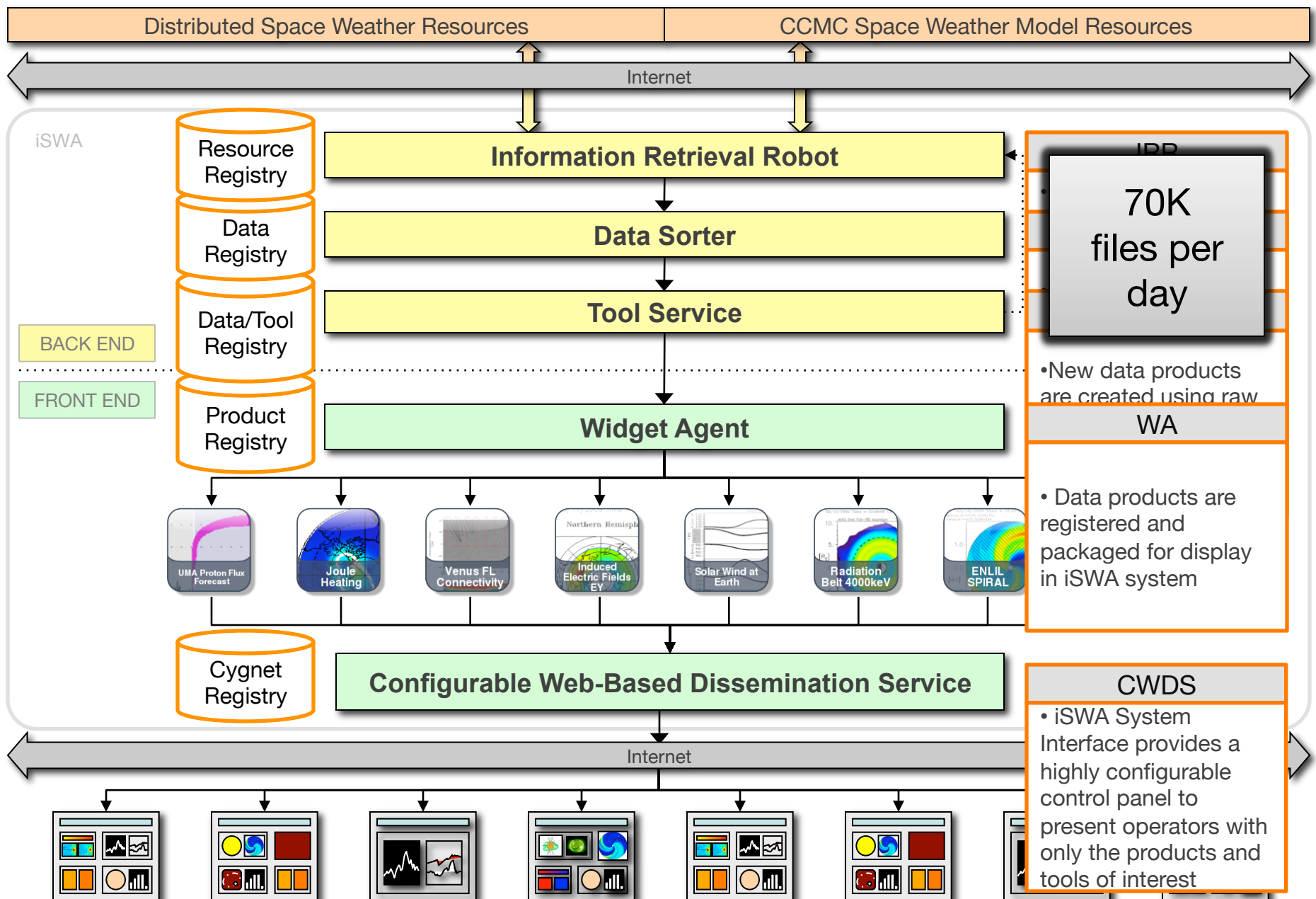| WARNING ! | | Spacecraft Charging Forecast | Martian Atmospheric Heating | . . . | Communication Outage | Solar Energetic Particle Forecast |
|---|---|---|---|---|---|---|

Energetic Proton Warning

Highly diverse and distributed space weather data consisting of the latest observational data along with the most advanced space weather model simulation output.
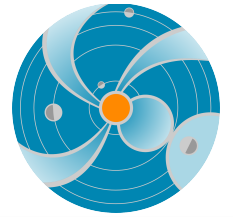
iSWA system collects data from a large and evolving list of sources. Data is sorted, characterized, and processed into 'mission decision supporting' products in response to individual user queries.

iSWA generates and provides a user-configurable display panel that can be accessed from a standard web browser. The end user can then customize their display to focus on specific products of interest.
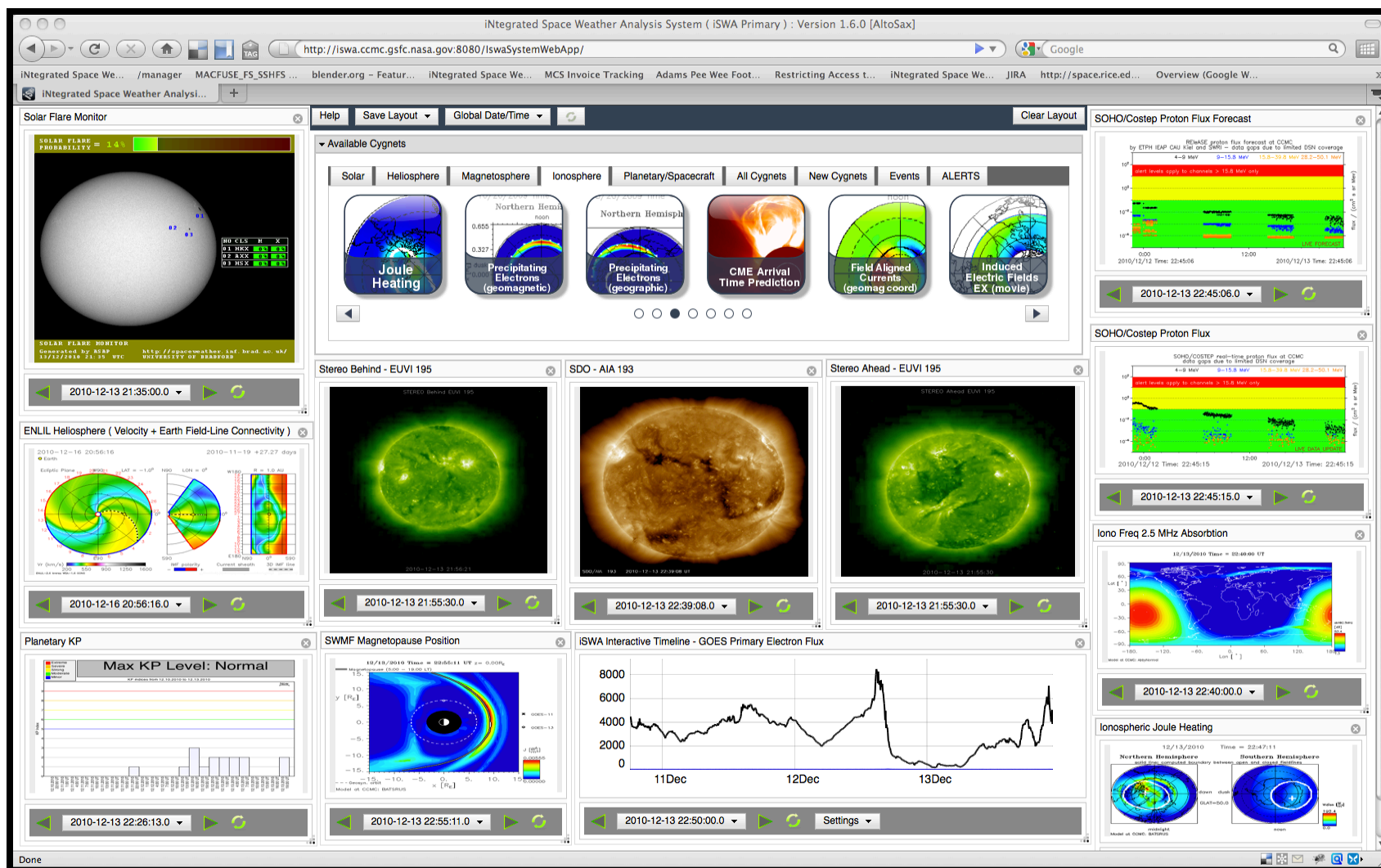
**Distributed Space Weather Resources** | **CCMC Space Weather Model Resources**

Internet

iSWA

Resource Registry

Data Registry

Data/Tool Registry

BACK END

FRONT END

Product Registry

**Information Retrieval Robot**

**Data Sorter**

**Tool Service**

**Widget Agent**

IRR

70K files per day

• New data products are created using raw

WA

• Data products are registered and packaged for display in iSWA system

UMA Proton Flux Forecast | Joule Heating | Venus FL Connectivity | Induced Electric Fields EY | Solar Wind at Earth | Radiation Belt 4000keV | ENLIL SPIRAL

Cygnet Registry

**Configurable Web-Based Dissemination Service**

CWDS

• iSWA System Interface provides a highly configurable control panel to present operators with only the products and tools of interest

Internet

• **493** Unique Data Feeds, **57** Million Files Registered and Archived, **359** Consumable Display Products currently managed in iSWA Cygnet Catalog
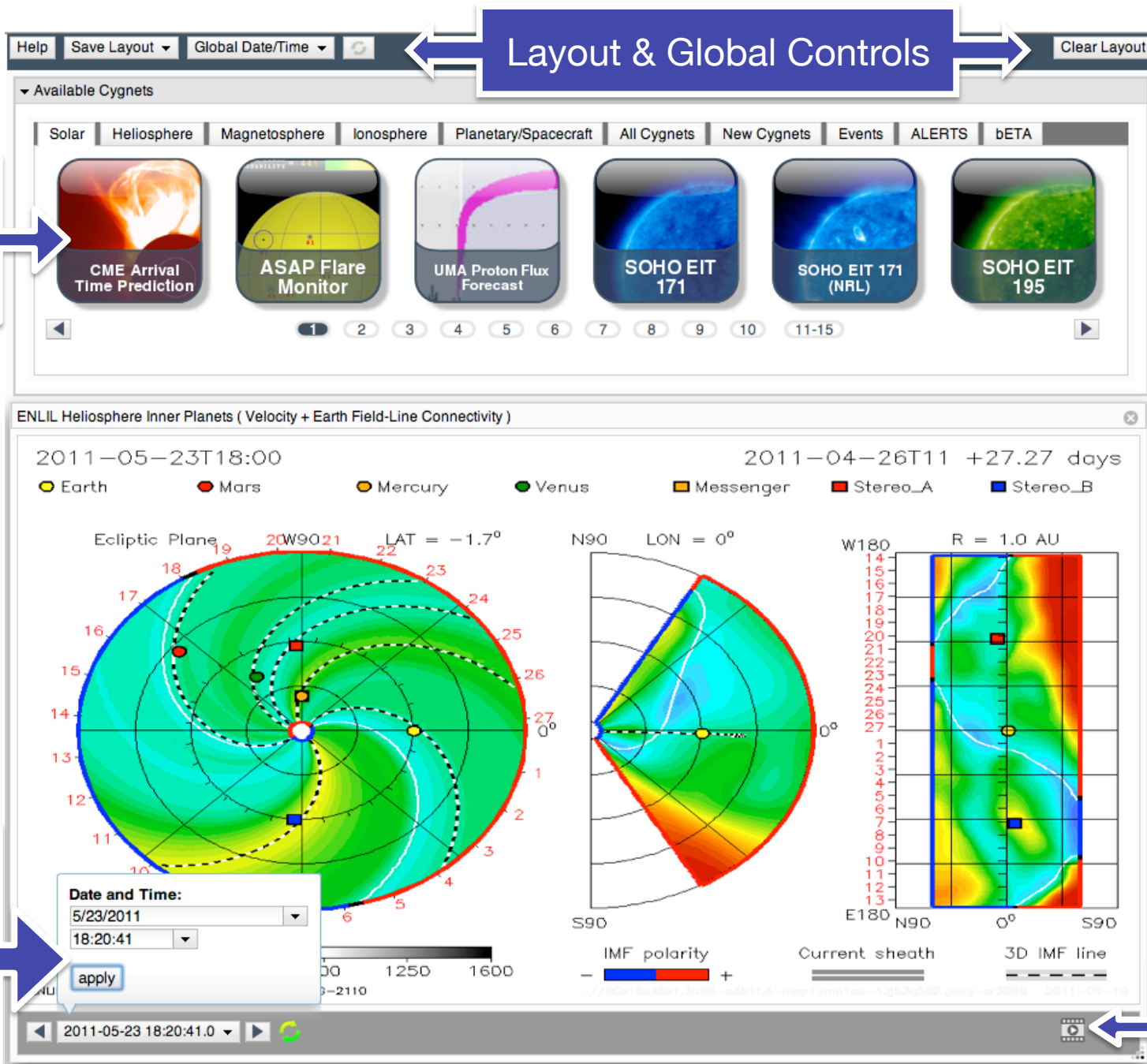
# Innovative Dissemination

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**

# Unprecedented Access to Space Weather Information



http://**iSWA**.ccmc.gsfc.nasa.gov

Layout & Global Controls

Clear Layout

Help | Save Layout ▼ | Global Date/Time ▼ | ↻

▼ Available Cygnets

| Solar | Heliosphere | Magnetosphere | Ionosphere | Planetary/Spacecraft | All Cygnets | New Cygnets | Events | ALERTS | bETA |

Cygnet Control Panel →

CME Arrival Time Prediction | ASAP Flare Monitor | UMA Proton Flux Forecast | SOHO EIT 171 | SOHO EIT 171 (NRL) | SOHO EIT 195

◄ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11-15 ►

ENLIL Heliosphere Inner Planets ( Velocity + Earth Field-Line Connectivity )

2011-05-23T18:00          2011-04-26T11 +27.27 days

○ Earth  ● Mars  ○ Mercury  ● Venus  ■ Messenger  ■ Stereo_A  ■ Stereo_B

Ecliptic Plane        W90        LAT = −1.7°        N90    LON = 0°        W180    R = 1.0 AU

E180    N90    0°    S90

IMF polarity      Current sheath      3D IMF line
−  ■■  +

Cygnet Date Controls Options →

**Date and Time:**
5/23/2011 ▼
18:20:41 ▼

apply

◄ 2011-05-23 18:20:41.0 ▼ ► ↻

Movie Mode Control →

# Dynamically Generated & Interactive Products: Solarscape

**Magnetic Connectivity Solarscape Viewer**

**Alerts/ Notifications**

Notification: Earth(Gong WSA Enlil): 16.6 degrees from active region.
Notification: Venus(Gong WSA Enlil): 2.6 degrees from active region.

**User Selectable Features** ( MAG4, NOAA Active Regions, CCMC Magnetic Connectivity )

**User Selectable Background** ( SDO , Generic Grid )

Mercury(Gong WSA Enlil)
Lat: 18.7 Lon: -137.1
Nearest Region: 77.81

11948  11946  11942  11945  11947

11944  11943  11938

- ○ NOAA Active Regions
- ● Earth(Gong WSA Enlil)
- ● Mars(Gong WSA Enlil)
- ○ Mercury(Gong WSA Enlil)
- ● Venus(Gong WSA Enlil)

2014-01-07 16:30:00    Background ▾    Features ▾
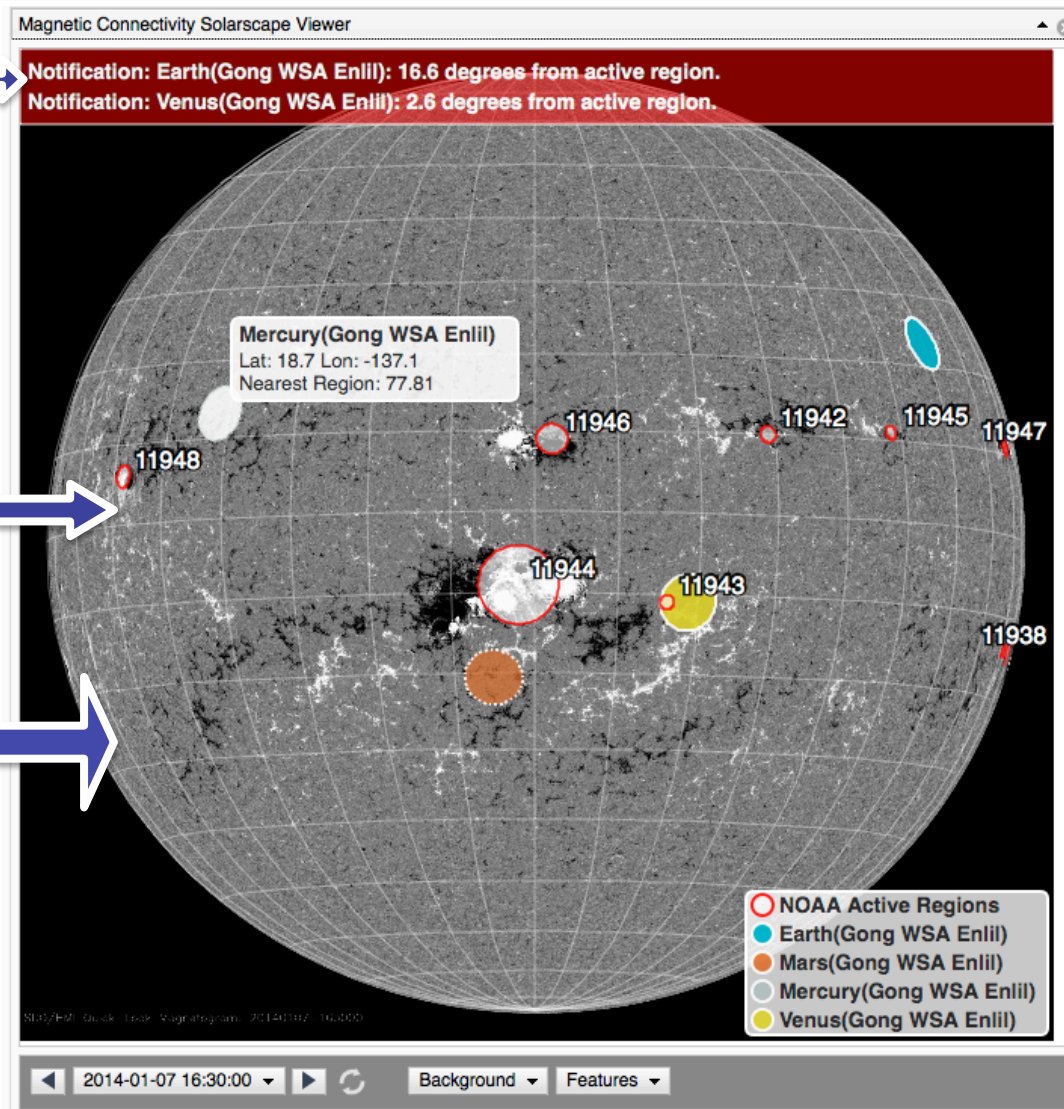
# Dynamic Product with User Selectable Features From Several Sources

iSWA

# Interactive Timelines

**Interactive CME alert tool with chronological record of SWx Center issued CME time of arrival predictions**
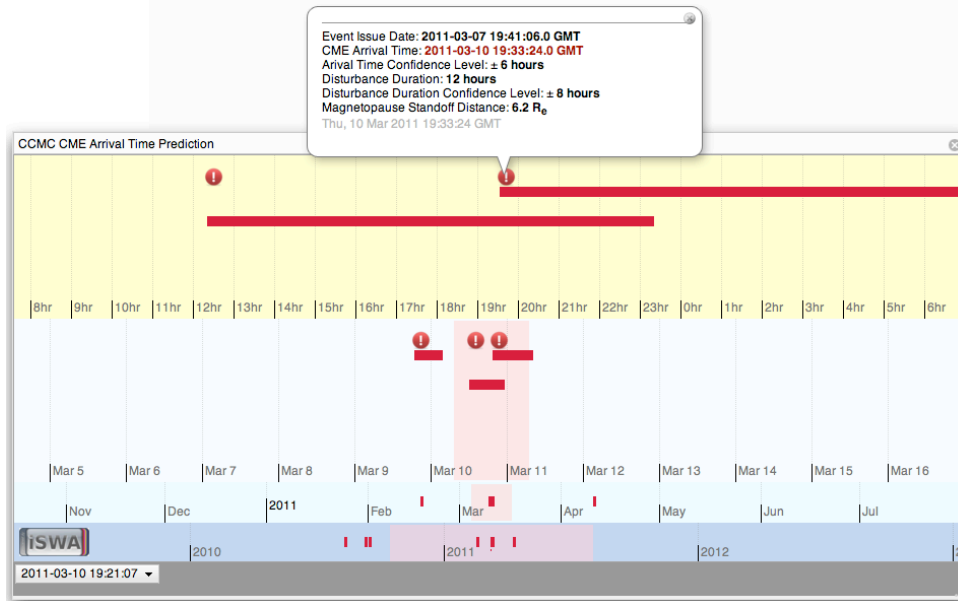
**Interactive timeline tool with pan, zoom, mouse-over, and quantity toggling functionality**

12
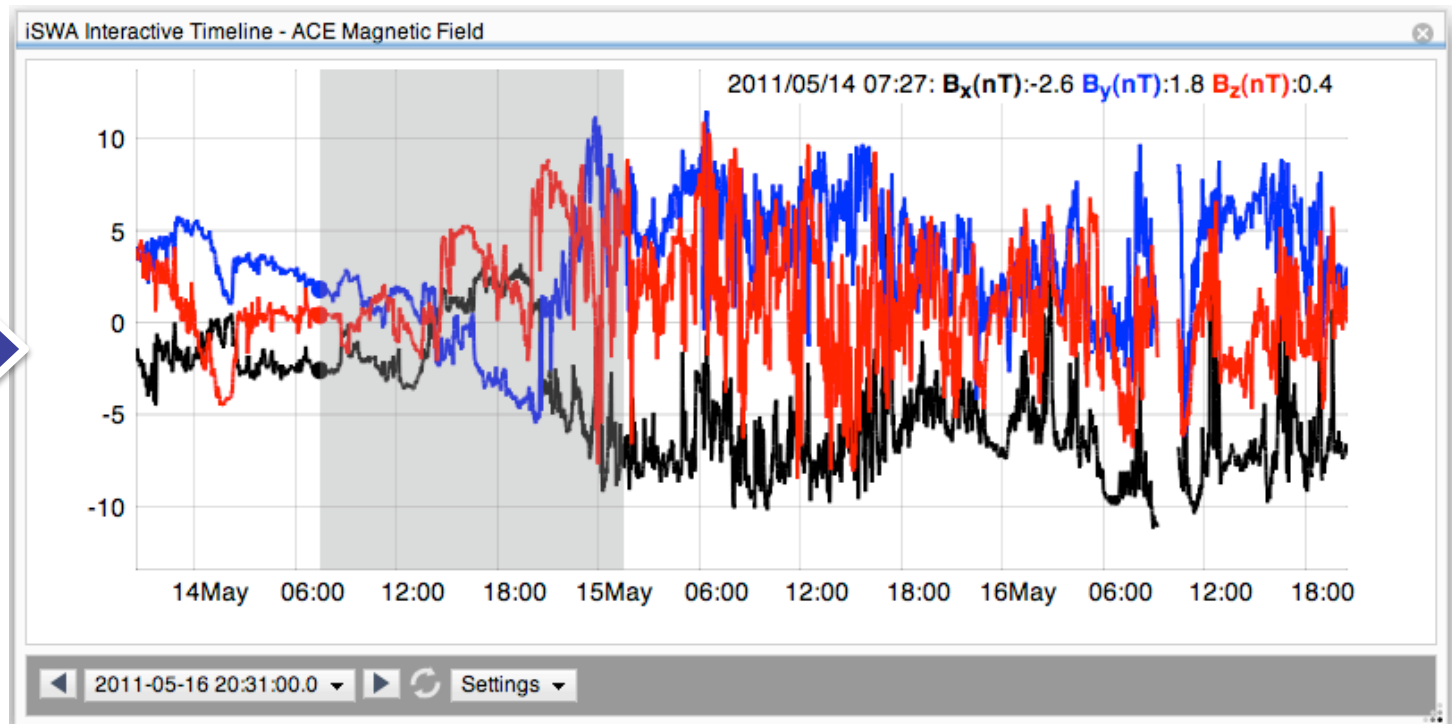
# Mobile Access Powered by iSWA
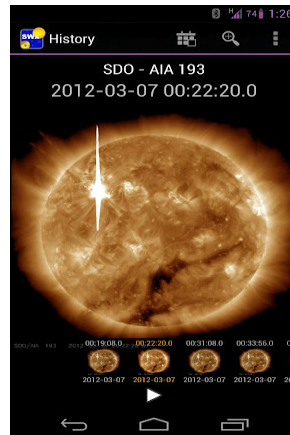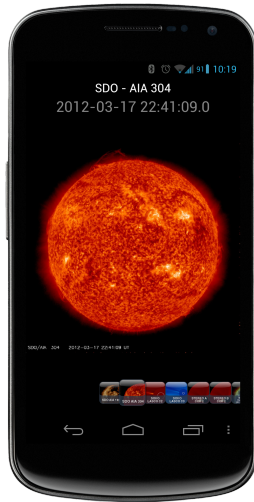


## Android Front-End to iSWA

- History Mode
- Movie Mode
- >50k Downloads
- Available in Google Play Store
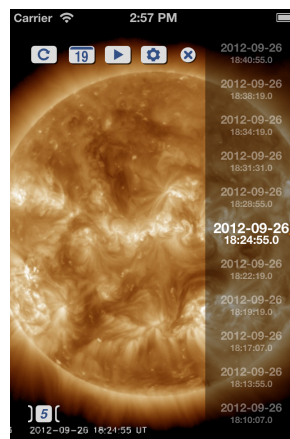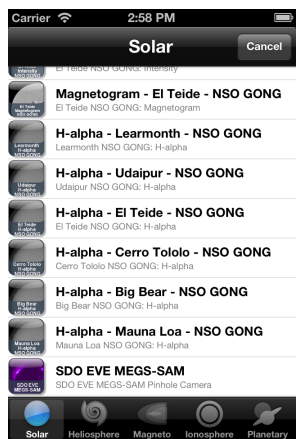


## IOS Front-End to iSWA

- >100k Downloads
- Available in App Store
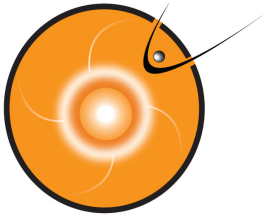
# Services for NASA Robotic Missions Powered by iSWA

1. Providing assistance in spacecraft anomaly resolution by assessing whether space weather has any role in causing the observed anomaly/anomalies.

2. Sending out weekly space weather reports/summaries to NASA mission operators, NASA officials and involved personnel.

3. Sending out timely space weather info/forecasts regarding adverse conditions throughout the solar system, such as significant CME events, elevated radiation levels, etc.

4. Providing general space weather support for NASA customers.



Photo Credit: Chris Gunn

# Education And Training Powered by iSWA
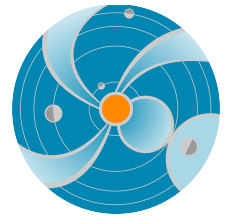


Arranged by NASA IV&V Educator Resource Center
High school teachers from West Virginia

Y. Zheng
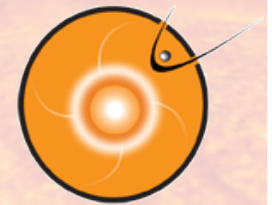
## New Systems/Extensions Powered by iSWA

- Project specific implementations
- Full iSWA feature set, infrastructure
- customized cygnet/product catalog
- **I**ntegrated **S**olar **E**nergetic **P**roton Event

Alert Warning System – Advanced Radiation Project
( OCT Game Changing Office )
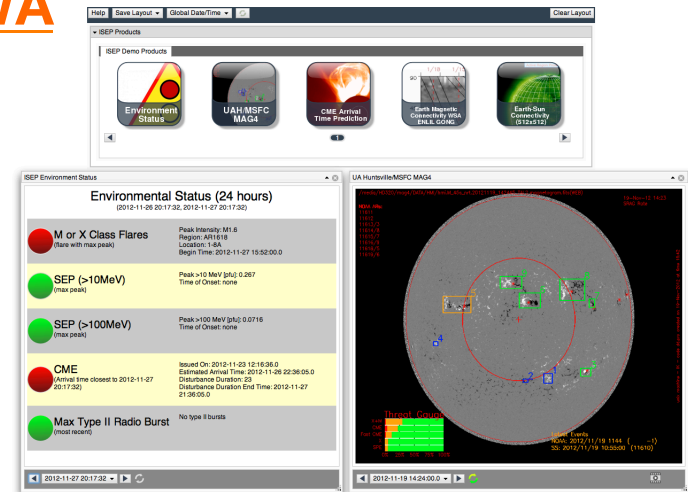


## Expanded Numerical Database - FlexDIT

- New parameters
- Custom alerts
- Dynamically generated products
- Data streaming for external applications

## Web Services

- Building web-based interfaces for machine-to-machine interaction
- Enabling external systems to query, access, and link to iSWA data

## Space Weather Event Catalog and Event Linking – Linking to DONKI

- Building catalog of space weather event, forecaster-logs, alerts, etc.
- Establishing linkages, relationships, cause-and-effects between activities

http://iSWA.ccmc.gsfc.nasa.gov
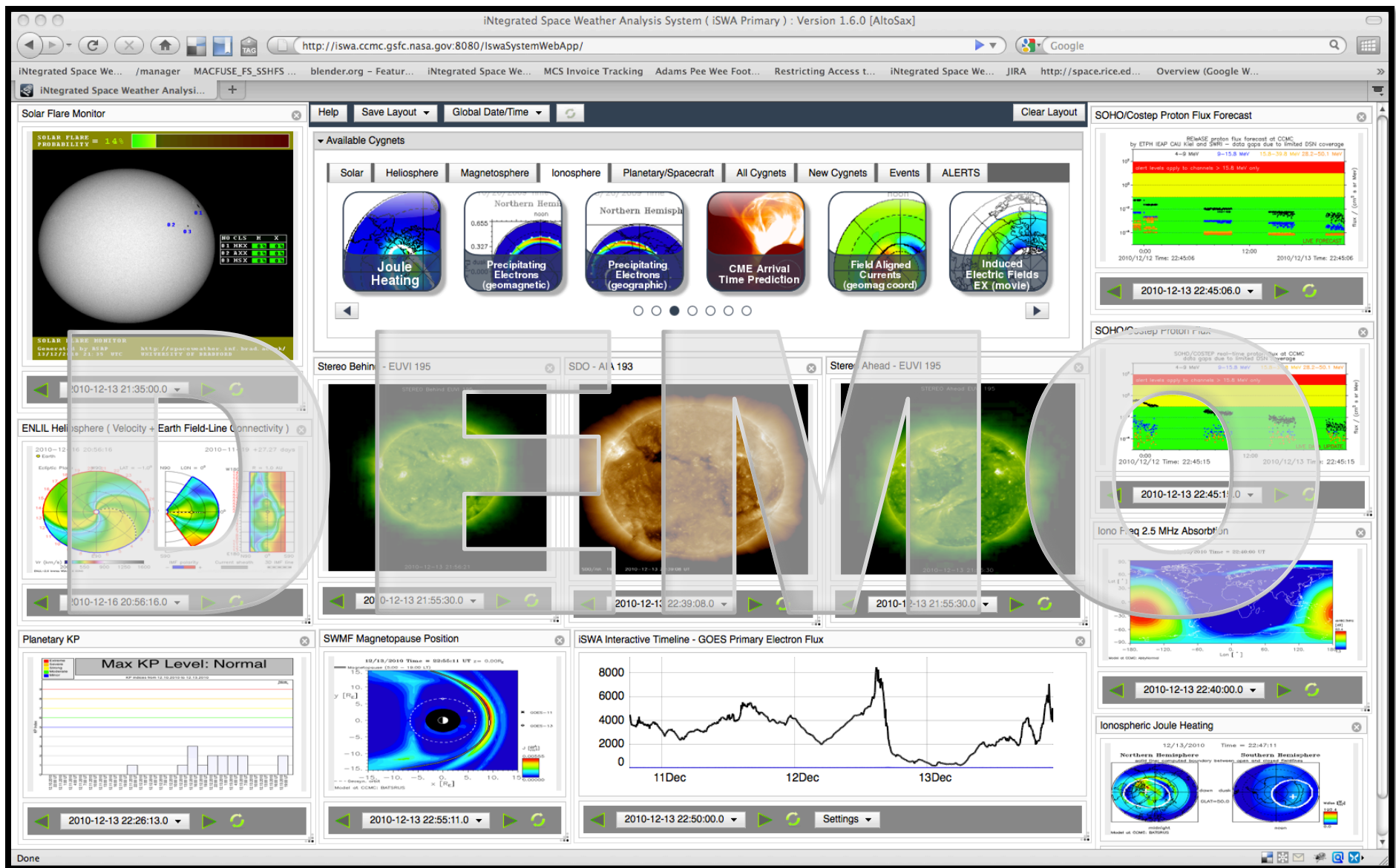
# BOOKMARK DEMO

- Space Weather Event 04/11/2013 - http://go.nasa.gov/13oVkrB
- Venus Transit - http://go.nasa.gov/13oR2k1
- St. Patricks Day Storm 03/15/2013 - http://go.nasa.gov/YGUeiO
- Filament Eruption 02/27/2013 - http://go.nasa.gov/XcgWDi
- Space Weather Event 09/28/2012 - http://go.nasa.gov/XGW0Eu
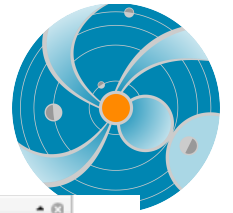- Space Weather Event 10/5/2012 - http://go.nasa.gov/XtGsmH
- Current 8-Day Timeline - http://go.nasa.gov/16TediU

http://iSWA.ccmc.gsfc.nasa.gov

# Supplemental Sides/Details
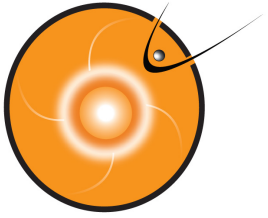
# Specific Examples…
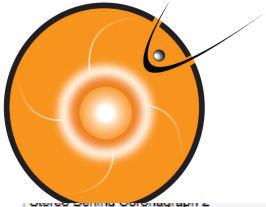
# Jan 23 flare (M8.7)/CME (v=2210km/s)
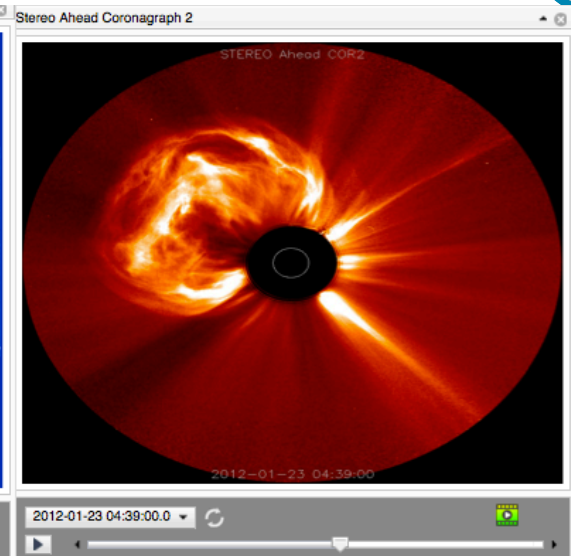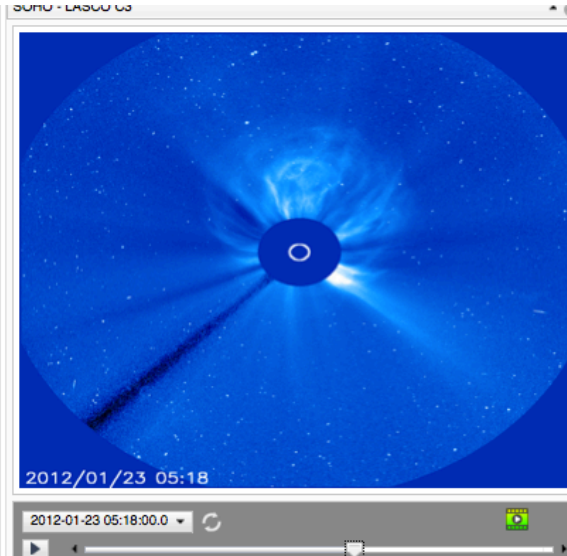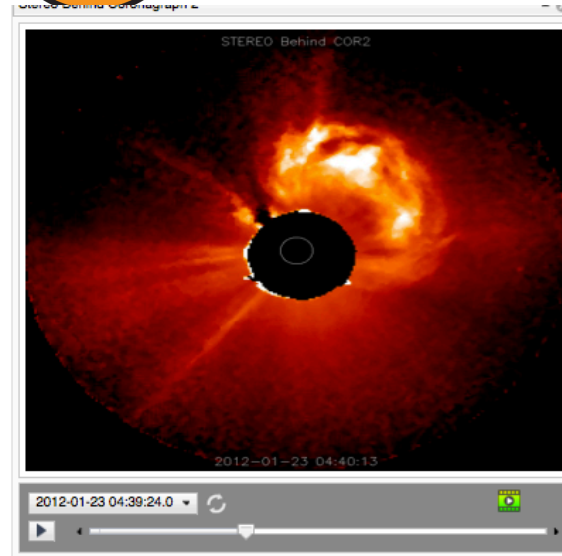


CME
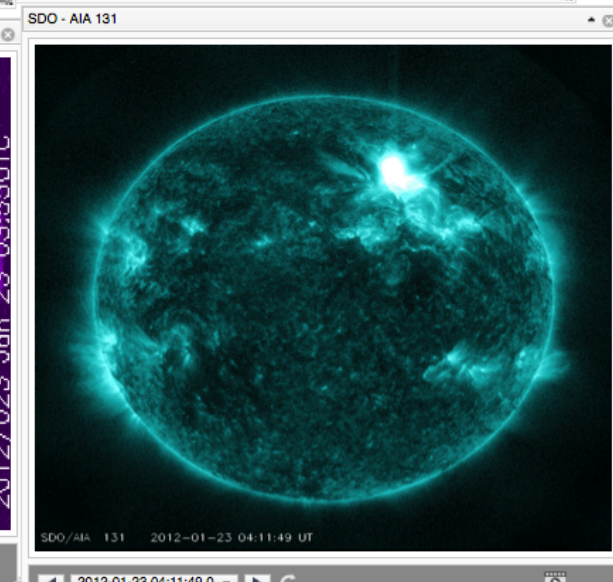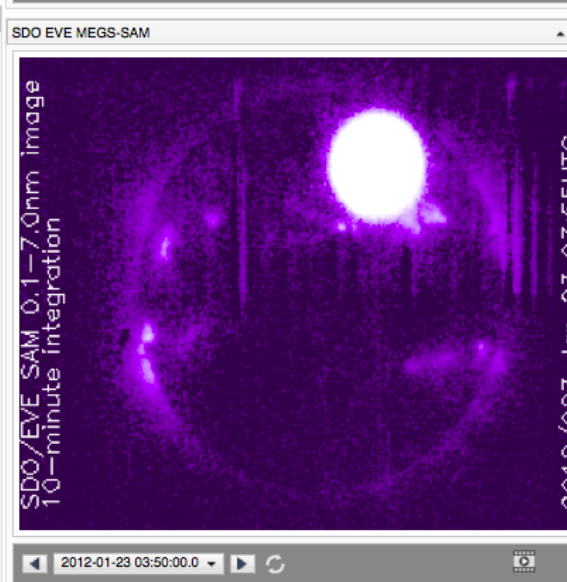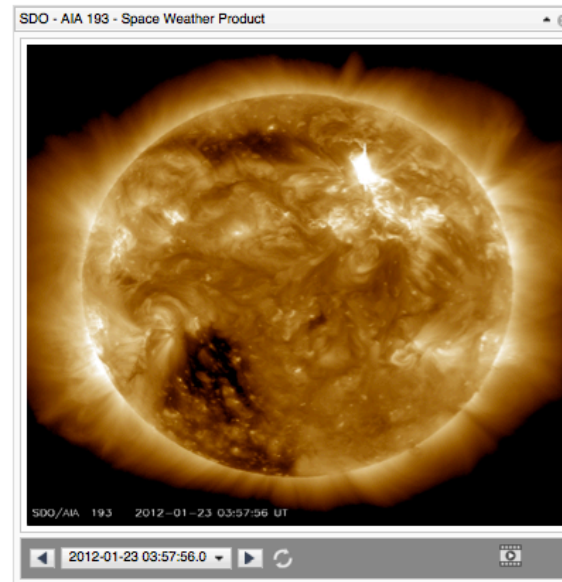
Flare
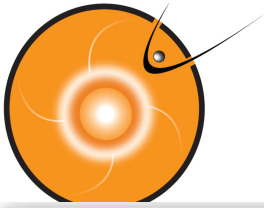
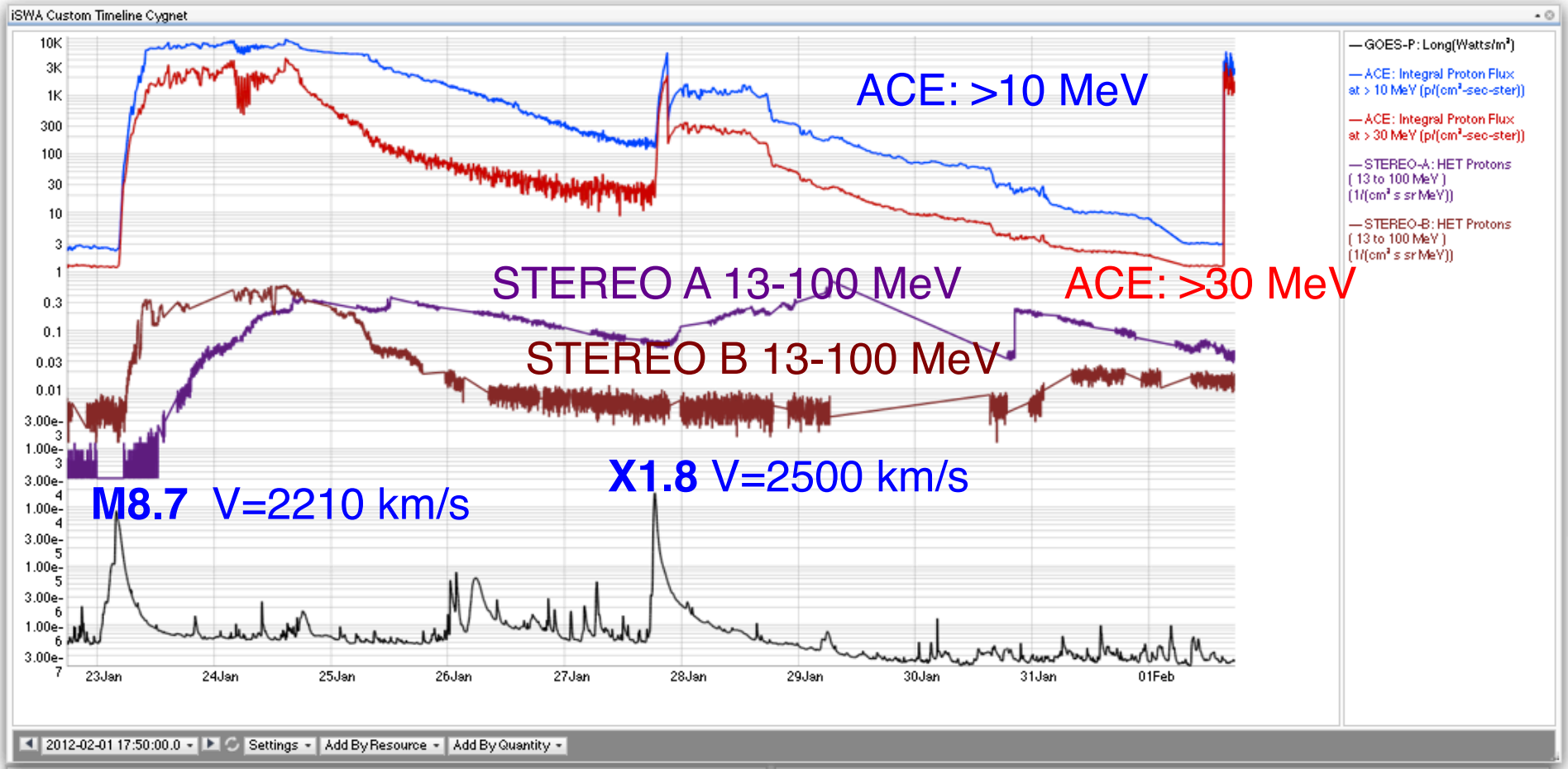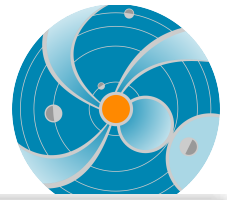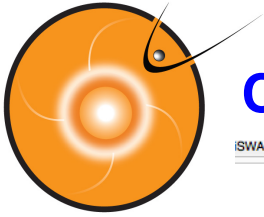# SEP: proton radiation (flare and CME)
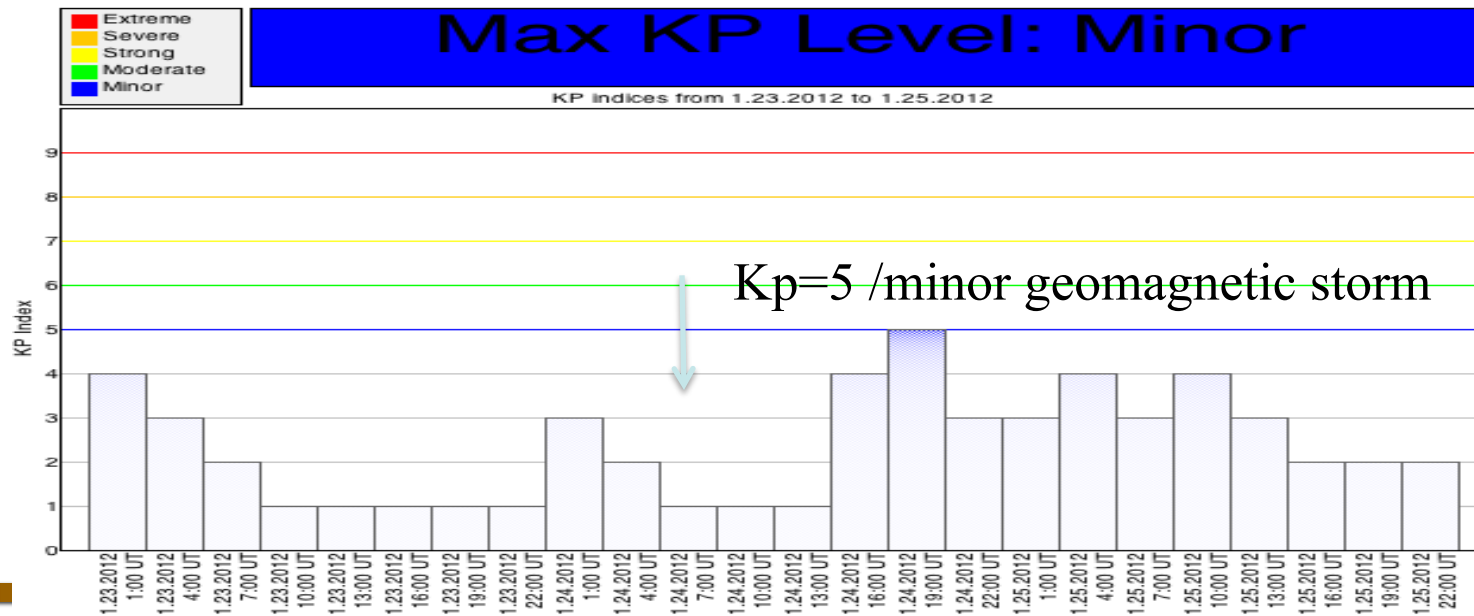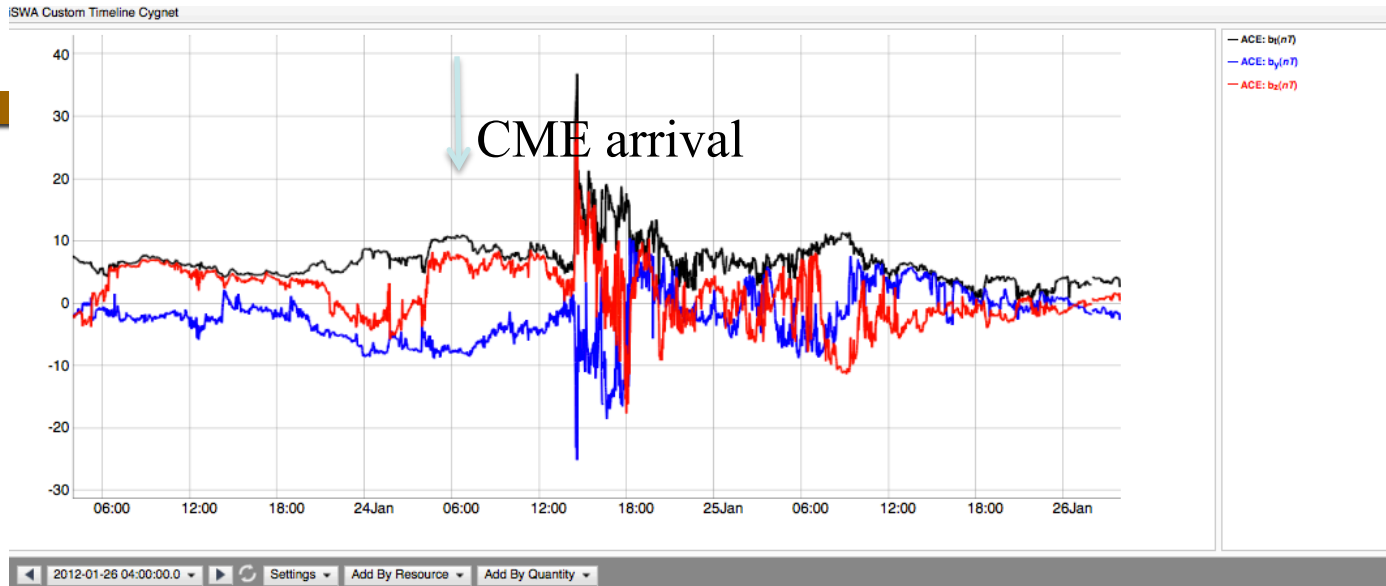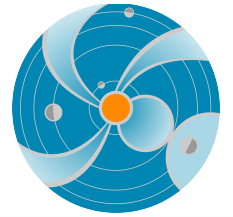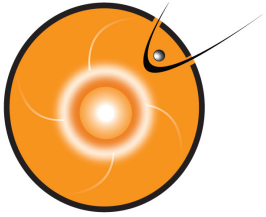
## iSWA SuperTimeline



The Jan 23 and Jan 27 flare/CME pairs were associated with the same active region 1402. Both events created significantly enhanced ion radiation (SEP flux levels).

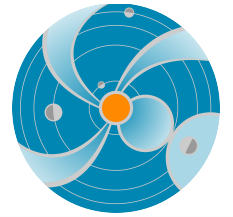**Several polar flights were rerouted due to the radiation**

# CME impact at Earth (a minor geomagnetic storm only)



CME arrival

Max KP Level: Minor

Kp=5 /minor geomagnetic storm

# An iSWA layout for the 23 Jan 2012 event

http://bit.ly/Jan23_27_2012_layout

Provide a dynamic view of the event with some key products

The Jan 23 event produced a very strong radiation storm
- slightly less than that of the March 7 2012 event

*Peak flux (Jan 23): 6310 pfu at Jan 24 15:30 UT*
*Peak flux (Mar 7):  6530 pfu at Mar 8: 11:15 UT*

Active Region 1429 activities during March 2012

Earthside Major Events

Backside major events