



SWPC SWFO User Readiness



**Safeguarding Society with
Actionable Space Weather Information**
Mon, 17 Apr 2023





Outline

- SWPC's Mission
- Product Philosophy
- Continuity and Change
- Products
 - CCOR
 - SWiPS
 - STIS
 - Mag
- Formats
- Accessibility

SWPC SWFO Team

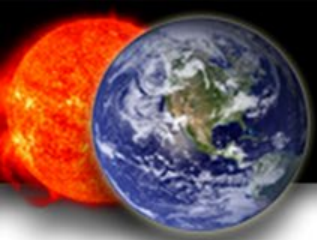
- Lead
 - Jeff Johnson
- Developers
 - Richard Sheppard
 - Michael Burek
 - Nathan Miles
 - Martin Aubrey
- Forecast Application Scientist
 - George Millward
 - Lois Landwer
- Additional contributions by
 - Tamara Bledsoe
 - Mark Miesch



SWPC Mission and Real-Time Solar Wind (RTSW)

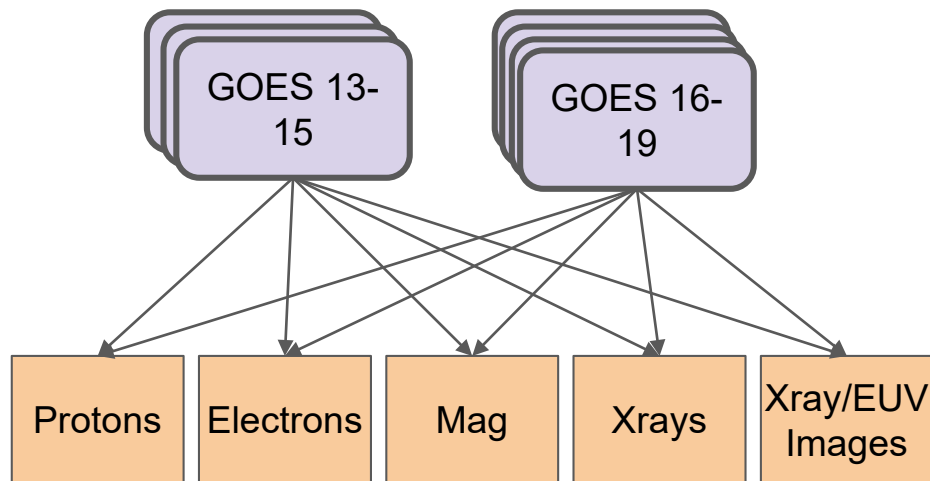
Safeguarding society with actionable space weather information

- 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
- Forecaster tools
 - CME Analysis Tool (CAT)
 - CME Naming Tool (CMENr)
 - Near-real-time movie loops (24-hr, 7-day, 27-day)
- SWPC Data Service
- Web Displays
 - Coronagraph images and movies
 - Real-Time Solar Wind
- Dashboards
 - Aviation, Electric Power, Emergency Management, Satellites, GPS, Radio Communications, Space Weather Enthusiasts
- Models
 - WSA-Enlil
 - OVATION (Aurora)
 - Geospace
 - WAM-IPE
 - REFM
 - CTIPe
 - Geoelectric
 - Magnetopause crossing



Product Philosophy

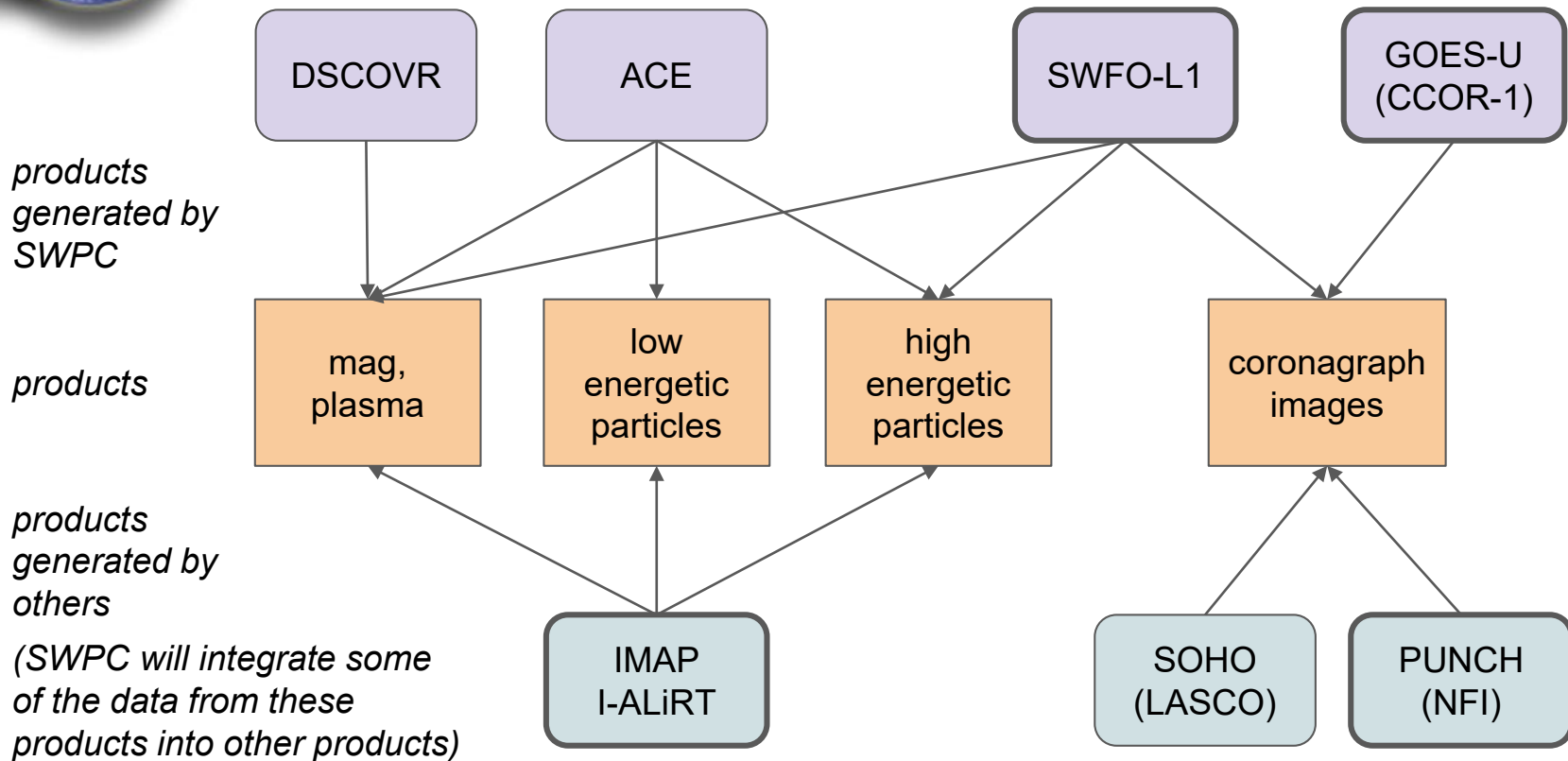
- Product-centric
- Source-agnostic
- Supports continuity of users
 - Consistent formats
 - Consistent content
- Customer engagement



GOES data products retain continuity as much as possible, even through series changes



SWFO Spacecraft to Product Mapping





Continuity and Change

Measurement	Today	SWFO Era
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 SWEFAM 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 mincadence, JSON, Dynamic displays



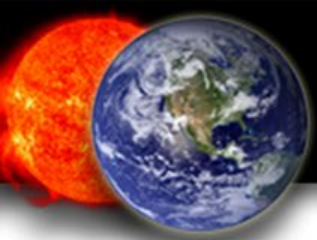
Level 3 Data Products

- 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

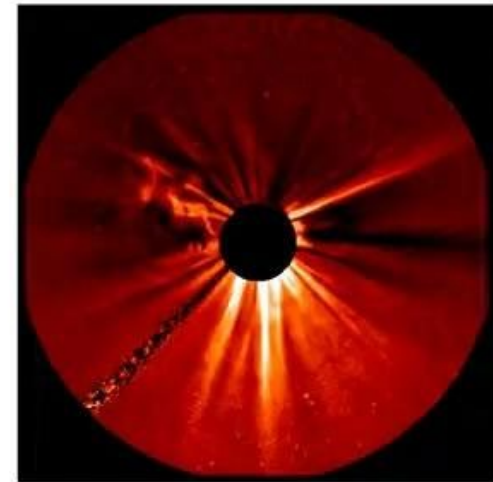
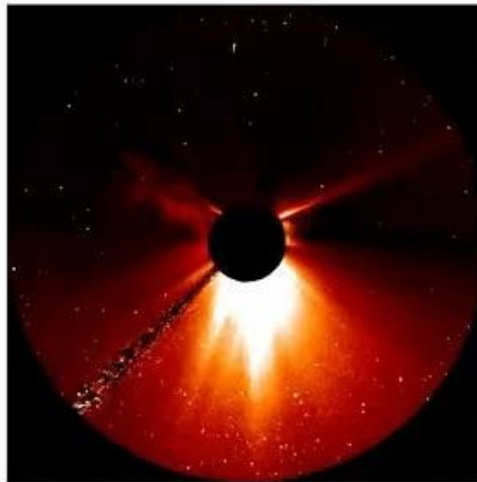
From full resolution right now extending to back to 'perpetuity'

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



CCOR

- 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)



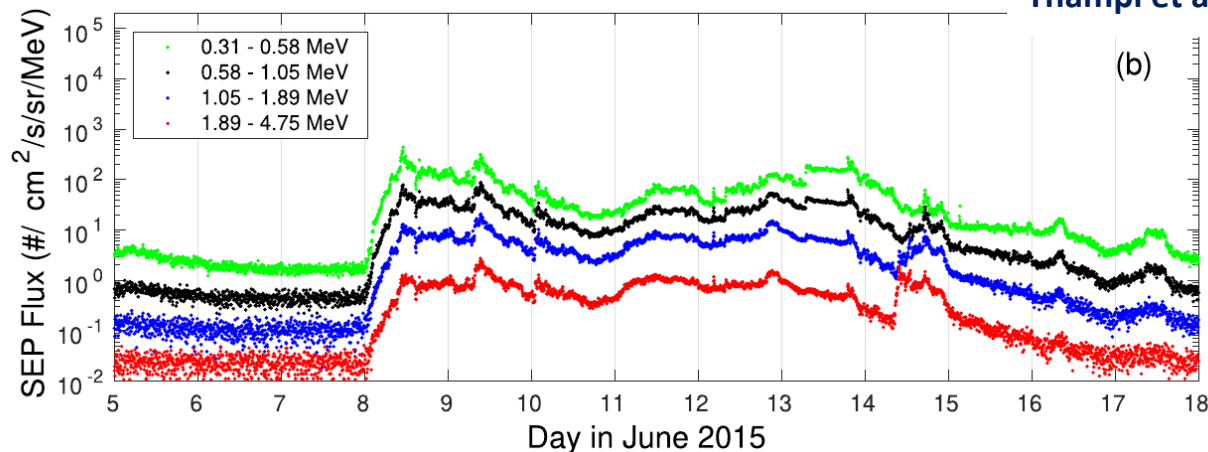
Level 3 processing will provide noise removal and feature enhancement compared to LASCO C3



STIS

Example Suprathermal proton plot from ACE/EPAM

Thampi et al (2019)



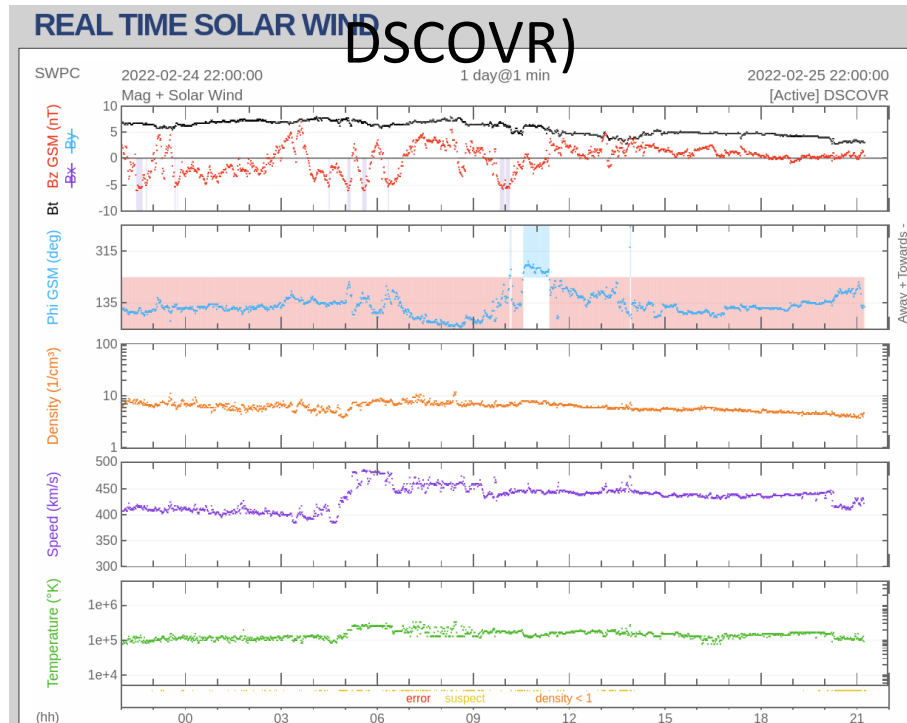
- Suprathermal Ion Differential Flux, 1 min cadence
- 8/4 ion/electron channels for data continuity with ACE/EPAM
- Provides situational awareness, alerts, and advanced warnings of approaching CMEs



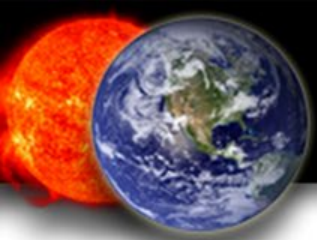
SWiPS and MAG

- SWiPS - Thermal Plasma
 - Ion velocity, density, and temperature
- MAG
 - Vector Magnetic Field
- Used for CME Arrival
 - Arrival time from speed
 - Intensity estimate from Bz, density, speed
 - Drives Geospace model

'SWiPS' and MAG (from DSCOVR)



Real-time Interactive online display

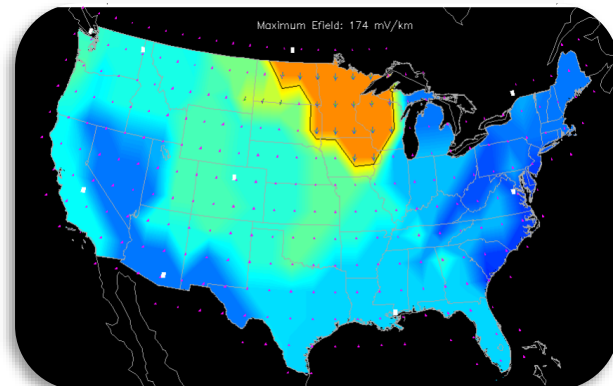
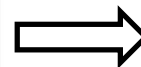
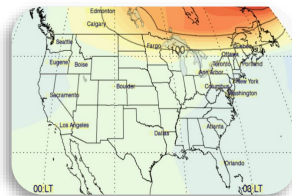


Advanced Model Application for RTSW

Real-Time
Ground-Based
Magnetometer Data

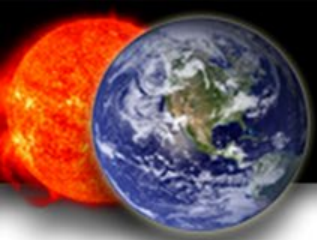


Geospace Predicted
Ground-Based
Magnetic Field Data



Goelectric Field Map

Real-Time Solar Wind is used to drive the Geospace model, which will soon be used to drive the Goelectric Model.



Near-Real-Time Files

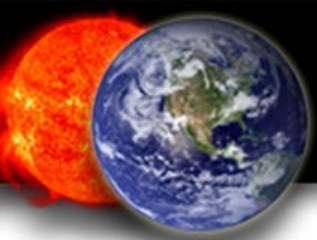
- L3 data product files will be continuously updated for use by forecasters to monitor real-time data.
 - Accessible by forecasters within SWPC via https protocol.
 - Pushed to the swpc.noaa.gov for access by external users.
- CCOR
 - Downsampled jpeg files
 - 1, 7, and 27-day movie loops as mp4 files.
- MAG/SWiPS/STIS
 - Time series data will be in JavaScript Object Notation (JSON) files extending the legacy DSCOV/ACE paradigm.
- Near-real-time files are ‘renderings’ of L3 data
 - Only the L3 data itself is archived





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

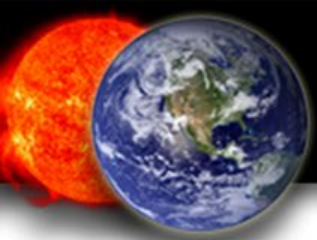


Conclusion

- SWPC's focus is product-centric/source-agnostic
 - High quality Level 3 processing algorithms
 - Standardized attributes
 - Easier for our customers to adapt to new data sources
 - Providing web-based documentation for users
- User feedback mechanisms
 - This meeting! (steven.hill@noaa.gov)
 - Through our website www.swpc.noaa.gov/content/contact-us
 - Product types and attributes can be adjusted depending on external user's needs (within limits)
- NCEI: Science grade and retrospective users



Backup Slides



Quick Look Files

- Quick Look files contain the most recent 15 minutes worth of L0-L2 data for use by instrument vendors and NCEI-CO to support anomaly investigation as it is happening.
- Every 15 minutes on the quarter hour, generate a set of raw and intermediate data level files containing the new data from that interval for use by instrument vendors to support real-time anomaly investigation.
 - Intermediate data level Quick Look files support quickly pinpointing the relevant code.
- Separate files for L0f/L0p and each data level L0b through L2 by instrument.
 - SWFO-L1 - 19 different files
 - L0f
 - CCOR-2: L0b, L1a, L2
 - MAG: L0b, L1a, L1b, L2
 - SWiPS: L0b, L1a, L1b, L2
 - STIS: L0b, L1a, L1b, L2
 - orbit, attitude
 - GOES-U - 5 different files
 - L0p
 - CCOR-1: L0b, L1a, L1b, L2
- Image data will be in FITS files and in situ data will be in netCDF format with metadata defined by the Calibration Working Group (CWG).
 - No special version of the L0a-L2 FITS files are required for Quick Look use.
 - SWFO-L1 orbit file will be in the format provided by C2.
- Files will be moved to the file transfer server via rsync where they will be accessible by vendors via sftp.
- Files will be retained for 30 days.
- Quick Look files are redundant with Day files and are therefore not archived.





Day Files

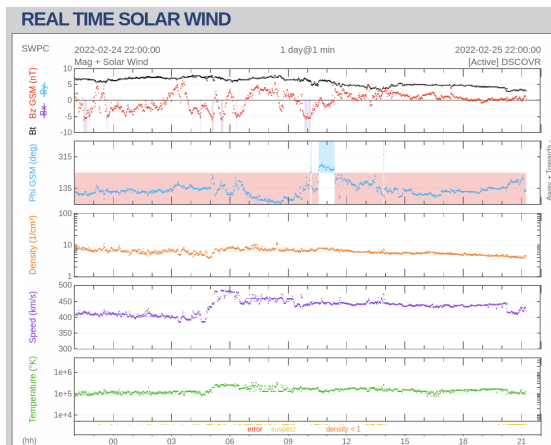
- Day files contain the last full UTC day's worth of L0-L3 data for permanent archival by NCEI-NC.
- Raw and intermediate data level files will be created every 24 hours (UTC day) at 0200Z containing the data from that period for archival by NCEI.
- Separate files for L0f/L0p and each data level L0b through L3 by instrument.
 - SWFO-L1 - 24 different files
 - L0f(realtime), L0f(backfill)
 - CCOR-2: L0b, L1a, L2, L3
 - MAG: L0b, L1a, L1b, L2, L3
 - SWiPS: L0b, L1a, L1b, L2, L3
 - STIS: L0b, L1a, L1b, L2, L3
 - orbit, attitude
 - GOES-U - 7 different files
 - L0p(realtime), L0p(backfill)
 - CCOR-1 L0b, L1a, L1b, L2, L3
- Files will be in FITS or netCDF format with metadata defined by the CWG.
- NCEI-provided day file generation software will replace the legacy code.
 - Written in python, the netCDF file generation code uses a template file which pre-defines the metadata, including global attributes and things like variables, their datatype, units, valid_range, etc.
 - The processing code makes a copy of the template, writes data to the variables, and finalizes the metadata.
- Files will be accessible by NCEI via sftp.
- Files will be retained until a matching Archival Receipt (AR) file has been received.





PGD to Operational/Retrospective Users Interface

- SWPC distributes products to forecasters and other operational users by making them available through a set of servers. This includes providing data to the instrument teams for checkout, anomaly resolution and other functions. **These interfaces will be presented in Section 5.**
- NCEI distributes data to retrospective users through the planned SWFO Science Center similar to the existing GOES-R and DSCOVR portals. **These interfaces will be presented in Section 6.**



DSCOVR SPACE WEATHER DATA PORTAL

1. [Space Weather Instruments](#)
2. [Data Descriptions](#)
3. [FAQ](#)
4. [Links](#)
5. [NCEI DSCOVR Team](#)



The **Deep Space Climate Observatory (DSCOVR)** is the replacement satellite for NASA's **Advanced Composition Explorer (ACE)** spacecraft to continue monitoring **solar wind** near the **L1 point**. DSCOVR observations are critical to our space weather ready nation. These data support forecasts and research of phenomena that have the potential to **disrupt and damage** Earth-based infrastructure.

Here, data are archived, [distributed](#), and [visualized](#) for magnetometer and faraday cup measurements. For realtime data, see the [Space Weather Prediction Center \(SWPC\) real time solar wind page](#). For information and data from the other instruments onboard DSCOVR, EPIC and NISTAR, see NASA's [Atmospheric Science Data Center](#).



SWFO Product Generation and Distribution

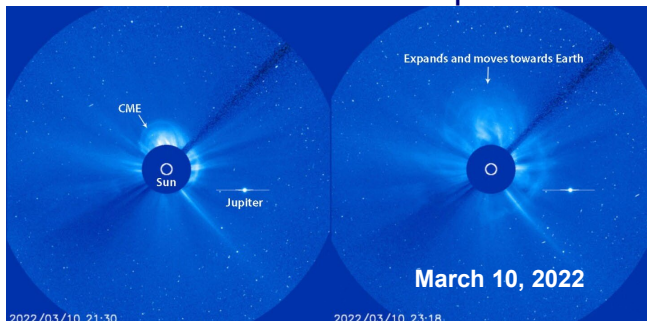
SWFO PGD will enable the following data products and space weather services:



1. Processing of L0 datastreams into science products:

- Coronal images (SOHO LASCO/C3)

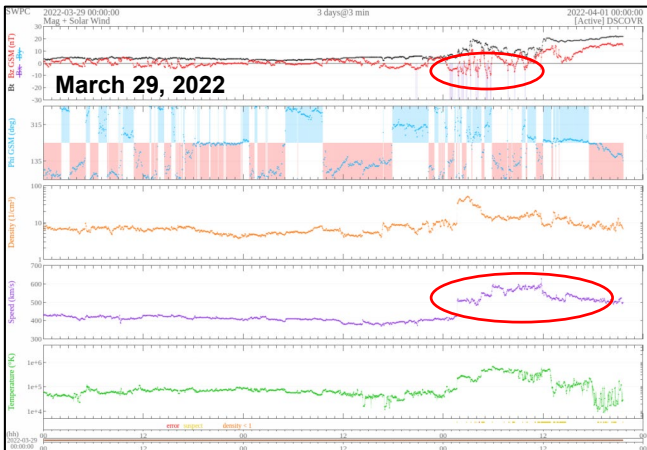
GOES-U CCOR-1, SWFO-L1 CCOR-2)



- Time series of solar wind plasma and magnetic field

(DSCOVR FC, MAG)

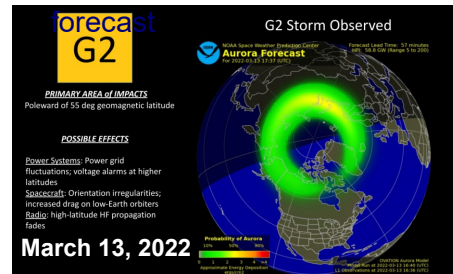
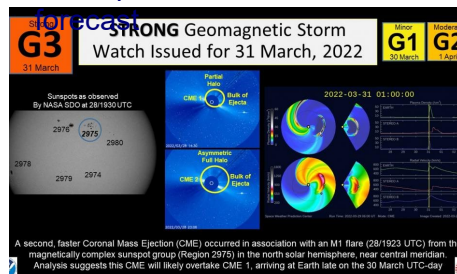
SWFO-L1 SWiPS, MAG as well as STIS)



2. Immediate use of the products in providing situational awareness and in reliably driving real-time models. Thus the data will result in SpWx nowcasts and forecasts

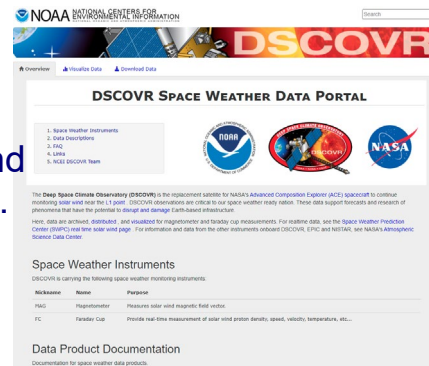
Heliospheric model and

Auroral model and



3. Archiving of data to enable access by the science community and numerous other users.

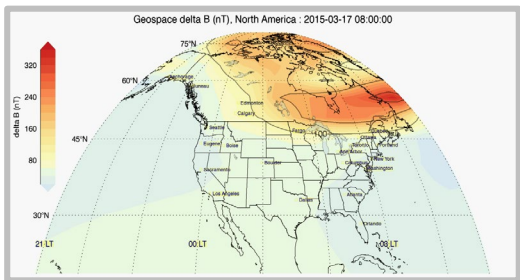
(DSCOVR Data Portal
SWFO Science Center)





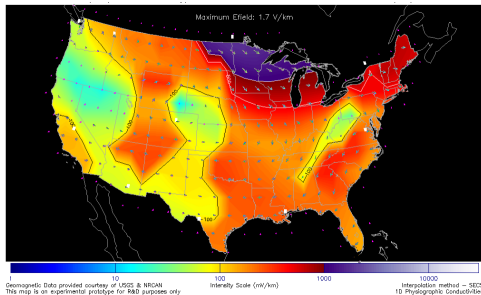
Predicting Regional Goelectric Fields Supporting Power Grids and other Customers

Predicted ground dB/dt using L1 solar wind
Geospace model (U. Mich) – Operational at SWPC

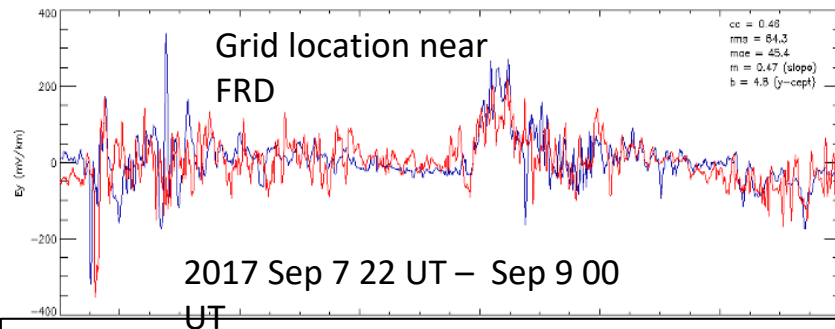


Nowcast 1-D Goelectric field using ground magnetometers – Operational at SWPC

Collaboration
USGS and NRCAN



Coupled Geospace/Goelectric model
Predicted (red) and Nowcast (blue)



- Predicted goelectric field combines dB/dt predictions with goelectric field calculations
- Goelectric field calculations include Earth conductivity
- Excellent agreement in predicted (red) and nowcast (blue) goelectric field