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

HSD

SED Software Engineering Division

Space Weather LAB

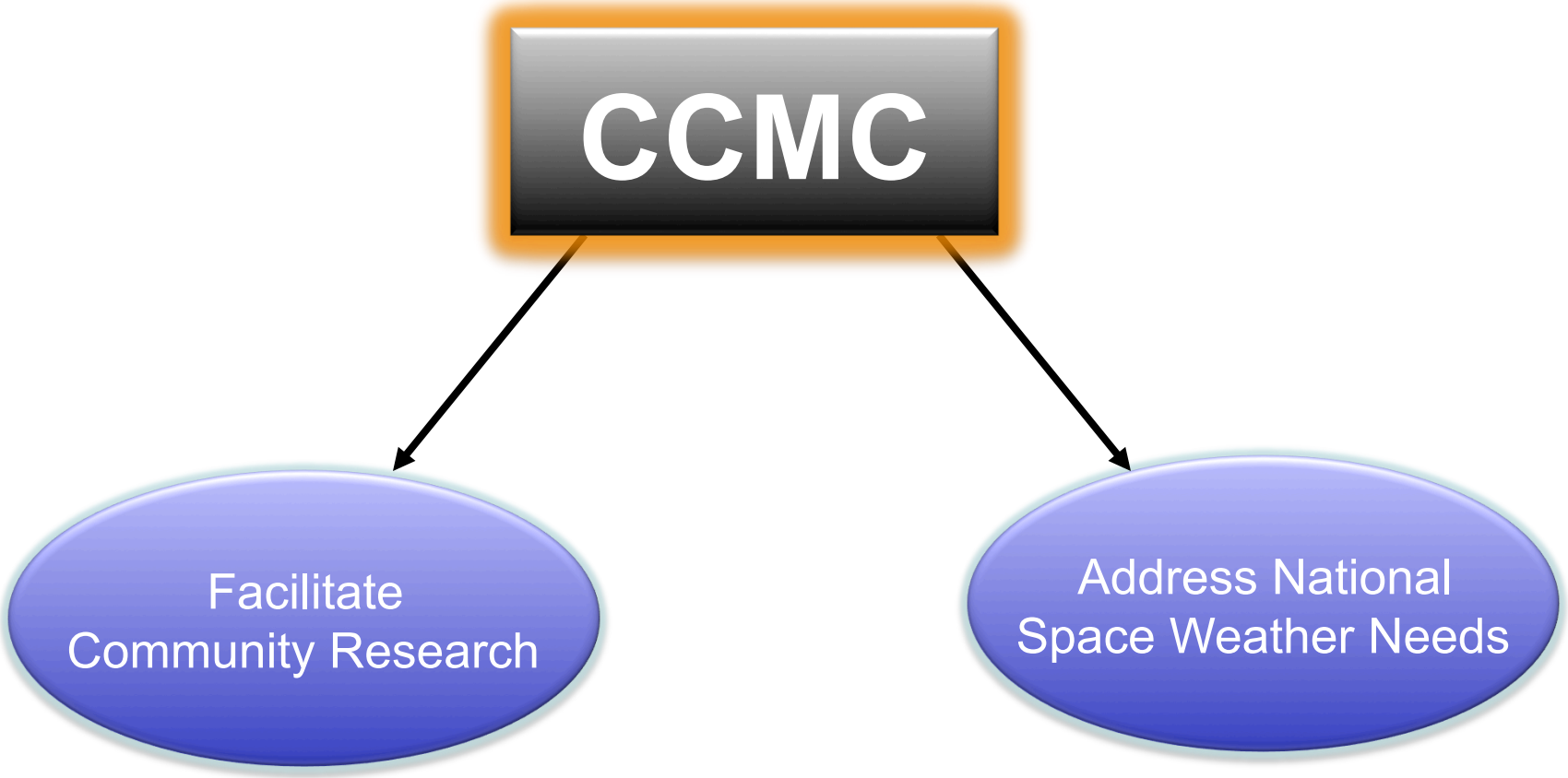
iSWA: Who, What, When, Why…

- Who
  - NASA, CCMC, SWRC
- What
  - Space Weather Analysis, Modeling, Forecasting
- When
  - 2008
- Why
  - Protect NASA assets
  - Support general space weather community
  - Engage and Education the Public

About The CCMC

"A US multi-agency partnership to enable, support and perform the research and development for next generation space science and space weather models."

CCMC Goals

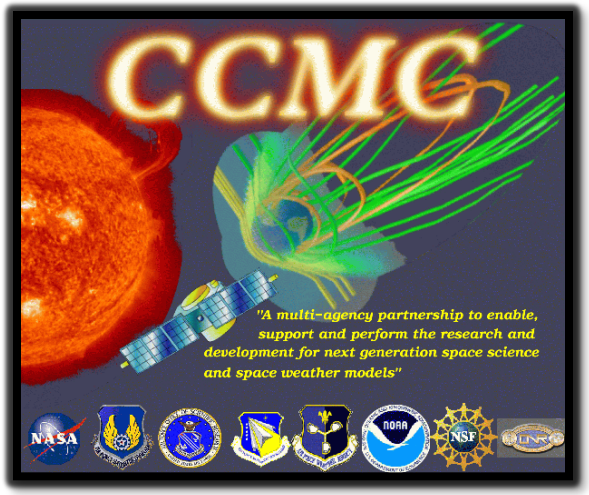


NASA, DoD and NOAA

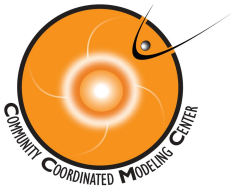
..through partnering with the international community

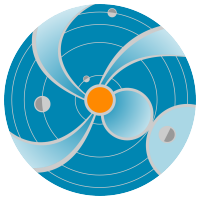
CCMC Products & Services

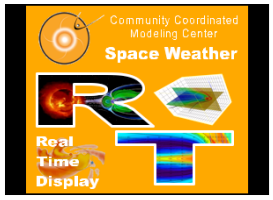
What the CCMC provides:

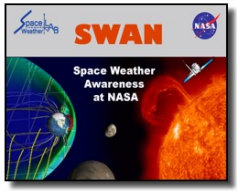


- Model Coupling in collaboration with model owners
- Scientific Validation of Models
- Metrics implementations
- Model Runs on Request
- Data Format Standardization
- Advanced Visualization
- Real-Time Products
- Support for Space Weather Center at GSFC
  - Issue Alerts, Warnings, & Anomaly Reports
  - SWx Support - develop tailored space weather analysis tools in support of NASA missions, Operations, and Forecasters

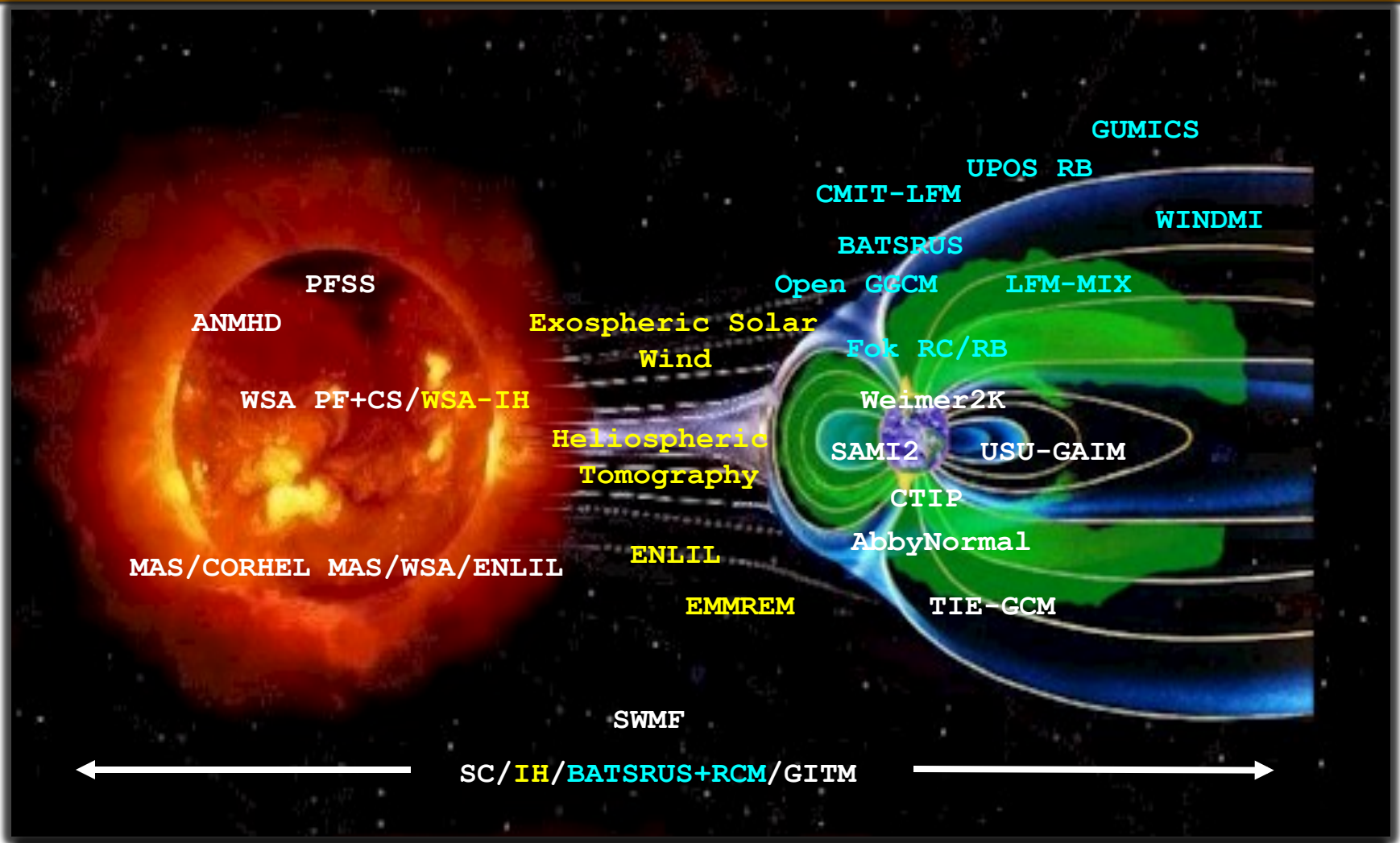








Space Weather Models at the CCMC



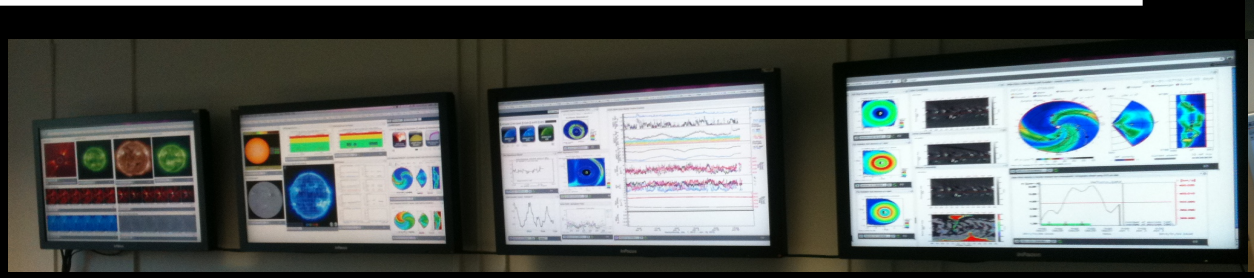
http://ccmc.gsfc.nasa.gov/models/

Computational Resources

- Dedicated Beowulf Computing Clusters for parallel codes
- Dedicated workstations for
  - Runs-on-request processing
  - serial codes
  - development environments (staff & guests)
  - visualization, movies-on-requests
  - web, wiki, svn, cvs, ftp, JIRA servers
  - lab computers
- Direct Attached Storage & Storage Area Network implementations – Active/Online
- Dedicated Network and Storage Fabrics

Computational Resources

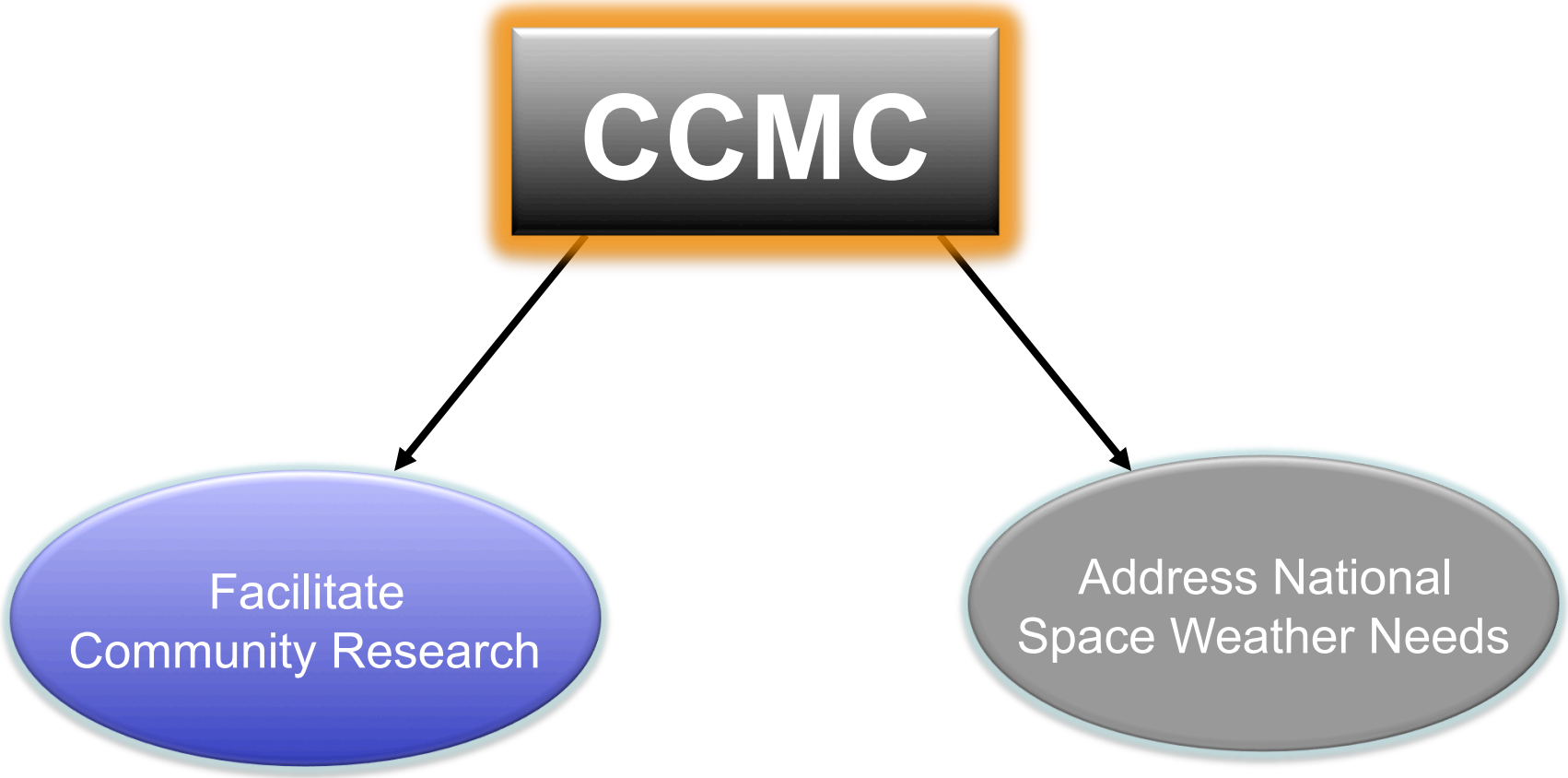
- Dedicated Infrastructure
  - 19 Rack Footprint
  - 5 Beowulf Clusters
  - 27 Enterprise Class Workstations
  - 1100 CPU Cores
  - .5 Petabyte of Storage
  - dedicated network
  - web, ftp, wiki, cvs, svn, file servers
- Multi-Building Setup for High Availability and Failover



Data Management & Dissemination

- CCMC RoR Database and Data Archive
  - All simulation results are online
- Data Trees for Model Input and Output
  - RoR input
  - RT input
  - RT output
- iSWA Database, Data Archive, and Web Services
  - Information Retrieval & Data Sorter Robot Modules
  - Data Streaming Service/API
  - Cygnet Streaming Service/API
  - Incoming Data Staging Areas
- FTP Drop Box and Download Area
- Kameleon Data Format Standardization Software Suite

CCMC Goals


CCMC
Facilitate
Community Research
Address National
Space Weather Needs
NASA, DoD and NOAA

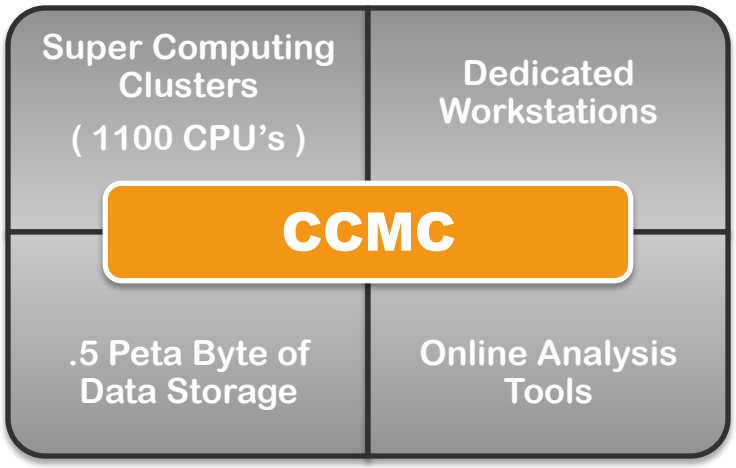
Model Simulation Runs-On-Request

http://ccmc.gsfc.nasa.gov

Requests

Results

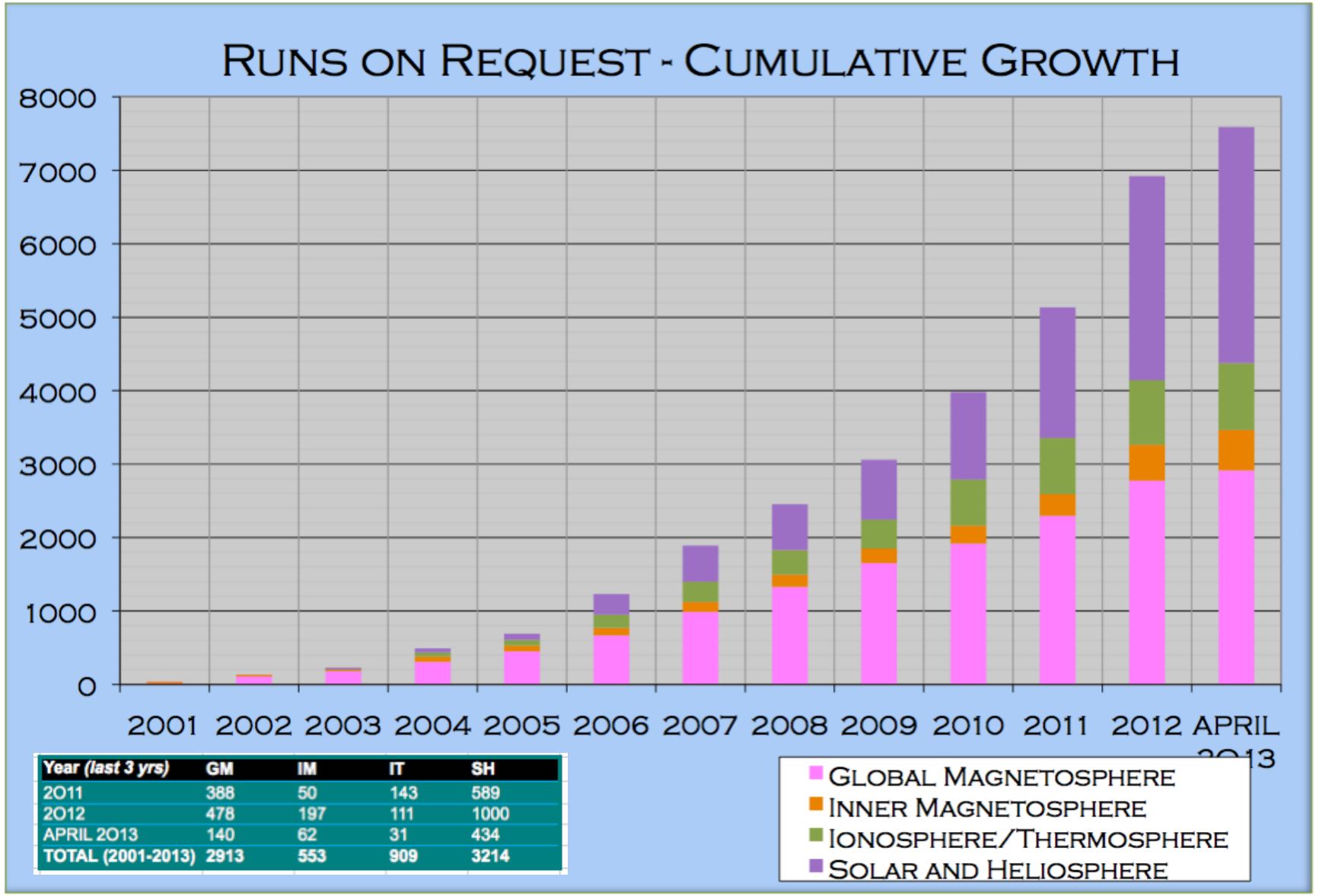
CCMC Center at NASA



- 25+ Available Models (covering from the Sun to Earth)
- User Configurable Input Parameters
- Data Downloads
- Simulation Archive
- Searchable Database
- Online Visualization Tools
- Downloadable Analysis Software
- Automated Movie Generation Tools

Runs-On-Request Usage Summary

Total ROR Runs by Domain



Year (last 3 yrs)	GM	IM	IT	SH
2011	388	50	143	589
2012	478	197	111	1000
APRIL 2013	140	62	31	434
TOTAL (2001-2013)	2913	553	909	3214

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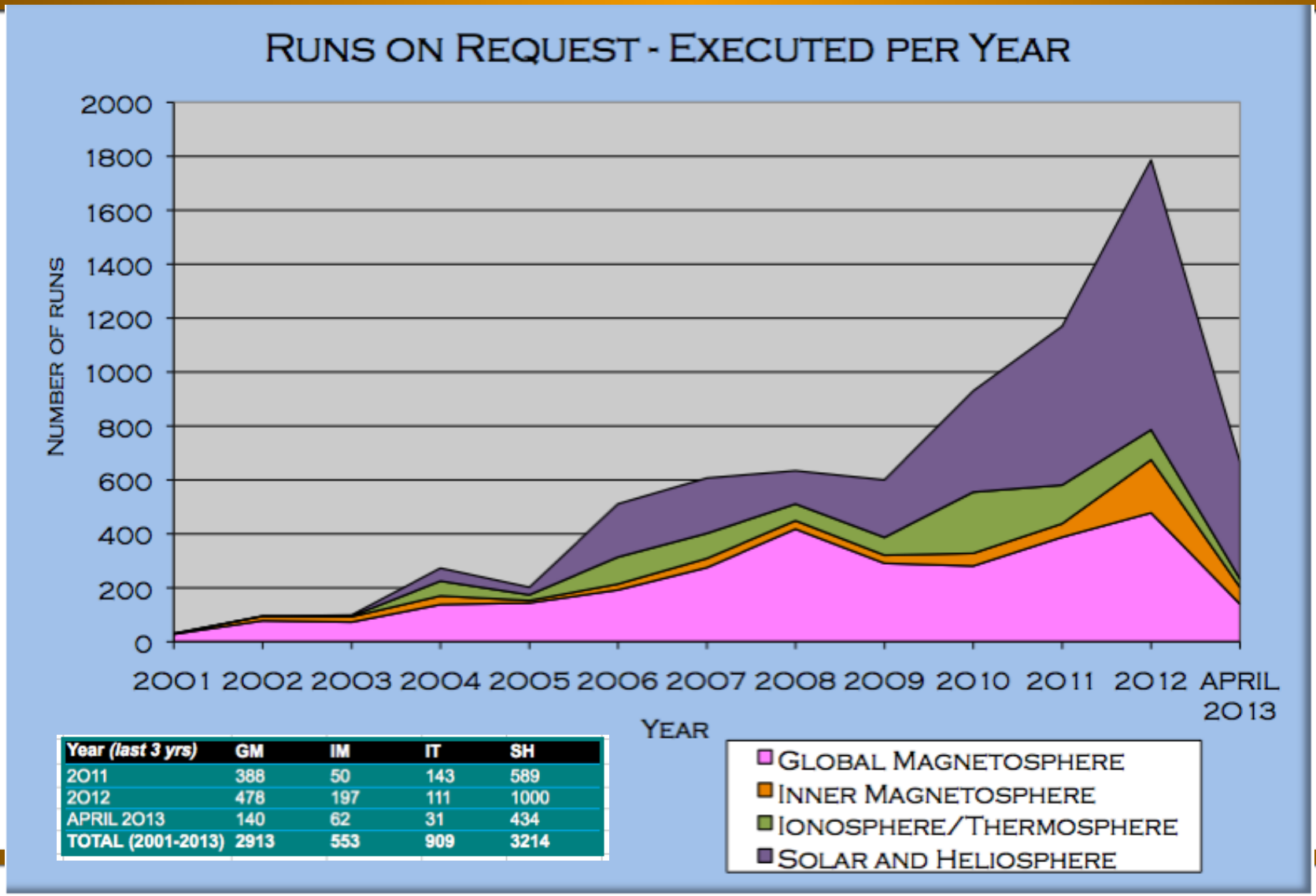

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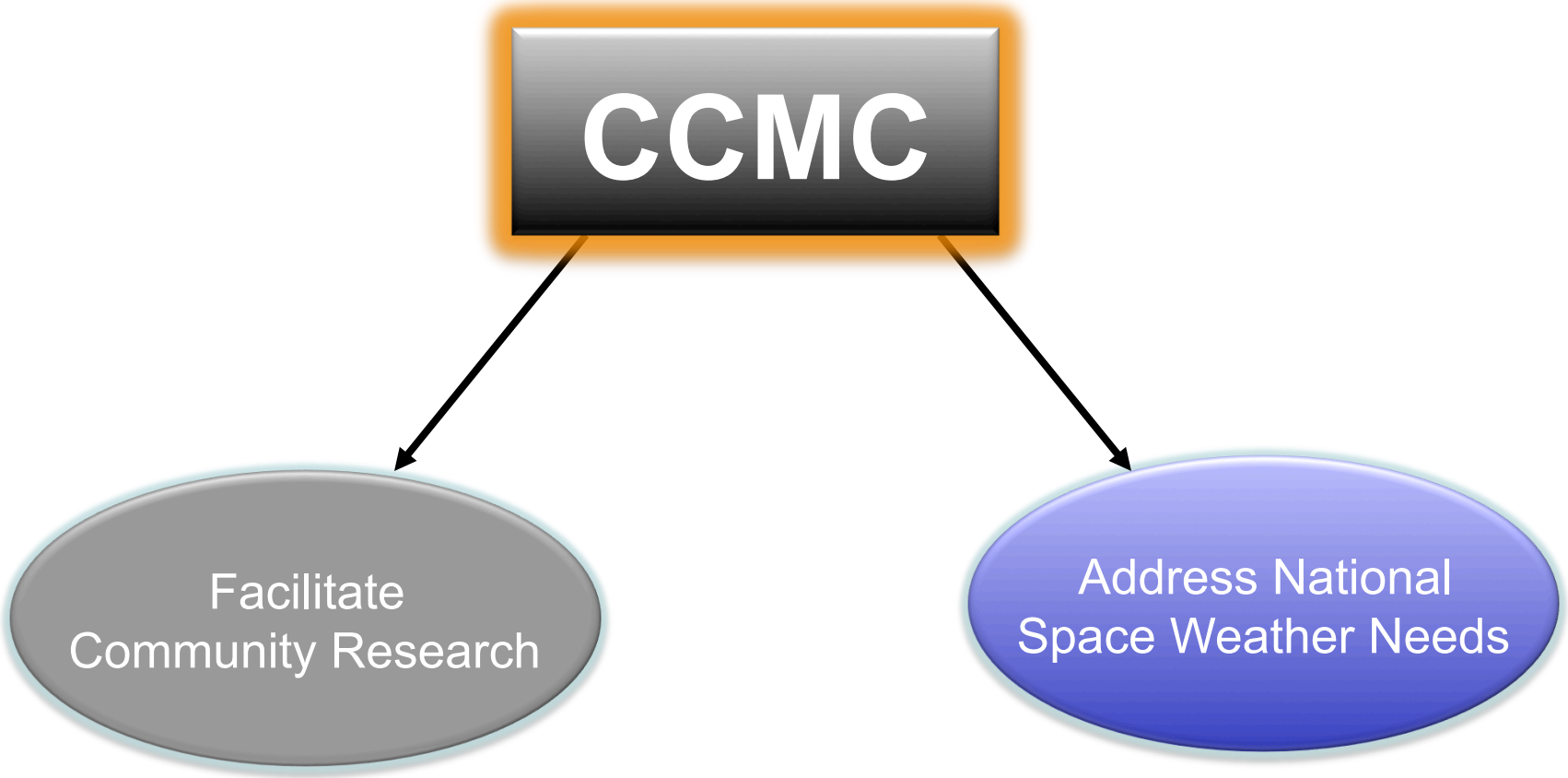
CCMC Goals



NASA, DoD and NOAA

NASA GSFC Space Weather Research Center (SWRC)

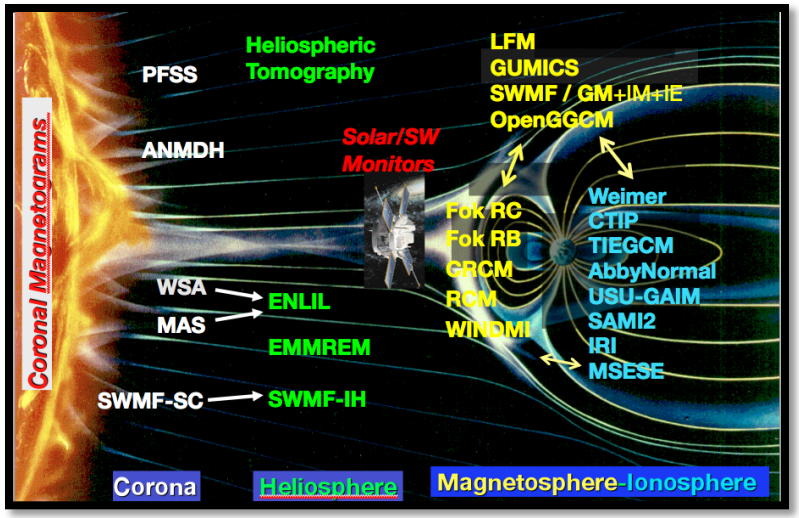
is a growing **CCMC Branch** with roots in its original **Support R2O** goal.

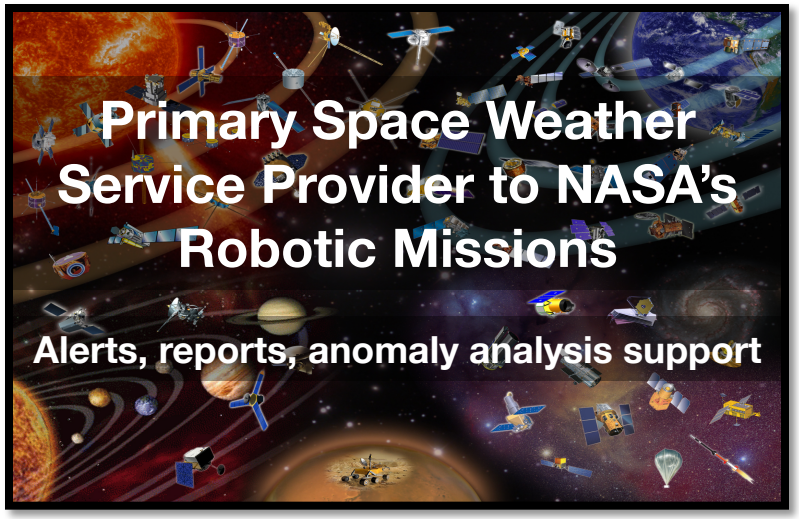
CCMC-SWRC: successful example of R2O & O2R

CCMC
(since 2000)

R2O

SWRC
(since 2010)





O2R

NASA GSFC Space Weather Research Center

Primary Objective:

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

since March 2010

NASA GSFC Space Weather Research Center

World Leading Modeling

COMMUNITY COORDINATED MODELING CENTER

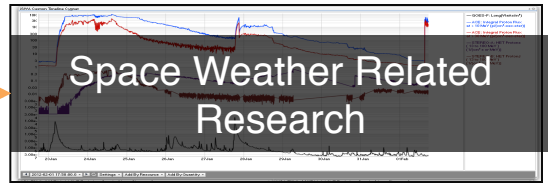
iSWA System

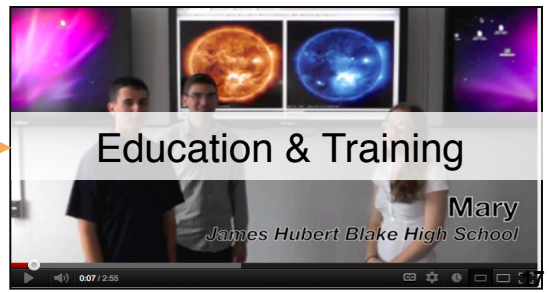
NASA, Other, Data Streams

Space Weather Research Center

Partnering

Johnson Space Center · NOAA · Air Force Weather Agency · ASTRA · EPRI · NiCT · esa · Met Office · KASI · JAXA · KMA · Meteorological Administration



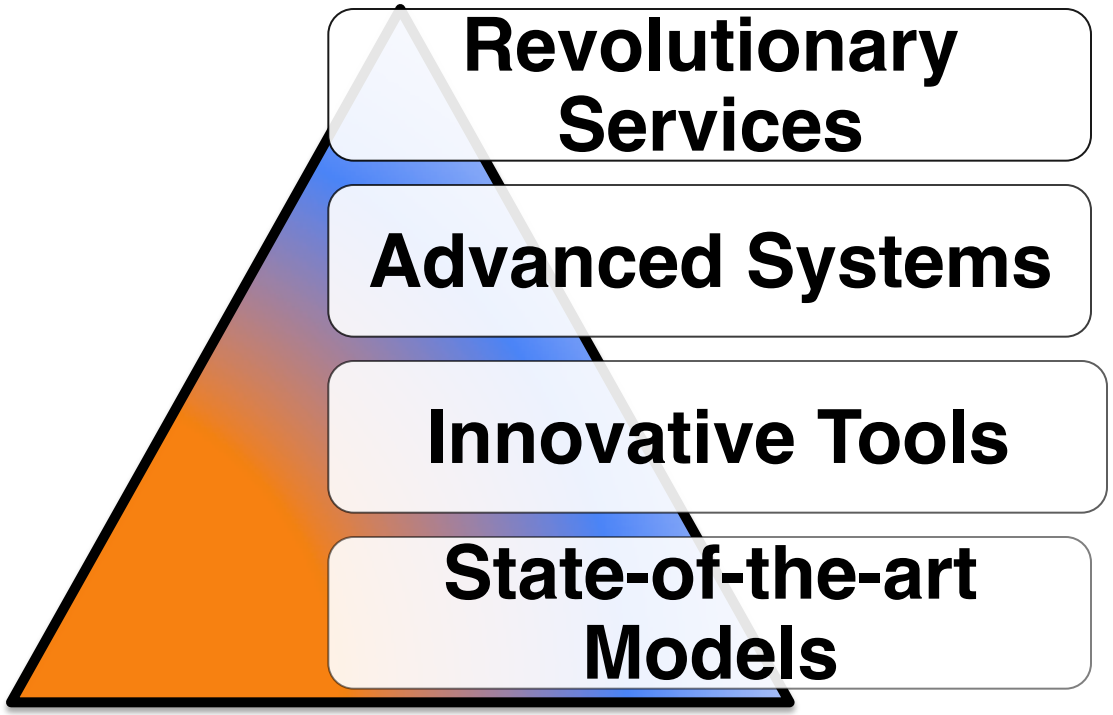


CCMC/SWRC

Space
Weather
Research
Center

Community
Coordinated
Modeling
Center

Pushing Frontiers of Space Science & Space Weather Research, Development & Operational Forecasting



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

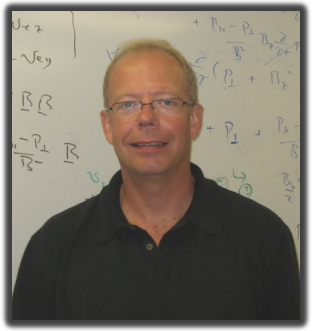
iSWA Solution & Deliverables

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

iSWA Project Team

David Berrios (587)
- Cygnet development
- Servlet development
- Performance tuning

Marlo Maddox (587)
- Project Lead/iSWA Co-PI
- System Architect
- Data model, database design
- Back-End development



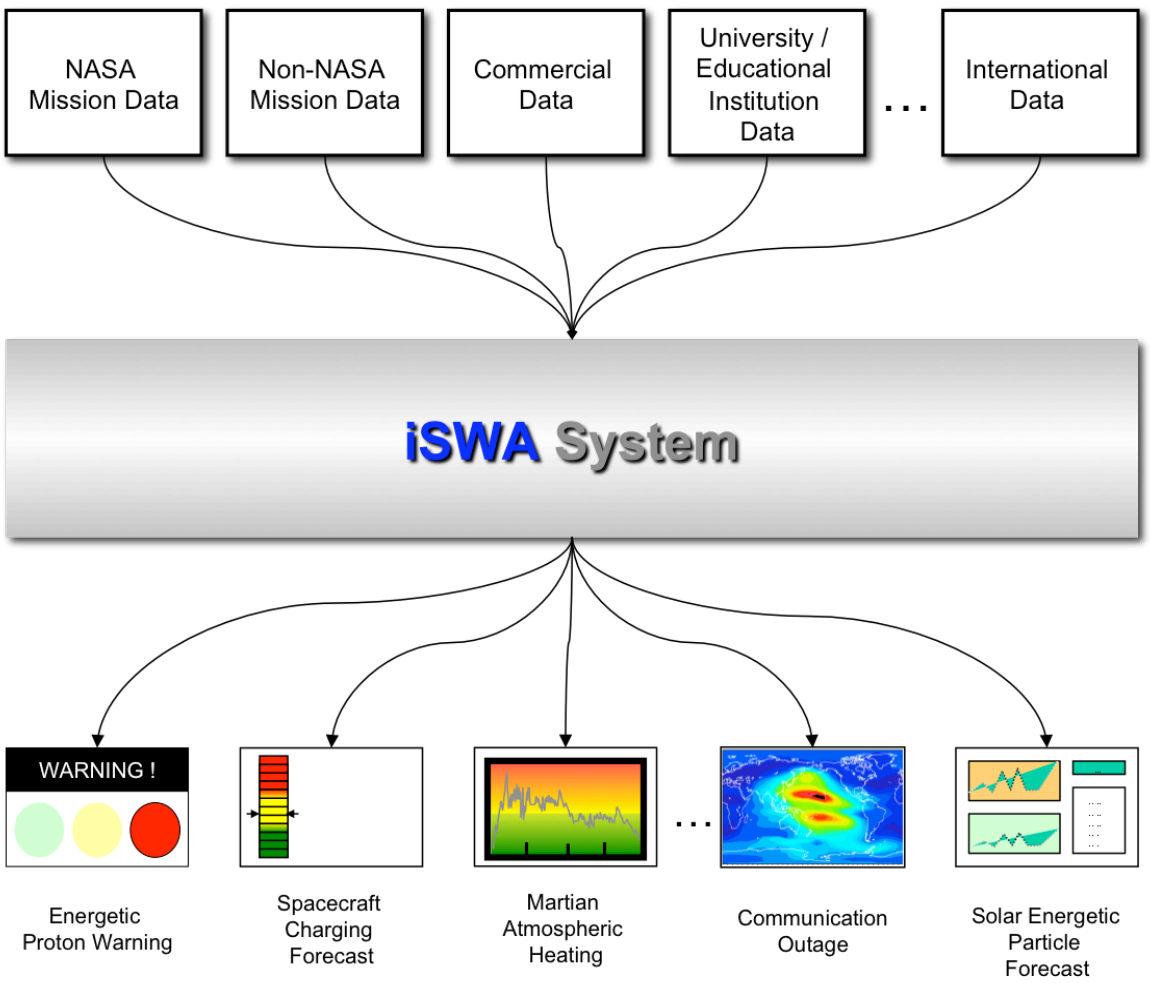
Michael Hesse (670)
- HSD Division Chief
- iSWA Co-PI
- iSWA Visionary Leader

Richard Mullinix (587)
- Front-End development
- User Interface
- Servlet development
- JS Framework & Ajax

Peyush Jain (587)
- JS Framework trade study
- Servlet development
- Interactive Timeline infrastructure and tools

Lutz Rastaetter (674)
- Real-Time Modeling
- Scientific Visualization
- Cygnet development

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.

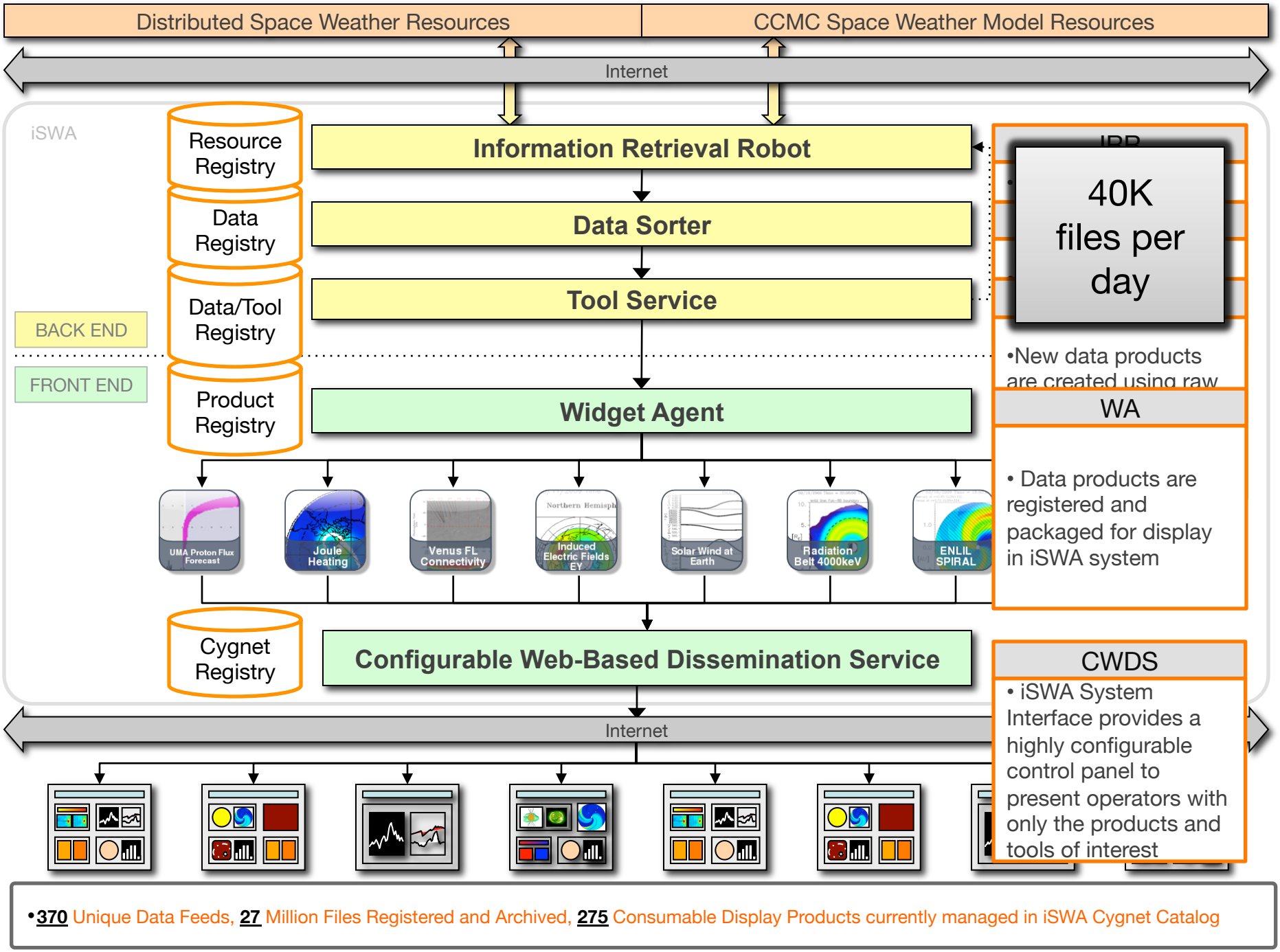
iSWA generates and provides a user-configurable display panel that can be accessed from a standard web browser. The end user can then customize their display to focus on specific products of interest.

iNTEGRATED SPACE WEATHER ANALYSIS SYSTEM

Data Management Challenges

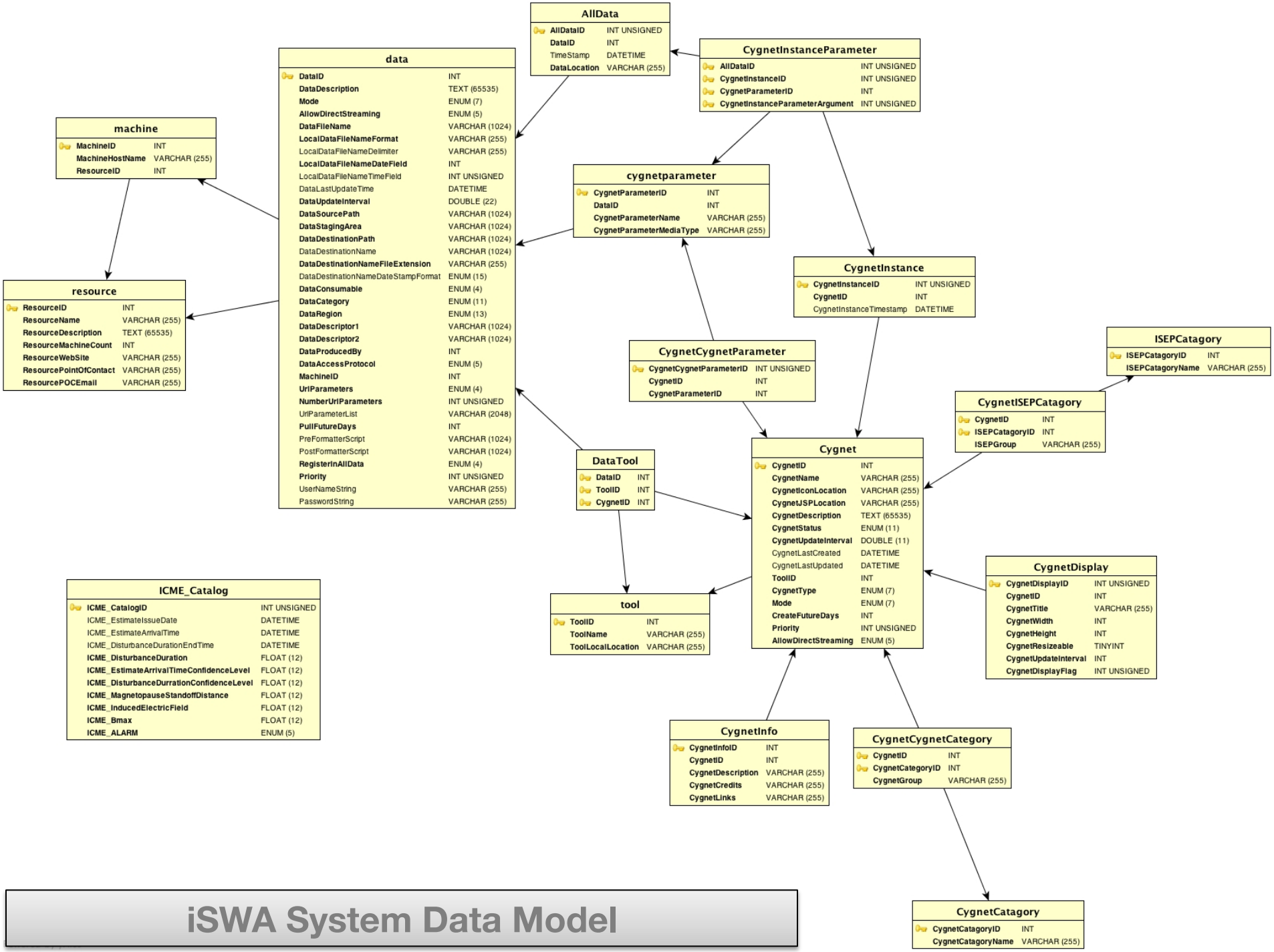
- Ingesting data streams from a variety of sources with varying:
  - Transfer Methods (push and pull)
  - Levels of availability
  - Access Protocols (http, ftp, scp, mv)
  - Naming Conventions
  - Update Intervals (efficient polling for new data)
  - Date & Time Stamp Formats i.e.

  [`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.)

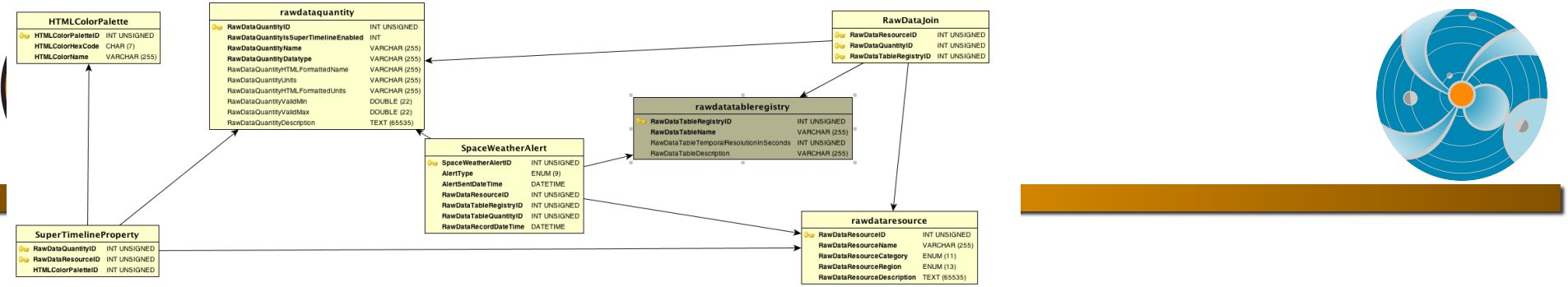

Distributed Space Weather Resources
CCMC Space Weather Model Resources
Internet
iSWA
Resource Registry
Data Registry
Data/Tool Registry
Product Registry
Information Retrieval Robot
Data Sorter
Tool Service
BACK END
FRONT END
Widget Agent
40K files per day
•New data products are created using raw
WA
• 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
•370 Unique Data Feeds, 27 Million Files Registered and Archived, 275 Consumable Display Products currently managed in iSWA Cygnet Catalog

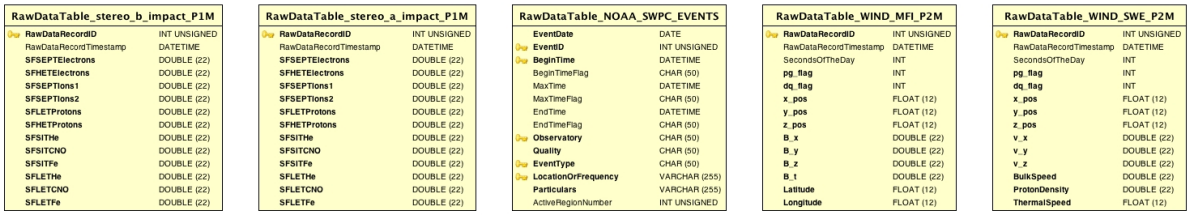
Database Schema Drill Down

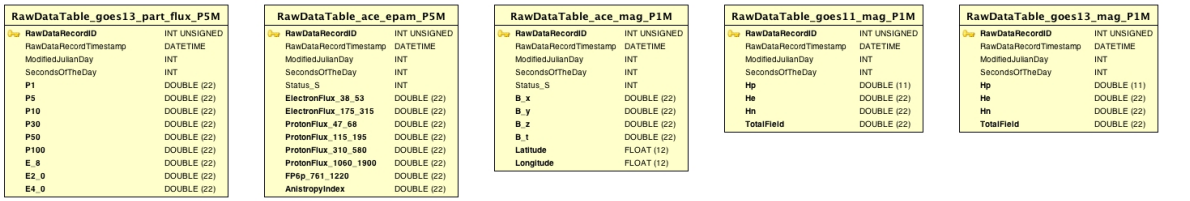
http://iswa3.ccmc.gsfc.nasa.gov/development/iswa_database_schema.jpg http://iswa3.ccmc.gsfc.nasa.gov/development/iswa_rawdata_database_schema.jpg

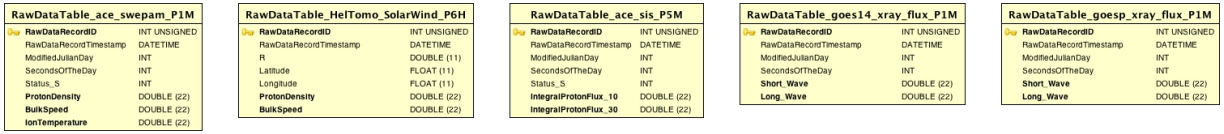


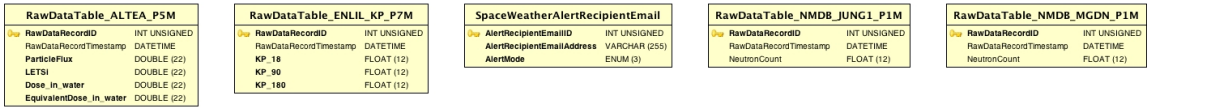
iSWA System Data Model

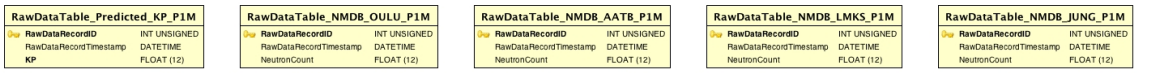


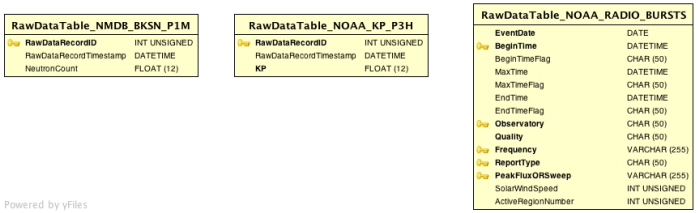




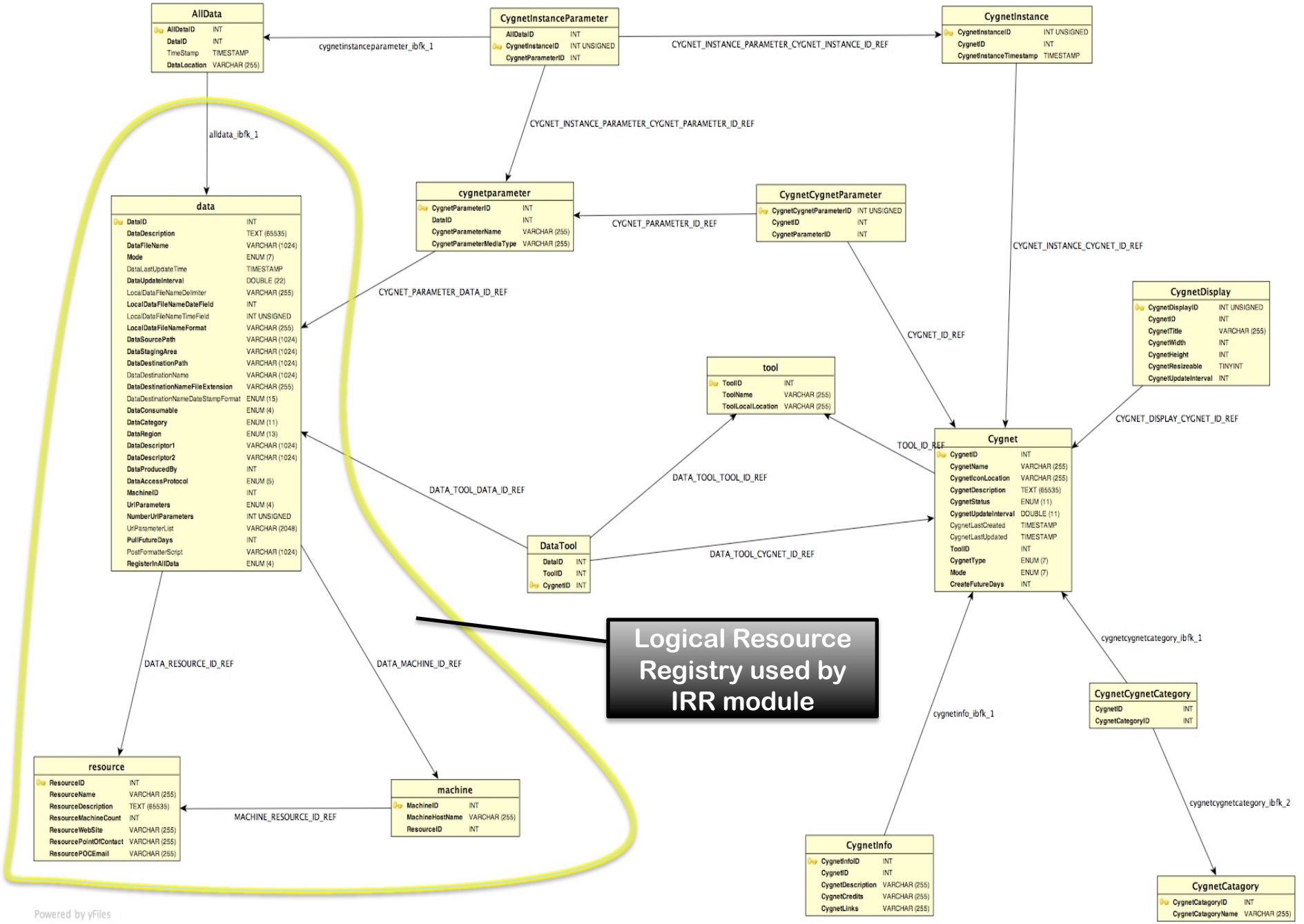








iSWA System "Raw Data" Data Model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CygnetInstanceTimestamp TIMESTAMP
alldata_ibfk_1
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CYGNET_INSTANCE_CYGNET_ID_REF
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DATA_MACHINE_ID_REF
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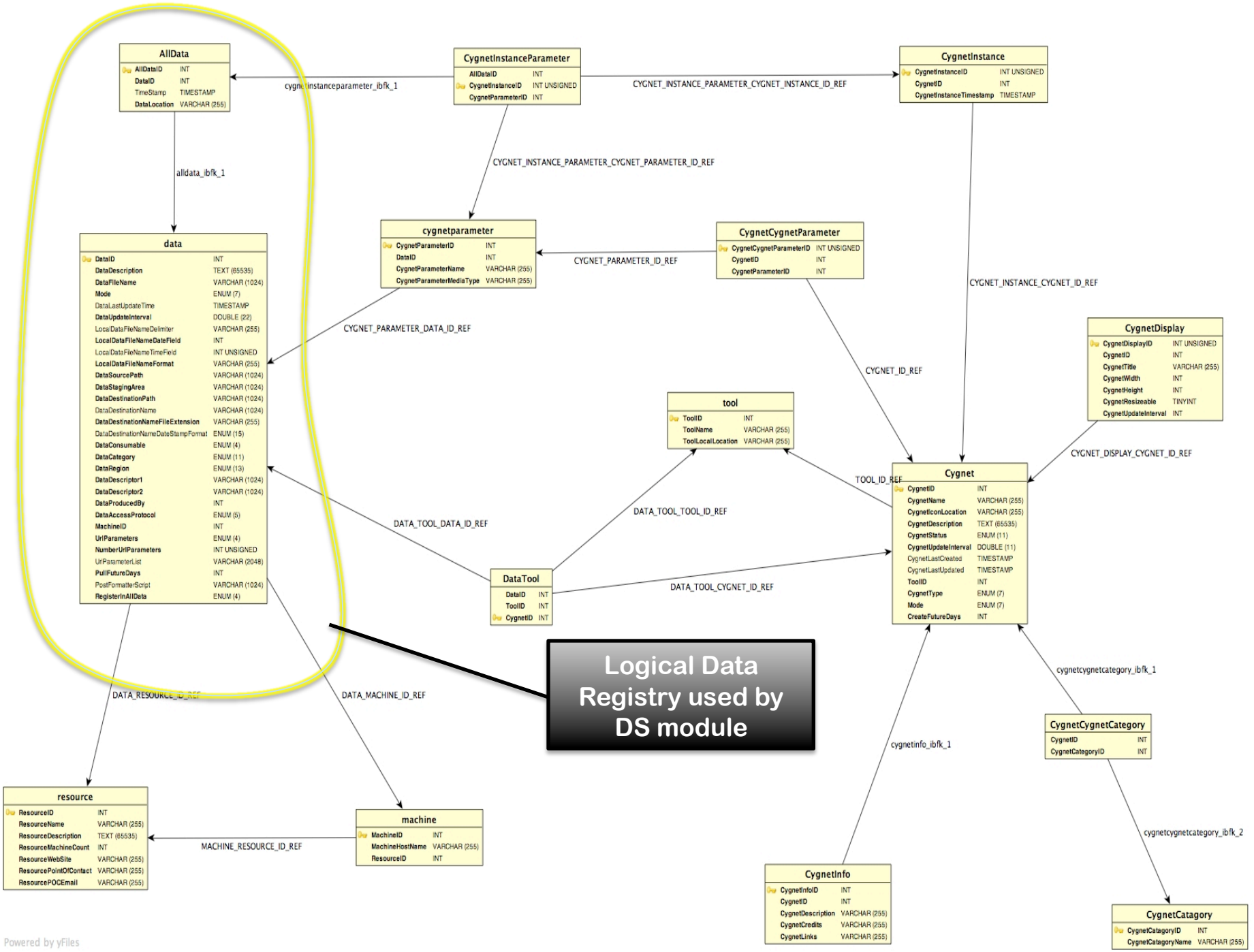
Powered by yFiles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UrlParameters ENUM (4)
NumberUrlParameters INT UNSIGNED
UrlParameterList VARCHAR (2048)
PullFutureDays INT
PostFormatterScript VARCHAR (1024)
RegisterInAllData ENUM (4)
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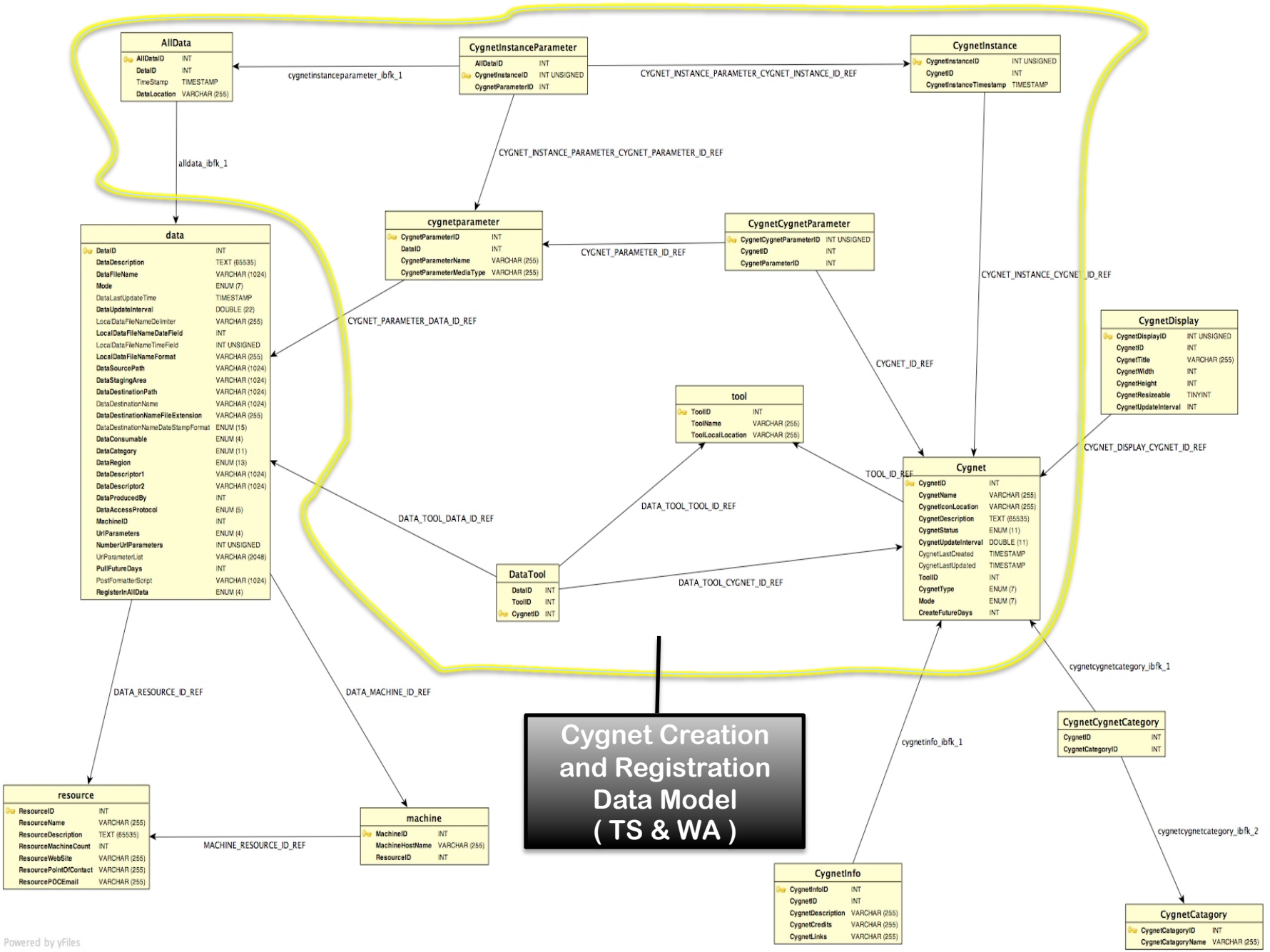
CygnetCygnetParameter
CygnetCygnetParameterID INT UNSIGNED
CygnetID INT
CygnetParameterID INT
CYGNET_PARAMETER_DATA_ID_REF
CYGNET_INSTANCE_CYGNET_ID_REF
CygnetDisplay
CygnetDisplayID INT UNSIGNED
CygnetID INT
CygnetTitle VARCHAR (255)
CygnetWidth INT
CygnetHeight INT
CygnetResizeable TINYINT
CygnetUpdateInterval INT
CYGNET_ID_REF
tool
ToolID INT
ToolName VARCHAR (255)
ToolLocalLocation VARCHAR (255)
CYGNET_DISPLAY_CYGNET_ID_REF
TOOL_ID_REF
Cygnet
CygnetID INT
CygnetName VARCHAR (255)
CygnetIconLocation VARCHAR (255)
CygnetDescription TEXT (65535)
CygnetStatus ENUM (11)
CygnetUpdateInterval DOUBLE (11)
CygnetLastCreated TIMESTAMP
CygnetLastUpdated TIMESTAMP
ToolID INT
CygnetType ENUM (7)
Mode ENUM (7)
CreateFutureDays INT
DATA_TOOL_DATA_ID_REF
DATA_TOOL_TOOL_ID_REF
DataTool
DataID INT
ToolID INT
CygnetID INT
DATA_TOOL_CYGNET_ID_REF
Logical Data Registry used by DS module
DATA_RESOURCE_ID_REF
DATA_MACHINE_ID_REF
cygnetcygnetcategory_ibfk_1
CygnetCygnetCategory
CygnetID INT
CygnetCategoryID INT
cygnetinfo_ibfk_1
cygnetcygnetcategory_ibfk_2
resource
ResourceID INT
ResourceName VARCHAR (255)
ResourceDescription TEXT (65535)
ResourceMachineCount INT
ResourceWebSite VARCHAR (255)
ResourcePointOfContact VARCHAR (255)
ResourcePOCEmail VARCHAR (255)
machine
MachineID INT
MachineHostName VARCHAR (255)
ResourceID INT
MACHINE_RESOURCE_ID_REF
CygnetInfo
CygnetInfoID INT
CygnetID INT
CygnetDescription VARCHAR (255)
CygnetCredits VARCHAR (255)
CygnetLinks VARCHAR (255)
CygnetCatagory
CygnetCatagoryID INT
CygnetCatagoryName VARCHAR (255)
Powered by yFiles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DataLocation VARCHAR (255)
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CygnetInstance
CygnetInstanceID INT UNSIGNED
CygnetID INT
CygnetInstanceTimestamp TIMESTAMP
cygnetinstanceparameter_ibfk_1
CYGNET_INSTANCE_PARAMETER_CYGNET_INSTANCE_ID_REF
alldata_ibfk_1
CYGNET_INSTANCE_PARAMETER_CYGNET_PARAMETER_ID_REF
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DataID INT
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DataFileName VARCHAR (1024)
Mode ENUM (7)
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DataUpdateInterval DOUBLE (22)
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LocalDataFileNameTimeField INT UNSIGNED
LocalDataFileNameFormat VARCHAR (255)
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DataDestinationPath VARCHAR (1024)
DataDestinationName VARCHAR (1024)
DataDestinationNameFileExtension VARCHAR (255)
DataDestinationNameDateStampFormat ENUM (15)
DataConsumable ENUM (4)
DataCategory ENUM (11)
DataRegion ENUM (13)
DataDescriptor1 VARCHAR (1024)
DataDescriptor2 VARCHAR (1024)
DataProducedBy INT
DataAccessProtocol ENUM (5)
MachineID INT
UrlParameters ENUM (4)
NumberUrlParameters INT UNSIGNED
UrlParameterList VARCHAR (2048)
PullFutureDays INT
PostFormatterScript VARCHAR (1024)
RegisterInAllData ENUM (4)
cygnetparameter
CygnetParameterID INT
DataID INT
CygnetParameterName VARCHAR (255)
CygnetParameterMediaType VARCHAR (255)
CygnetCygnetParameter
CygnetCygnetParameterID INT UNSIGNED
CygnetID INT
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CYGNET_PARAMETER_ID_REF
CYGNET_INSTANCE_CYGNE_ID_REF
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CYGNET_ID_REF
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CygnetID INT
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CygnetWidth INT
CygnetHeight INT
CygnetResizeable TINYINT
CygnetUpdateInterval INT
CYGNET_DISPLAY_CYGNET_ID_REF
tool
ToolID INT
ToolName VARCHAR (255)
ToolLocalLocation VARCHAR (255)
TOOL_ID_REF
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CygnetName VARCHAR (255)
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CygnetDescription TEXT (65535)
CygnetStatus ENUM (11)
CygnetUpdateInterval DOUBLE (11)
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CygnetLastUpdated TIMESTAMP
ToolID INT
CygnetType ENUM (7)
Mode ENUM (7)
CreateFutureDays INT
DATA_TOOL_DATA_ID_REF
DATA_TOOL_TOOL_ID_REF
DataTool
DataID INT
ToolID INT
CygnetID INT
DATA_TOOL_CYGNET_ID_REF
DATA_RESOURCE_ID_REF
DATA_MACHINE_ID_REF
cygnetcygnetcategory_ibfk_1
Cygnet Creation and Registration Data Model (TS & WA)
CygnetCygnetCategory
CygnetID INT
CygnetCategoryID INT
cygnetinfo_ibfk_1
cygnetcygnetcategory_ibfk_2
resource
ResourceID INT
ResourceName VARCHAR (255)
ResourceDescription TEXT (65535)
ResourceMachineCount INT
ResourceWebSite VARCHAR (255)
ResourcePointOfContact VARCHAR (255)
ResourcePOCEmail VARCHAR (255)
machine
MachineID INT
MachineHostName VARCHAR (255)
ResourceID INT
MACHINE_RESOURCE_ID_REF
CygnetInfo
CygnetInfoID INT
CygnetID INT
CygnetDescription VARCHAR (255)
CygnetCredits VARCHAR (255)
CygnetLinks VARCHAR (255)
CygnetCatagory
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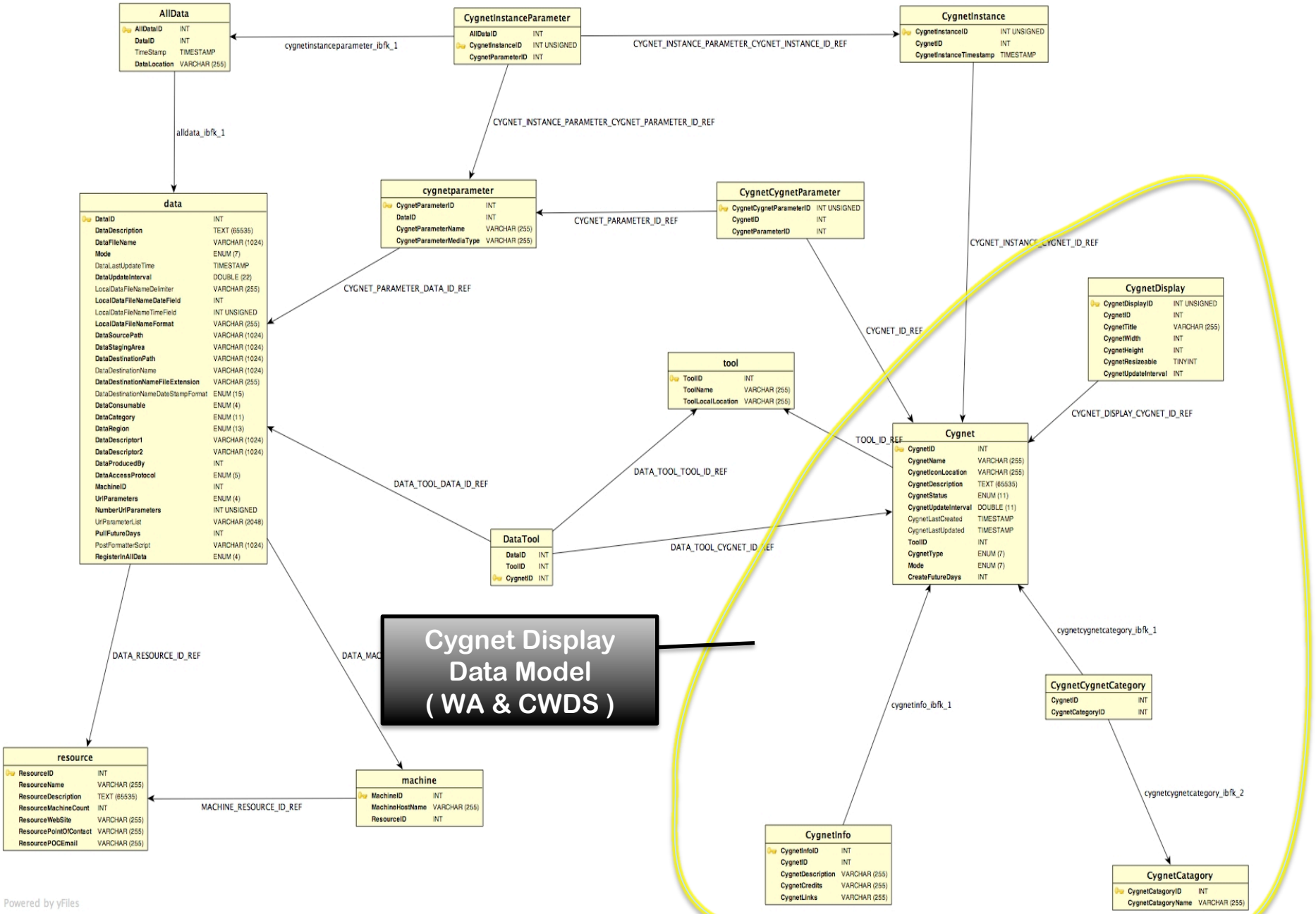
CygnetCatagoryName VARCHAR (255)
Powered by yFiles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DataUpdateInterval DOUBLE (22)
LocalDataFileNameDelimiter VARCHAR (255)
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DataSourcePath VARCHAR (1024)
DataStagingArea VARCHAR (1024)
DataDestinationPath VARCHAR (1024)
DataDestinationName VARCHAR (1024)
DataDestinationNameFileExtension VARCHAR (255)
DataDestinationNameDateStampFormat ENUM (15)
DataConsumable ENUM (4)
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DataRegion ENUM (13)
DataDescriptor1 VARCHAR (1024)
DataDescriptor2 VARCHAR (1024)
DataProducedBy INT
DataAccessProtocol ENUM (5)
MachineID INT
UrlParameters ENUM (4)
NumberUrlParameters INT UNSIGNED
UrlParameterList VARCHAR (2048)
PullFutureDays INT
PostFormatterScript VARCHAR (1024)
RegisterInAllData ENUM (4)
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CygnetWidth INT
CygnetHeight INT
CygnetResizeable TINYINT
CygnetUpdateInterval INT
CYGNET_DISPLAY_CYGNET_ID_REF
tool
ToolID INT
ToolName VARCHAR (255)
ToolLocalLocation VARCHAR (255)
TOOL_ID_REF
Cygnet
CygnetID INT
CygnetName VARCHAR (255)
CygnetIconLocation VARCHAR (255)
CygnetDescription TEXT (65535)
CygnetStatus ENUM (11)
CygnetUpdateInterval DOUBLE (11)
CygnetLastCreated TIMESTAMP
CygnetLastUpdated TIMESTAMP
ToolID INT
CygnetType ENUM (7)
Mode ENUM (7)
CreateFutureDays INT
DATA_TOOL_DATA_ID_REF
DATA_TOOL_TOOL_ID_REF
DataTool
DataID INT
ToolID INT
CygnetID INT
DATA_TOOL_CYGNET_ID_REF
Cygnet Display
Data Model
(WA & CWDS)
DATA_RESOURCE_ID_REF
DATA_MAC
cygnetcygnetcategory_ibfk_1
CygnetCygnetCategory
CygnetID INT
CygnetCategoryID INT
cygnetinfo_ibfk_1
cygnetcygnetcategory_ibfk_2
resource
ResourceID INT
ResourceName VARCHAR (255)
ResourceDescription TEXT (65535)
ResourceMachineCount INT
ResourceWebSite VARCHAR (255)
ResourcePointOfContact VARCHAR (255)
ResourcePOCEmail VARCHAR (255)
machine
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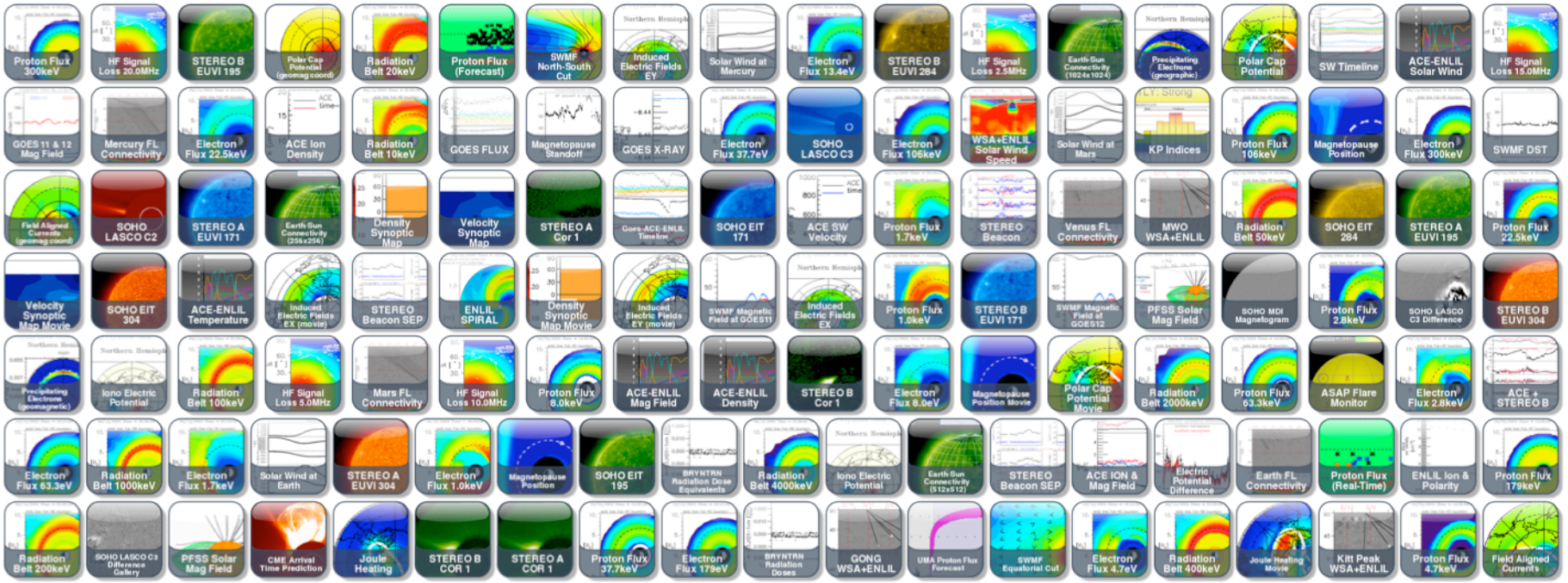
CygnetInfoID INT
CygnetID INT
CygnetDescription VARCHAR (255)
CygnetCredits VARCHAR (255)
CygnetLinks VARCHAR (255)
CygnetCatagory
CygnetCatagoryID INT
CygnetCatagoryName VARCHAR (255)
Powered by yFiles

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

iSWA Design Highlights

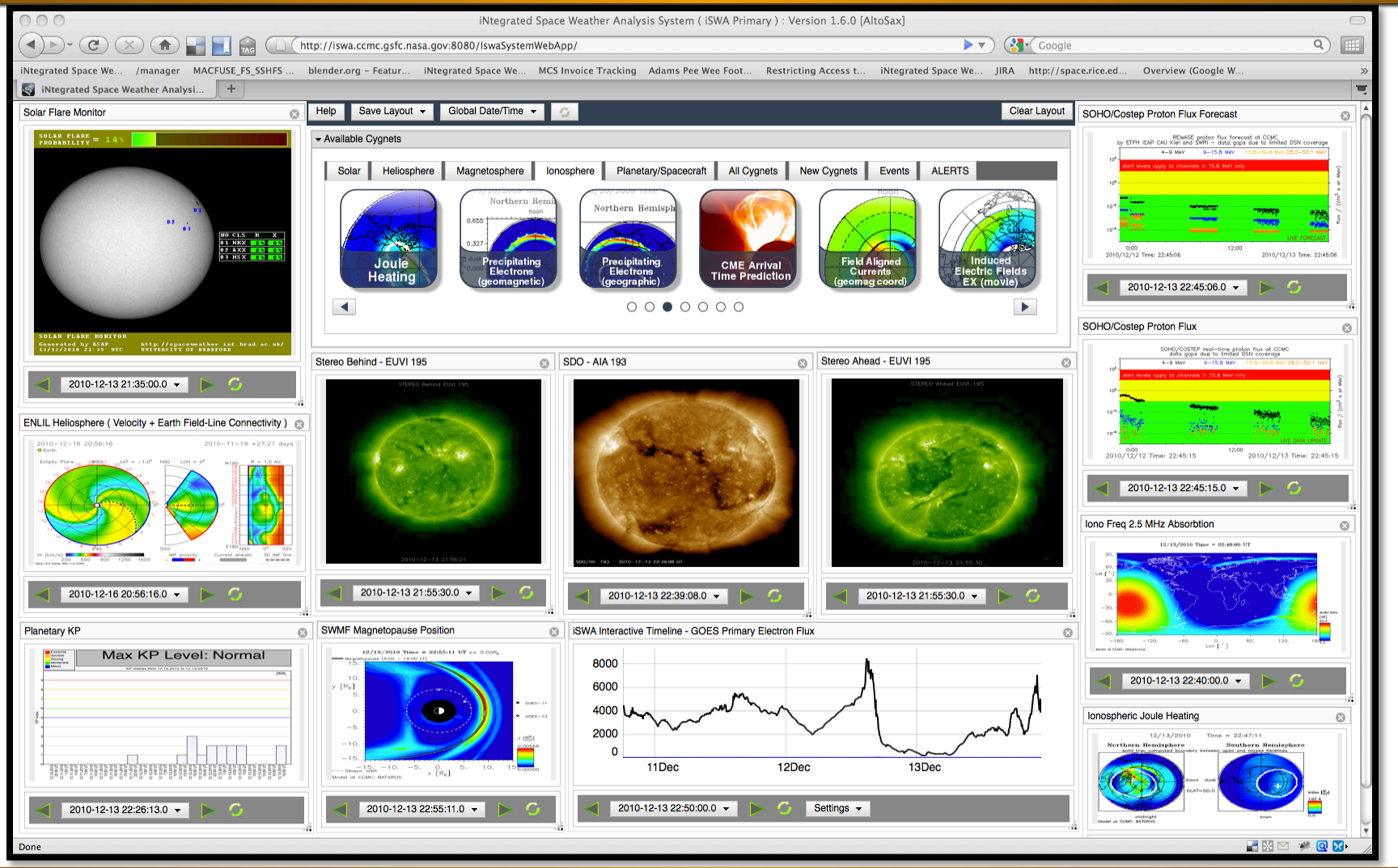
BACK END

- **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

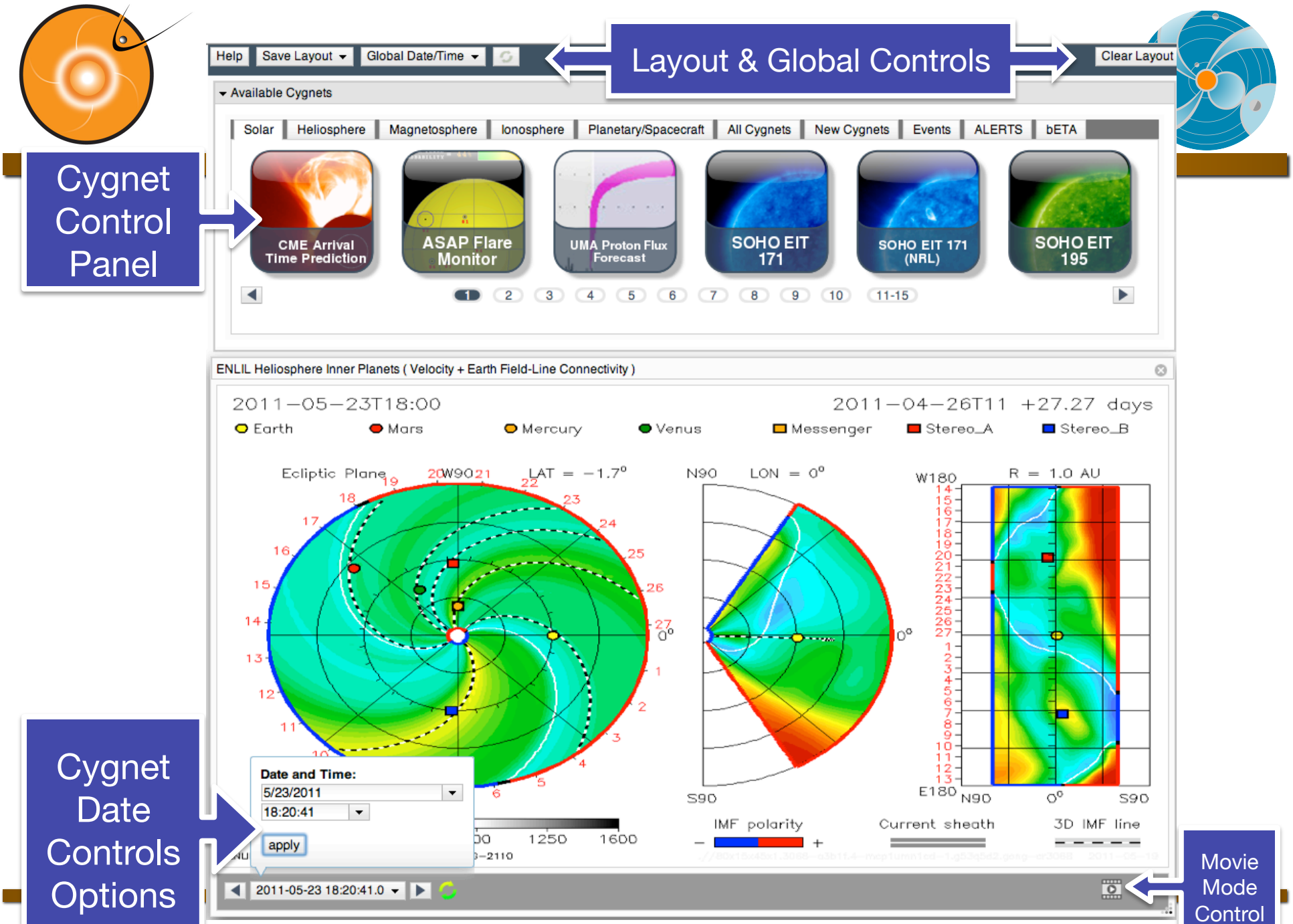
FRONT END

- **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**~~

Unprecedented Access to Space Weather Information

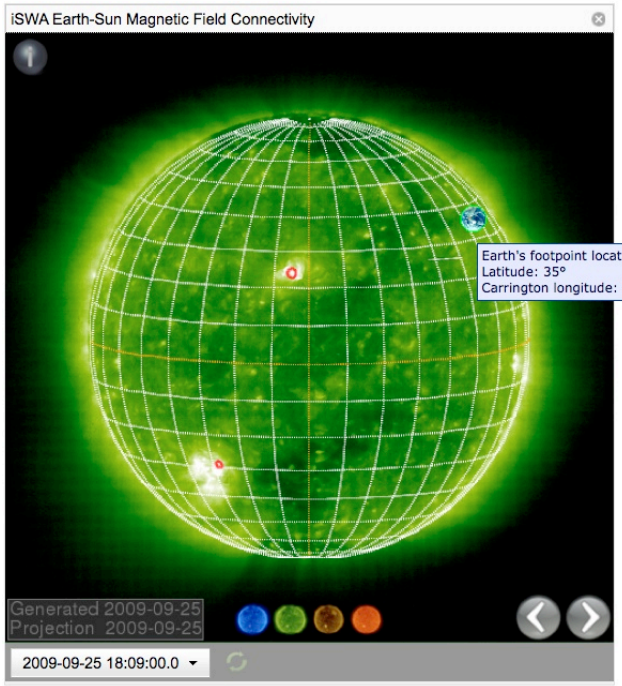


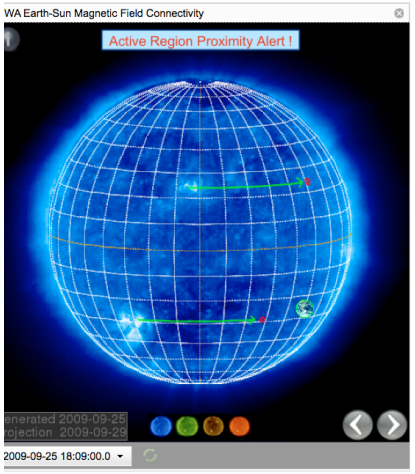
http://iSWA.ccmc.gsfc.nasa.gov

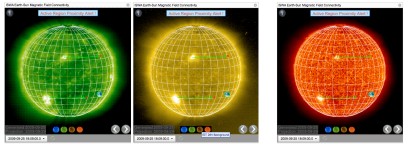

Layout & Global Controls
Cygnet Control Panel
Cygnet Date Controls Options
Movie Mode Control
Help
Save Layout
Global Date/Time
Clear Layout
Available Cygnets
Solar
Heliosphere
Magnetosphere
Ionosphere
Planetary/Spacecraft
All Cygnets
New Cygnets
Events
ALERTS
bETA
CME Arrival Time Prediction
ASAP Flare 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
LAT = −1.7°
N90
LON = 0°
W180
R = 1.0 AU
S90
E180
IMF polarity
Current sheath
3D IMF line
Date and Time:
5/23/2011
18:20:41
apply
2011-05-23 18:20:41.0

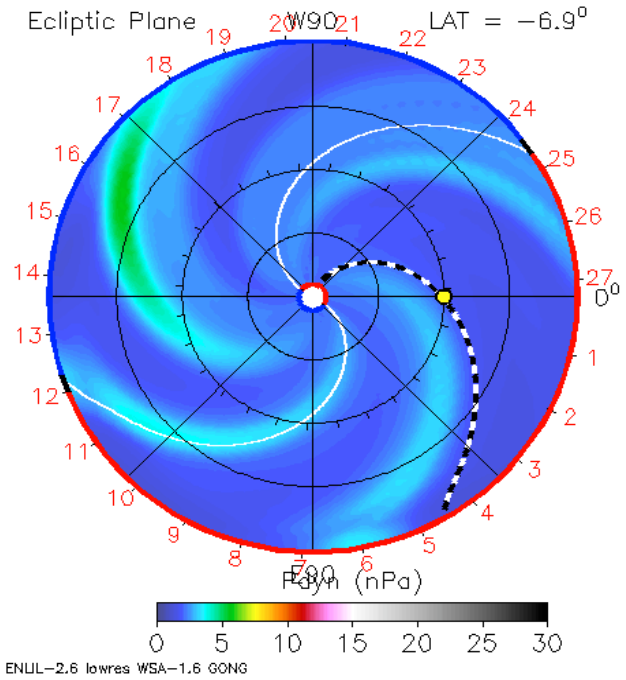
Sample iSWA Products/ Cygnets

Monitor Magnetic Connectivity and Proximity to Active Regions



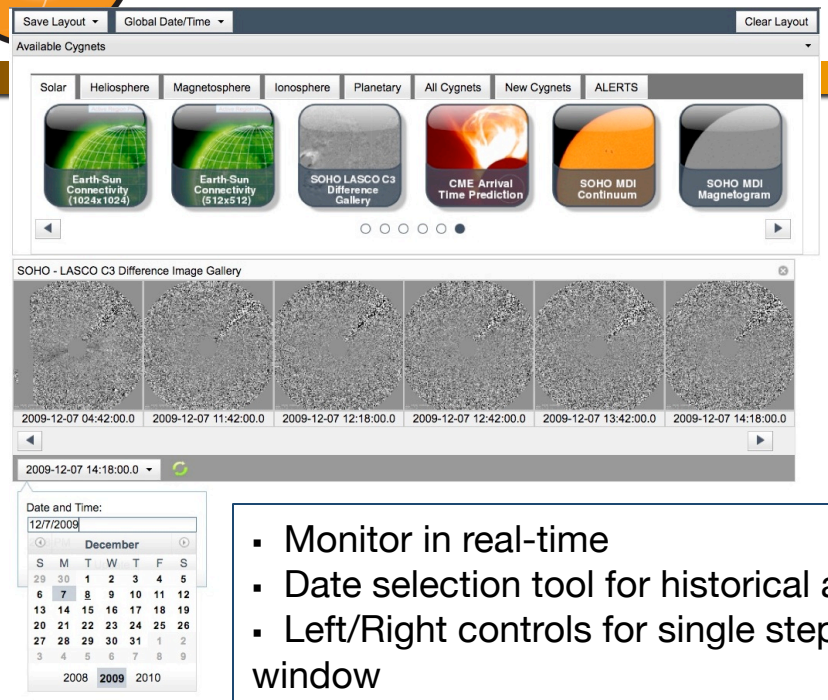


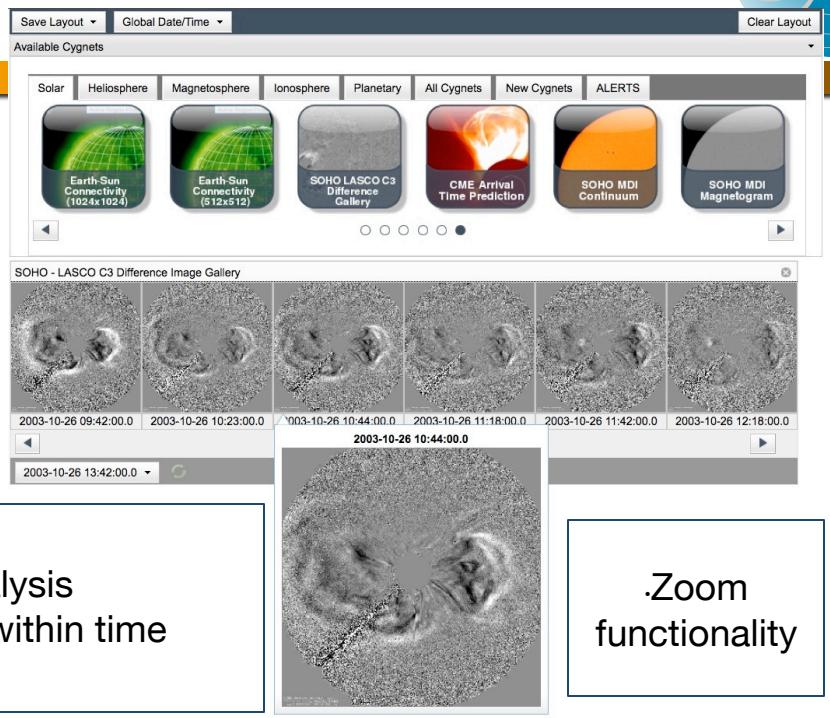




- Monitor active regions and their proximity to magnetically connected foot-point locations of the earth
- View future projections of active regions and foot-point locations
- Date selection tool for historical analysis
- Select different EIT wavelengths
- Monitor in real-time

Monitor CME propagation in real-time or for historical events

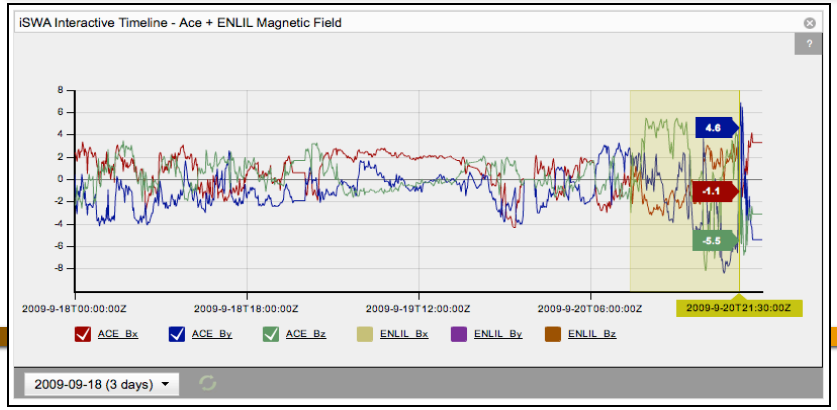




- Monitor in real-time
- Date selection tool for historical analysis
- Left/Right controls for single steps within time window

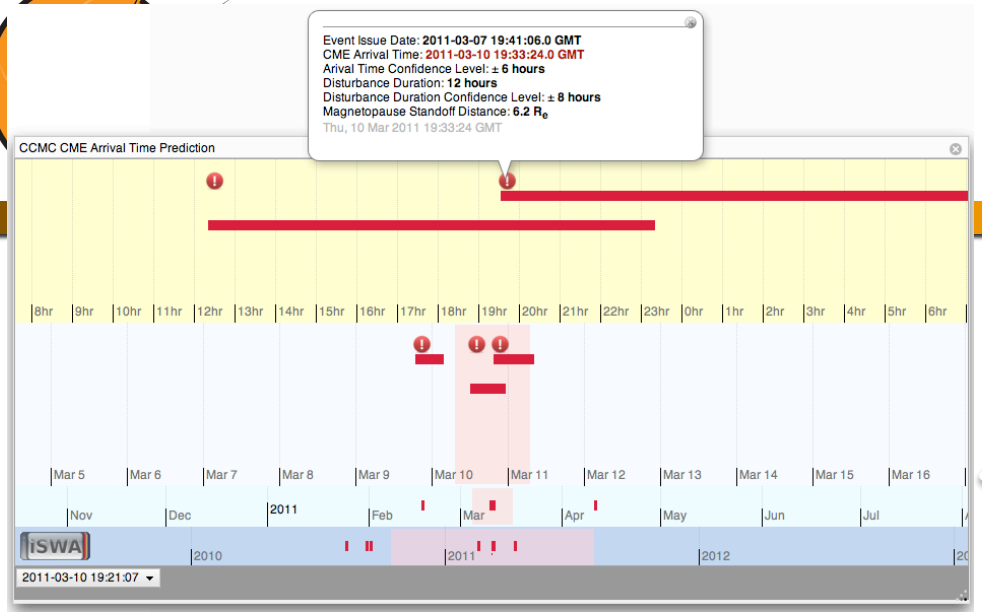
.Zoom functionality

Super Timelines



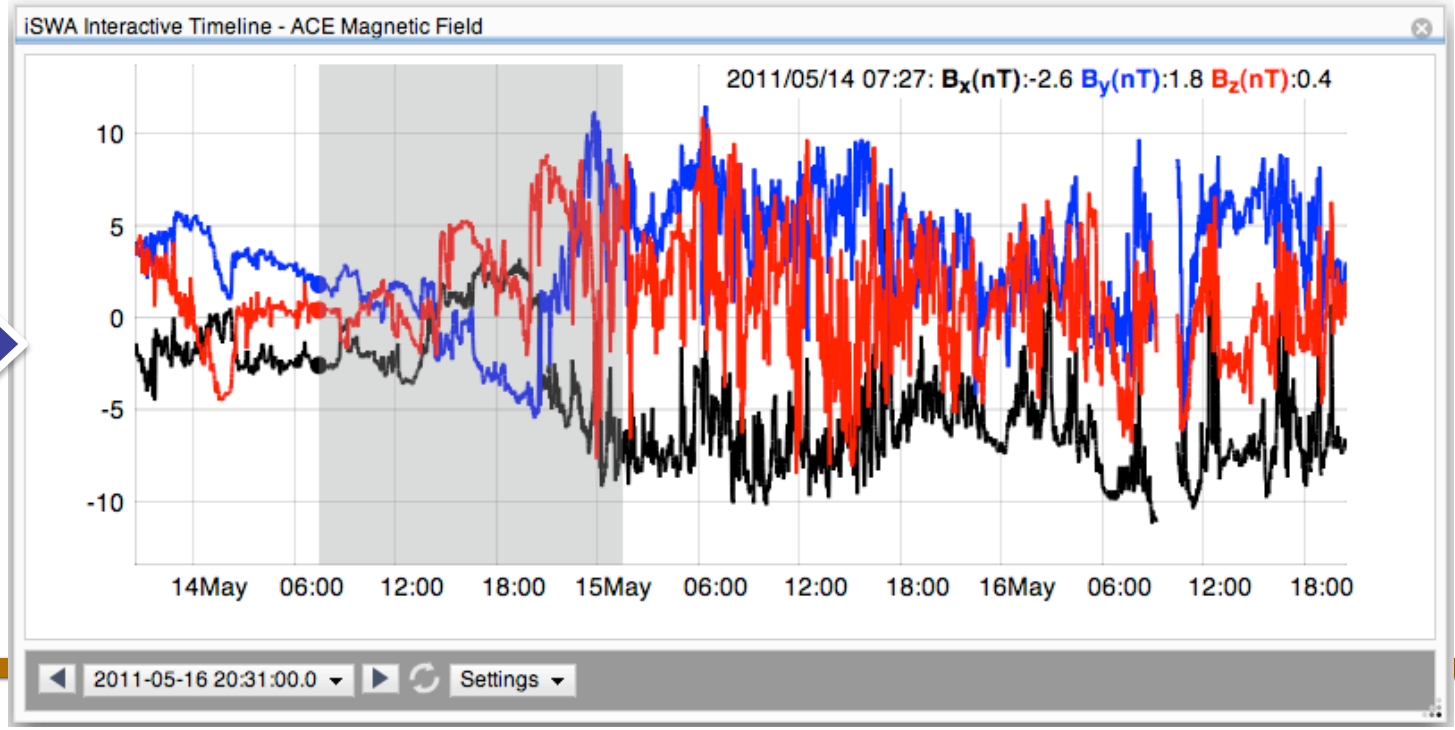
- Mouse over to view specific data values
- Zoom in feature
- Toggle on/off specific quantities
- Selectable time range 1 - 10 days
- User selectable resources & quantities

Interactive Products

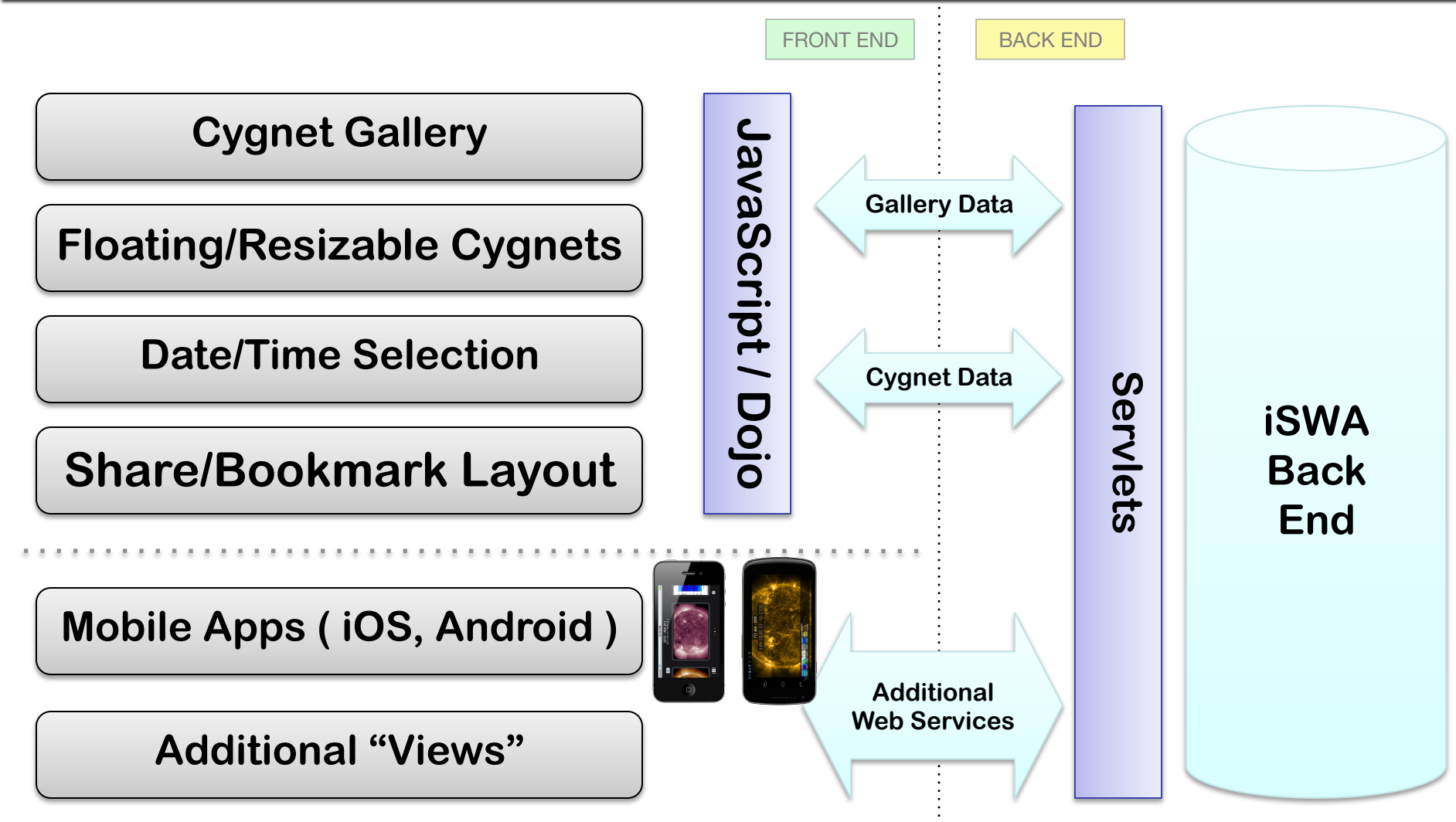


Interactive CME alert tool with chronological record of SWx Center issued CME time of arrival predictions

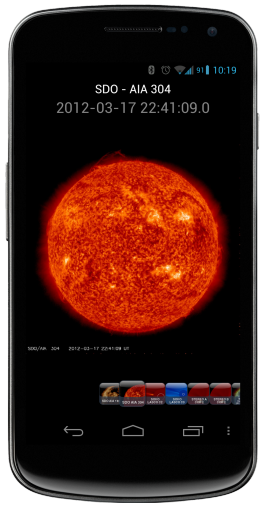
Interactive timeline tool with pan, zoom, mouse-over, and quantity toggling functionality

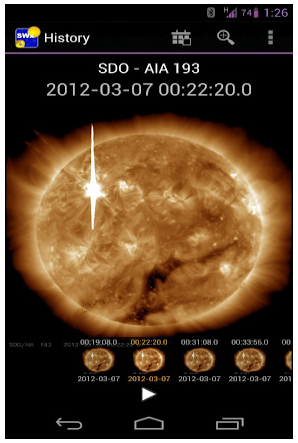


Widget Agent & Configurable Web based Dissemination Service



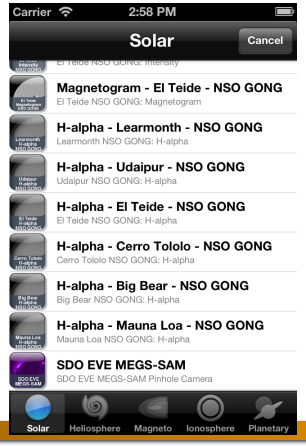
Mobile Access Powered by iSWA

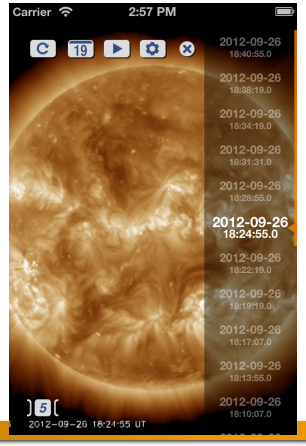




Android Front-End to iSWA

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

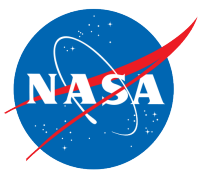


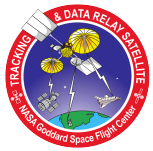


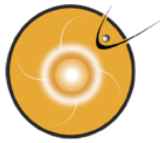
IOS Front-End to iSWA

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

Who Uses iSWA?












iSWA User Community

- 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

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

Usage/Growth

…some other notable iSWA stats:

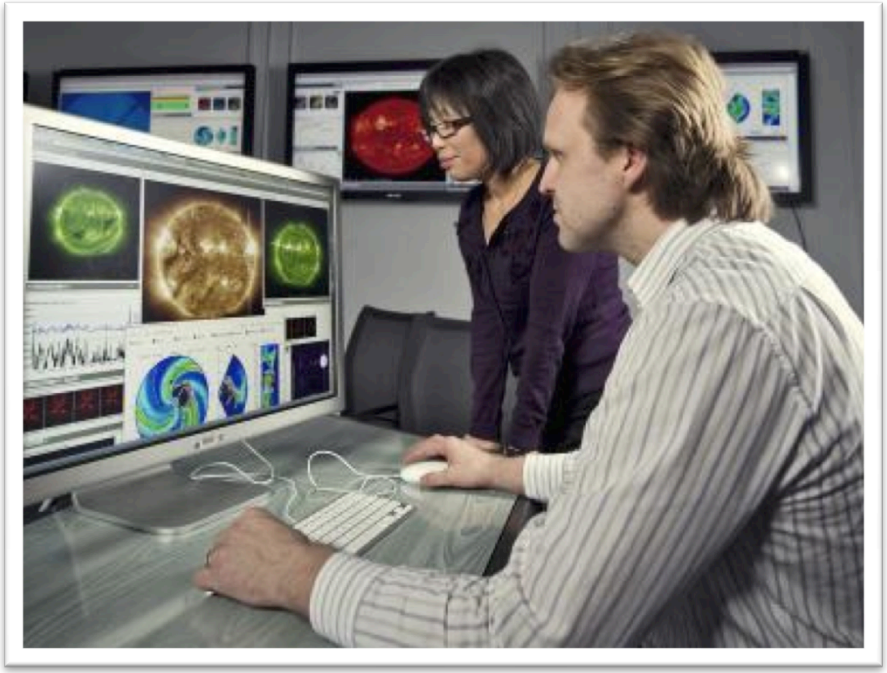
Two Week Web Service Snapshot From 3/1/2013 – 3/15/2013

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.

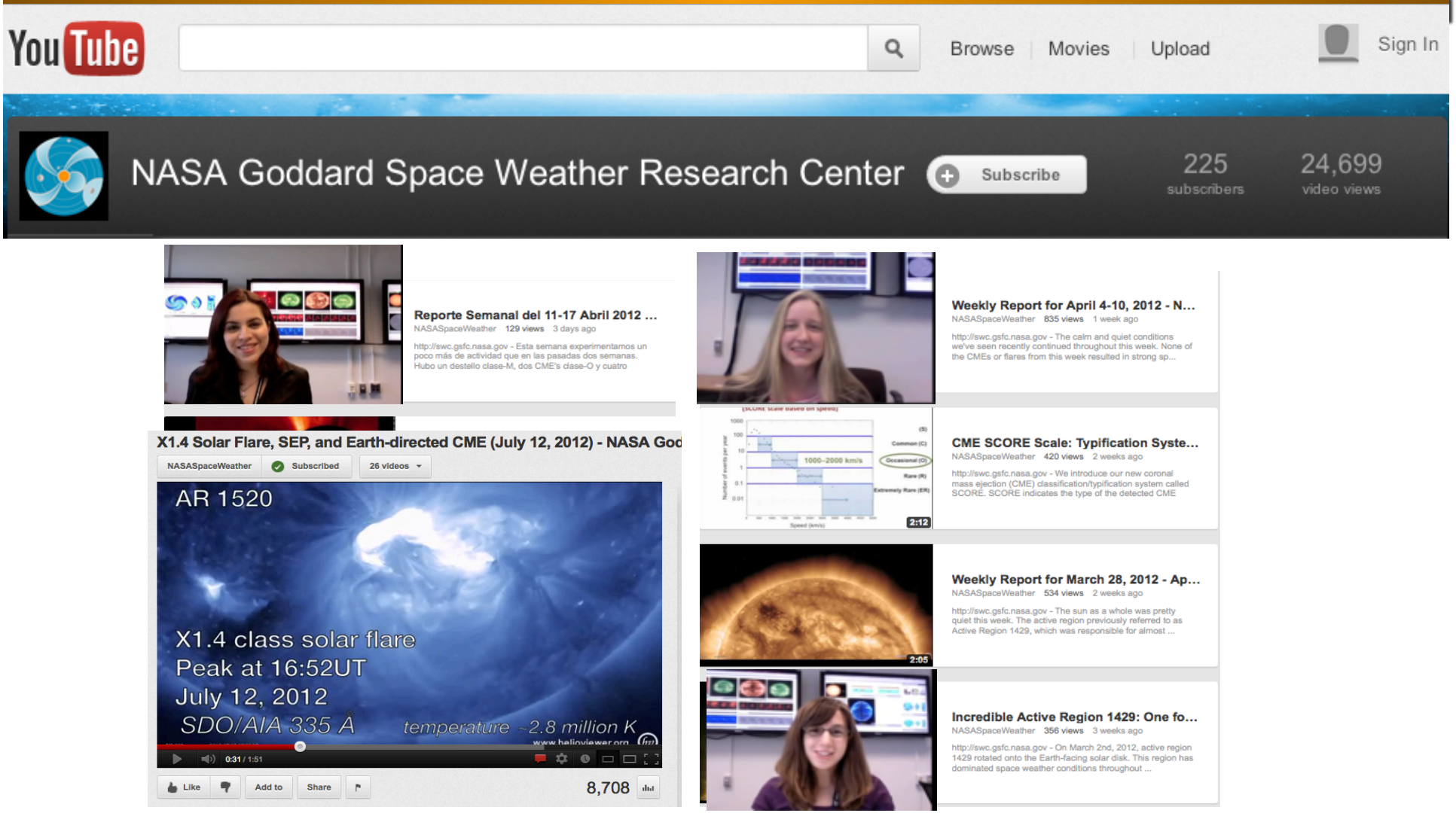
4. Providing general space weather support for NASA customers.

Education And Training Powered by iSWA

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

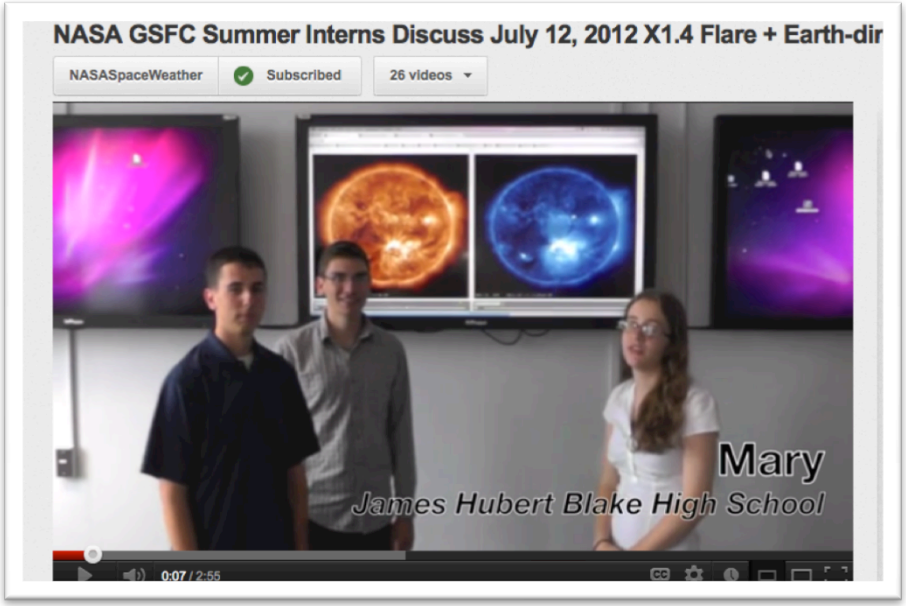
Y. Zheng

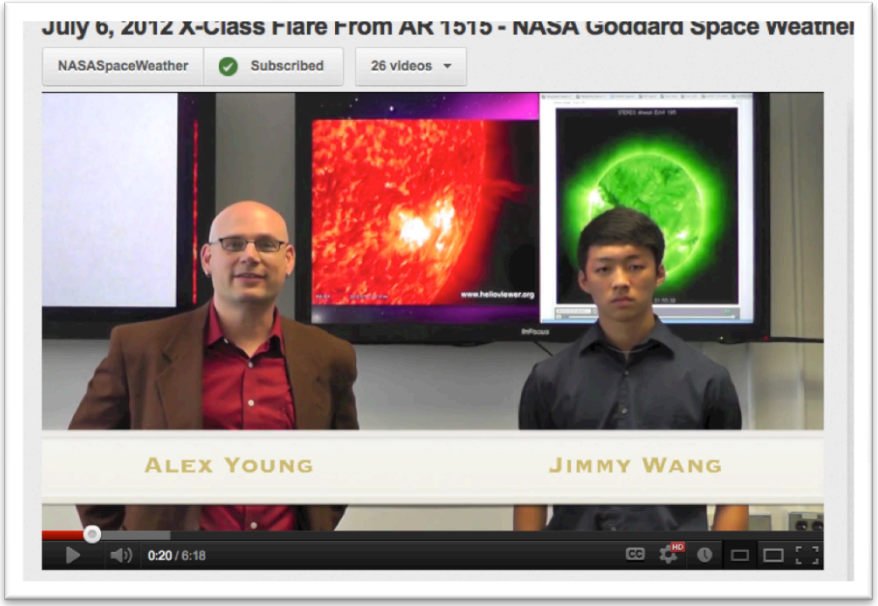
Training Young Scientists & Educating the Public Powered by iSWA



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

Summer Interns Learning Space Weather Science Powered by iSWA





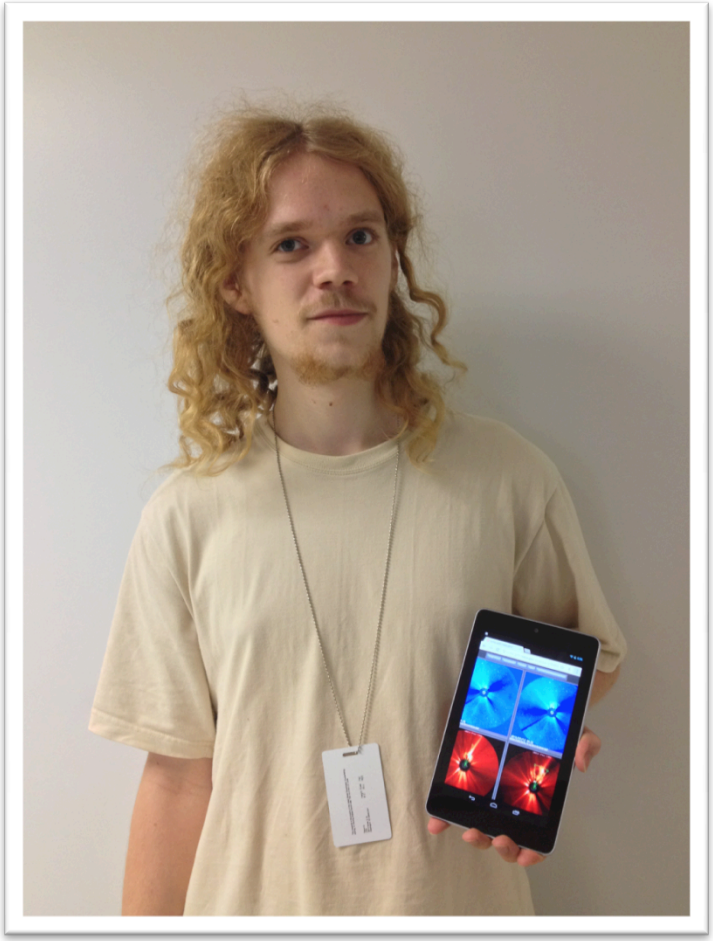
- Impressed with their progress
- Space weather excites them
  - ✓ Real time
  - ✓ Creative experimental research forecasts
  - ✓ Help NASA robotic missions
  - ✓ Responsibilities

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

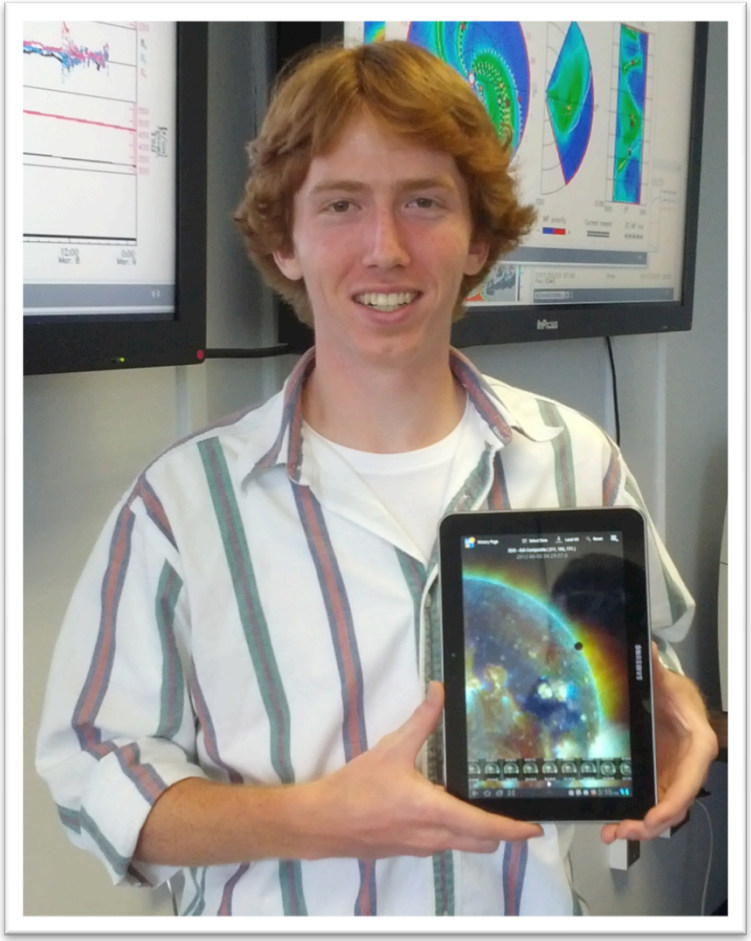
Jack LaSota

Web-based CME Analysis Tool



Justin Boblitt

Android iSWA App



CME Tool Link Sample Analysis Link 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 HA
Before & After

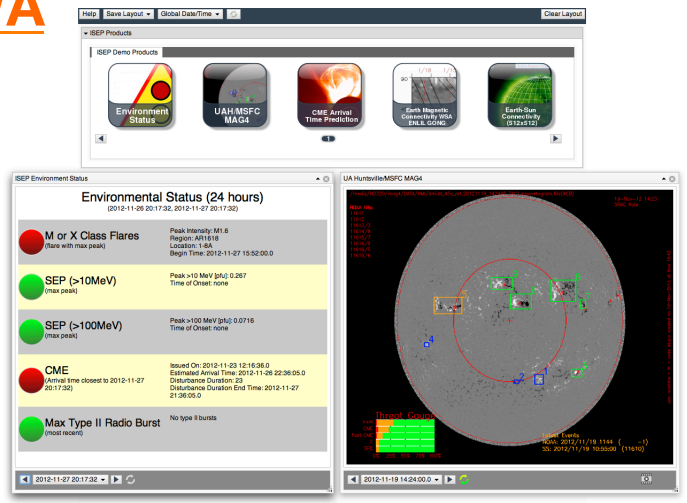
HA DETAIL REMOVED FOR WEB

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

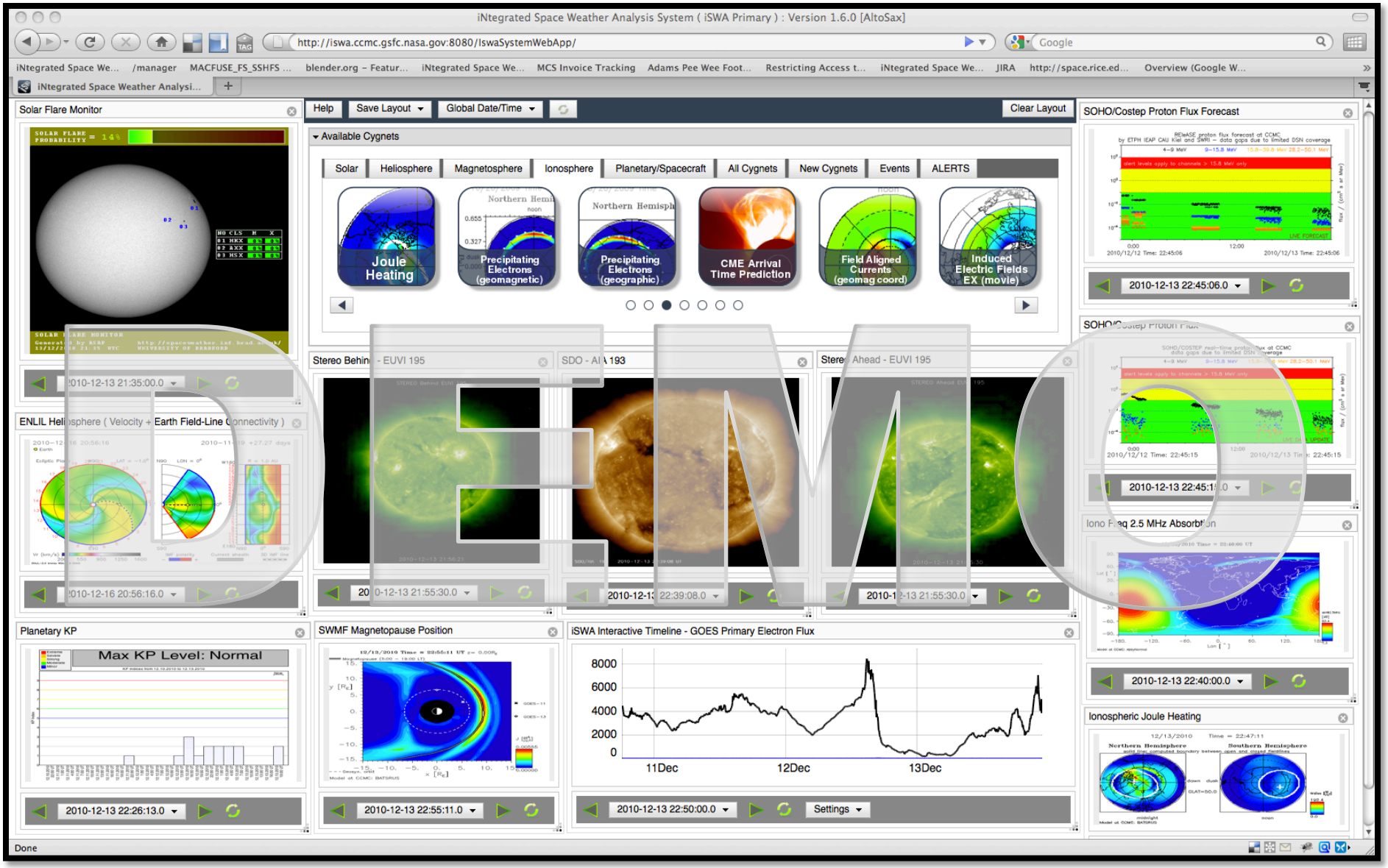
Space Weather Event Catalog and Event Linking

- 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



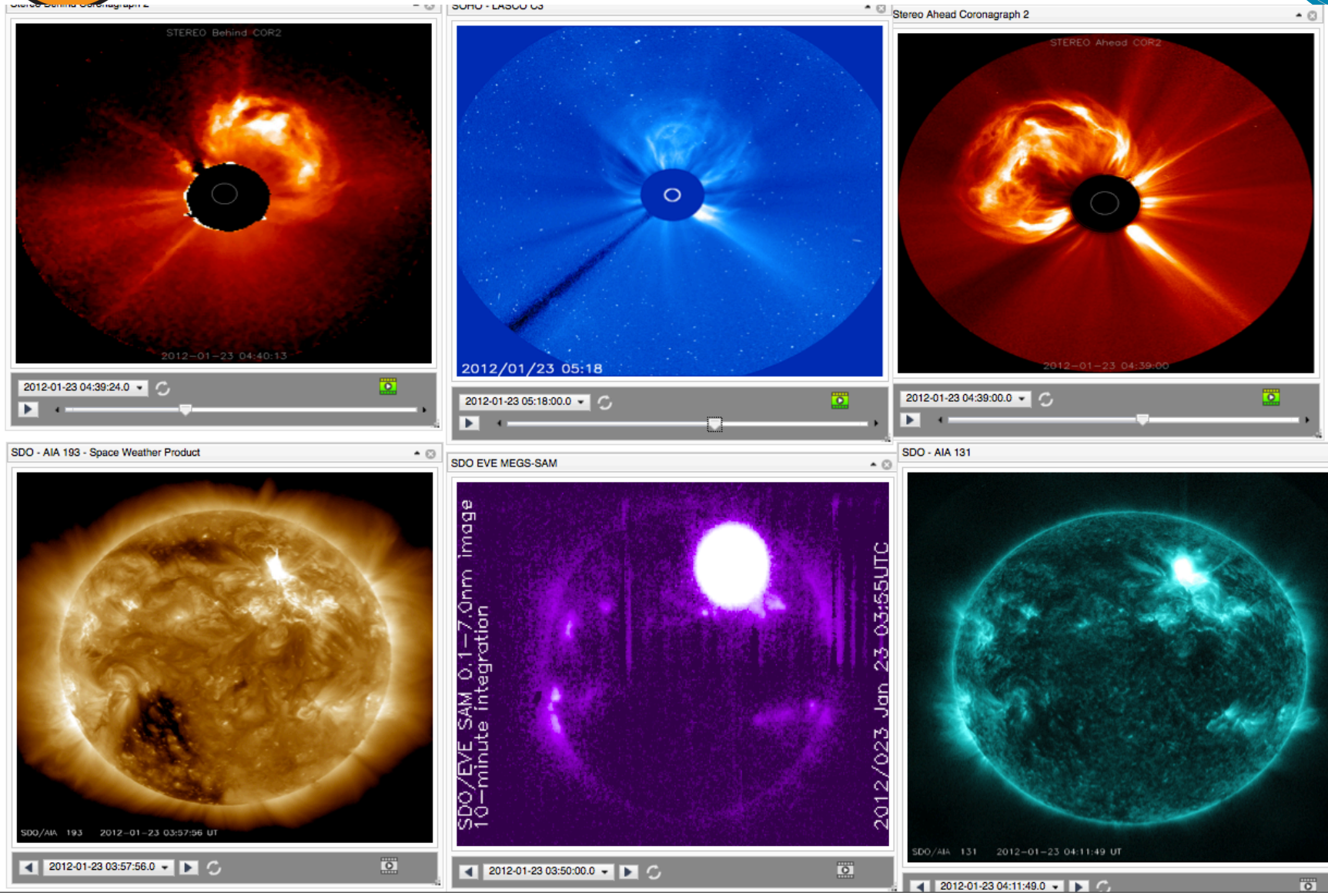
http://iSWA.ccmc.gsfc.nasa.gov

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

Specific Examples…

Jan 23 flare (M8.7)/CME (v=2210km/s)

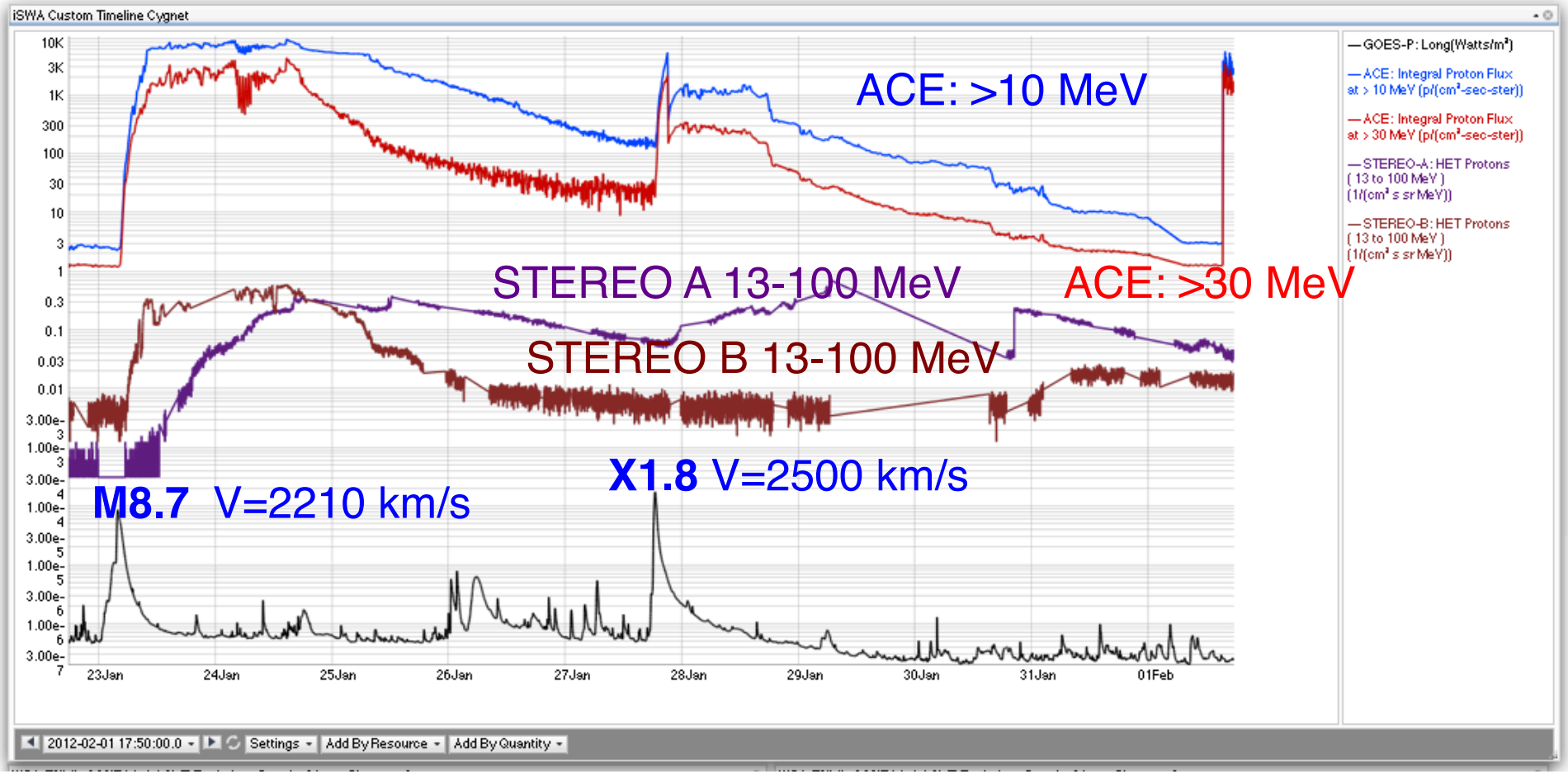


CME

Flare

SEP: proton radiation (flare and CME)

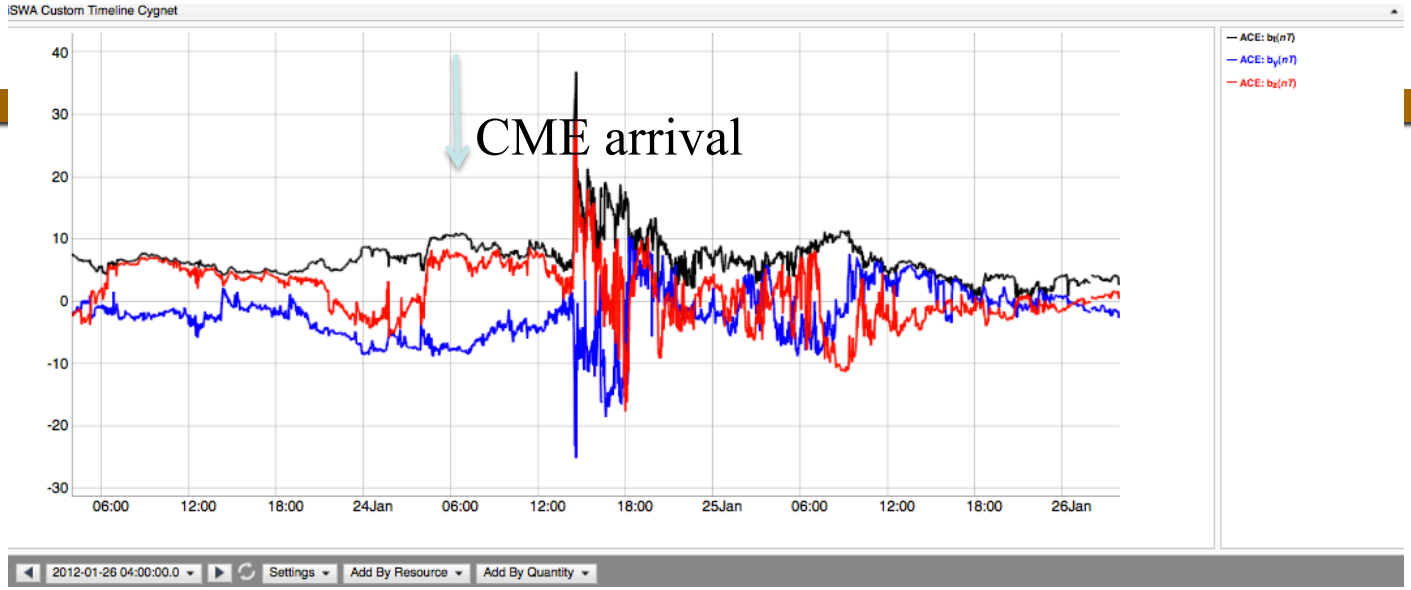
iSWA SuperTimeline

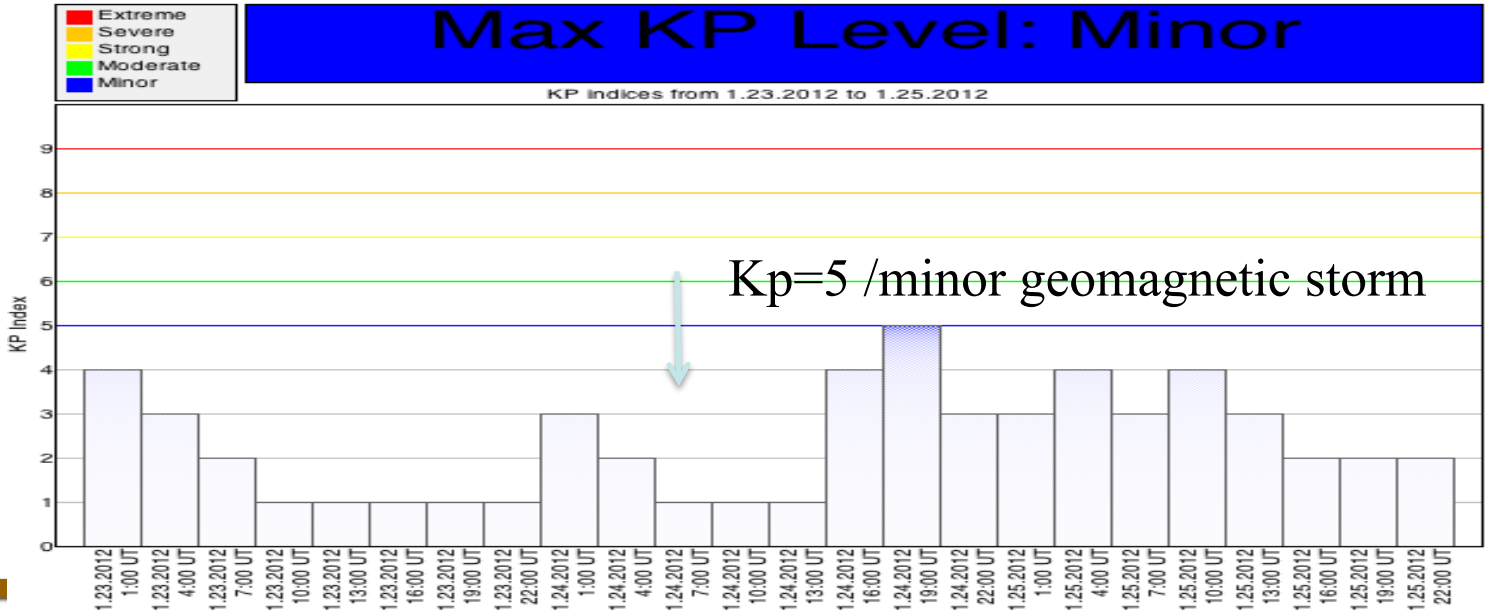


The Jan 23 and Jan 27 flare/CME pairs were associated with the same active region 1402. Both events created significantly enhanced ion radiation (SEP flux levels).

Several polar flights were rerouted due to the radiation

CME impact at Earth (a minor geomagnetic storm only)





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

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

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> 40K IOS downloads

> 17K Android downloads

END