

National Aeronautics and Space Administration



The iNtegrated Space Weather Analysis System

*M. Maddox
and the CCMC, SWRC, & ISWA Team*

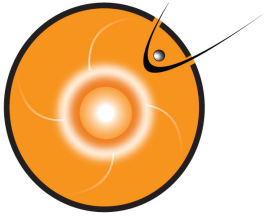
*587 / Science Data Processing Branch
674 / Space Weather Laboratory*

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



www.nasa.gov

NASA Goddard Space Flight Center *Software Engineering Division*



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

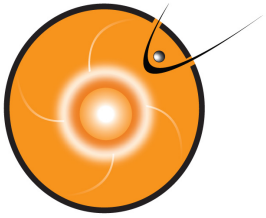
- Existing space weather resources are diverse and scattered
- Data accessibility
- Accurate real time now-casting & forecasting of the space environment
- Historical space weather impact analysis

Initial Requirements Gathering

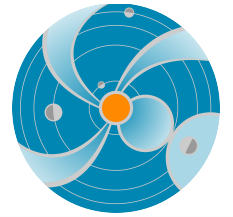
- GSFC SSMO, JSFC SRAG

Refined Requirements

- Space Weather Workshops for NASA Robotic Missions

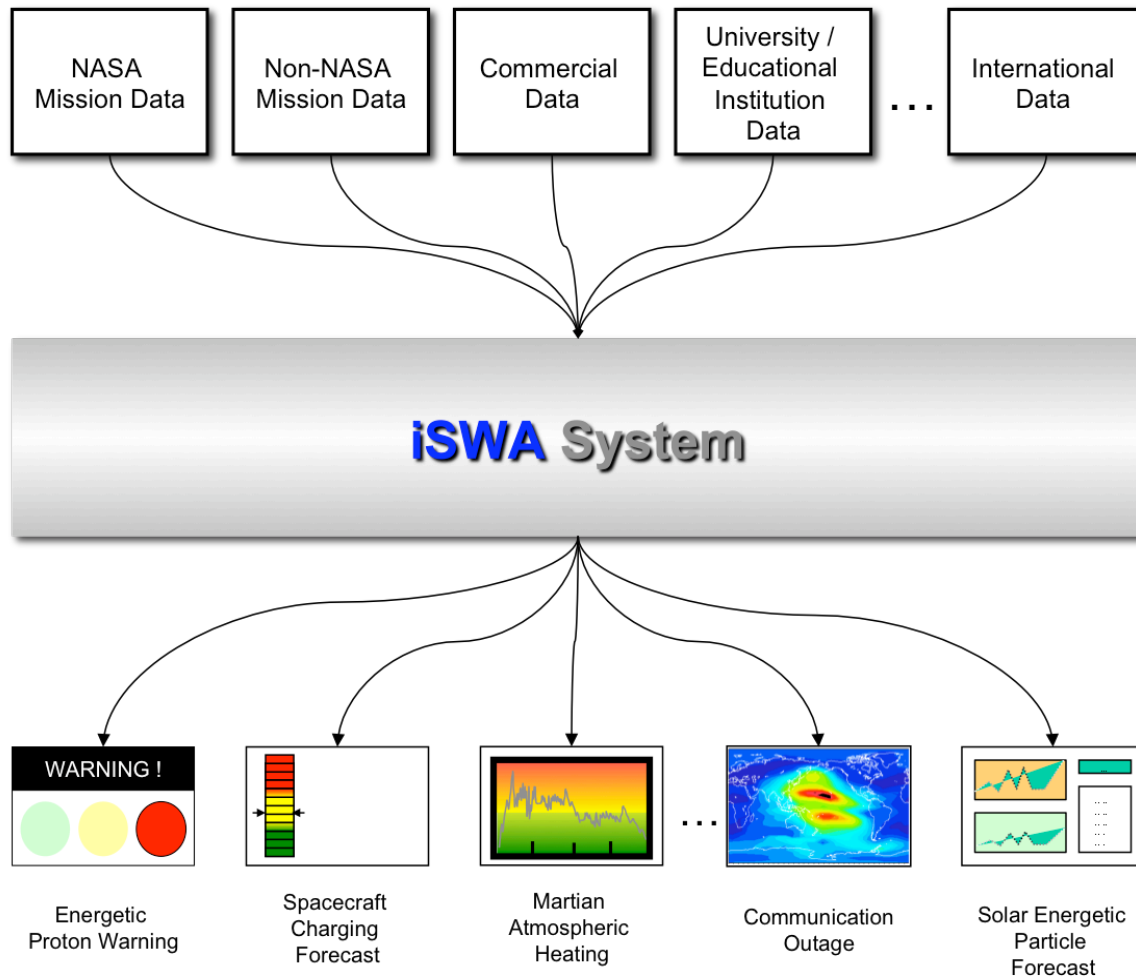


iSWA Solution & Deliverables



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

iNTEGRATED SPACE WEATHER ANALYSIS SYSTEM

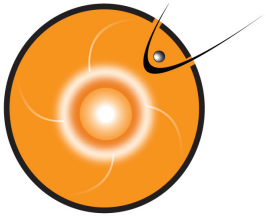


Highly diverse and distributed space weather data consisting of the latest observational data along with the most advanced space weather model simulation output.

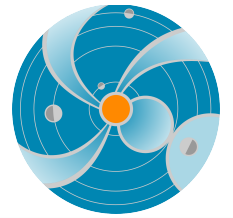
iSWA system collects data from a large and evolving list of sources. Data is sorted, characterized, and processed into 'mission decision supporting' products in response to individual user queries.

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.

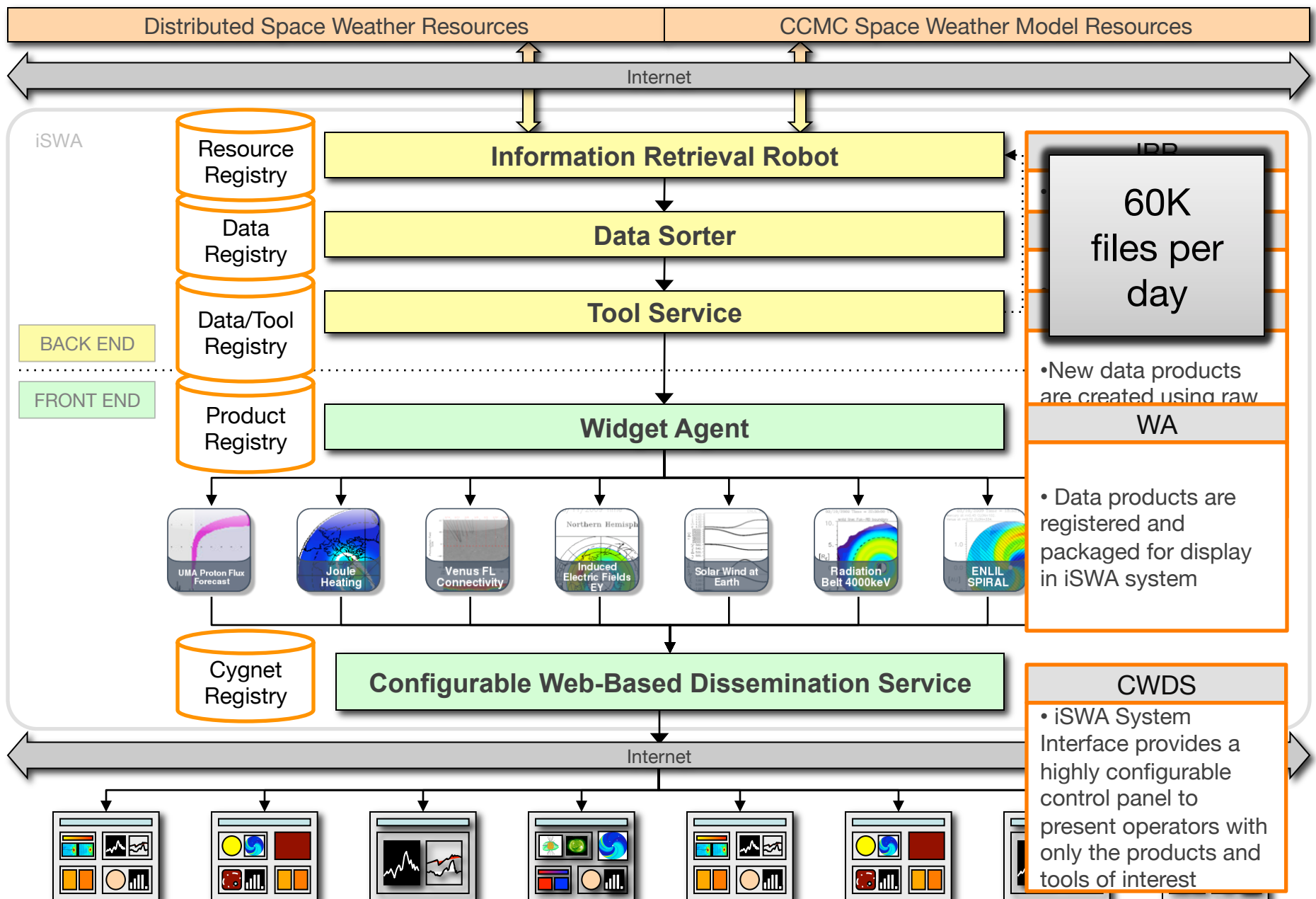
iNTEGRATED SPACE WEATHER ANALYSIS SYSTEM



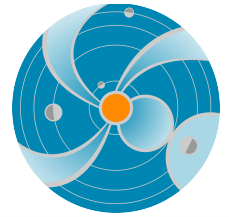
Data Management Challenges



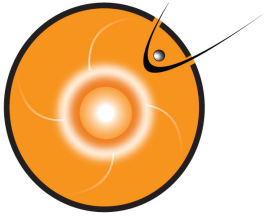
- Ingesting data streams from a variety of sources with varying:
 - Transfer Methods (push and pull)
 - Levels of availability
 - Access Protocols (http, ftp, scp, mv)
 - Naming Conventions
 - Update Intervals (efficient polling for new data)
 - Date & Time Stamp Formats i.e.
[2011-01-01_212500] or [2011-1-1_212500] or [20100101_212500] or
[2011_001_212500] or [2010_Jan_01_212500] or [latest] or...
- Sorting, Archiving, and Management
 - Persistent storage (file system or database)
 - Cataloging, How to keep track of what is where
 - Scalability, Additional storage
- Changes (urls, names, formats, extensions, etc.)



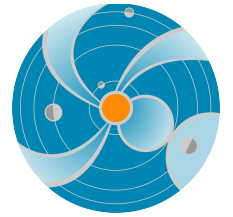
• **370** Unique Data Feeds, **27** Million Files Registered and Archived, **275** Consumable Display Products currently managed in iSWA Cygnnet Catalog



7



iSWA Design Highlights



BACK END

- **Comprehensive data model that drives the system**
 - Minimizes need for actual code modifications
 - Allows rapid additions and modifications to data feeds and display products
- **Every granule of data is registered, cataloged, and archived**
 - Access data products for any available time period
 - Generate new tools and functionality using multiple existing data products

FRONT END

- **Consistent Interface with uniquely identifiable product icons**
- **Customizable layout**
 - automatically saved on browser exit
 - can be bookmarked and shared
- **Auto updating products and tools**
- **Individual and global date search functionality for historical impact analysis**
- **Detailed descriptions for data products**

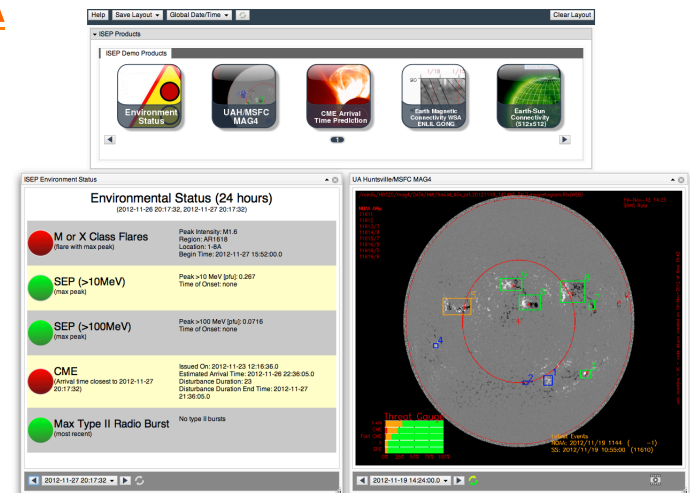


iSWA Updates/Activities



New Systems/Extensions Powered by iSWA

- Project Specific Implementations with Full iSWA Feature Set, Infrastructure
- Customized Cygnet/Product Catalog
- Integrated Solar Energetic Proton Event Alert Warning System – Advanced Radiation Protection Project (STMD Game Changing Office)



Expanded Numerical Database

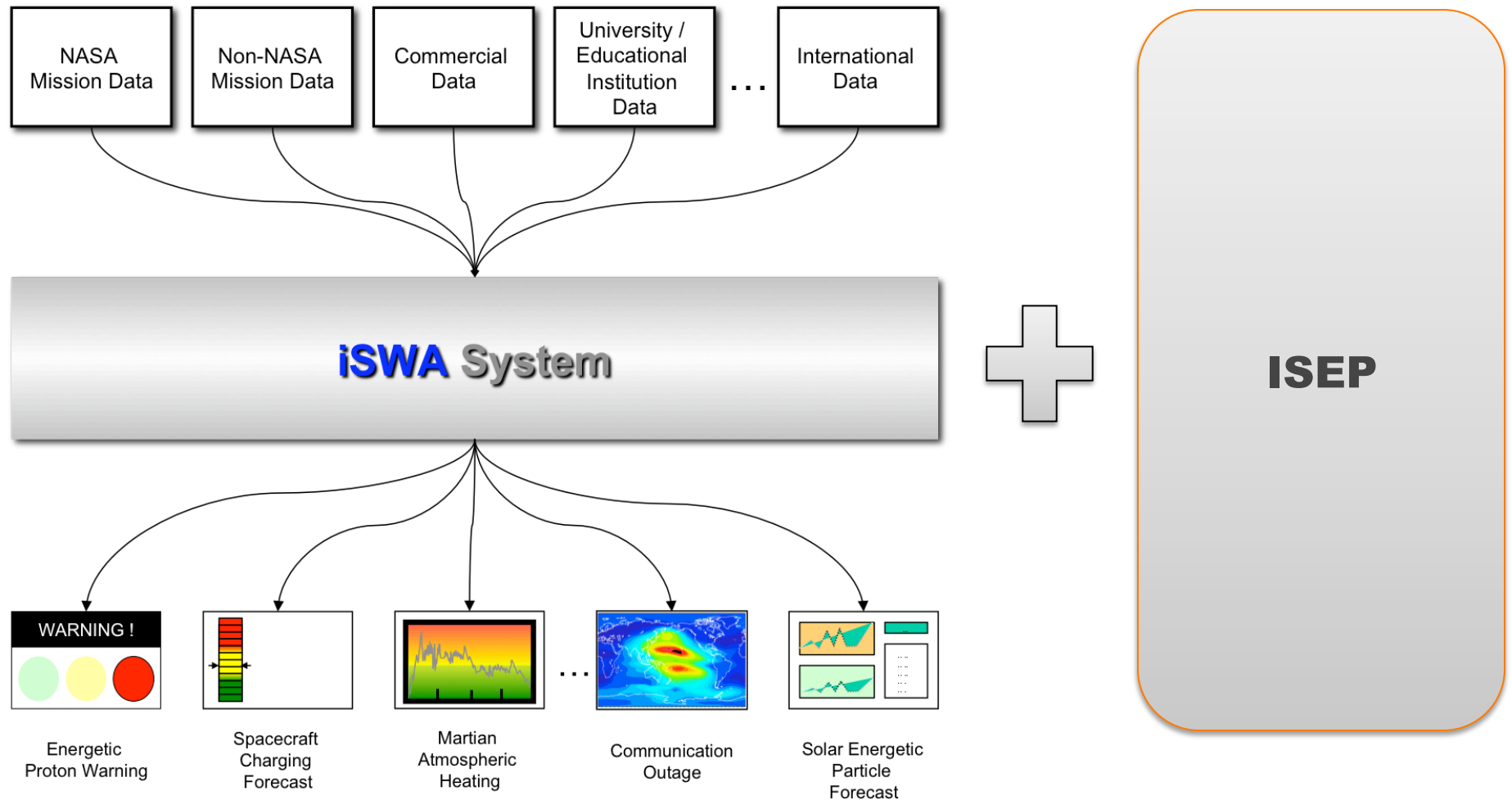
- New parameters
- Custom alerts
- Dynamically generated products
- Data streaming for external applications

Web Services

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

Integrated Solar Energetic Proton Event Alert Warning System

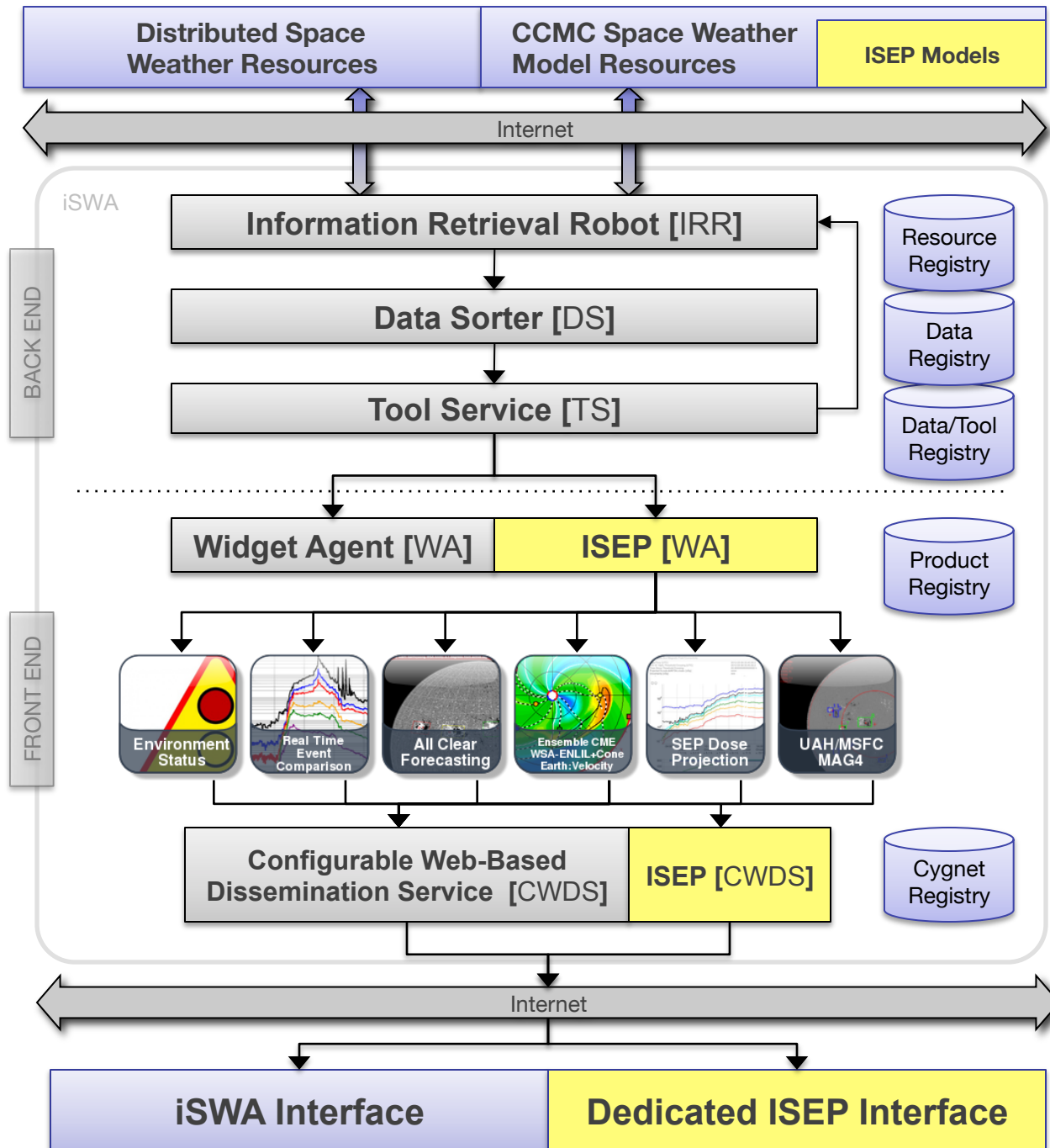
<http://iSWA.gsfc.nasa.gov/ISEP>



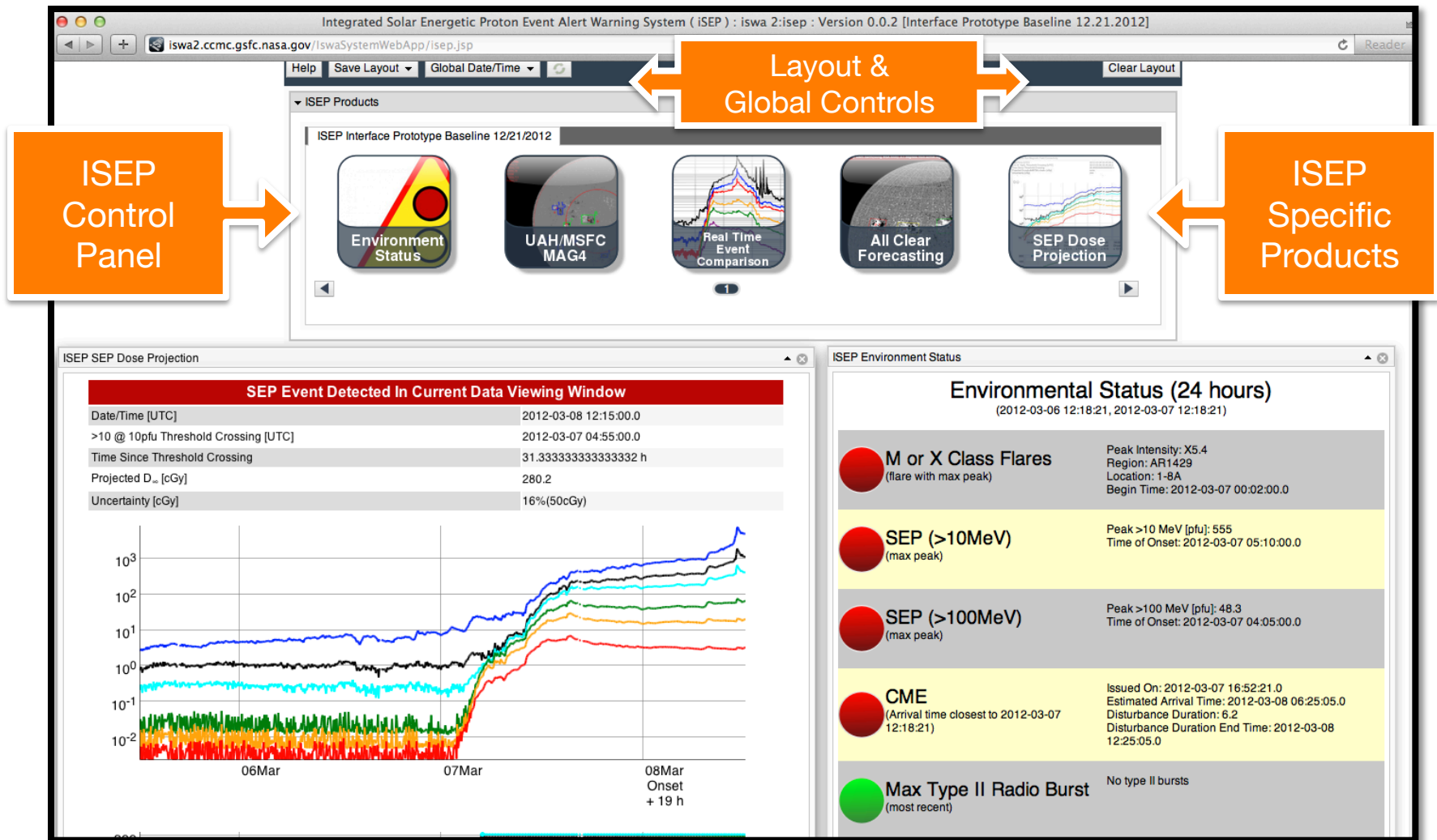
...flexible and robust decisional support tool for space weather

ISEP System

ISEP components are integrated into the iSWA system framework providing a solid development and operational platform. A modular architecture ensures new models, data, features, and functionality can be added to the system.



ISEP Interface Beta

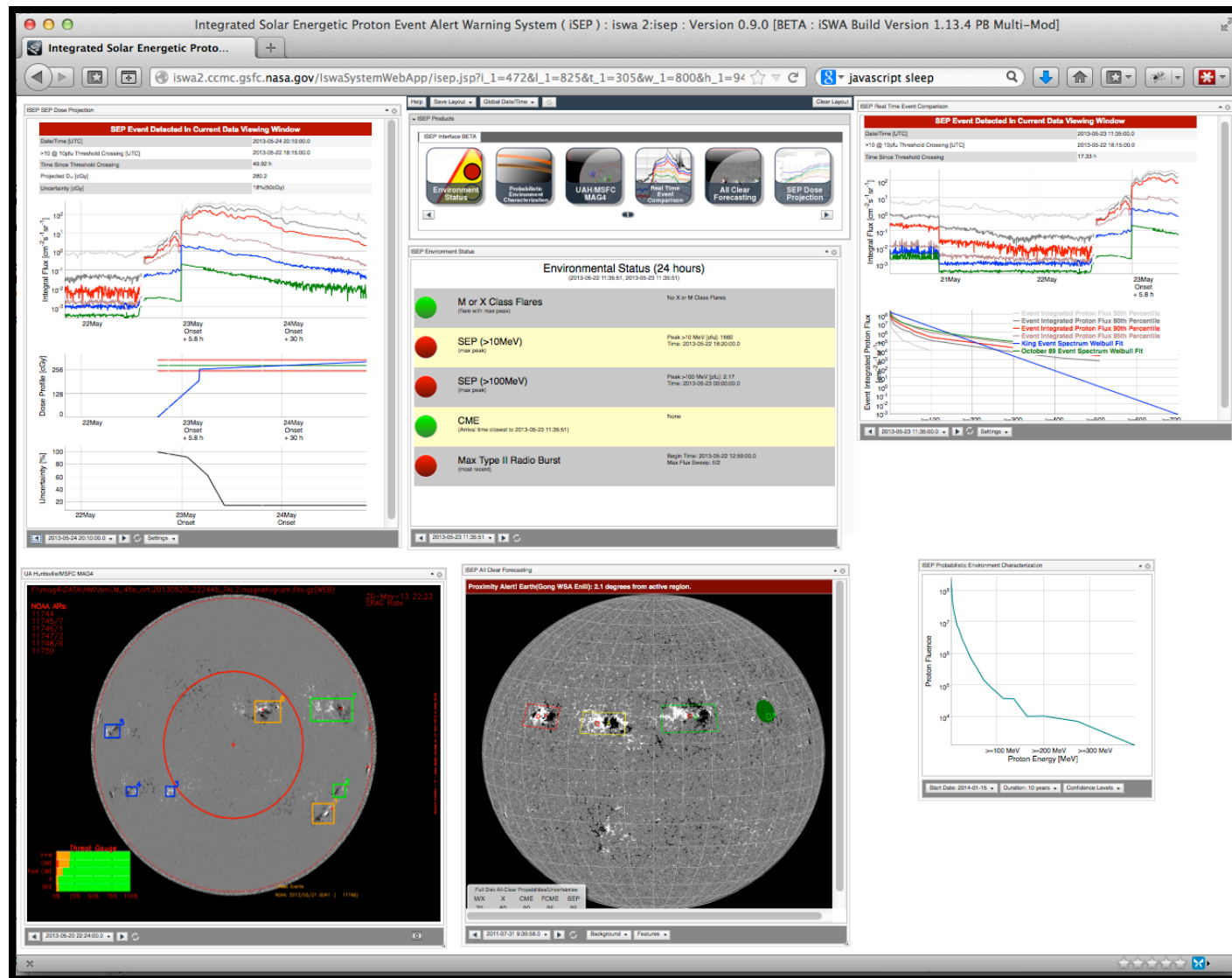


Customizable Products. Date Manipulation Controls. Save Layout Features.

Integrated Solar Energetic Proton Event Alert Warning System

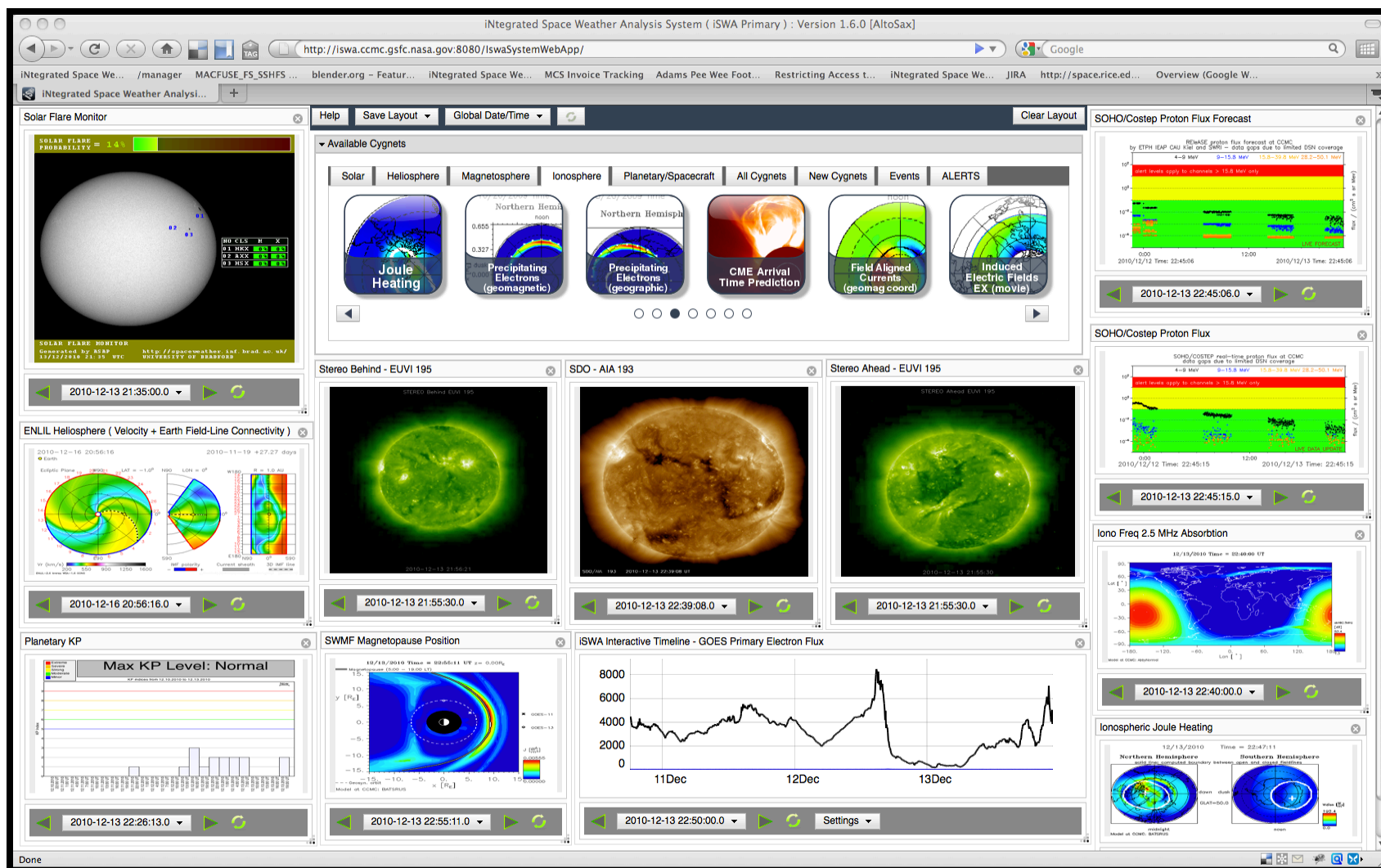
<http://iSWA.gsfc.nasa.gov/ISEP>

- Real Time Info ● Interactive ● Web Accessible ● User Customizable ● Extensible

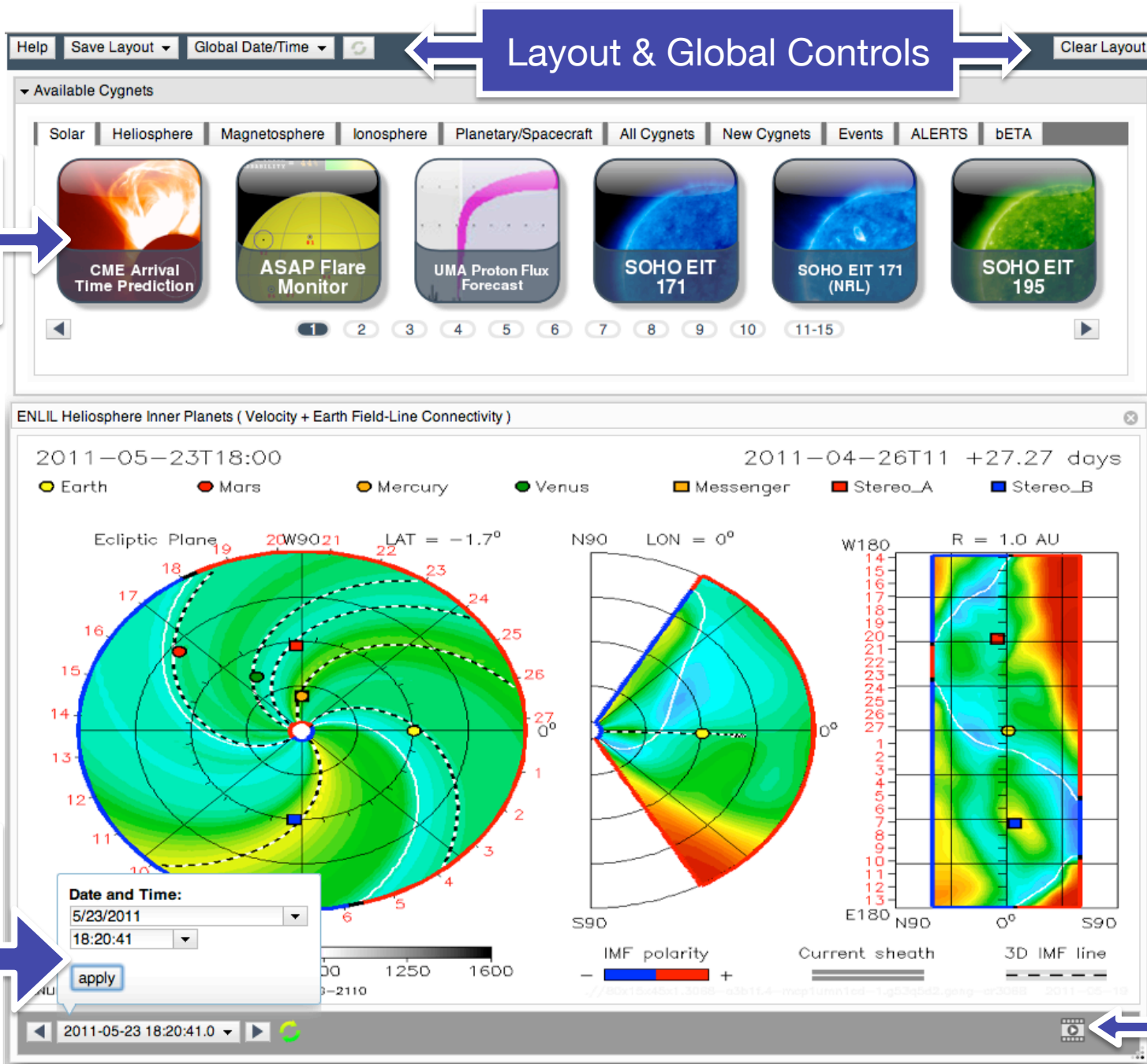




Unprecedented Access to Space Weather Information



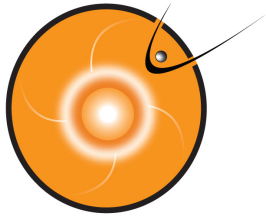
<http://iswa.ccmc.gsfc.nasa.gov>



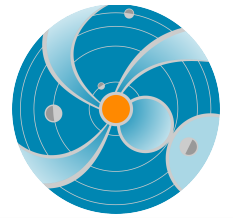
Cygnets
Control
Panel

Cygnets
Date
Controls
Options

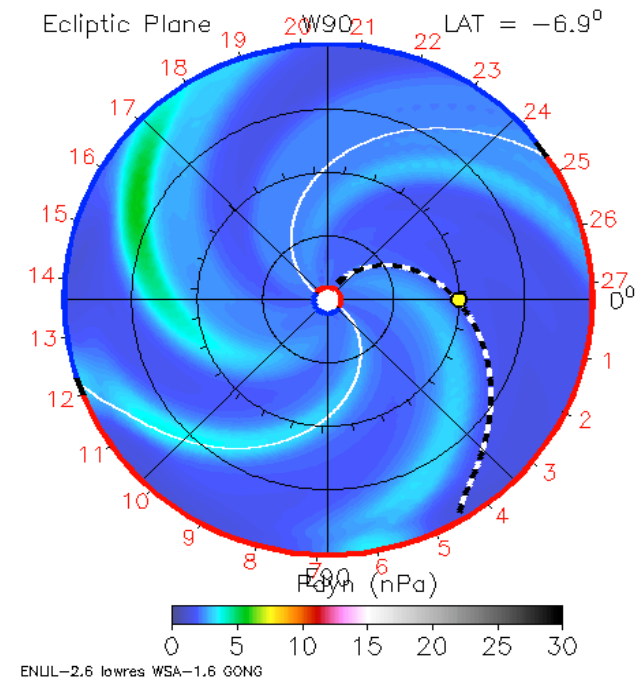
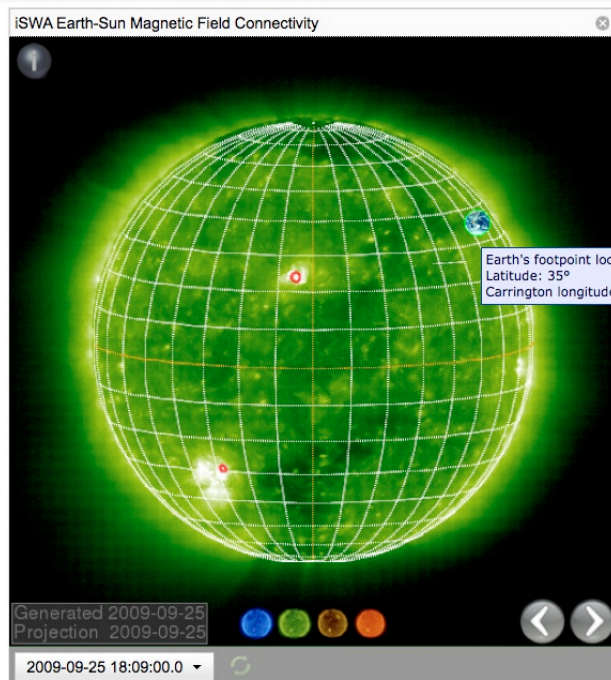
Movie
Mode
Control



Sample iSWA Products/ Cygnets

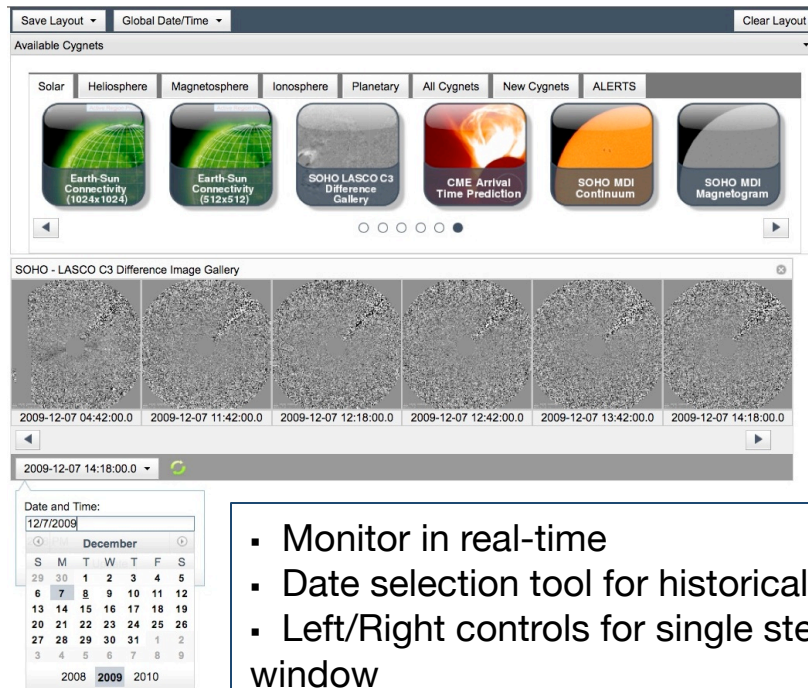


Monitor Magnetic Connectivity and Proximity to Active Regions

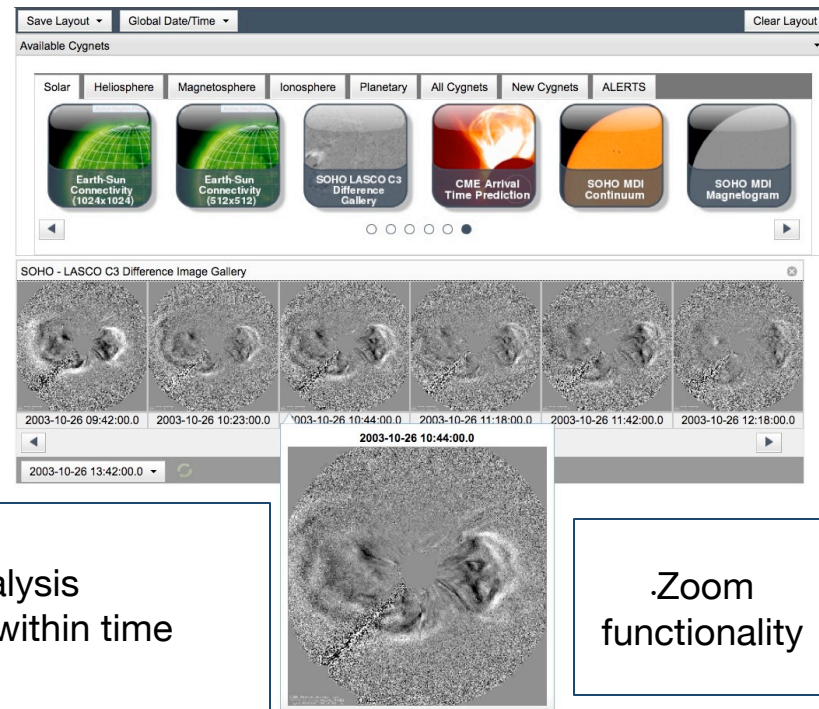


- Monitor active regions and their proximity to magnetically connected foot-point locations of the earth
- View future projections of active regions and foot-point locations
- Date selection tool for historical analysis
- Select different EIT wavelengths
- Monitor in real-time

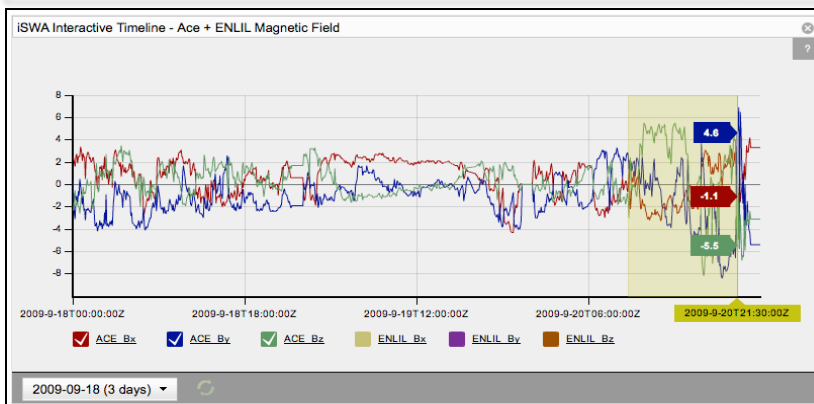
Monitor CME propagation in real-time or for historical events



- Monitor in real-time
- Date selection tool for historical analysis
- Left/Right controls for single steps within time window



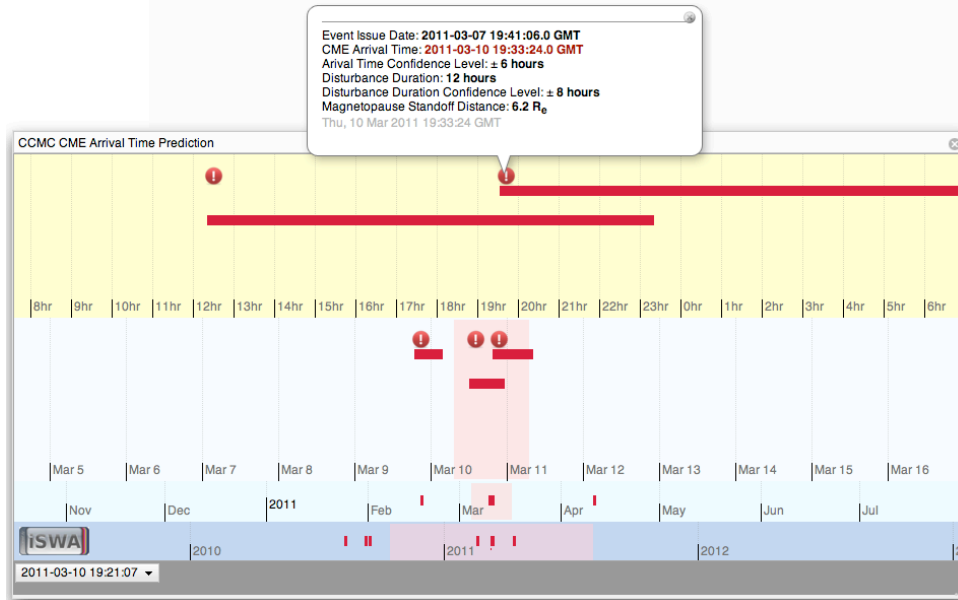
Super Timelines



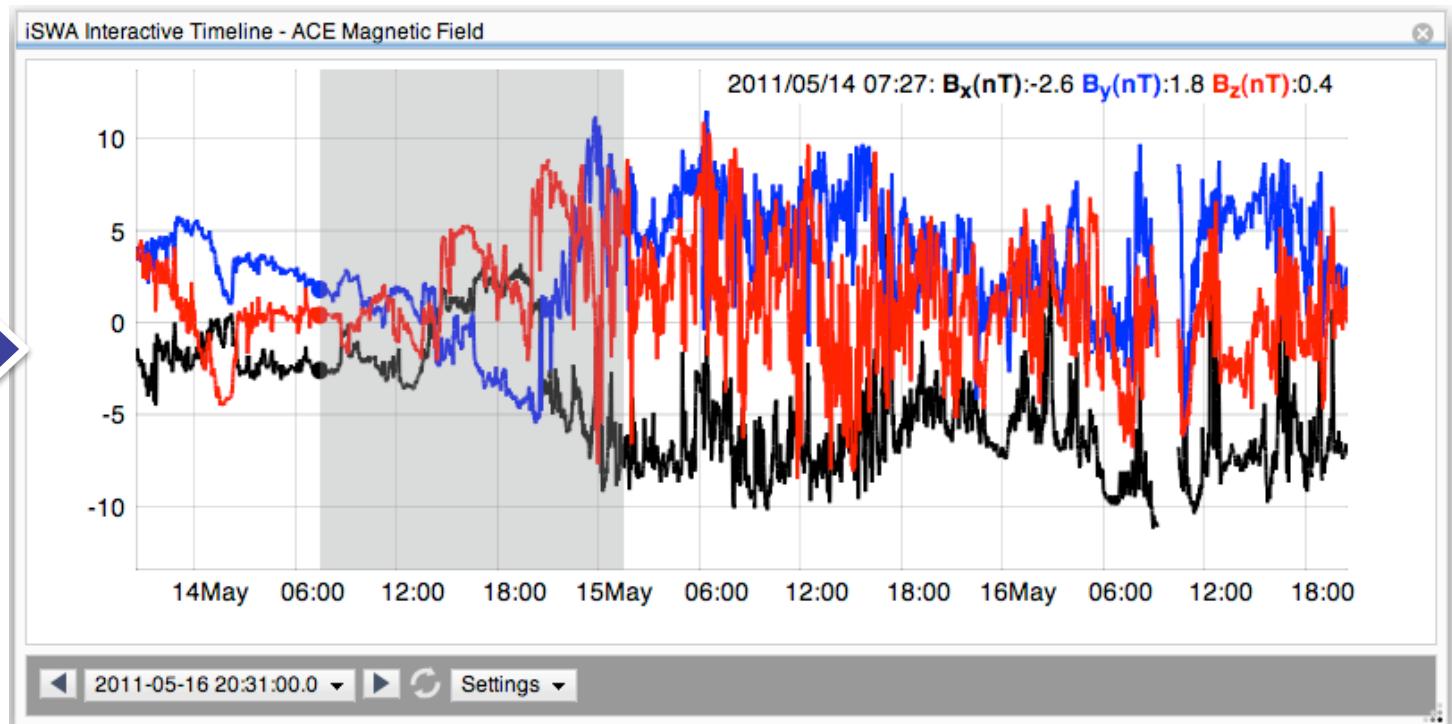
- Mouse over to view specific data values
- Zoom in feature
- Toggle on/off specific quantities
- Selectable time range 1 - 10 days
- User selectable resources & quantities

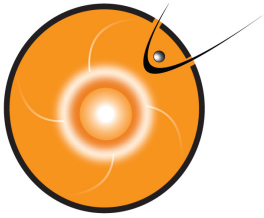
Interactive Products

Interactive CME alert tool with chronological record of SWx Center issued CME time of arrival predictions

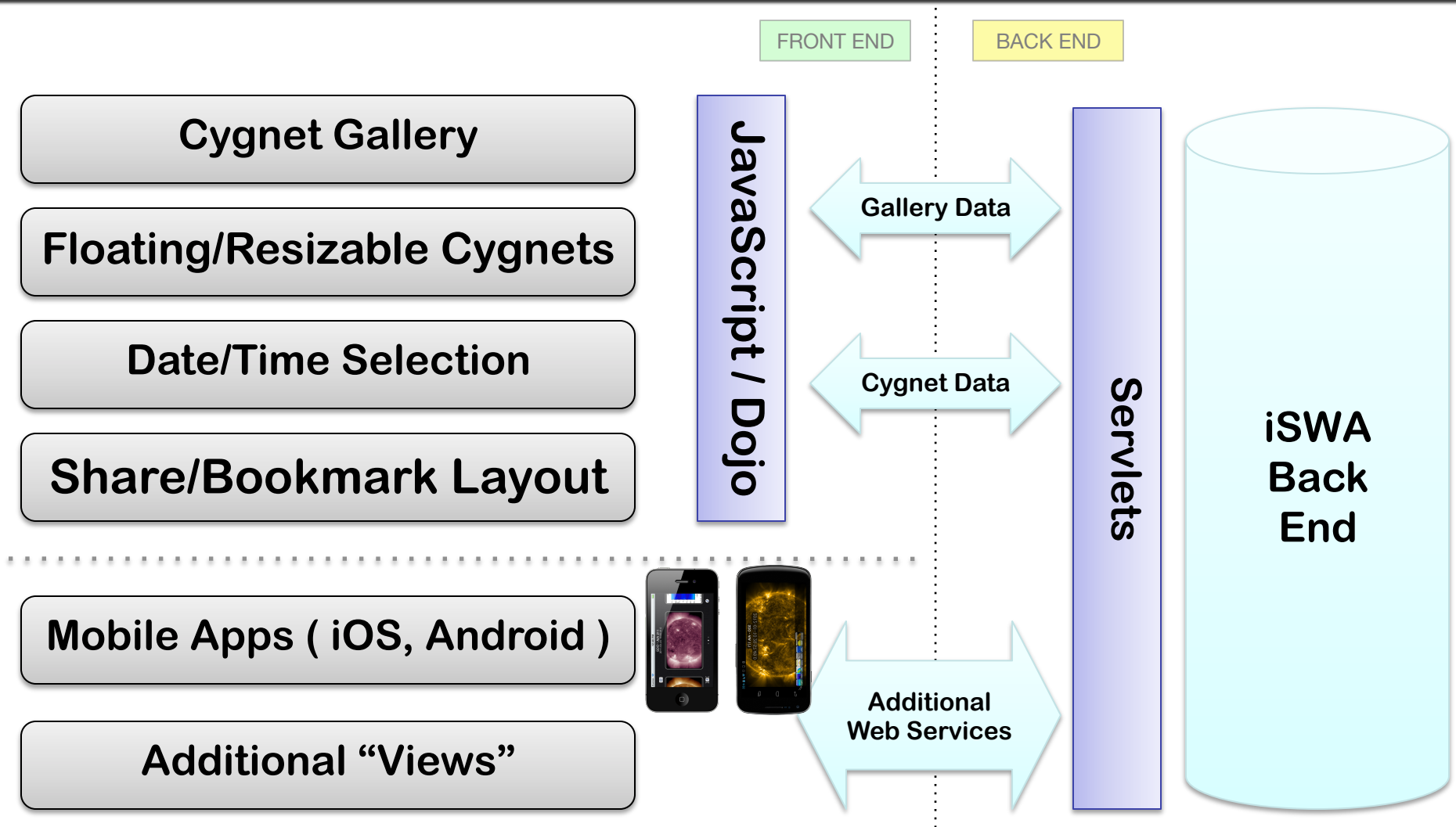
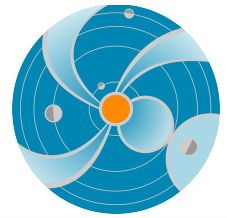


Interactive timeline tool with pan, zoom, mouse-over, and quantity toggling functionality



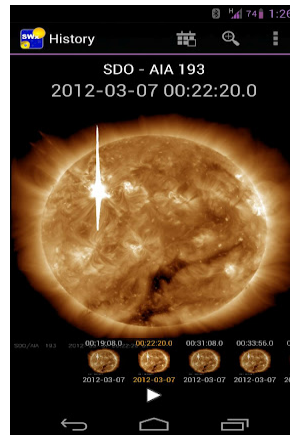
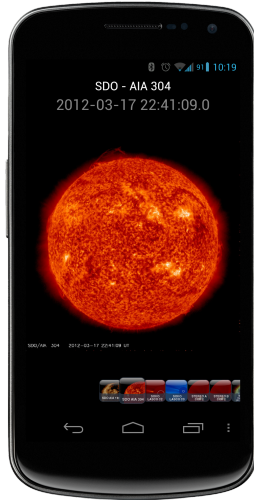


Widget Agent & Configurable Web based Dissemination Service



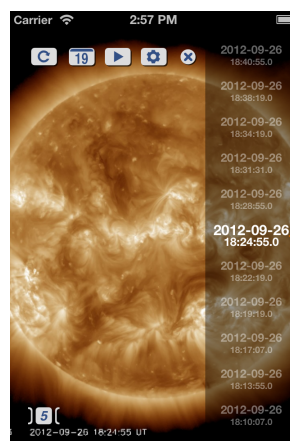
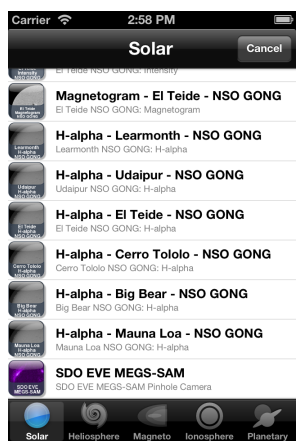


Mobile Access Powered by iSWA



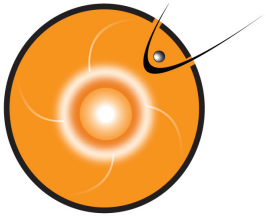
Android Front-End to iSWA

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

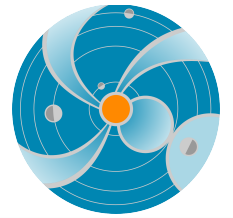


IOS Front-End to iSWA

- History Mode (coming soon)
- Movie Mode (coming soon)
- >100k Downloads
- Available in App Store

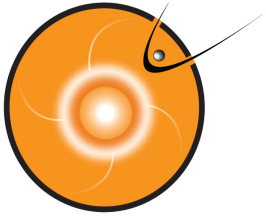


Usage/Growth

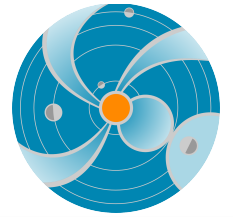


2008 - 2009 [TRL 6]	2010-2011 [TRL 7/8]	2012-2013(4/18/2013) [TRL 7/8]
iSWA Version 1.0	iSWA Version 1.9.8	iSWA Version 1.13.3
171 Data Feeds	370 Data Feeds	427 Data Feeds
6 Million Data Files	27 Million Data Files	43 Million Data Files
135 SWx Products/Cygnets	275 SWx Products/Cygnets	312 SWx Products/Cygnets
3K Visits (2008, 2009)	170K Visits (2010, 2011)	265K Visits (2012 – 2013 4/18/2013)
728 NASA Visits (2008,2009)	10K NASA Visits (2010, 2011)	8.5K NASA Visits (2012-2013 4/18/2013)
671 Unique Visitors (2008, 2009)	70K Unique Visitors (2010, 2011)	102K Unique Visitors (2012-2013 4/18/2013)
0 twitter followers @NASAiSWA	132 twitter followers @NASAiSWA	927 twitter followers @NASAiSWA

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



Usage/Growth



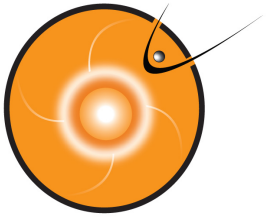
...some other notable iSWA stats:

Two Week Web Service Snapshot From 3/1/2013 – 3/15/2013

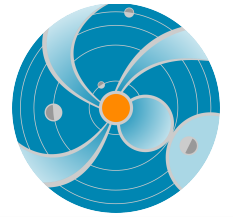
iswa3: 1.1 Million Cygnet Requests

iswa2: 1.3 Million Cygnet Requests

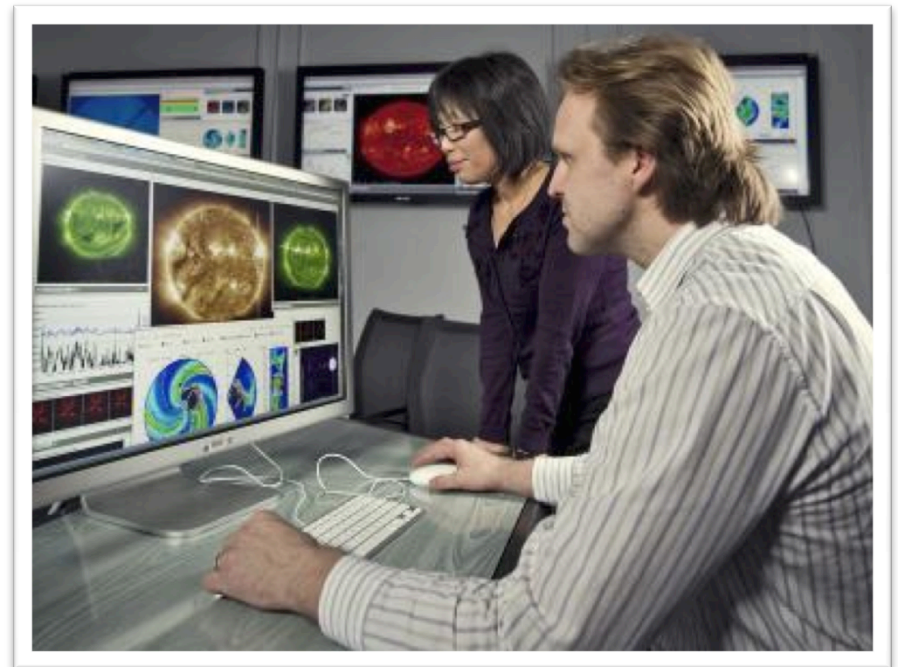
iswax: 0.8 Million Cygnet Requests

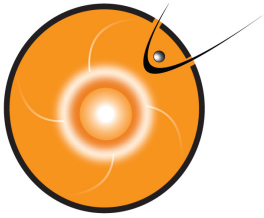


Services for NASA Robotic Missions Powered by iSWA

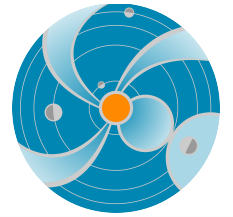


1. Providing assistance in spacecraft anomaly resolution by assessing whether space weather has any role in causing the observed anomaly/anomalies.
2. Sending out weekly space weather reports/summaries to NASA mission operators, NASA officials and involved personnel.





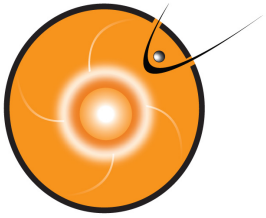
Services for NASA Robotic Missions Powered by iSWA



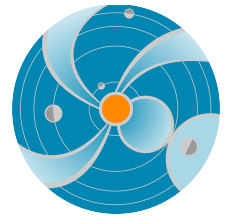
3. Sending out timely space weather info/forecasts regarding adverse conditions throughout the solar system, such as significant CME events, elevated radiation levels, etc.
4. Providing general space weather support for NASA customers.



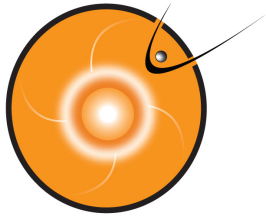
Photo Credit: Chris Gunn



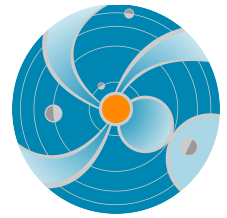
Education And Training Powered by iSWA



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



Training Young Scientists & Educating the Public Powered by iSWA



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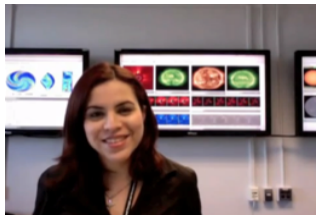


NASA Goddard Space Weather Research Center

+ Subscribe

225
subscribers

24,699
video views



Reporte Semanal del 11-17 Abril 2012 ...

NASASpaceWeather 129 views 3 days ago

<http://swc.gsfc.nasa.gov> - Esta semana experimentamos un poco más de actividad que en las pasadas dos semanas. Hubo un destello clase-M, dos CME's clase-O y cuatro



Weekly Report for April 4-10, 2012 - N...

NASASpaceWeather 835 views 1 week ago

<http://swc.gsfc.nasa.gov> - The calm and quiet conditions we've seen recently continued throughout this week. None of the CMEs or flares from this week resulted in strong sp...

X1.4 Solar Flare, SEP, and Earth-directed CME (July 12, 2012) - NASA Goddard Space Weather Research Center

NASASpaceWeather

Subscribed

26 videos

AR 1520

X1.4 class solar flare

Peak at 16:52UT

July 12, 2012

SDO/AIA 335 Å

temperature ~2.8 million K

0:31 / 1:51

Like

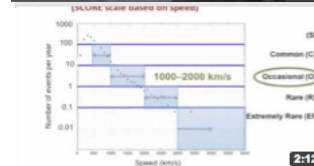
Comment

Add to

Share

Print

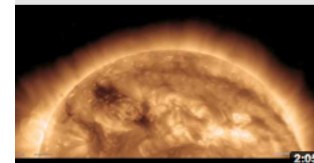
8,708



CME SCORE Scale: Typification Syste...

NASASpaceWeather 420 views 2 weeks ago

<http://swc.gsfc.nasa.gov> - We introduce our new coronal mass ejection (CME) classification/typification system called SCORE. SCORE indicates the type of the detected CME



Weekly Report for March 28, 2012 - Ap...

NASASpaceWeather 534 views 2 weeks ago

<http://swc.gsfc.nasa.gov> - The sun as a whole was pretty quiet this week. The active region previously referred to as Active Region 1429, which was responsible for almost ...

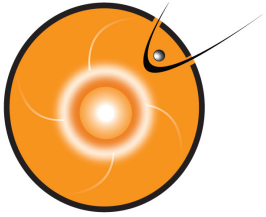


Incredible Active Region 1429: One fo...

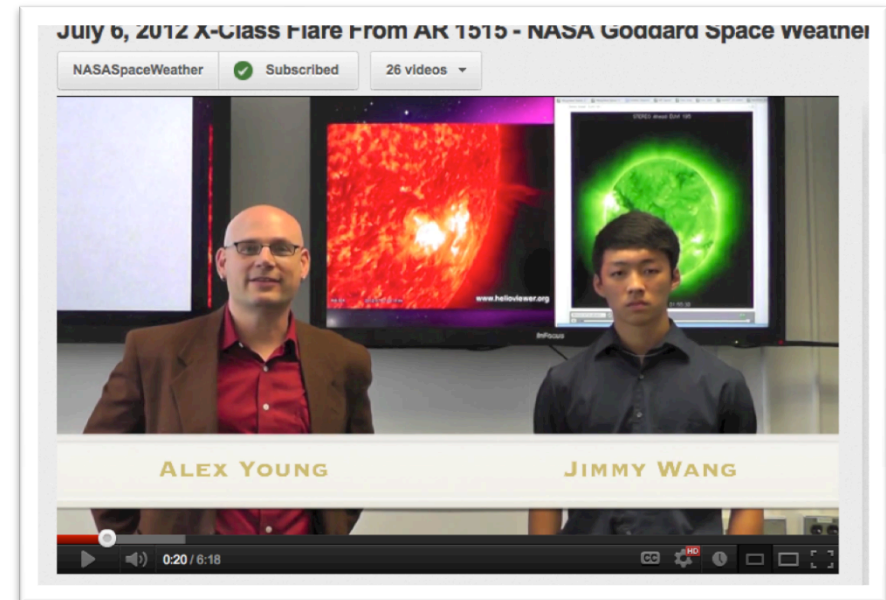
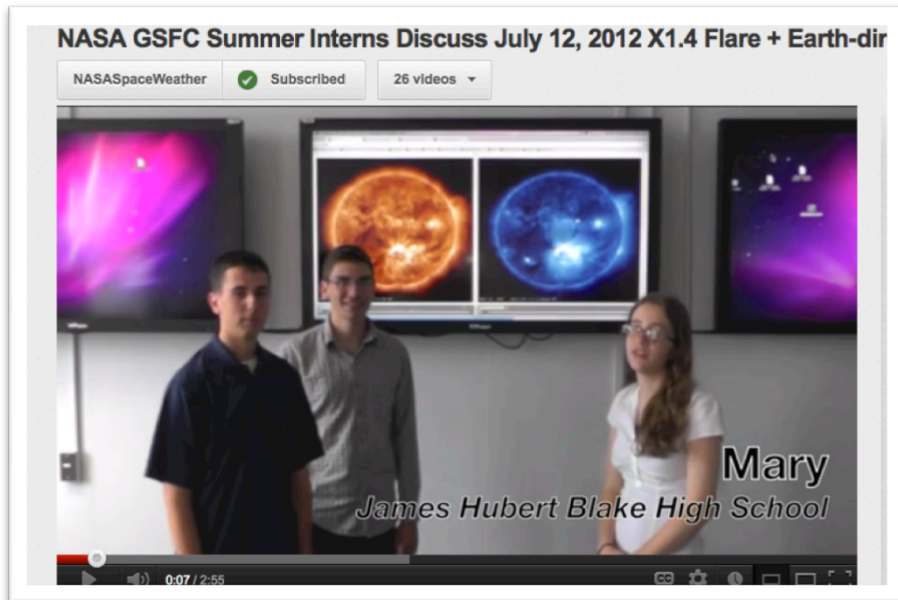
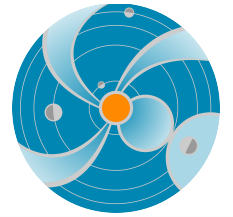
NASASpaceWeather 356 views 3 weeks ago

<http://swc.gsfc.nasa.gov> - On March 2nd, 2012, active region 1429 rotated onto the Earth-facing solar disk. This region has dominated space weather conditions throughout ...

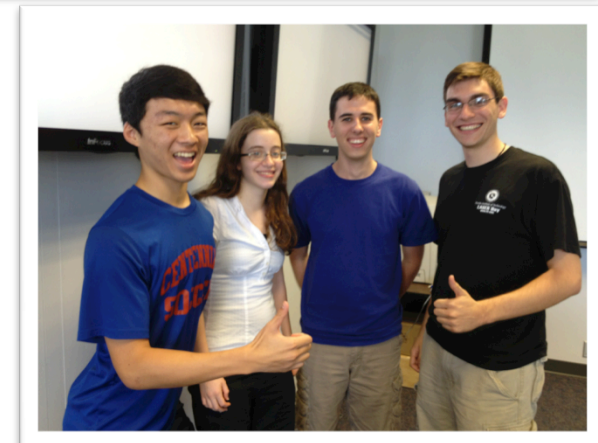
C. Black, D. Berrios, L. Mays, J. Collado-Vega, R. Evans



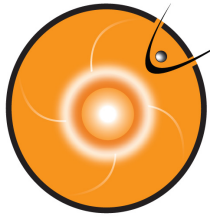
Summer Interns Learning Space Weather Science Powered by iSWA



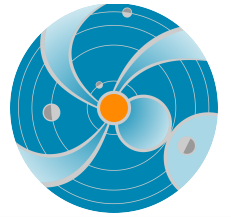
- Impressed with their progress
- Space weather excites them
 - ✓ Real time
 - ✓ Creative experimental research forecasts
 - ✓ Help NASA robotic missions
 - ✓ Responsibilities



C. Black, D. Berrios, L. Mays, J. Collado-Vega, R. Evans, A. Young



Undergraduate Computer Science Interns SW Research Analysis Tool Development Powered by iSWA



Jack LaSota

Web-based CME Analysis Tool

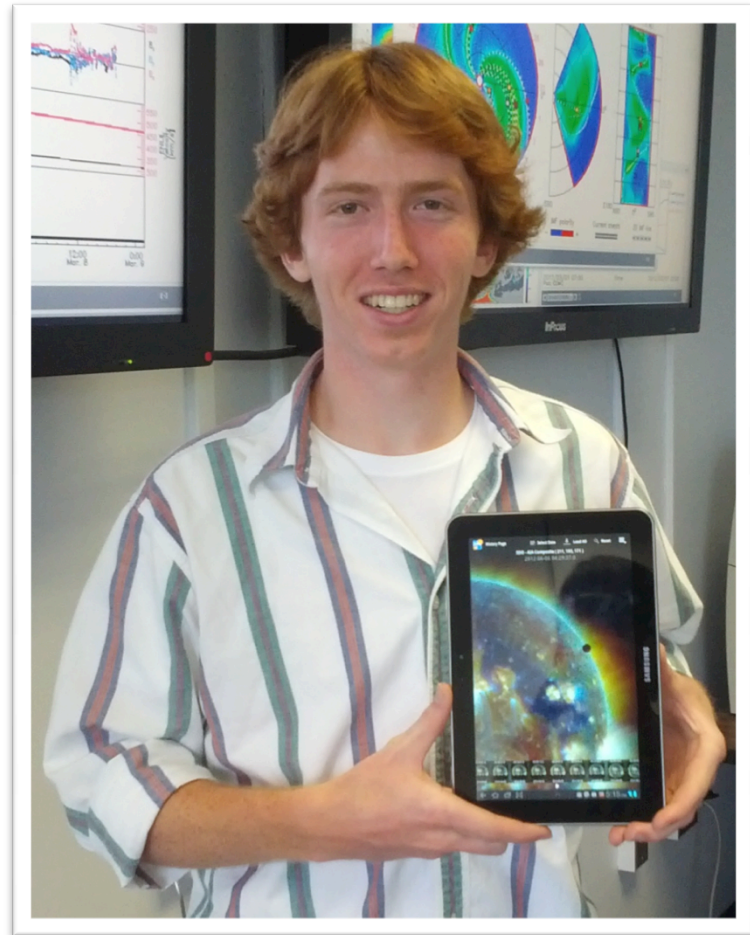


[CME Tool Link](#)

[Sample Analysis Link](#)

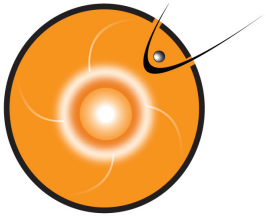
Justin Boblitt

Android iSWA App

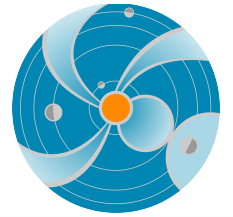


[iTunes Link](#)

[Android Link](#)



iSWA Impact



NASA

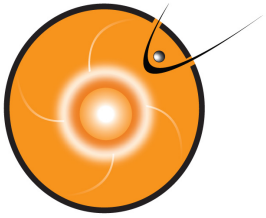
- iSWA provides a new capability to quickly assess [past](#), [present](#), and [expected](#) space weather effects.
 - Mission operators have a resource to assist in both anomaly resolution as well as potential space weather impacts.
- iSWA has helped enable the Space Weather Laboratory to establish a new [Space Weather Center](#) service [providing alerts](#), anomaly reports, and weekly space weather summaries based on iSWA tools and products.

External Agencies

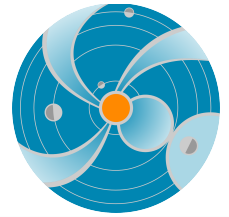
- Air Force Space Weather Agency can [monitor the iSWA system 24x7 for CME eruptions](#) and notify the CCMC as soon as an event is detected. A notification triggers a CME Cone Model calculation at CCMC that [estimates the CME arrival time, duration, and expected impact on earth](#).
- iSWA has enabled numerous collaborations with data, model, and product developers/providers who want their tools to be available in iSWA.

Science, Education, and Public Outreach

- Researchers, universities, and “citizen scientists” have access to a comprehensive suite of real-time and historical space environment data products.



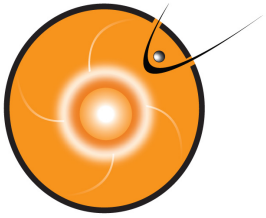
iSWA Impact



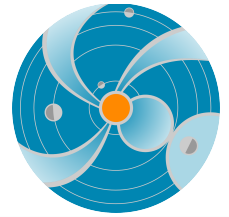
New Products, Services, & Business

- Integral tool for **NASA Space Weather Center**
- iSWA is integral component of several new proposals and activities. One currently underway between GSFC and SRAG at JSC.
- Interoperable interfaces allow external entities to tap into iswa data streams. UK Met Office, Korea Meteorological Administration.
- Mobile **NASA Space Weather** applications for IOS and Android Devices-both powered by iSWA
- Framework for external development activities.





High Availability Architecture



- IP failover
- Load Balancing proxy/virtual proxy front end servers
- Database Replication
- Data Tree Replication/Mirroring
- Multi-site backups systems (multi-building in our case)
- Redundant Storage Fabrics
- Software-Monitoring Software (health, performance)
- ~~Network Failover with Dual Homing~~ (not allowed per gsfc security)

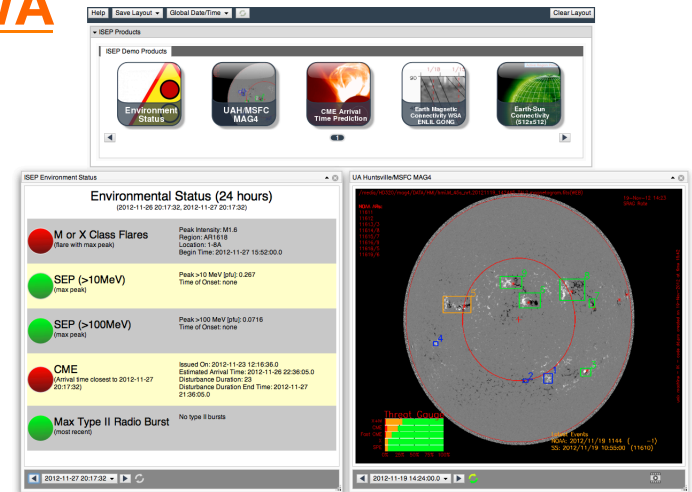


iSWA Updates/Activities



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

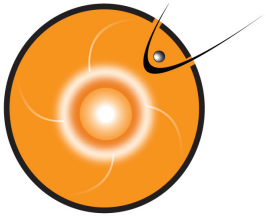
- New parameters
- Custom alerts
- Dynamically generated products
- Data streaming for external applications

Web Services

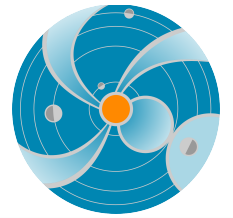
- Building web-based interfaces for machine-to-machine interaction
- Enabling external systems to query, access, and link to iSWA data

Space Weather Event Catalog and Event Linking

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

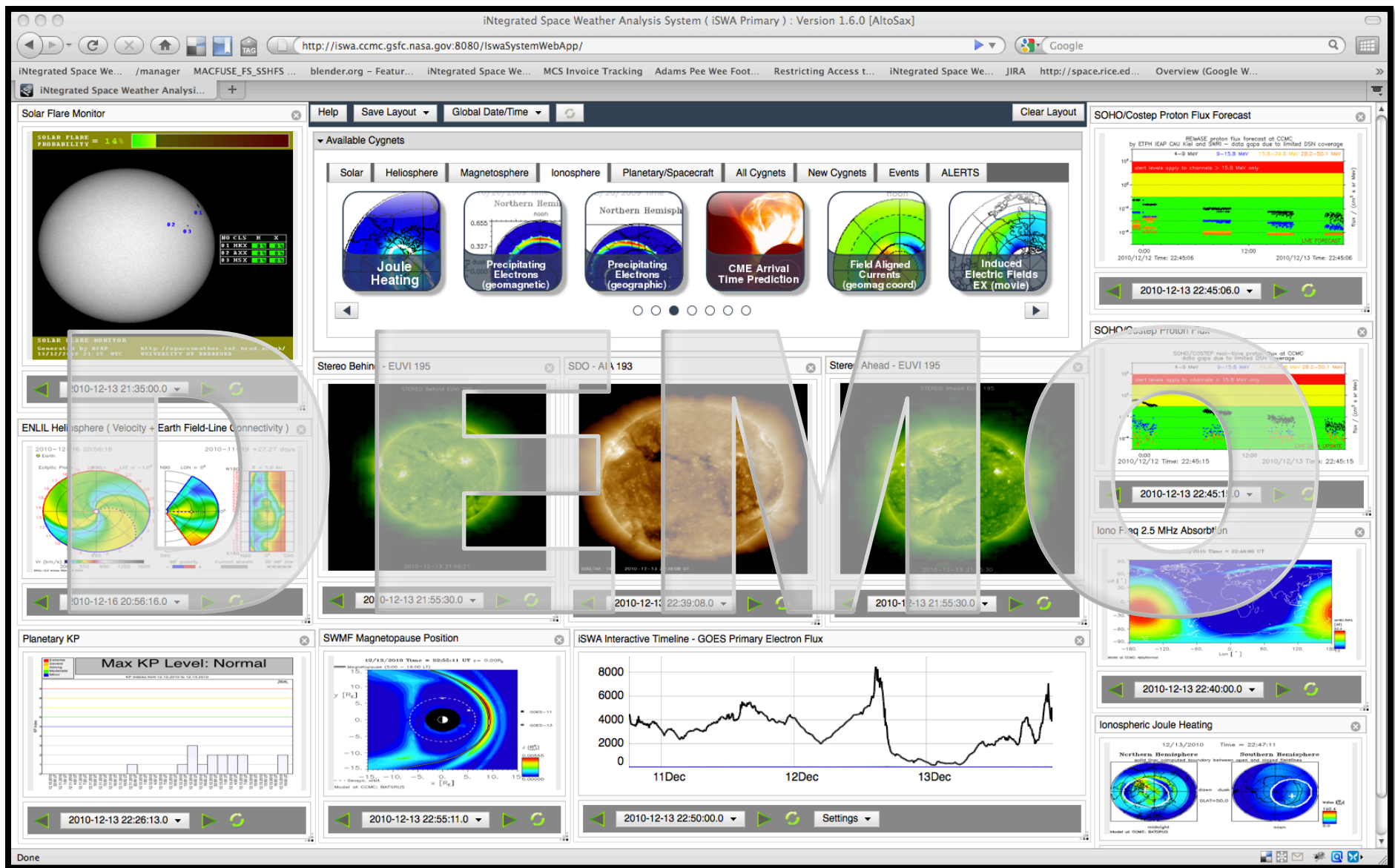


Summary / Future



SWL, CCMC, & Space Weather Research Center aim to advance space weather specification and forecasting capabilities...

- Increased computing capacity
- Increased storage capacity
- Ingest state-of-the-art space weather models
- Update existing space weather model suite
- Continue to advance model output metadata standards
- Improve visualization techniques
- Improve real-time and forecasting capabilities
- Generate custom tools and services
- Improve general public knowledge and access to space weather



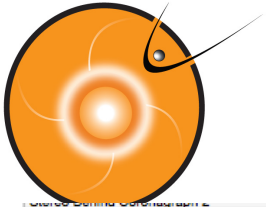
<http://iswa.ccmc.gsfc.nasa.gov>

BOOKMARK DEMO

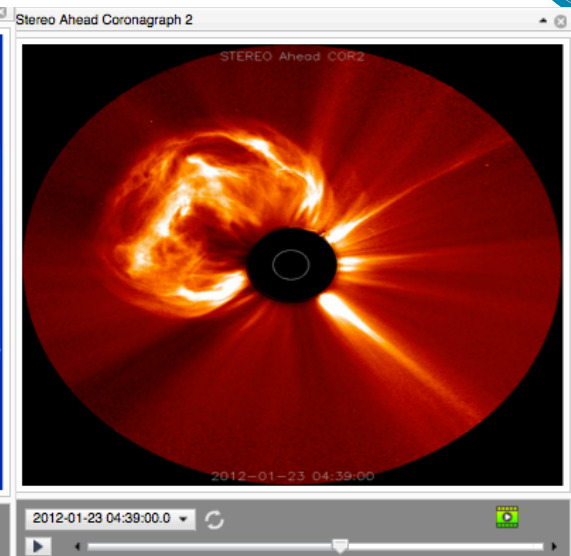
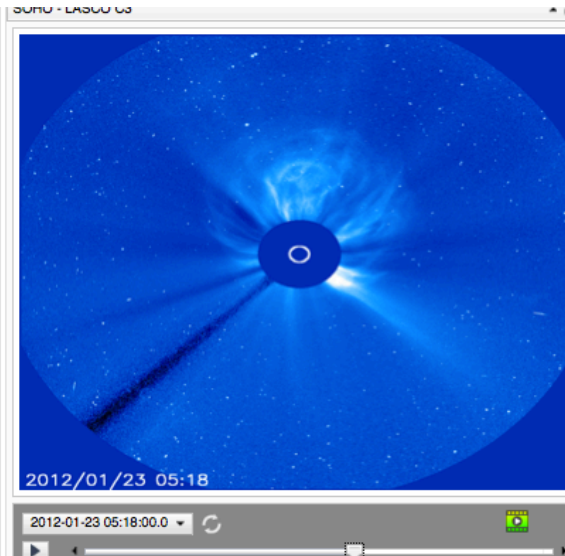
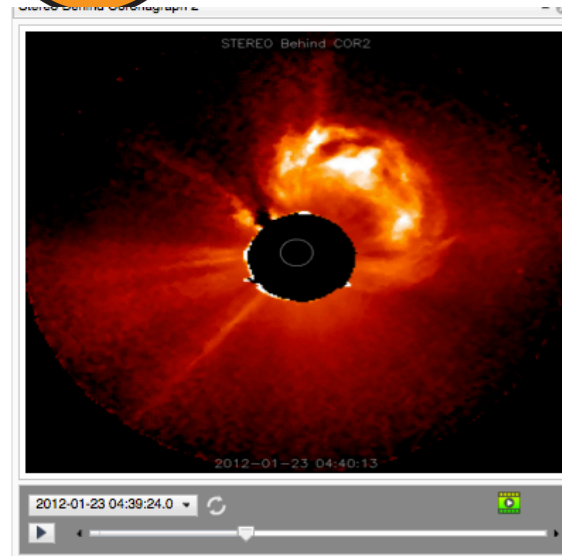
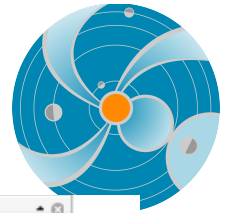
- Space Weather Event 04/11/2013 - <http://go.nasa.gov/13oVkrB>
- Venus Transit - <http://go.nasa.gov/13oR2k1>
- St. Patricks Day Storm 03/15/2013 - <http://go.nasa.gov/YGUeiO>
- Filament Eruption 02/27/2013 - <http://go.nasa.gov/XcgWDi>
- Space Weather Event 09/28/2012 - <http://go.nasa.gov/XGW0Eu>
- 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>

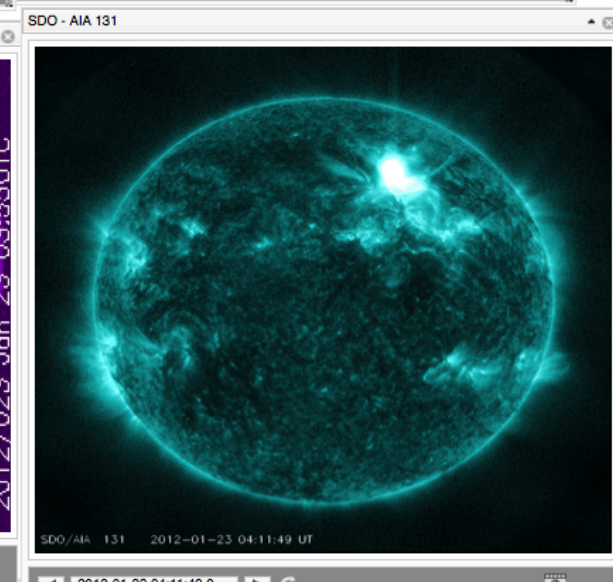
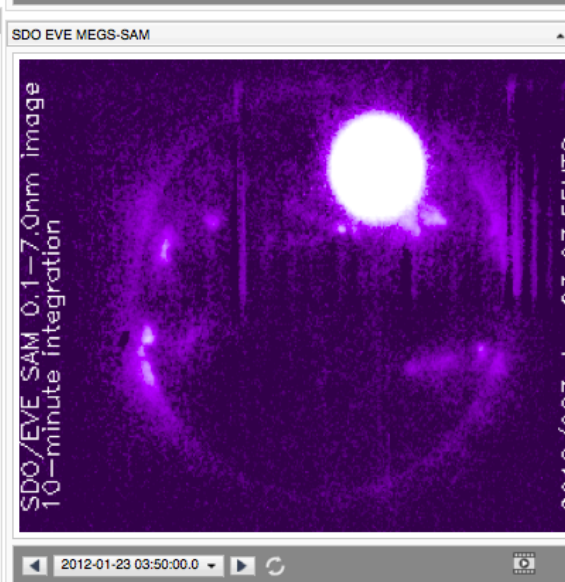
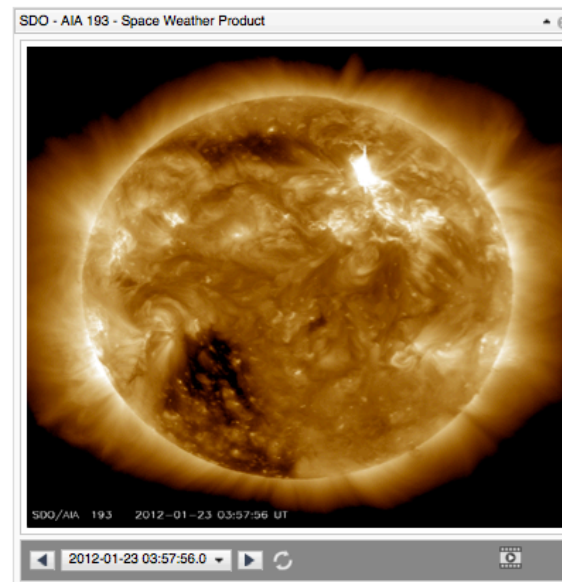
Specific Examples...



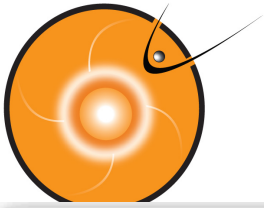
Jan 23 flare (M8.7)/CME ($v=2210\text{km/s}$)



CME

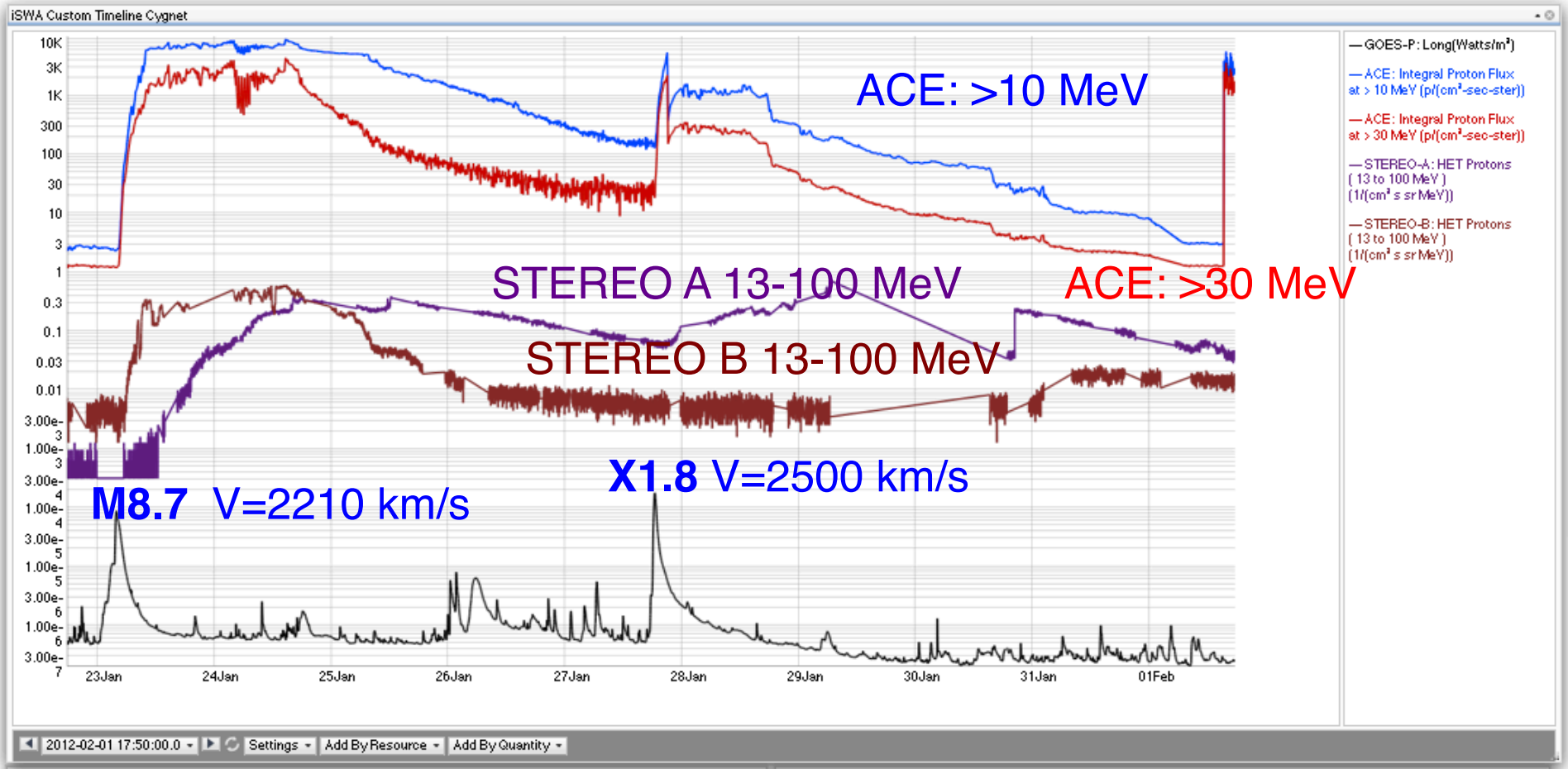


Flare



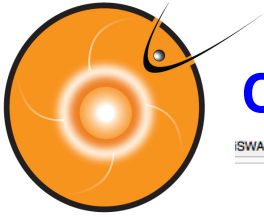
SEP: proton radiation (flare and CME)

iSWA SuperTimeline

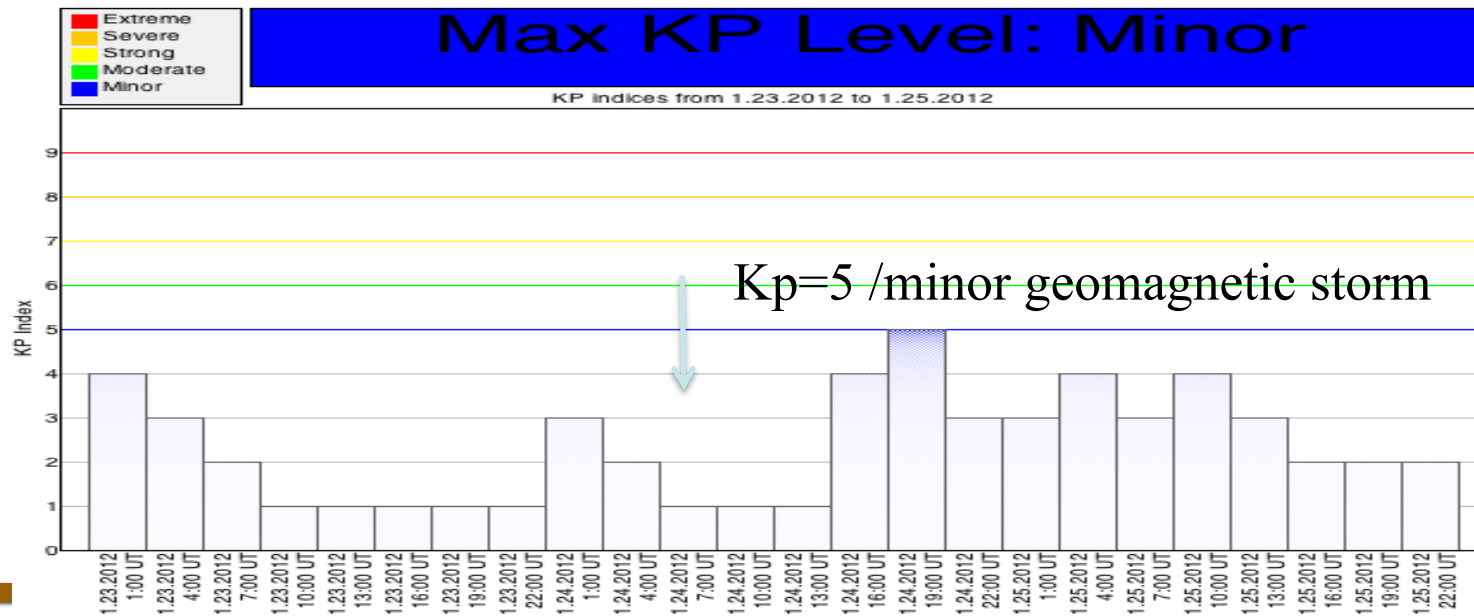
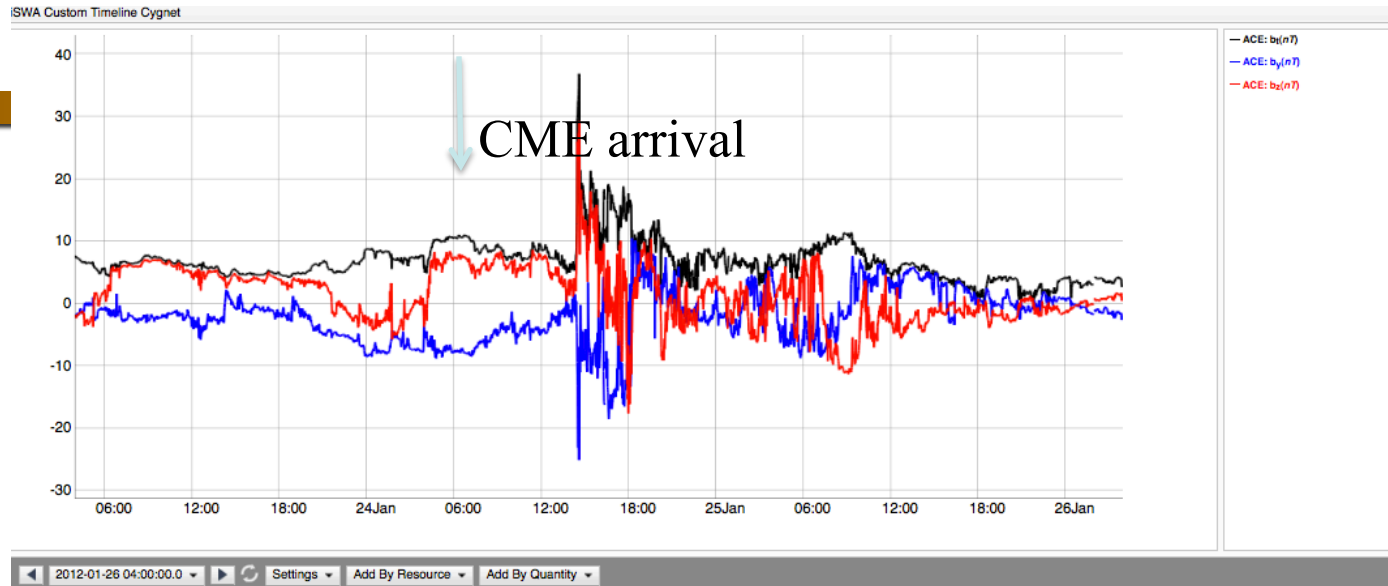
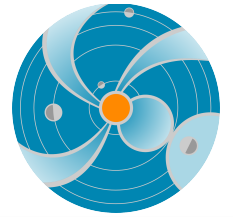


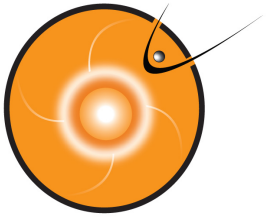
The Jan 23 and Jan 27 flare/CME pairs were associated with the same active region 1402. Both events created significantly enhanced ion radiation (SEP flux levels).

Several polar flights were rerouted due to the radiation

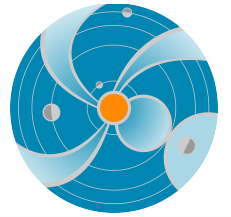


CME impact at Earth (a minor geomagnetic storm only)





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

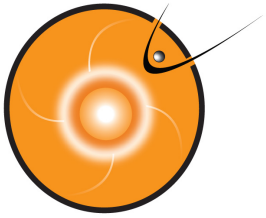
Active Region 1429 activities during March 2012

[Earthside Major Events](#)

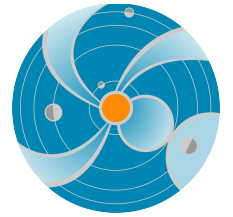
[Backside major events](#)

Who Uses iSWA?



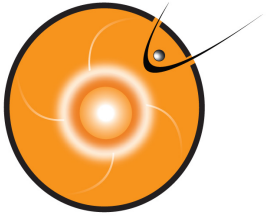


Present /In-Progress Users

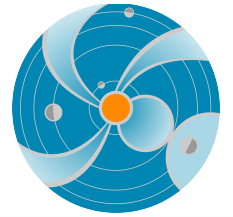


- NASA GSFC (SSMO)
- NASA MSFC (ISS)
- NASA JSC (SRAG)
- NASA LRC (CALIPSO)
- AI Solutions/GSFC Conjunction Assessment Risk Analysis Team
- UK Met Office
- Air Force Weather Agency
- Air Force Institute Of Technology
- Electric Power Research Institute
- Belgium Institute Of Technology
- Space Research Institute, Russia IKI RAN
- Korea Meteorological Administration
- Space Environment Technologies

- Heliophysics Summer School
- CISM Summer School
- CCMC Research & Event Studies
- Space Science Programs (CUA, Michigan, GMU, Embry-Riddle, UCLA, ITU, AFIT, BU)
- Korea Astronomy and Space Science Institute (KASI)
- Department Of Homeland Security
- Federal Aviation Administration
- Power Grid Community (NERC, EPRI)
- NASA TDRSS
- Japan Aerospace Exploration Agency
- American Museum Of Natural History



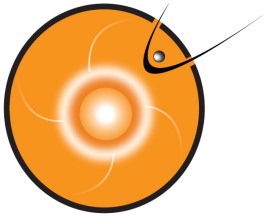
Potential Users



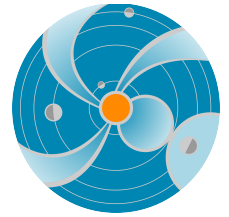
- Any agency, entity, or individual with space weather requirements and/or interests
- Extended educational use (training, K-12, higher education)
- Extended research use (case studies, correlation studies, historical events, general space weather research)

iSWA software can be applied to any agency, group, or project with general data ingestion, storage, management, display, & dissemination needs....

- “instant ground system” for other NASA projects
- turn-key software system for commercial and/or educational data management and dissemination
- customizable interface for existing data archives and sets



iSWA Impact



NASA

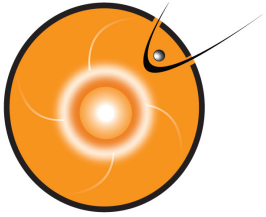
- iSWA provides a new capability to quickly assess past, present, and expected space weather effects.
 - Mission operators have a resource to assist in both anomaly resolution as well as potential space weather impacts.
- iSWA has helped enable the Space Weather Laboratory to establish a new **Space Weather Center** service providing alerts, anomaly reports, and weekly space weather summaries based on iSWA tools and products.

External Agencies

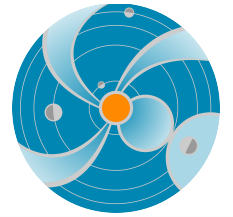
- Air Force Space Weather Agency can monitor the iSWA system 24x7 for CME eruptions and notify the CCMC as soon as an event is detected. A notification triggers a CME Cone Model calculation at CCMC that estimates the CME arrival time, duration, and expected impact on earth.
- iSWA has enabled numerous collaborations with data, model, and product developers/providers who want their tools to be available in iSWA.

Science, Education, and Public Outreach

- Researchers, universities, and “citizen scientists” have access to a comprehensive suite of real-time and historical space environment data products.



iSWA Impact

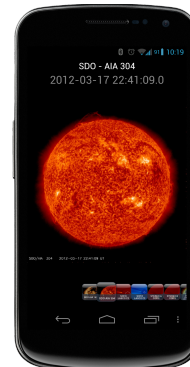


New Products, Services, & Business

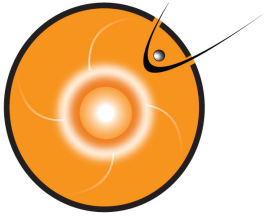
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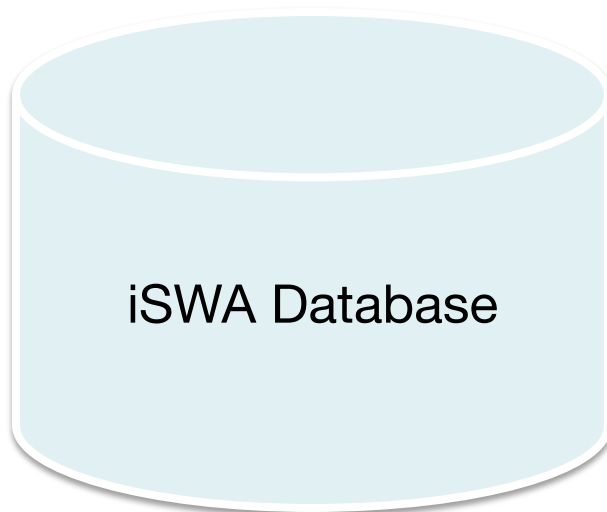
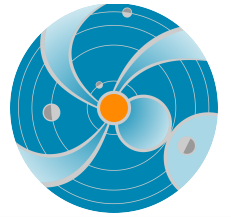
> 40K IOS downloads
> 17K Android downloads



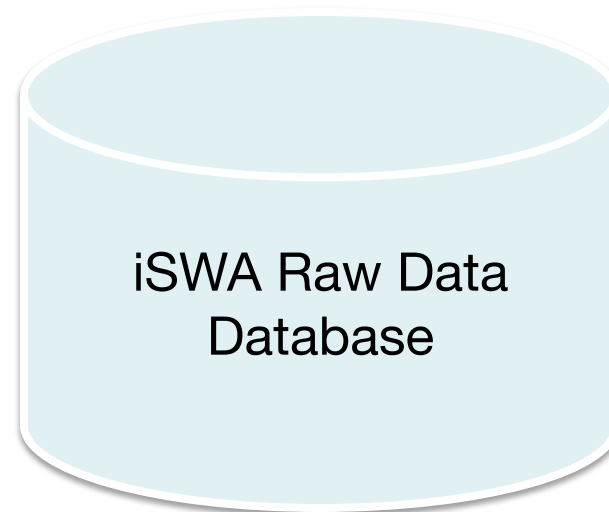
BACKUP SLIDES



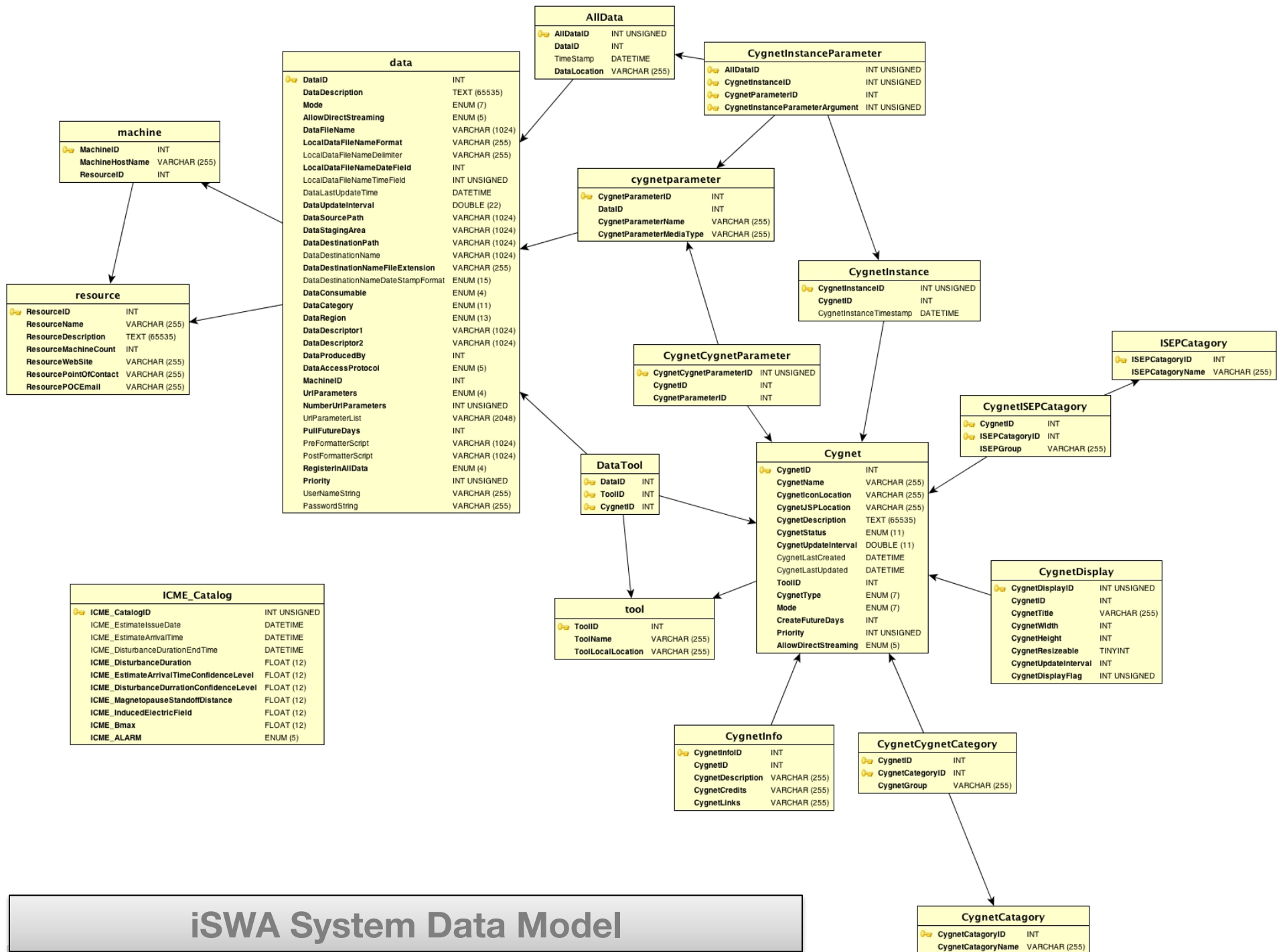
Database Schema Drill Down



iSWA Database



iSWA Raw Data
Database



iSWA System Data Model



