SWPC SWFO User Readiness

Safeguarding Society with
Actionable Space Weather Information

Mon, 15 Apr 2024

Outline

Background

GOES-U

SWFO-L1

Conclusion

Team

- Lead
  - Jeff Johnson
- Developers
  - Nathan Miles
  - Martin Aubrey
  - Michael Burek
  - Richard Sheppard
  - Mark Nakasone
- Scientists
  - George Millward
  - Lois Landwer
- Other Contributors
  - Tamara Bledsoe
  - Mark Miesch
  - Tibor Durgonics
  - Ratina Dodani
  - Vic Pizzo

SWPC Mission and SWFO

Models, Applications, and Displays associated with coronagraph images and real-time solar wind data

Models
WSA-Enlil
OVATION (Aurora)
Geospace
WAM-IPE
REFM
CTIPe
Geoelectric
Magnetopause crossing

SWPC Data Service

Forecaster tools
CME Analysis Tool (CAT)
CME Naming Tool (CMENT)
Near-real-time movie loops (24-hr, 7-day, 27-day)

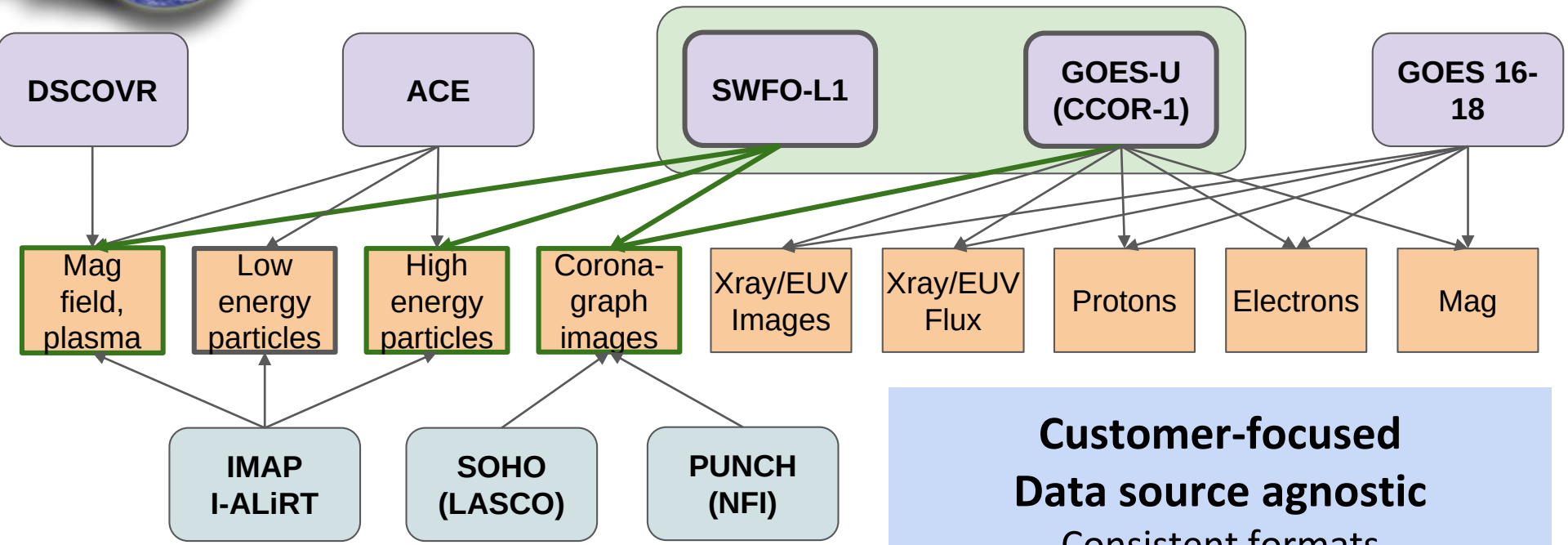
Dashboards
Aviation, Electric Power, Emergency Management, Satellites, GPS, Radio Communications, Space Weather Enthusiasts

Web Displays
Coronagraph images and movies
Real-Time Solar Wind

National Critical Notifications
Power Grid (NERC Hotline)
FEMA

Forecasts, Reports, Watches, and Warnings
Geomagnetic Storm Watches
Aviation Advisories
Forecast Discussion
Weekly Highlights and 27-day Forecast
Solar and Geophysical Event Reports

Product Philosophy



Customer-focused

Data source agnostic

Consistent formats

Consistent content

Supports continuity of users

Continuity and Change

Measurement	Today	SWFO/GOES-U
Coronal Images	SOHO LASCO C2 & C3 Pass through from NASA/GSFC, 12 min cadence	GOES-U CCOR-1 SWFO-L1 CCOR-2 2048x1920 pix; 15 min cadence; jpeg files; 1, 7, 27 day animations, FITS
Thermal Plasma Ion Velocity, Density, and Temperature	ACE SWEPAM DSCOVR FC 1 min cadence, ASCII, JSON	SWFO-L1 SWiPS 1 min cadence, JSON, Dynamic displays
Suprathermal Ion Differential Flux	ACE EPAM 5 min cadence, ASCII, JSON	SWFO-L1 STIS 1 min cadence, JSON, Dynamic displays
Vector Magnetic Field	ACE DSCOVR MAG 1 min cadence, ASCII, JSON	SWFO-L1 MAG; 1 sec cadence, 1 min cadence, JSON, Dynamic displays

Level 3 Data Products

- CCOR
  - Images at 15 minute cadence
  - Incorporated into animations
- MAG
  - 1 sec cadence
  - 1 min cadence synced with UTC
- SWiPS
  - 1 min cadence synced with UTC
- STIS
  - 1 min cadence synced with UTC
  - Selected Energy channels
    - ACE/EPAM (8/4 ion/electron channels) for data continuity

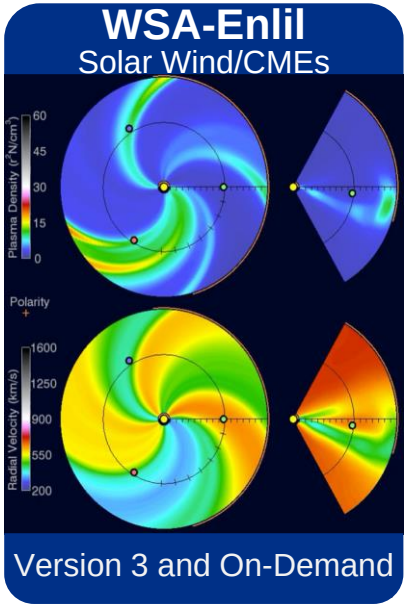
Level 3 data products are derived environmental variables that have been resampled. They are the primary products used by forecasters and customers

From full resolution right now extending back to ACE mission

2hr/6h/1d/3d/7d/30d/54d/1y/5y/30y

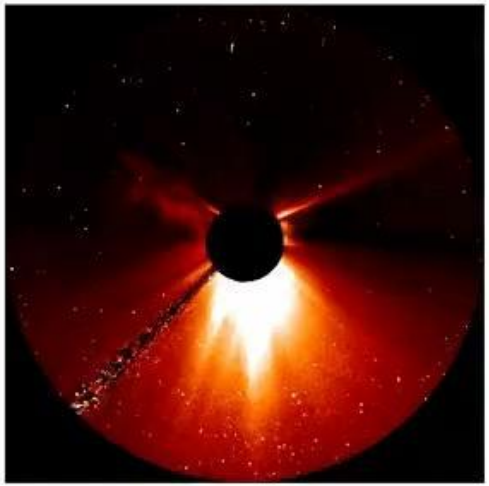
GOES-U Launch NET June 25, 2024

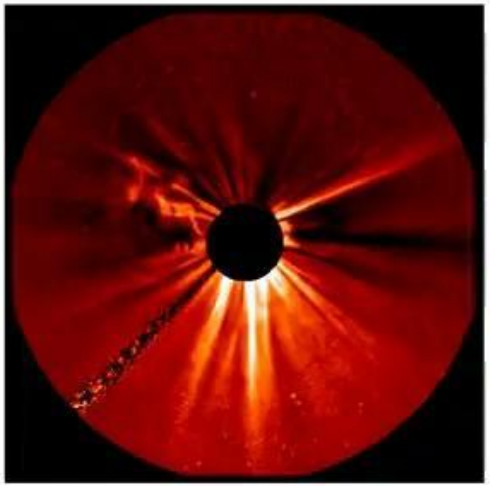
- Software
  - Launch-ready release 3.0 Dec. 20, 2023
  - CME Analysis Tool (CAT) integration
- Testing
  - System integration tests January - March 2024
  - Public web display
- Training
  - Forecaster familiarization and training briefings
- Future work
  - UKMO pyCAT collaboration
  - Investigating JHelioviewer support



CCOR Level 3 Products

- High-quality images for use with movies, applications, forecasts, alerts
- Downsample 50% for use by SWPC forecasters and stakeholders.
  - 1024 x 960 for optimal viewing on computer screens
  - Movies 1 day, 7 day, 27 day (no decimation, 96 frames/day)

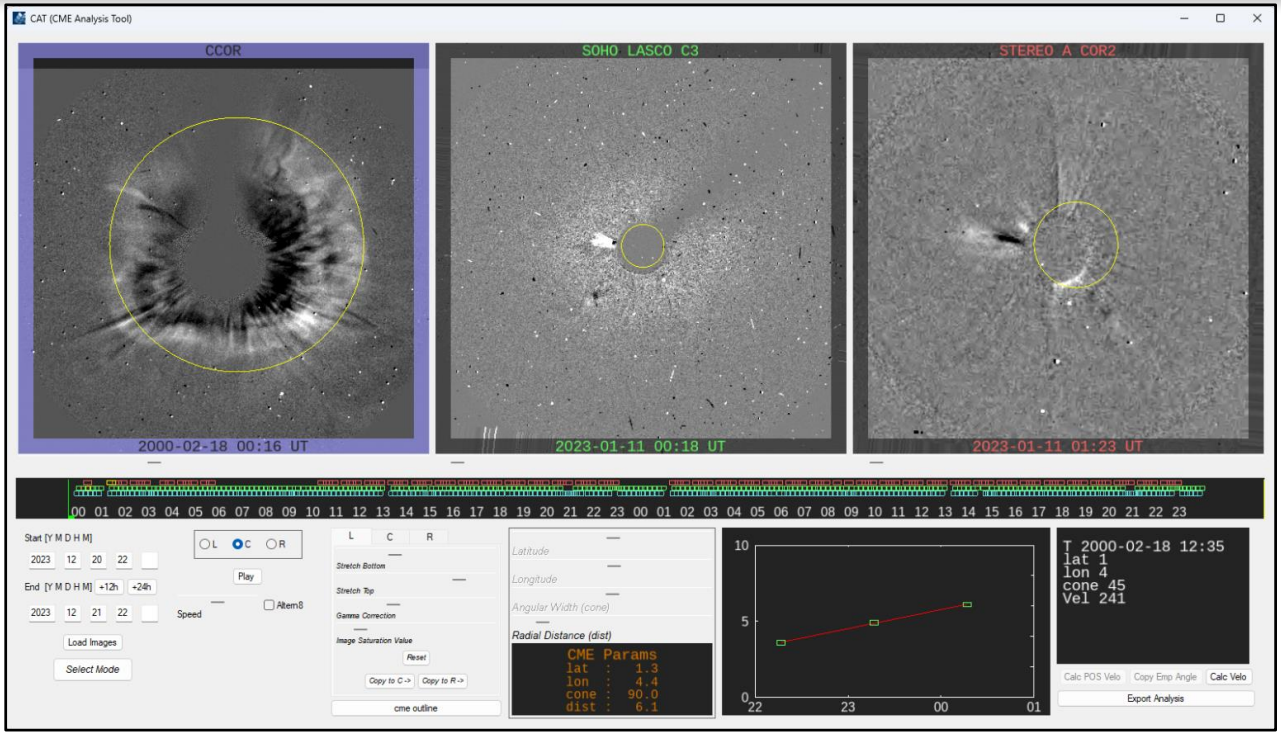




Level 3 processing removes noise and enhances feature compared to LASCO C3

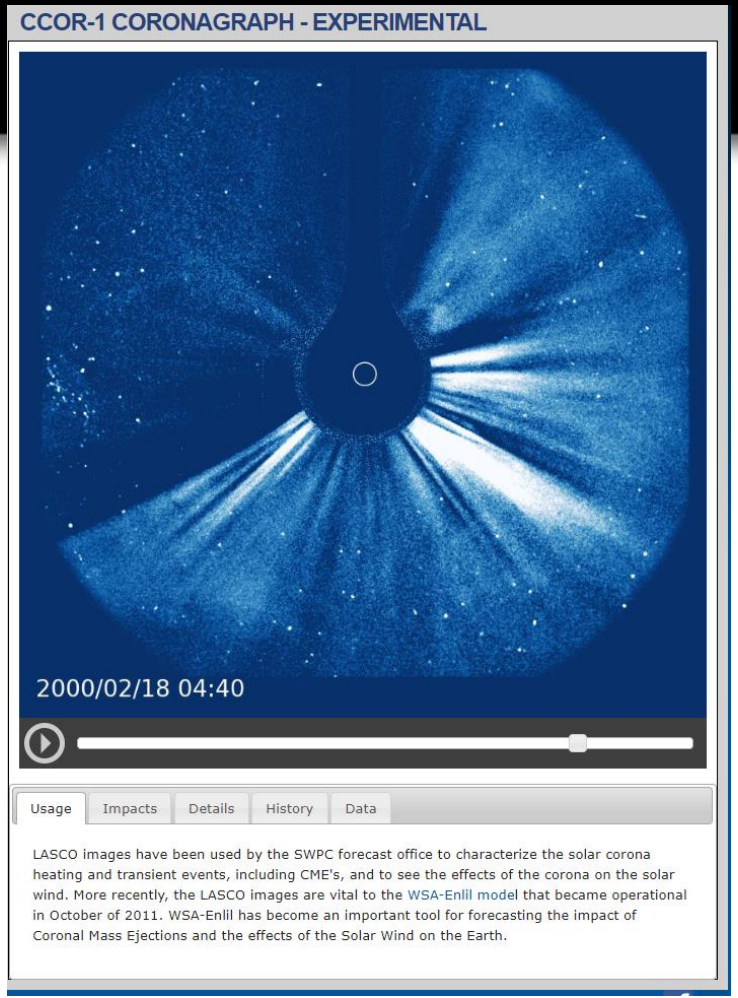
CME Analysis Tool (CAT)

- Measurements:
  - Speed
  - Angular extent
  - Plane of sky (POS) angle
- Essential input for WSA-Enlil solar wind model



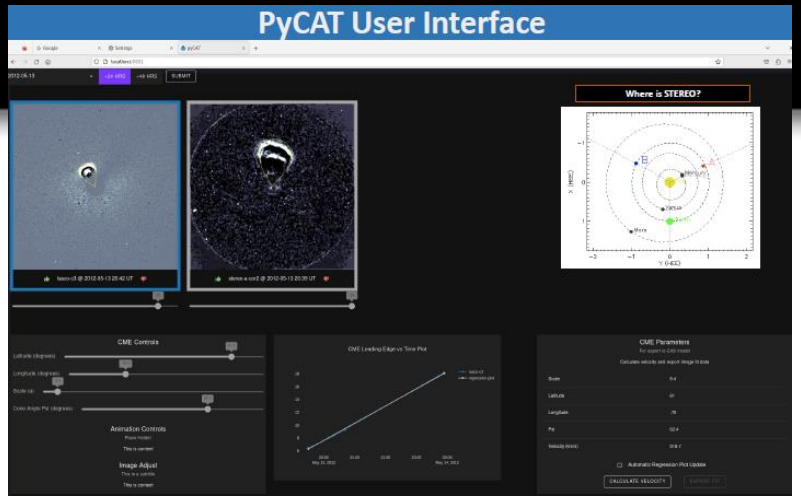
Public Web Display

- Purpose: Situational Awareness
- Data flow to website and animations demonstrated
- RT JPEG images and MPEG movie files provided for download

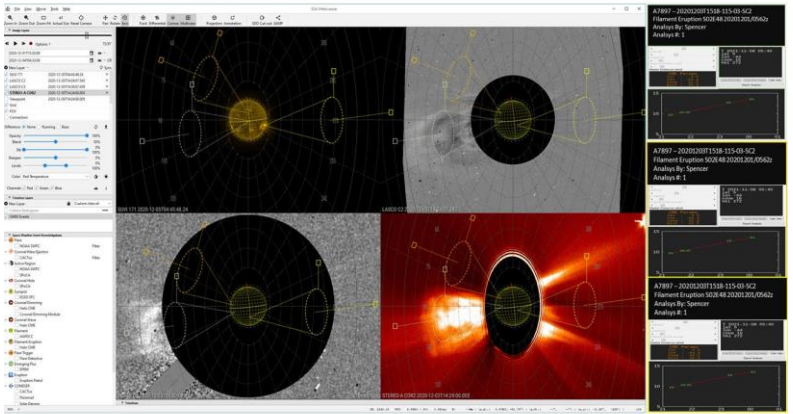


Future Work

- pyCAT
  - Joint effort with UKMO
  - Migrate CAT from IDL to Python
  - Extend capabilities
- JHelioviewer
  - Provide compatibility with this workhorse application
  - Integrate with other solar image data
  - JPEG2000 file support



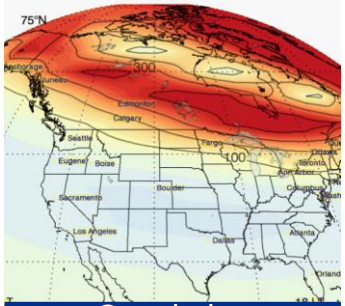
JHelioviewer



SWFO-L1 Launch NET April 2025

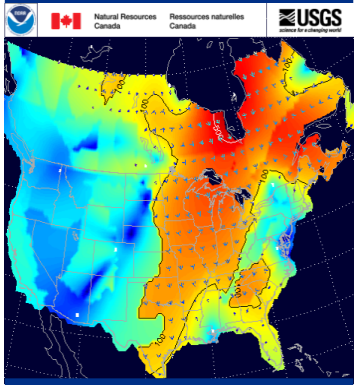
- System
  - System Integration Review January 23-24
- Software
  - Awaiting some algorithm inputs
  - Launch Ready Release 4.0 September 2024
  - Timeline Viewer for data display
- Future Work
  - Artemis Support
  - Predictive Geoelectric Model

Geospace
Regional Geomagnetic Response



Coupled to Geoelectric to provide forecast

Geoelectric
Grid Resilience

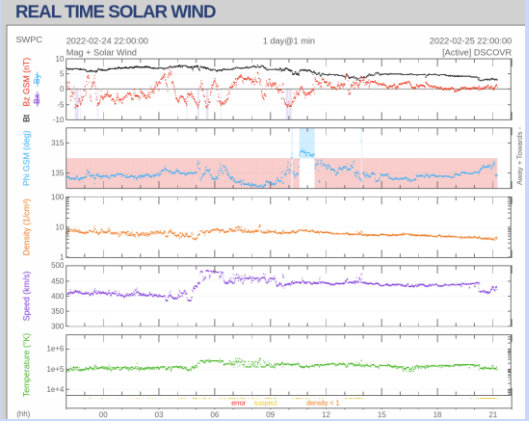


Expanded to Canada

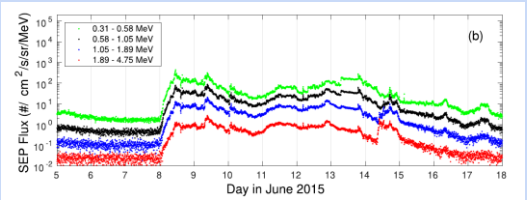
SWiPS and MAG

- SWiPS - Thermal Plasma
  - Ion velocity, density, and temperature
- MAG
  - Vector Magnetic Field
- STIS
  - Suprathermal Ion Differential Flux
  - 8/4 ion/electron channels
  - Data continuity with ACE/EPAM

“SWiPS” and MAG (DSCOVR)



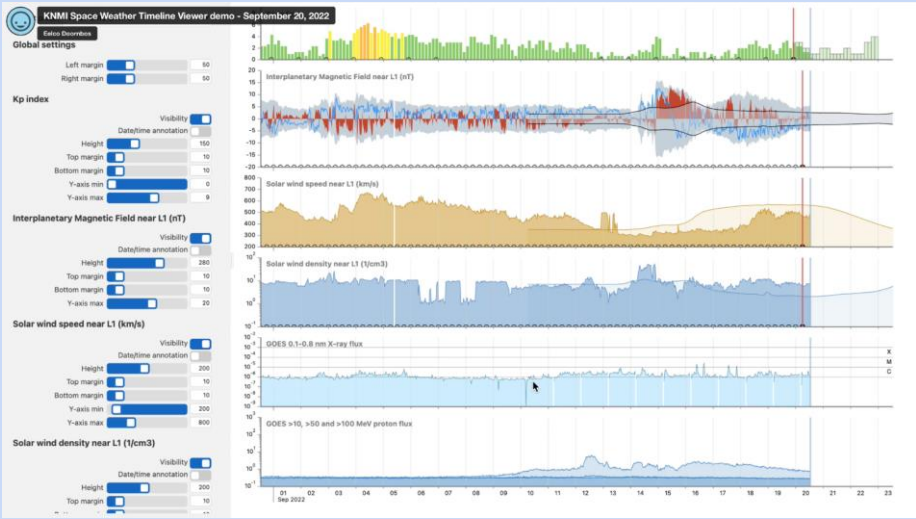
“STIS” Suprathermal protons (ACE/EPAM)



Thampi et al (2019)

Applications

- SWiPS & MAG
  - Used for CME Arrival
    - Arrival time from speed
    - Intensity estimate from Bz, density, speed
    - Drives Geospace model
- STIS
  - Provides situational awareness, alerts, and advanced warnings of approaching CMEs



New Display and data services based on HAPI and KNMI timeline viewer

HAPI

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

JGR Space Physics

Technical Reports: Methods | Free Access

HAPI: An API Standard for Accessing Heliophysics Time Series Data

Robert S. Weigel, Jon Vandegriff, Jeremy Faden, Todd King, D Aaron Roberts, Bernard Harris, Robert Candey, Nand Lal, Scott Boardsen, Chris Lindholm, Doug Lindholm ... See all authors

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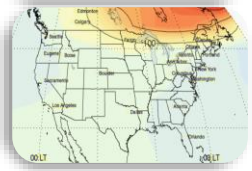
Future Work

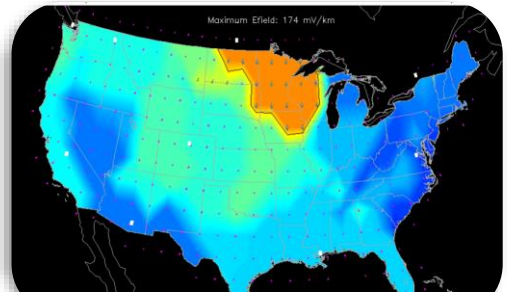
- Dashboard for NASA SRAG Artemis support
  - Coronagraph (LASCO; CCOR)
  - RTSW (ACE/DSCOVR; SWiPS & MAG)
  - Suprathermal Ions (ACE EPAM; STIS)
  - Target readiness L-1 year for testing and training

- Predictive Regional Geoelectric Fields Model

Real-Time
Ground-Based Magnetometer Data

Geospace Predicted Ground-Based Magnetic Field Data





Geoelectric Field Map

Access

- SWPC data products served to the public via SWPC's website:
  - https://www.swpc.noaa.gov/products
- Visualization tools are provided; data files can be downloaded:
  - https://www.swpc.noaa.gov/products/real-time-solar-wind
- Web service provided for use by automated systems:
  - https://www.swpc.noaa.gov/content/data-access
  - https://services.swpc.noaa.gov (base services URL)
- Archive is maintained by NCEI

Conclusion

- SWPC's product-centric, source-agnostic approach serves RTSW and Coronagraph data through a wide variety of products and services to support our customers
- GOES-U and CCOR are ready for launch, post-launch testing, and will be ready for operations
- SWFO-L1 efforts are proceeding on pace and will ultimately provide new predictive capabilities and support for Artemis

Backup Slides

Quality Management System (QMS) Certification

SWPC's newly implemented QMS recommended for ISO 9001:2015 certification!

Certification Audit

Zero non-conformities:

A remarkable accomplishment for a newly implemented QMS.

Audit report - highly effective processes:

Customer Focus
Leadership
Risk Management
Corrective Action
Internal Audit
System Mgmt
Review

Government and Military Certification Systems, Inc.

Finalizing The Assessment
ISO 9001 & The 7 Management Principles

Notes to Auditor: Complete this portion during Auditor Caucus time prior to closing meeting. Any "Not Effective" response should be followed by placing a note in the "Notes" section below. This portion will be used as one measures of quality management system improvement between surveillance/recertification audits.

Complete for ISO 9001: 2015 Assessments.

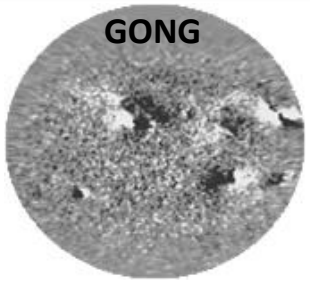
CUSTOMER FOCUS - The organization has demonstrated a high level of customer focus and awareness. Customer needs are clearly understood and customer requirements are being met.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
LEADERSHIP - The organization has demonstrated *effective* leadership necessary to ensure *effective* quality management that has enhanced customer satisfaction. Personnel are involved in meeting organizational goals and objectives.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
INVOLVEMENT OF PEOPLE - The organization has demonstrated *effective* use of personnel and has involved people throughout the organization to bring about *effective* quality management.	☐ Highly Effective ☒ Effective ☐ Effective But Needs Improvement ☐ Not Effective
PROCESS APPROACH - The organization has demonstrated *effective* process-based quality management and has identified and managed its linked processes *effectively*. Linkages between processes are adequately defined and implemented.	☐ Highly Effective ☒ Effective ☐ Effective But Needs Improvement ☐ Not Effective
SYSTEM APPROACH – The organization has demonstrated *effective* management of its system of related processes in meeting its objectives.	☐ Highly Effective ☒ Effective ☐ Effective But Needs Improvement ☐ Not Effective
CONTINUAL IMPROVEMENT - The organization has demonstrated that it has implemented *effective* improvement processes that measure and report upon the organizations performance.	☐ Highly Effective ☒ Effective ☐ Effective But Needs Improvement ☐ Not Effective
RISKS AND OPPORTUNITIES – The organizations has an effective system to address risks and opportunities.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
CORRECTIVE ACTION - The organization has demonstrated that it understands root cause analysis, correction, and corrective action AND understands that the sources of correction action can originate from audit results, process failure, product failure, customer complaints, and supplier nonconformances.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
INTERNAL AUDIT SYSTEM – The Internal audit system has proven to be effective.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
MANAGEMENT REVIEW – Management Review has been conducted and proven to be effective.	☒ Highly Effective ☐ Effective ☐ Effective But Needs Improvement ☐ Not Effective
Notes:	

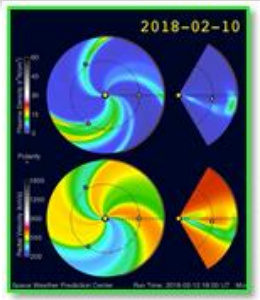
Management System Overall Effectiveness Over Three Years:

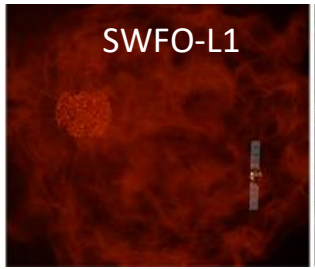
Stage 2 Audit ☐ Highly Effective ☒ Effective ☐ Effective But Needs Improvement ☐ Not Effective

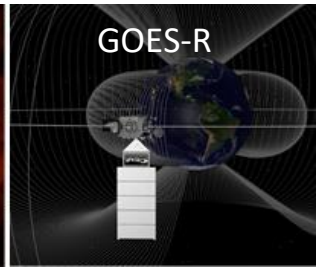
Observations Improvements

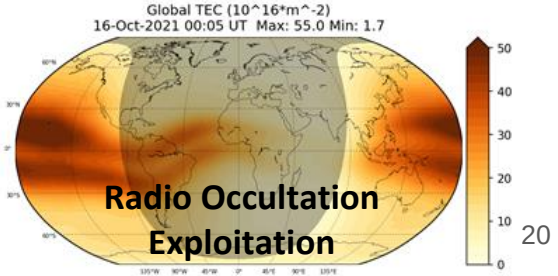
- Global Oscillation Network Group (**GONG**)
  - Operational Sustainment and Resiliency
  - GONG Replacement
- Assessment of **commercial magnetometers**
  - CRADA w/ Computational Physics, Inc.
- Radio Occultation Exploitation (**Spire**)
- GOES-R Integration - **GOES 17 & 18**
- Space Weather Follow-On (**SWFO**)
- NESDIS **Space Weather Next** Program











Near-Real-Time Files

- L3 data product files will be continuously updated for use by forecasters to monitor real-time data.
  - Accessible by forecasters within SWPC via https protocol.
  - Pushed to the swpc.noaa.gov for access by external users.
- MAG/SWiPS/STIS
  - Time series data will be in JavaScript Object Notation (JSON) files extending the legacy DSCOVR/ACE paradigm.
  - HAPI, KNMI Timeline Viewer
- Near-real-time files are ‘renderings’ of L3 data
  - Only the L3 data itself is archived

Space Weather-Ready Nation

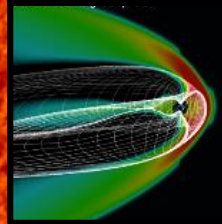
A Nation Ready, Responsive, and Resilient to Space Weather

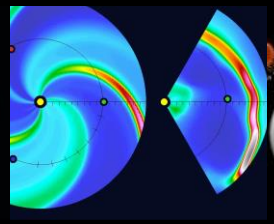
NOAA SWPC SPACE WEATHER PREDICTION CENTER

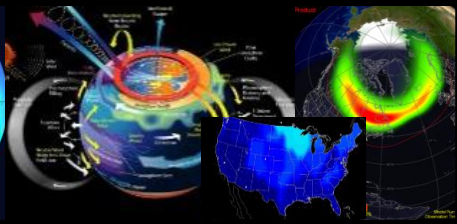
Critical Observations

Improved understanding with new modeling and R2O2R capabilities

SPACE WEATHER PREDICTION TESTBED







Partnerships – the entire Space Weather Enterprise working together

Better information connected to key stakeholders for better decisions - enhance National resilience