SWFO - National Centers for Environmental Information

National Environmental Satellite, Data, and Information Service

17 April 2023

William Rowland, C. Bethge, J. Darnel, K. Hallock, F. Inceoglu, B. Kress, P. Loto'aniu, J. Machol, N. Merati, L. Rachmeler, R. Redmon, J. Riley, J. Rodriguez, Don Schmit, X. Wei, et al.

National Centers for Environmental Information (NCEI)

Acquiring, Preserving, Monitoring, Assessing, and Creating Authoritative Environmental Data

The science-based NCEI organization produces and archives authoritative environmental data to enable individuals, businesses, and governments to make informed decisions.

In the SWFO and SW Next Program, NCEI will:

- Develop and manage the SWFO Science Center, with DSCOVR as heritage
- Develop and maintain the scientific product creation algorithms for SWFO, and the operational product creation algorithms for SW Next.
- Calibrate, validate, and ensure scientific accuracy of all SWFO and SW Next data products
- Archive all SWFO and SW Next data products and provide data access for non-operational users—scientists, researchers, general public, educators, etc.
- Provide scientific, instrumental, and product expertise

NCEI's Space Weather Team

Branch Chief: Stephanie Herring
Section Chief: Laurel Rachmeler

Stewardship & Development
William Rowland (lead architect)
Kevin Hallock (lead)
Kim Baugh (Data Manager)
Stefan Codrescu (Software Developer)
Liam Kilcommons (Software Dev)
Ann Marie Mahon (Software Dev)
Josh Riley (Data Manager/Software Dev)
Xue Wei (Software Dev)
Pamela Wyatt (Data Manager)
TBD (Data Manager, ~spring 2023)
TBD (Software Dev, ~spring 2023)
TBD (Software Dev, ~spring 2023)

Data Analysts (multi-discipline)
Sarah Auriemma
Alison Jarvis
Fadil Inceoglu
Elysia Lucas (~May 2023)

Solar
Janet Machol (SWx CIRES Lead & Irradiance lead)
Don Schmit (Imagery lead)
Christian Bethge
Jon Darnel
Gabe Dima
Brooke Kotten (student)
Larisza Krista
Jamie Mothersbaugh
TBD (~summer 2023)

Magnetic Fields
Paul Loto'aniu (lead)
Aspen Davis
Ale Pacini

Space Particles
Brian Kress (lead)
Juan Rodriguez (CIRES finance lead)
Thanasis Boudouridis
Trevor Leonard

Federal Billets
TBD (Heliophysics Data Steward, ~spring 2023)
TBD (Geospace Data Steward, ~late 2023)

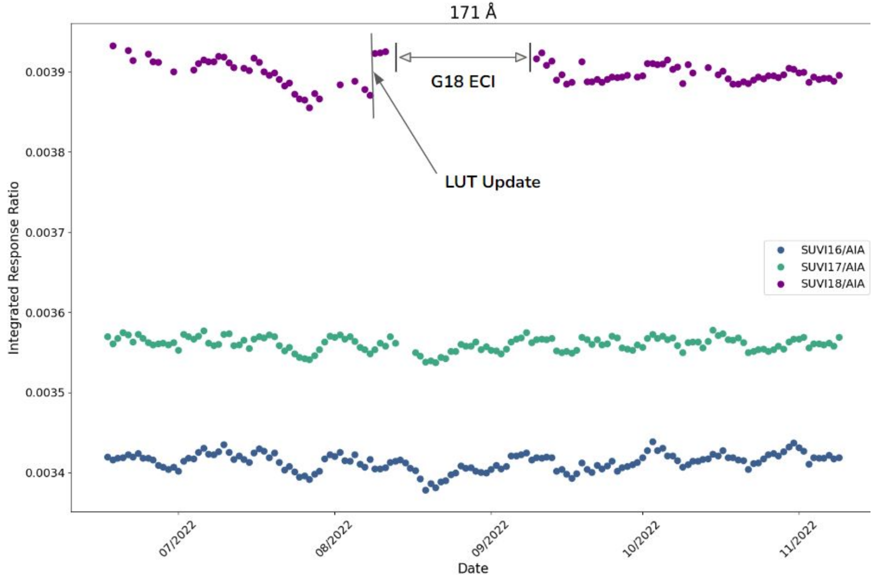
OGSSD
Rob Redmon (SWx scientist and NCAI lead)

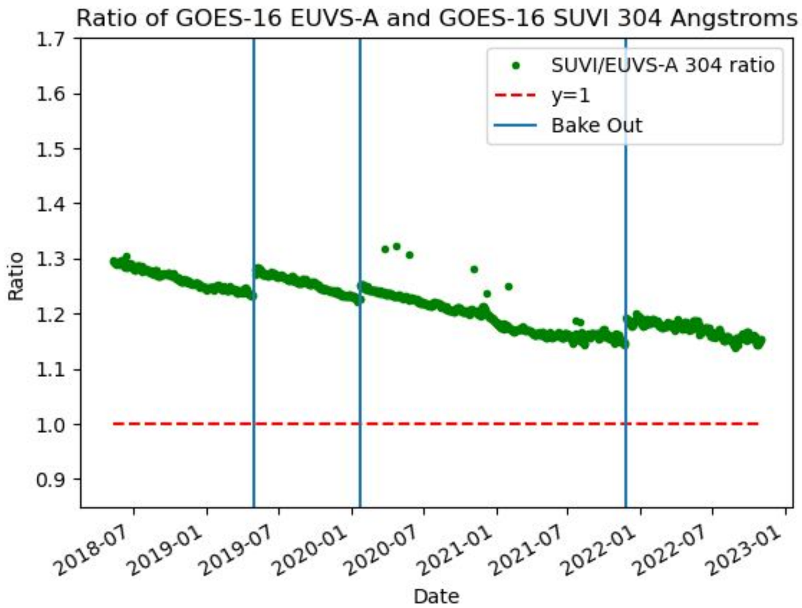
Laurel is acting as GSDB Branch Chief for at least Jan to June 2023.
William is acting as STP Section Chief.

SWFO Product List (Archive)

Instrument	Operational from SWPC	Reprocessed/Scientific from NCEI	Total Data Volume
CCOR-1 (GOES-U)	Day files: L0, L0b, L1a, L1b, L2, L3+ Tiers 1 and 2	Day files: L1a, L2, L3+ Tiers 1 and 2	Ops = 1.3 TB/yr Retro = 0.9 TB/yr
CCOR-2	Day files: L0, L0b, L1a, L1b, L2, L3+ Tiers 1 and 2	Day files: L1a, L2, L3+ Tiers 1 and 2	Ops = 1.3 TB/yr Retro = 0.9 TB/yr
SWiPS	Day files: L0, L0b, L1a, L1b, L2, L3+ Tiers 1 and 2	Day files: L1b, L2, L3+ Tiers 1 and 2	Ops = 0.2 TB/yr Retro = 0.2 TB/yr
STIS	Day files: L0, L0b, L1a, L1b, L2, L3+ Tiers 1 and 2	Day files: L1b, L2, L3+ Tiers 1 and 2	Ops = 0.2 TB/yr Retro = 0.1 TB/yr
MAG	Day files: L0, L0b, L1a, L1b, L2, L3+ Tiers 1 and 2	Day files: L1b, L2, L3+ Tiers 1 and 2	Ops = 0.2 TB/yr Retro = 0.1 TB/yr

Cal/Val - SUVI Degradation





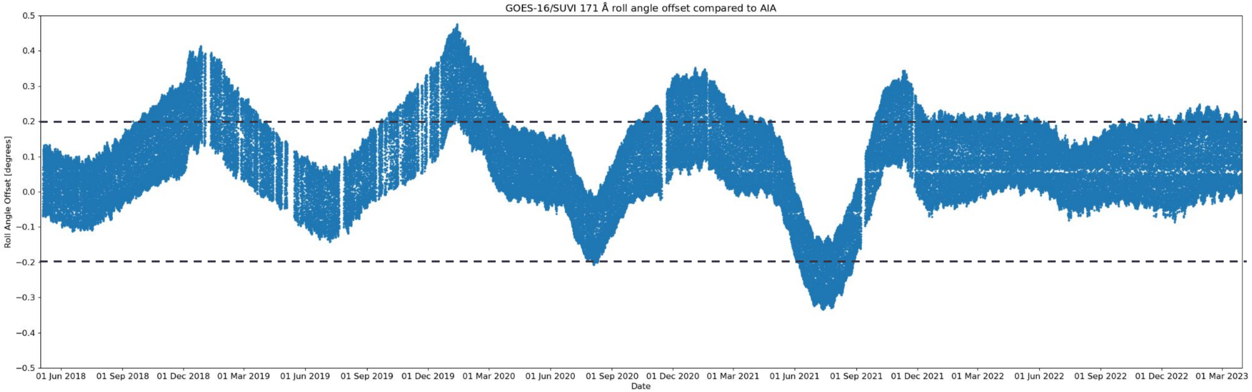
NCEI uses comparable solar instruments (NASA's SDO-AIA and NOAA's EXIS-EUVSA) to track the relative performance degradation of the SUVI instruments.

GOES-18 SUVI Provisional PS-PVR, J. Darnel et. al

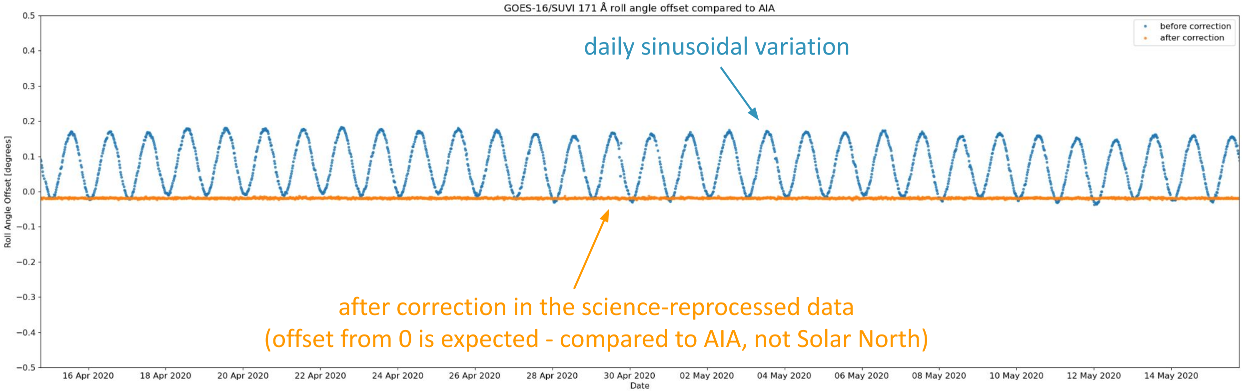
Cal/Val - SUVI Roll Angle

GOES-16/SUVI uncorrected roll angle variation compared to AIA (May 2018 - March 2023)

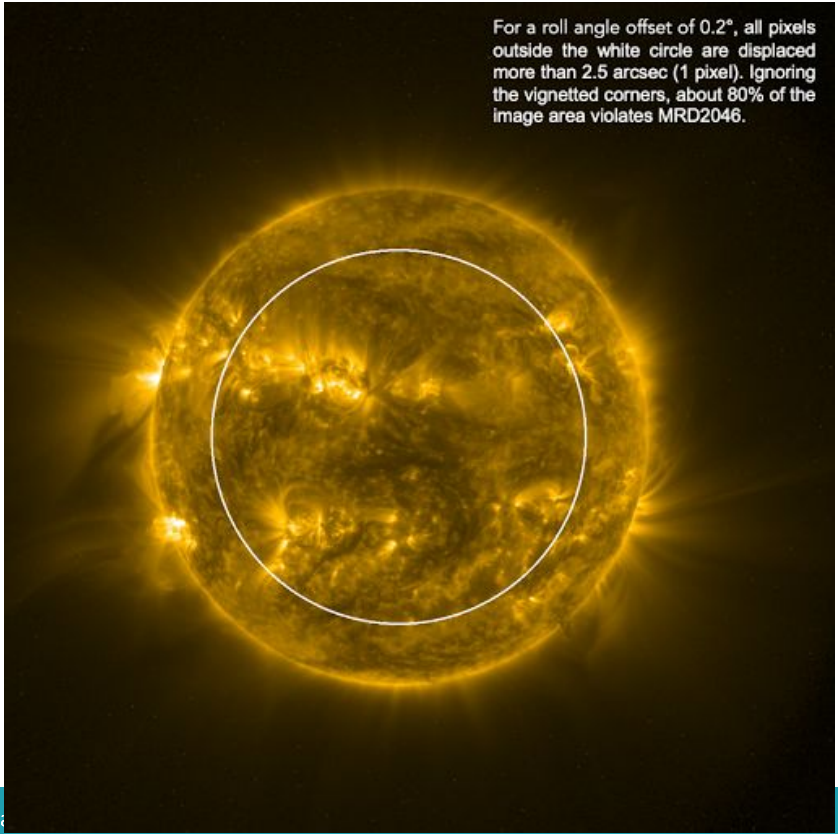
Impact of a .2 degree variation (i.e. outside of dashed lines) is shown on the next slide.



Zooming in on 15 April - 15 May 2020

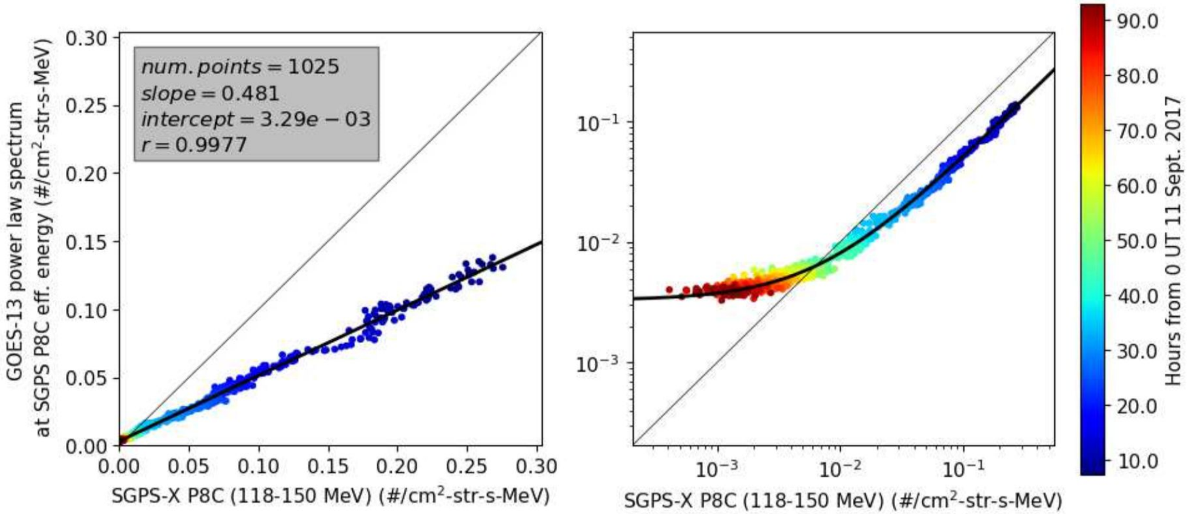


Cal/Val - SUVI Roll Angle Impacts



GOES-R Series Solar and Galactic Proton Sensor (SGPS) Cross Instrument Comparisons with Legacy GOES Energetic Particle Sensors (EPS)

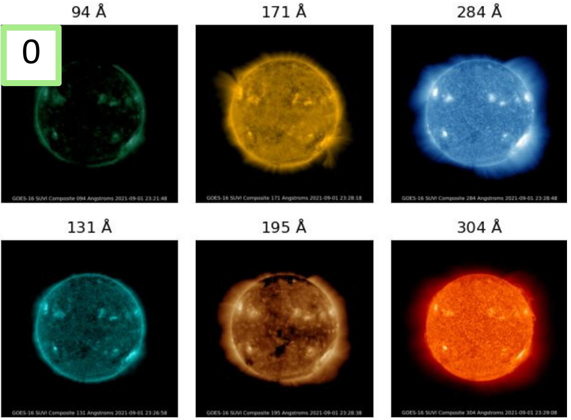
- These cross-satellite comparisons reveal systematic differences between SGPS and EPS measurements.
- They are critical for establishing continuity with legacy NOAA measurements and understanding changes in long-term trends in Solar Particle Event fluxes.
- They are also important for accounting for changes in space weather model results where legacy GOES energetic particle measurements have been used as model inputs.



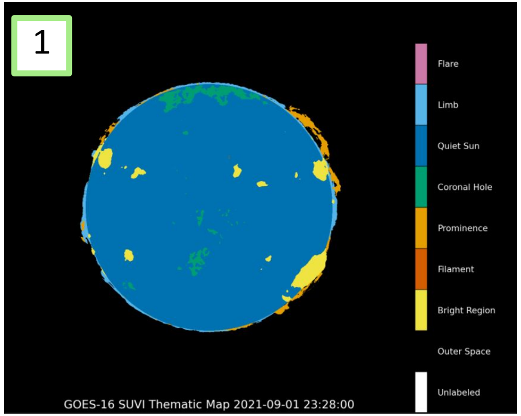
GOES-13 West Energetic Particle Sensor (EPS) vs. GOES-16 Solar and Galactic Proton Sensor -X P8C scatter plots of simultaneous 5 min averages from 11-16 Sept. 2017 using linear and log scales. A power law is fit to the EPS fluxes, and comparisons with the EPS spectrum are made at SGPS channel effective energies. The same data and OLS fit is shown in both panels. The SGPS fluxes exceed the EPS measurements by approximately a factor of two [Kress et al., 2021, doi:10.1029/2021SW002750].

Advancing AI Research to Operations (R2O2R)

Characterizing the Sun with GOES-16 Solar Ultraviolet Imager



Random Forest

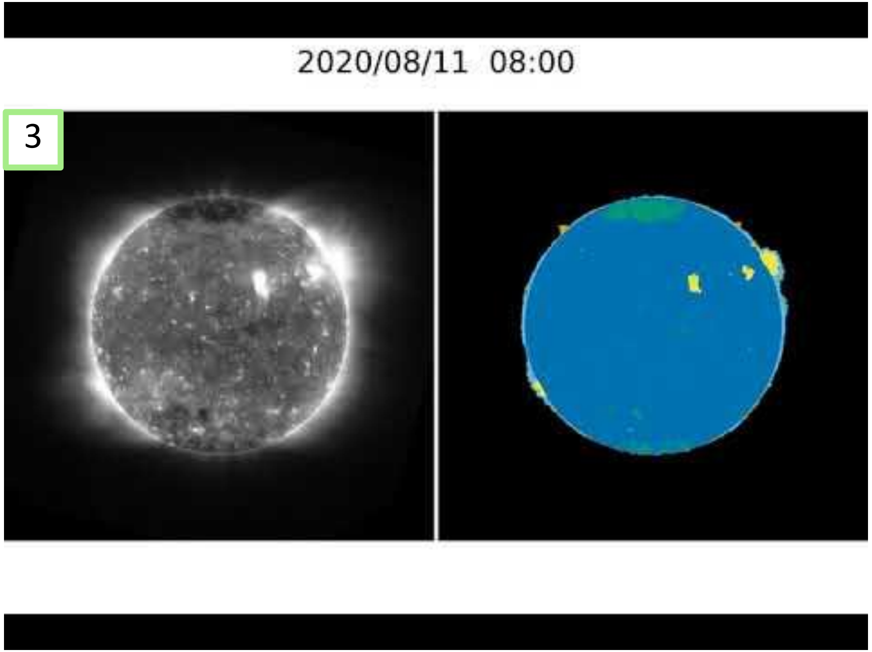


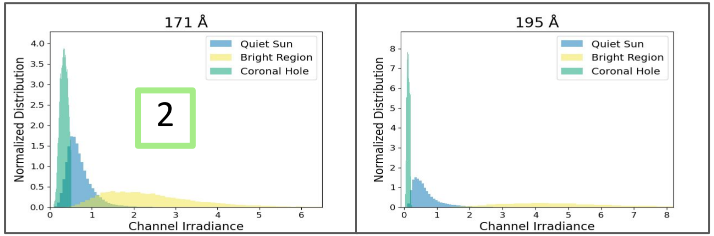
Thematic maps provide automatic, real-time classification of solar features, which is useful for space weather forecasters. These maps enable both real-time event monitoring / prediction and long-term statistical studies.

GOES-16 Solar Ultraviolet Imager (SUVI) composite images, observed in **six extreme ultraviolet** wavelengths, are input to a random forest algorithm to generate a thematic map.

As seen in the histograms below, irradiance distributions for different themes overlap in certain wavelengths, but have distinct, separate profiles in others. A random forest is an ideal solution to approach the complexity of wavelength combinations that can be used to isolate a given theme.

For some themes, such as flares and filaments, irradiance information alone is insufficient for classification. For these, we are investigating other forms of machine learning incorporating temporal and spatial information, such as CNNs.





Thematic maps are **publicly available** on the GOES-R Space Weather Page, with **example code** to display the data. The work of Hughes et al. describes the problem and previous algorithms, and the code used to produce these results can be found at github.com/jmbhughes/thmap.

Please contact Alison Jarvis (alison.jarvis@noaa.gov) or Chris Bethge (christian.bethge@noaa.gov) with any questions.

What is Scientific Data Stewardship?

Scientific data stewardship “encompasses all activities that preserve and improve the information content, accessibility, and usability of data and metadata”. Federally funded digital research data are required to be: preserved and secure; available, discoverable, and accessible; credible, understandable, and interoperable; usable and useful; sustainable and extendable; citable, traceable, and reproducible [1].

NCEI’s scientific stewardship of GOES-R and DSCOVR space weather products meets all of these guiding principles, with Findable, Accessible and Interoperable being the most efficiently verifiable (e.g. internet discoverable and in internationally standard formats). Reusability and Scientific authority are verified via user feedback and literature reviews.

***FAIR**: Guiding Principles for scientific data management and stewardship*

Findable
Metadata and data should be findable for both humans and computers

Interoperable
Data needs to work with applications or workflows for analysis, storage and processing

F A I R

Accessible
Once found, users need to know how the data can be accessed

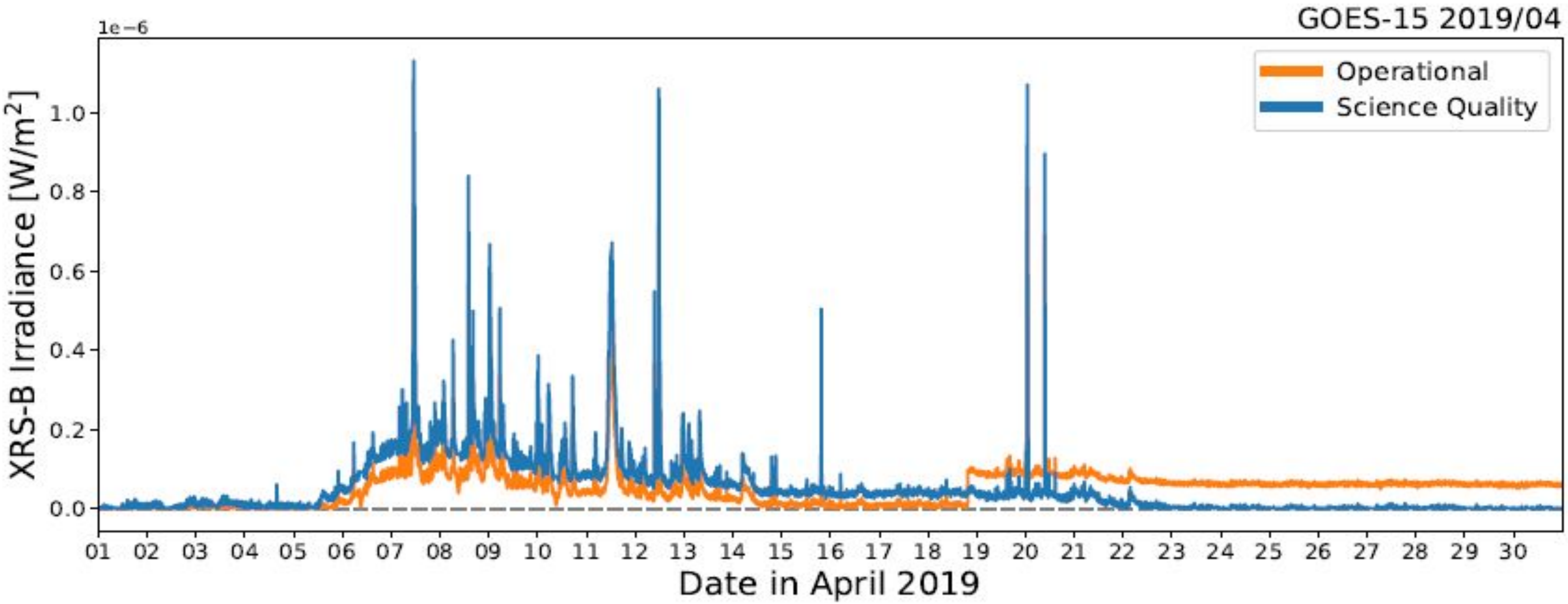
Reusable
The goal of **FAIR** is to optimise data reuse via comprehensive well-described metadata

+

Scientifically Authoritative
Arriving at the most scientifically correct and analysis ready data is an iterative process, incorporating User feedback and emerging science.

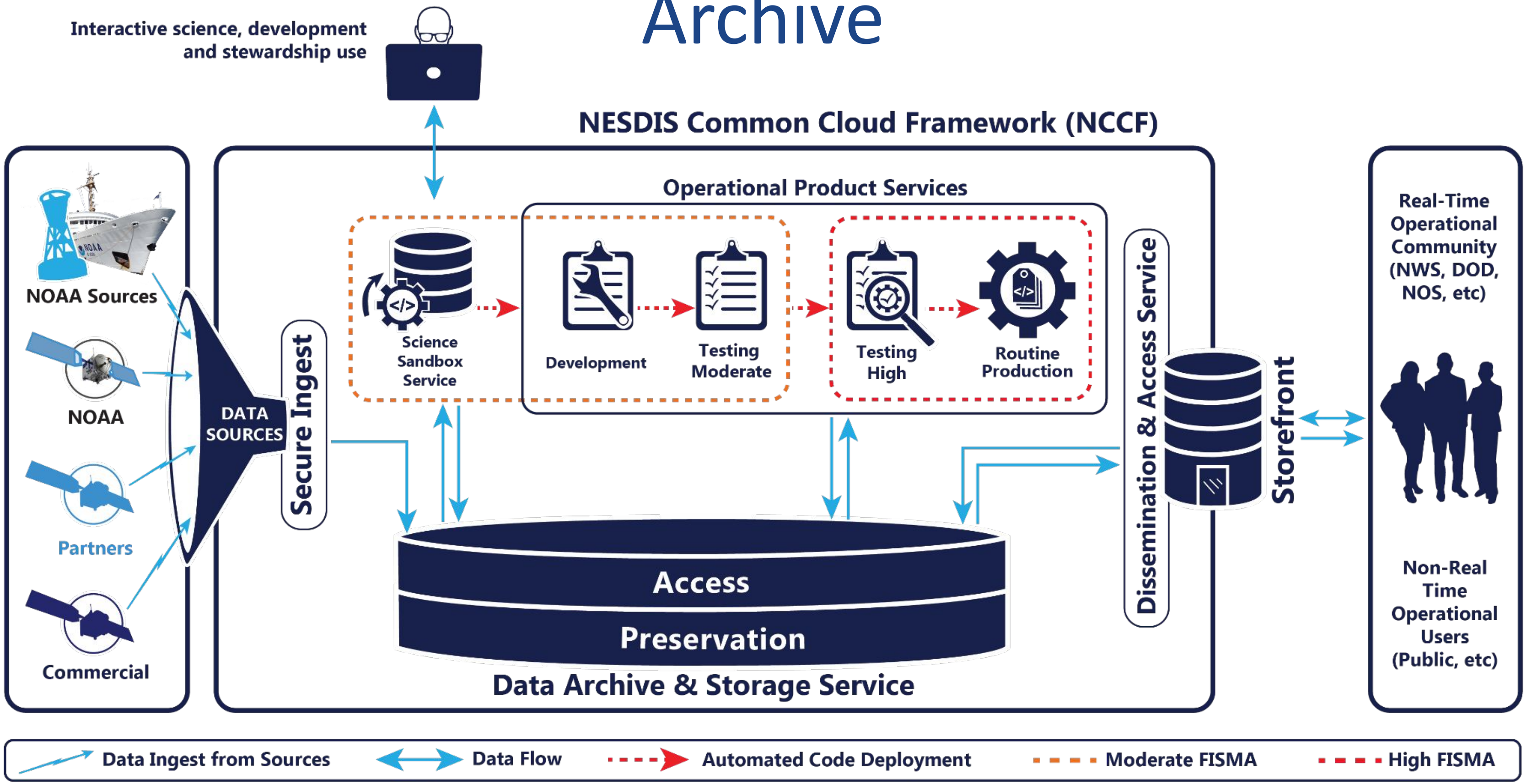
[1]Adapted from NCEI publication Peng et al. (2018), https://datascience.codata.org/article/10.5334/dsj-2018-015/

Scientific Stewardship

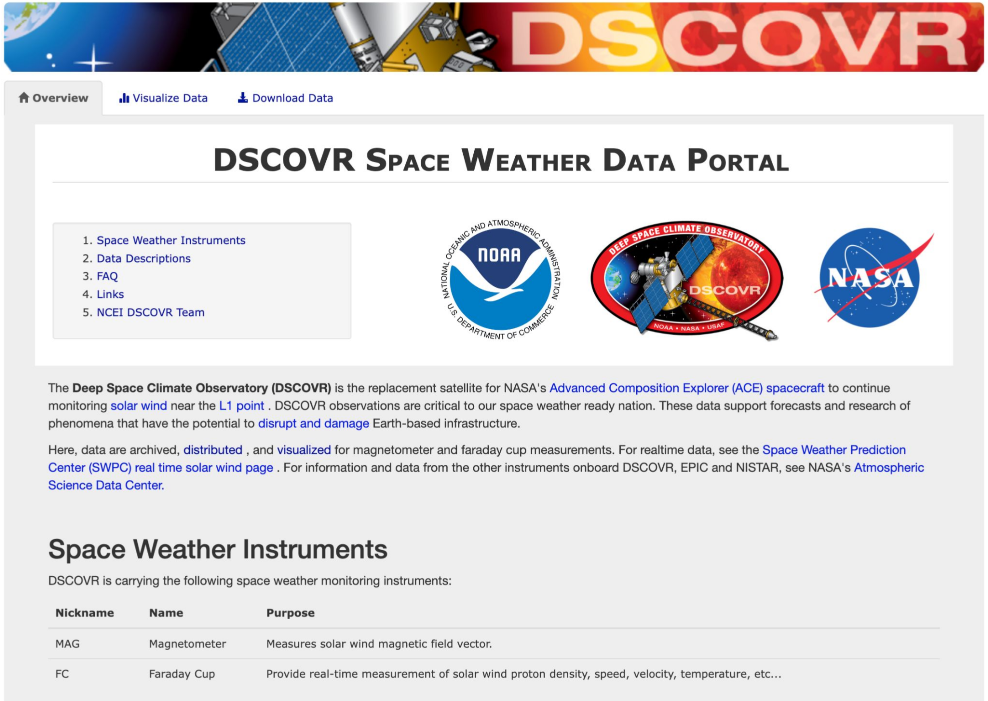


Additional information available at **Poster Sessions on Tuesday, 04/18**, "Solar and Interplanetary Research and Applications," 9:35-10:45AM and 2:45-3:45PM. ***"50 Years of GOES XRS Science-Quality Data"***, *J. Mothersbaugh et. al*

Archive


Interactive science, development and stewardship use
NESDIS Common Cloud Framework (NCCF)
Operational Product Services
Science Sandbox Service
Development
Testing Moderate
Testing High
Routine Production
NOAA Sources
NOAA
Partners
Commercial
DATA SOURCES
Secure Ingest
Access
Preservation
Data Archive & Storage Service
Dissemination & Access Service
Storefront
Real-Time Operational Community (NWS, DOD, NOS, etc)
Non-Real Time Operational Users (Public, etc)
Data Ingest from Sources
Data Flow
Automated Code Deployment
Moderate FISMA
High FISMA

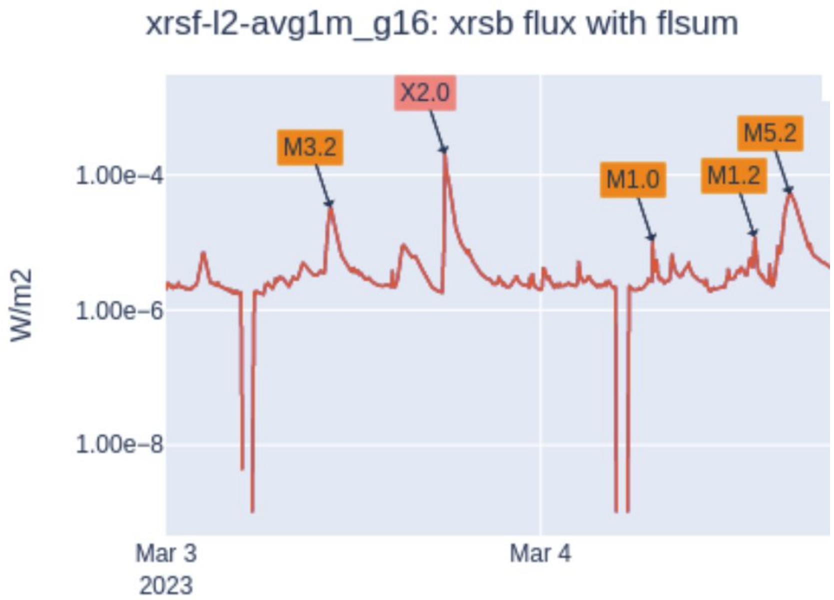
Science Center (1/2)

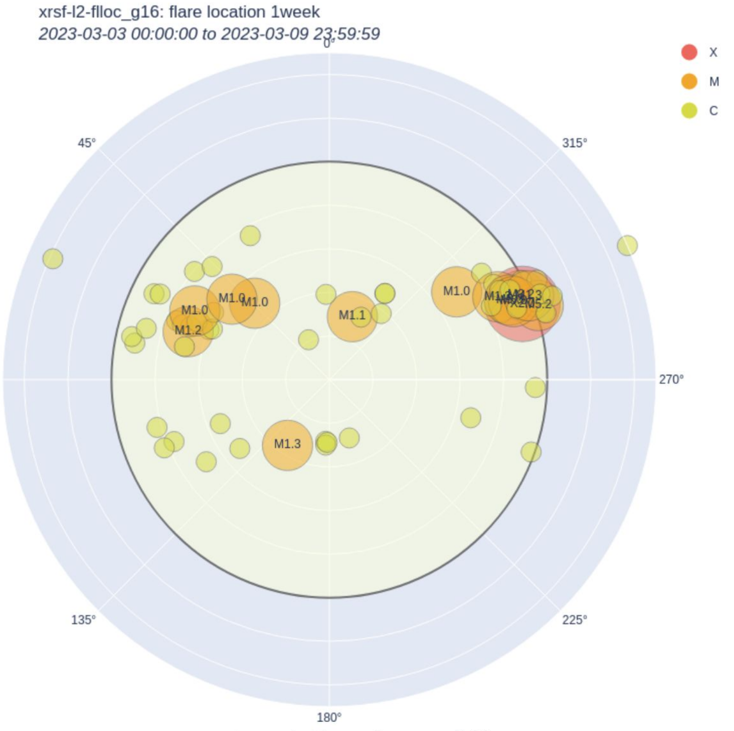


Loto'aniu, P. T. M., Romich, K., Rowland, W., Codrescu, S., Biesecker, D., Johnson, J., et al. (2022). Validation of the DSCOVR spacecraft mission space weather solar wind products. Space Weather, 20, e2022SW003085. https://doi.org/10.1029/2022SW003085

Science Center (2/2)

Automated plotting example: XRS flare/event

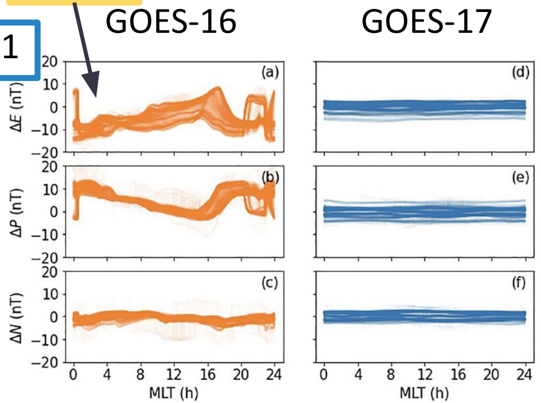




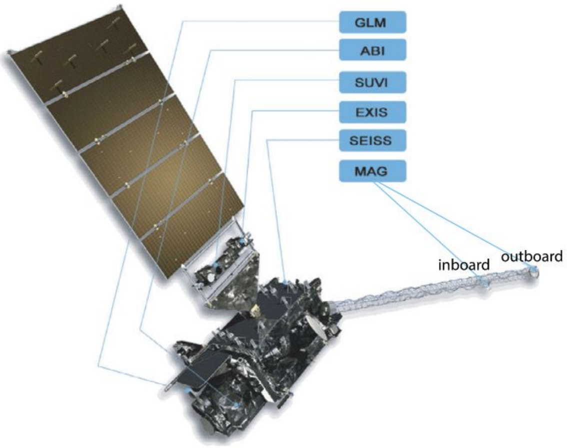
Correcting Geosynchronous Magnetic Field using Transfer Learning

Errors

1



Outboard - Inboard time series for the E-component (ΔE), the P-component (ΔP), and the N-component (ΔN) for GOES-16 (a–c) and GOES-17 (d–f)



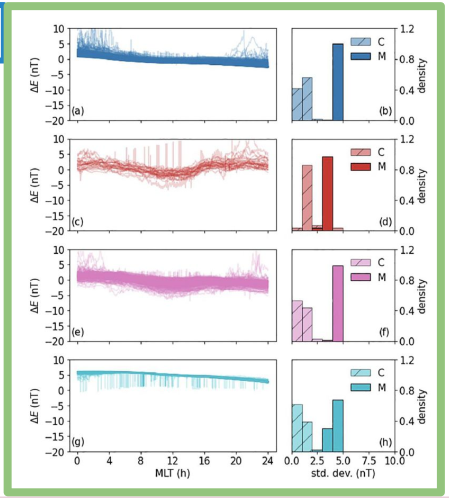
2

Four clusters of anomalous data detected in the Earthward-component of the magnetic field data.

…**due to Earth shadowing of the spacecraft during eclipse seasons**

Transfer Learning

3



Correction via LSTMs using transfer learning from GOES-17. The left panel shows the difference between GOES-16 measured OB and corrected IB E-component magnetic field values for each cluster. On the right panel, we show the standard deviations calculated for the offsets between the measured OB and IB (darker colors) and also the standard variations in the differences between the measured OB and corrected IB (hatched bars).

Inceoglu and Loto'aniu, Space Weather, 2021
https://doi.org/10.1029/2021SW002892

Standards and additional Collaborations

- Metadata
  - NCEI requires ISO 19115-2 collection-level metadata for all data.
  - In some cases (e.g. DSCOVR) our team has sometimes elected to create additional metadata for standards tailored to this community, such as SPASE.
- SWFO Science Portal API
  - Provides a superset of the functionality of Heliophysics API (HAPI), by including a few additional items we need for our sites.
    - Therefore it is relatively straightforward to write a converter to permit a HAPI query to be answered via our API.
    - For DSCOVR this type of mapping program was created (thanks Bob Weigel)
  - This makes it possible to better support connections to VxOs and CDAWeb that are expected to be using HAPI.
- Our team has a strong collaboration with CDAWeb as well as various VxO stakeholders.

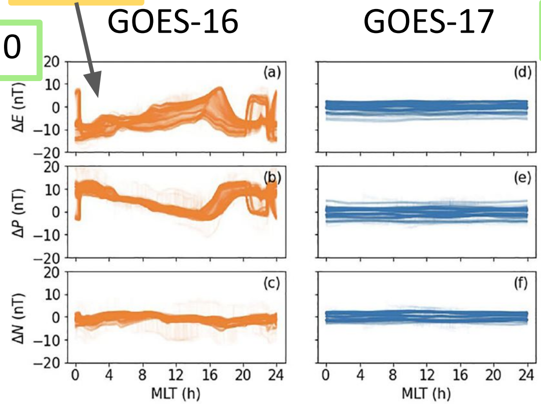
Backups

Advancing AI Research to Operations (R2O2R)

Correcting Geosynchronous Magnetic Field using Transfer Learning

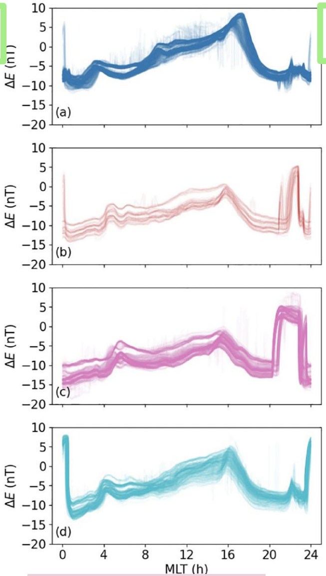
Errors

0



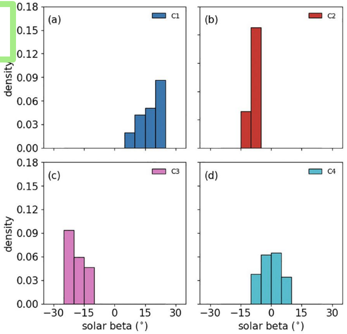
Outboard - Inboard time series for the E-component (ΔE), the P-component (ΔP), and the N-component (ΔN) for GOES-16 (a–c) and GOES-17 (d–f)

1



Four clusters from k-Shape, C1 (a), C2 (b), C3 (c), and C4 (d), detected in the GOES-16 OB-IB E-component magnetic field data.

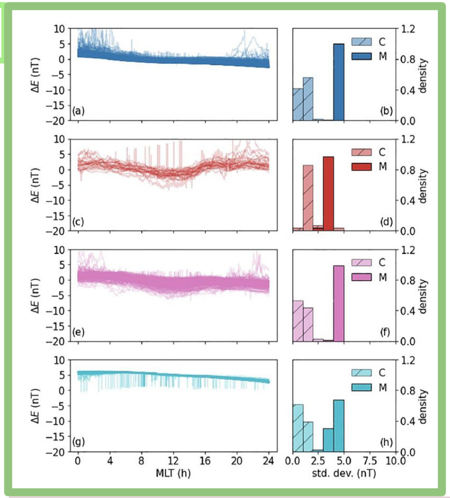
2



Distribution of the solar beta angles in C1 (a), C2 (b), C3 (c), and C4 (d). The solar beta is a measure of the amount of time that a satellite is in direct sunlight. The ΔE trends for each cluster are consistent with thermally induced contamination **due to Earth shadowing of the spacecraft during eclipse seasons** as defined by β, and due to spacecraft shadowing of the boom.

Transfer Learning

3



Correction via LSTMs using transfer learning from GOES-17. The left panel shows the difference between GOES-16 measured OB and corrected IB E-component magnetic field values for each cluster. On the right panel, we show the standard deviations calculated for the offsets between the measured OB and IB (darker colors) and also the standard variations in the differences between the measured OB and corrected IB (hatched bars).

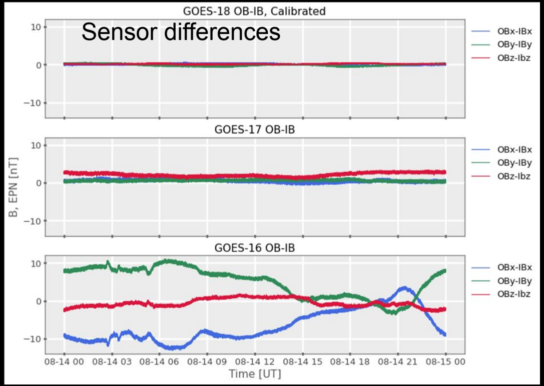
Inceoglu and Loto'aniu, Space Weather, 2021
https://doi.org/10.1029/2021SW002892

GOES-18 GMAG

Powered on : March 23, 2022 Provisional passed : September 16, 2022

NOAA/NCEI - CU/CIRES

Paul Loto'aniu, Aspen Davis, Alison Jarvis,
Ale Pacini, Fadil Inceoglu



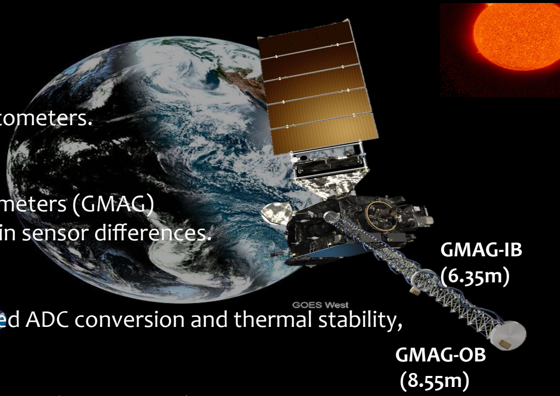
GOES-R MAG: Pair of boom-mounted 3-axis fluxgates magnetometers.
Sampling rate = 10 Hz

GOES-18 : Goddard Planetary Magnetospheres Lab magnetometers (GMAG)
-much better stability and much less daily variation in sensor differences.

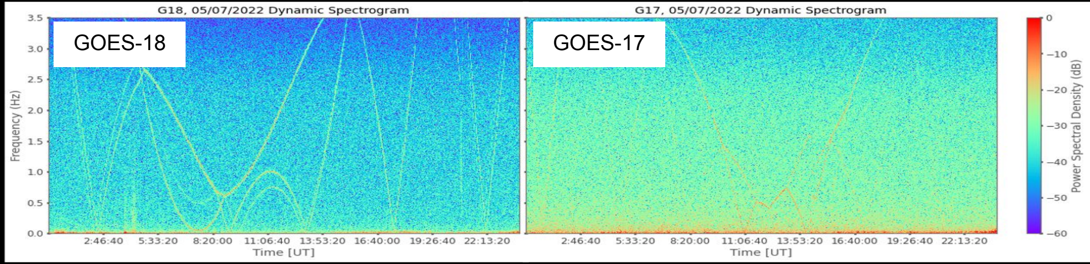
GOES-17 : MEDA MAG
-improved spacecraft magnetic cleanliness, improved ADC conversion and thermal stability, still variation in daily sensor differences

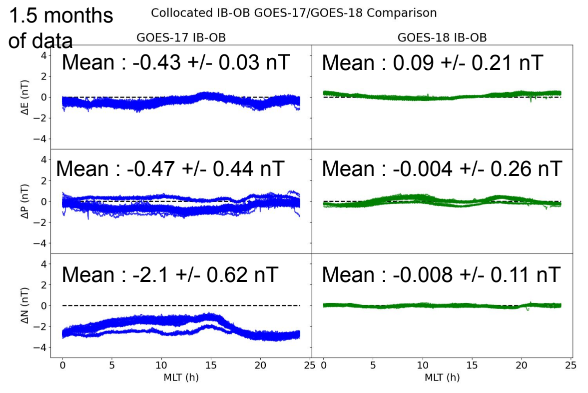
GOES-16 : Macintyre Electronic Design Associates magnetometers (MEDA MAG)
-ADC conversion and thermal issues, significant spacecraft interference, large diurnal variation ranging -10 to 10nT

➔ GOES-18 GMAG : has smaller mean sensor differences and better stability over 1.5 months

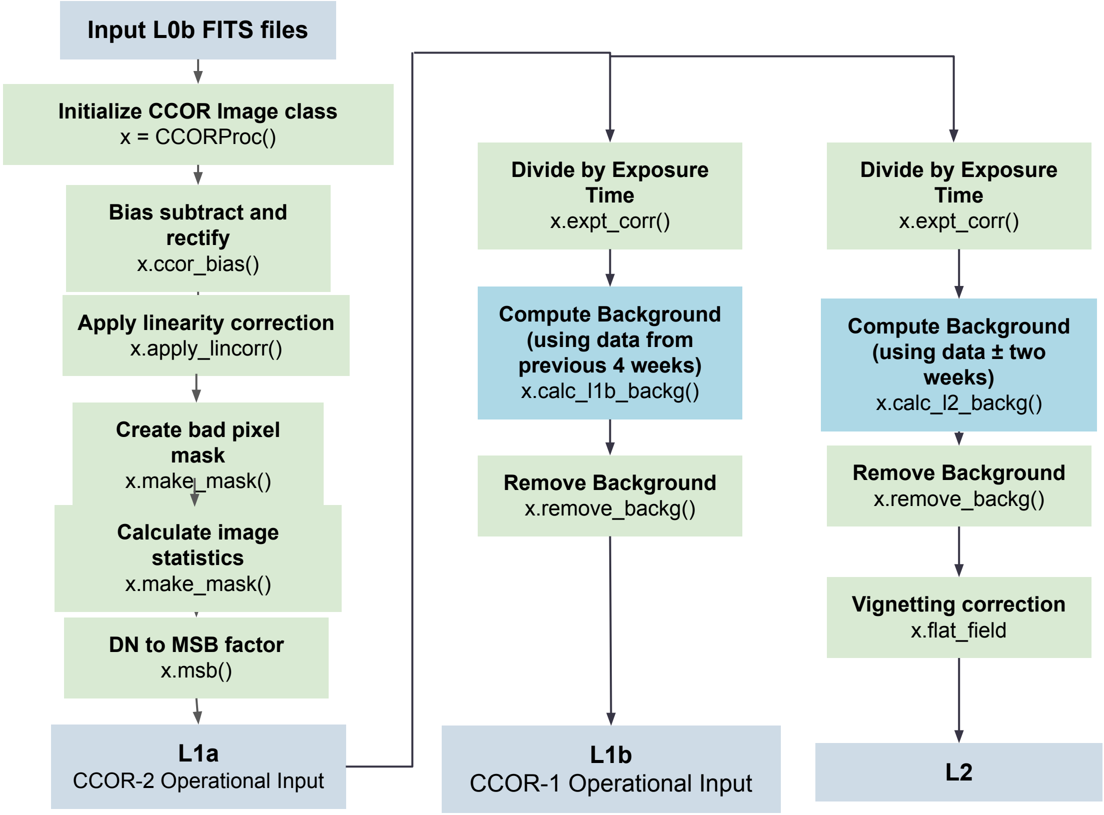


GOES-18 GMAG has significant reduction in background noise level
-amplitude of background noise is ~0.1nT



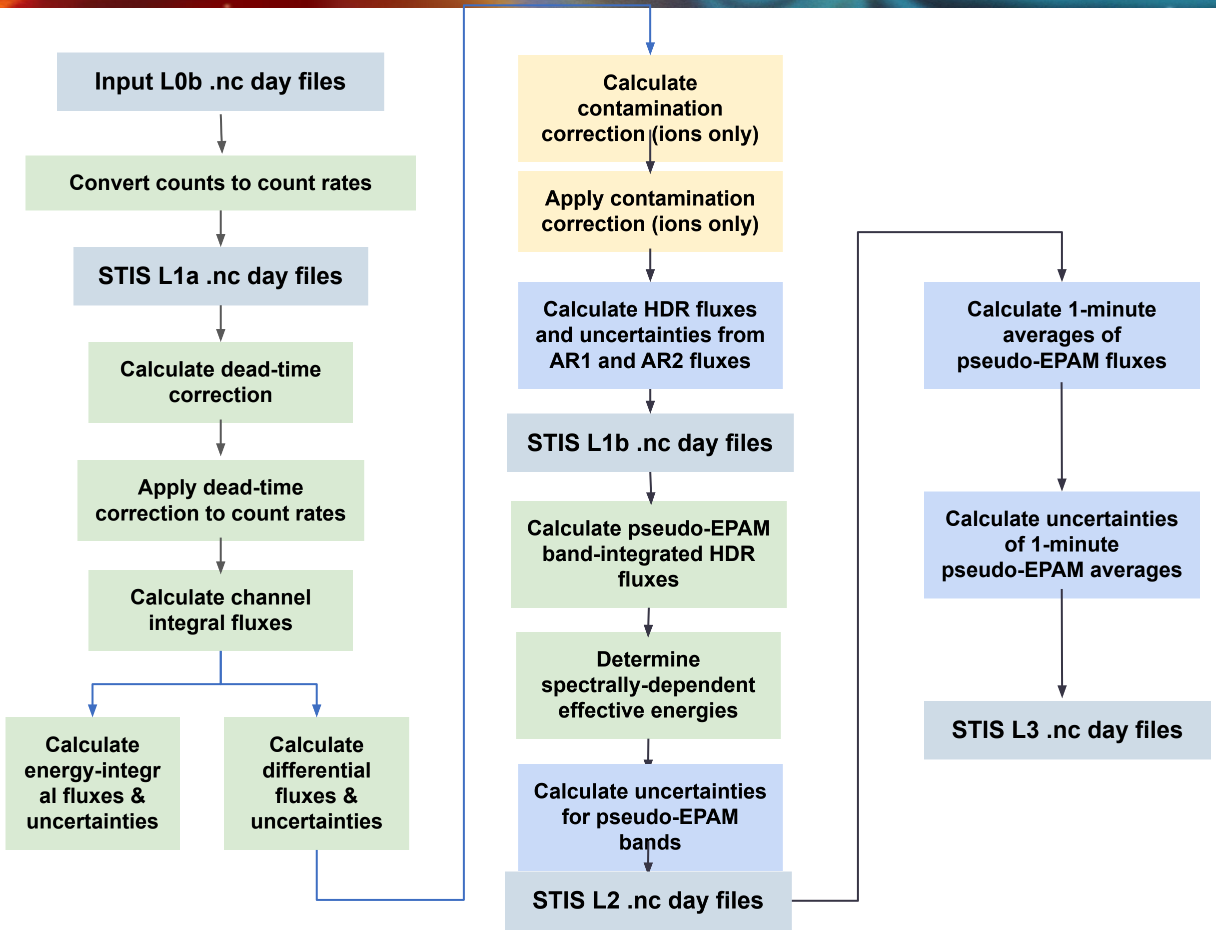


CCOR Scientific Pipeline



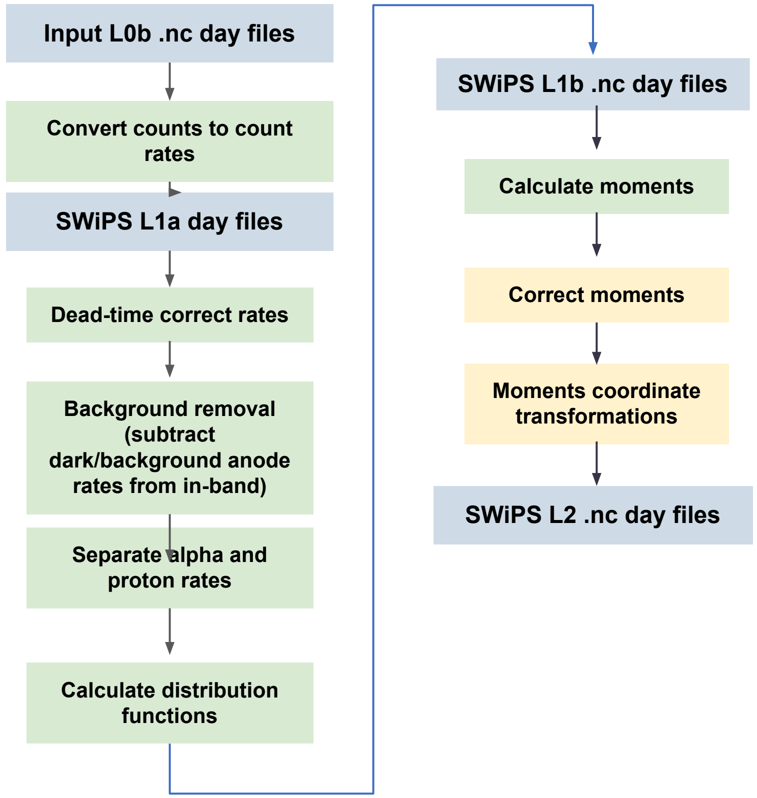
Preliminary NCEI Pipeline Design (Python Class + Methods)

STIS Scientific Pipeline



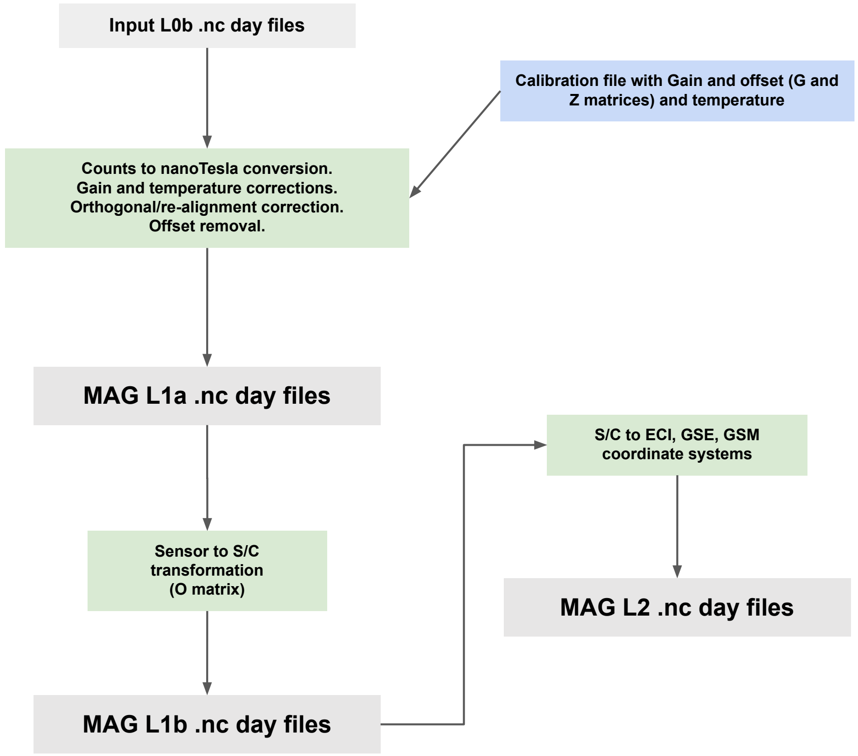
Preliminary NCEI STIS L0b to L3 Pipeline Design

SWiPS Scientific Pipeline



Preliminary NCEI SWiPS L0b to L2 Pipeline Design

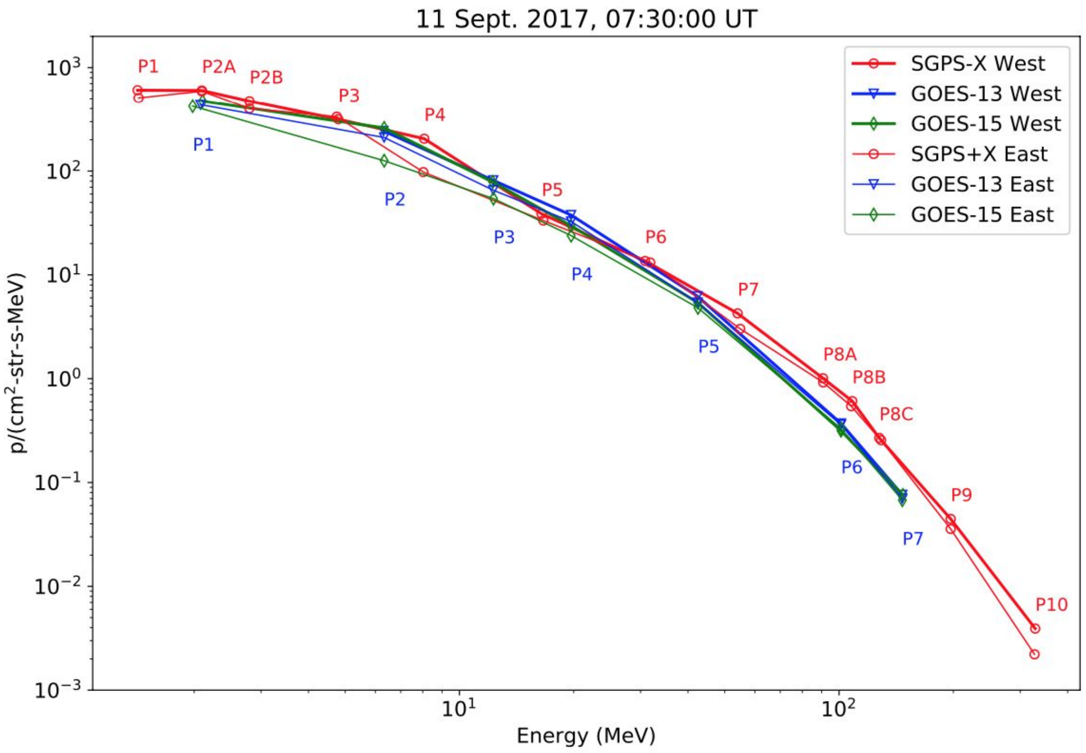
MAG Scientific Pipeline



Preliminary NCEI MAG L0b to L2 Pipeline Design

Example of Comparison of spectra from GOES-16 Solar and Galactic Proton Sensors and GOES-13 Energetic Particle Sensors.

Comparison of spectra from Geostationary Operational Environmental Satellites (GOES)-16 Solar and Galactic Proton Sensor (SGPS), GOES-13 Energetic Particle Sensor (EPS), and GOES-15 EPS at 7:30 UT near the event peak flux during the September 2017 GLE. GOES-16, GOES-13, and GOES-15 measurements are shown with red, blue, and green traces, respectively. East and west fluxes are shown by the thin and thick traces, respectively.



GOES-16 SGPS 5-minute Averaged Fluxes from the September 2017 Solar Particle Events

Full Solar and Galactic Proton Sensor (SGPS) September 2017 data set available from the NOAA - National Centers for Environmental Information Geostationary Operational Environmental Satellites-R website, including P1–P10 (differential) and P11 E (500 MeV) integral fluxes from east- and west-facing SGPS units. The complete September 2017 SGPS data set is available from the NOAA-NCEI website at https://www.ngdc. noaa.gov/stp/satellite/goes-r.html.