Peer Stakeholder-Product Validation Review (PS-PVR) for

GOES-17 EXIS XRS L1b Full Maturity

19 August 2020

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Quick Summary

- GOES-16 XRS went operational in January 2020
  - GOES-17 operational soon at SWPC.
- GPA: most ADRs resolved, a few remain.
- Instrument
  - No surprises. GOES-16 and -17 behavior is similar.
  - Studies done with L1b, L2, and L0-processed data.
  - A few instrument issues remain.
  - PLPT tests PASSED
- On-orbit calibrations
  - LASP handed off L0 cal tools to NCEI
  - NCEI will submit first LUTs this week.
- Data: operational and new science-quality available from NCEI.
- Solar activity low since launch. SC 25 has begun.

EXIS

SPACE WEATHER PREDICTION CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Saturday, August 15, 2020 22:41:50 UTC

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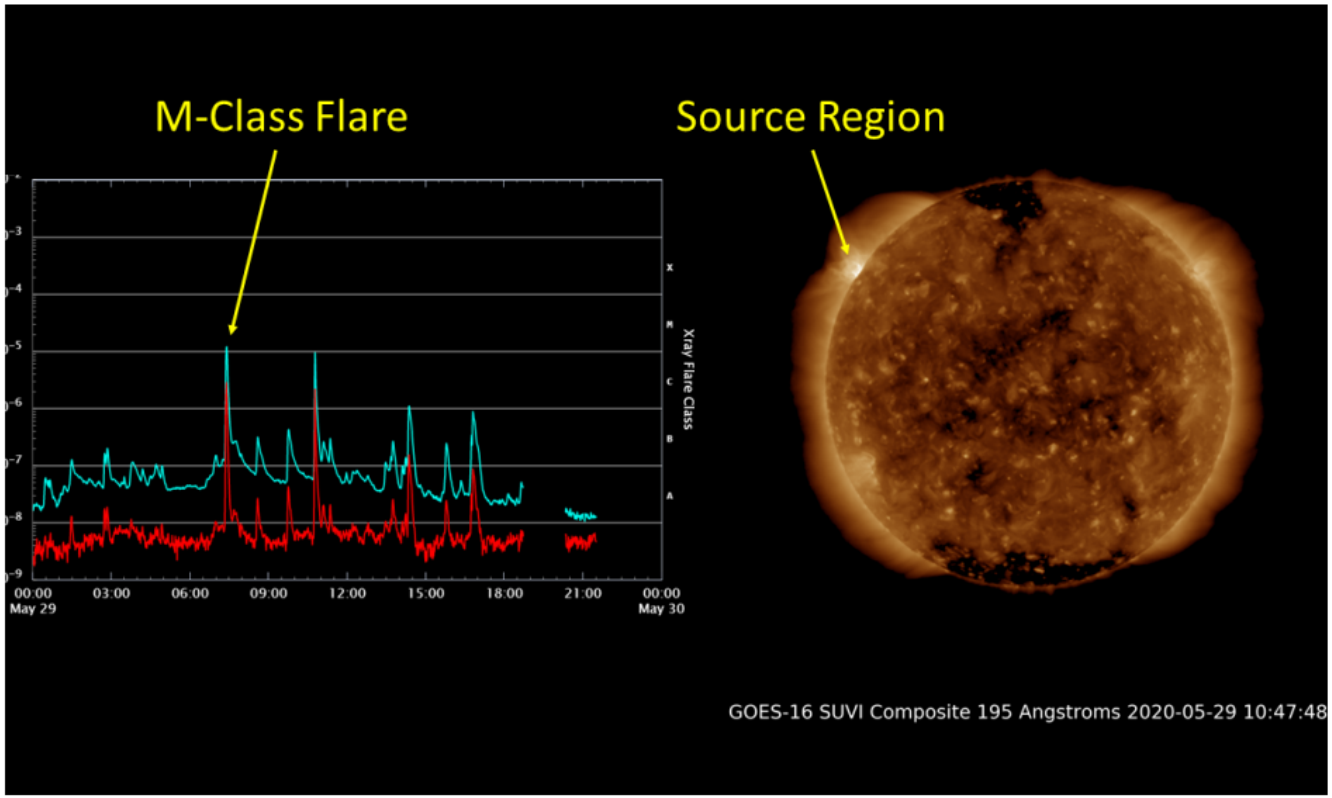
CURRENT SPACE WEATHER CONDITIONS on NOAA Scales

R none S none G none

FIRST M-CLASS FLARE OBSERVED IN YEARS 29 May 2020



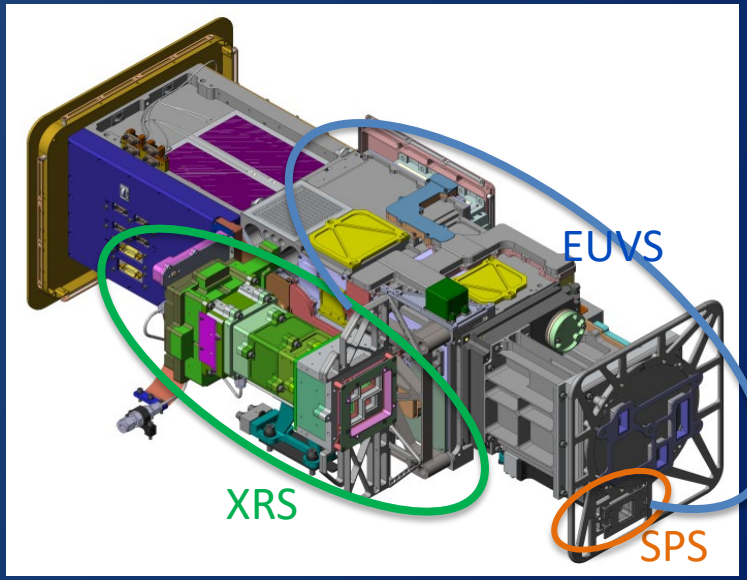
FIRST M-CLASS FLARE OBSERVED IN YEARS

published: Monday, June 01, 2020 20:04 UTC

For the first time since 20 Oct 2017, an M1 (R1-Minor) X-ray flare was observed from the Sun. The region that produced the flare was located just around the NE limb. Although the flare activity has been impulsive, several coronal mass ejections (CME) have been observed from the region in coronagraph imagery. Given the location near the limb, none of the CMEs are expected to be Earth-directed. As the region rotates further onto the visible disk we'll be able to gather more details about its magnetic complexity and future flare potential.

EUV and X-Ray Irradiance Sensors (EXIS)

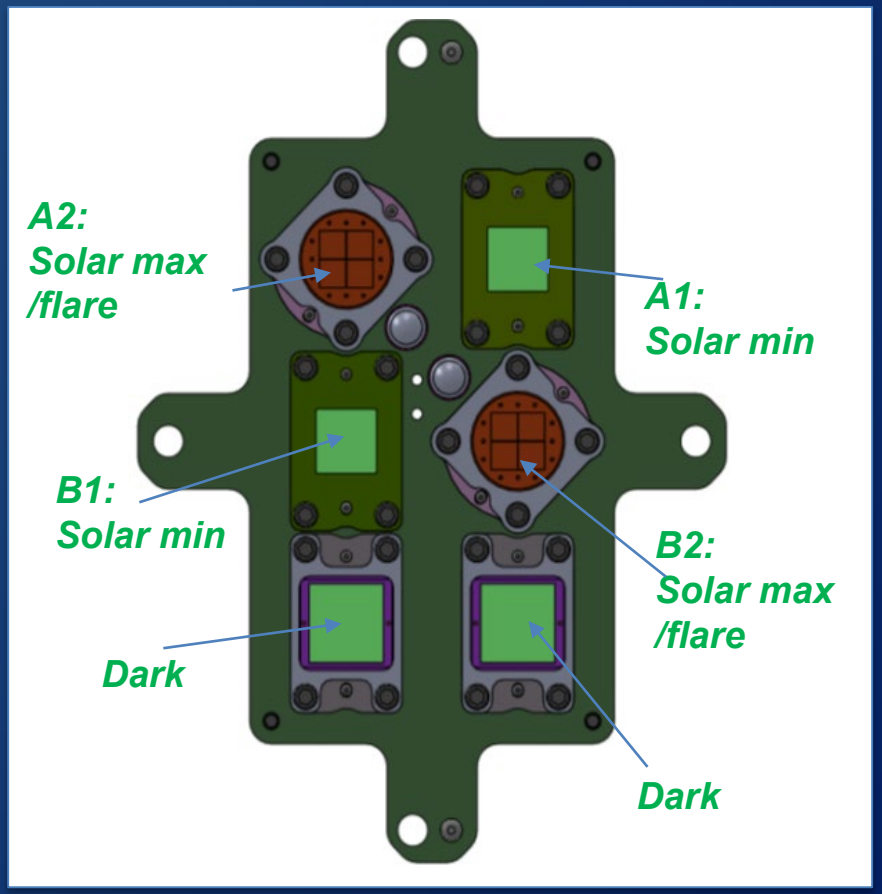
- X-Ray Sensor (XRS)
  - Monitor solar flares
    - Impacts communications and navigation
    - Warning for potential SEP events
- Extreme Ultraviolet Sensor (EUVS)
  - Measures ultraviolet irradiance which impacts upper atmosphere
- Sun Pointing Sensor (SPS)
  - Used for alignment (quad diode, 3.5° FOV)



EXIS was designed, built and tested by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado.

X-Ray Sensor (XRS)

- 2 soft X-ray wavelength bands
  - A is 0.05-0.4 nm
  - B is 0.1-0.8 nm; used for flare index
- 12 diodes total
  - Silicon photodiodes with Be filters
  - A1, B1 - low solar activity
  - A2, B2 - solar max/flare
  - 2 dark diodes
- Main L2 products
  - X-ray flux time series
    - 1 sec and averaged
  - flare event detection
  - flare location on solar disk



SWPC uses XRS for Radio Blackout Warnings

flare index from 1-minute averaged XRS-B1

Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
R 5	**Extreme**	**HF Radio:** Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. **Navigation:** Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 (2×10^{-3})	Less than 1 per cycle
R 4	**Severe**	**HF Radio:** HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. **Navigation:** Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	**Strong**	**HF Radio:** Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. **Navigation:** Low-frequency navigation signals degraded for about an hour.	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	**Moderate**	**HF Radio:** Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. **Navigation:** Degradation of low-frequency navigation signals for tens of minutes.	M5 (5×10^{-5})	350 per cycle (300 days per cycle)
R 1	**Minor**	**HF Radio:** Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. **Navigation:** Low-frequency navigation signals degraded for brief intervals.	M1 (10^{-5})	2000 per cycle (950 days per cycle)

REVIEW OF PREVIOUS STATUS: PROVISIONAL MATURITY ASSESSMENT

Previous Status: L1b Issues

- G17 Provisional PS-PVR was held 24 April 2019
- Listed issues were to be resolved by Full Validation
- Numerous fixes implemented since Provisional Validation PS-PVRs
- Remaining issues discussed in next section
- Delivery of “next EXIS” will be around February 2021.

ADR	Issue	Delivery Date at Provisional PS-PVR	Status Aug 2020
397	*percent_uncorrectable_L0_errors* < 0	06.03	closed
523	Remove SpWx L1b dependency on APID 384	08.00	“next EXIS”
612	Set attribute for alg_container to 'not in use'	09.00	closed
795	XRS packet_count - max range, long name	08.01	closed
872	G17 solar array currents wrong	09.00	open
892	G17 XRS irregular file start, end times	-	“next EXIS”
894	Lunar transit flag not set properly	-	“next EXIS”
445	XRS and EUVS L1b outages during flares	PR 06.07	closed

Previous Status: Instrument Issues

Issues at Provisional Validation that were to be resolved by Full Validation.

Remaining issues are discussed in later sections and in Readme data caveats.

#	Issue	Description	Status in August 2020
1	XRS electron contamination	The XRS flux signal at low X-ray fluxes and high electron fluxes is contaminated by the electron signal.	A fix has been implemented in the L2 data processing. Coefficients are currently under revision
2	XRS-A is larger by 34% on GOES-16 and -17 than on GOES-15.	XRS-A: GOES-17/GOES-15 = 1.34	The source of this discrepancy is unknown and is under investigation.
3	Dark radiation coefficients are set to 0	The dark radiation coefficient is used to correct the signal for proton contamination during SEP events. It is currently not being applied.	Analysis to determine this term will be done in the future after there are more SEP events. Signals will be artificially high during SEP events, especially in the A2 and B2 channels.
4	Dark counts	Improve dark counts with values from periods of lowest electron fluxes. Applies to all channels except B1.	LUT updates to be submitted in September.

L1B PRODUCT QUALITY ASSESSMENT

GPA Issues

- 98 XRS-related ADRs have been closed since 2016
- 8 issues impacting Full Validation. Deliver of “next EXIS” will be Feb 2021.

ADR	Issue	*	Description / Impacts	OE Delivery Date
523	Reduce APID 255 volume		Save disk space by reducing attitude packet from 20 to 0.8 Hz.	with GLM/SEISS targeted patch in September
872	G17 solar array current APID error		G16 and G17 addresses are different for mnemonic results in bad data (Flight issue)	to be fixed for G18 and G19 only
892	Irregular XRS file start/end times		Several days have bad filenames	“next EXIS”
894	Lunar transit and other pointing issues		18 EXIS variables set incorrectly when there are pointing issues	“next EXIS”
958	Make double precision LUT variables		Improve accuracy of results	“next EXIS”
1002	Move leap seconds note to metadata		Fixes units attribute for time variables.	DO 09.01 2020-09-02
1063	*sps_observation_times* error		SPS timestamps incorrect results in incorrect elements in averages for angles (and EUVS).	“next EXIS”
1087	Pointing during eclipses		Only one flag should be set at a time and pointing flag should not be set during eclipse. Revise pointing flag names.	“next EXIS”

* Impact on data: Minor Impact | Moderate Impact

Post-Launch Product Tests (PLPTs) for Full Validation

Test ID*	Test Title	Operator	Status	Criteria
13	XRS Flare Location Comparison (L1b)	NCEI	Pass	[1]
14	XRS/EUVS/Mg II Inter-Satellite Comparisons (L1b)	LASP/NCEI	Pass	[2]

Full Validation Success Criteria:

[1] X-class flares can be detected with an accuracy of better than 5 arcmin.

[2] For this cross-comparison, there is no pass/fail on the result itself.

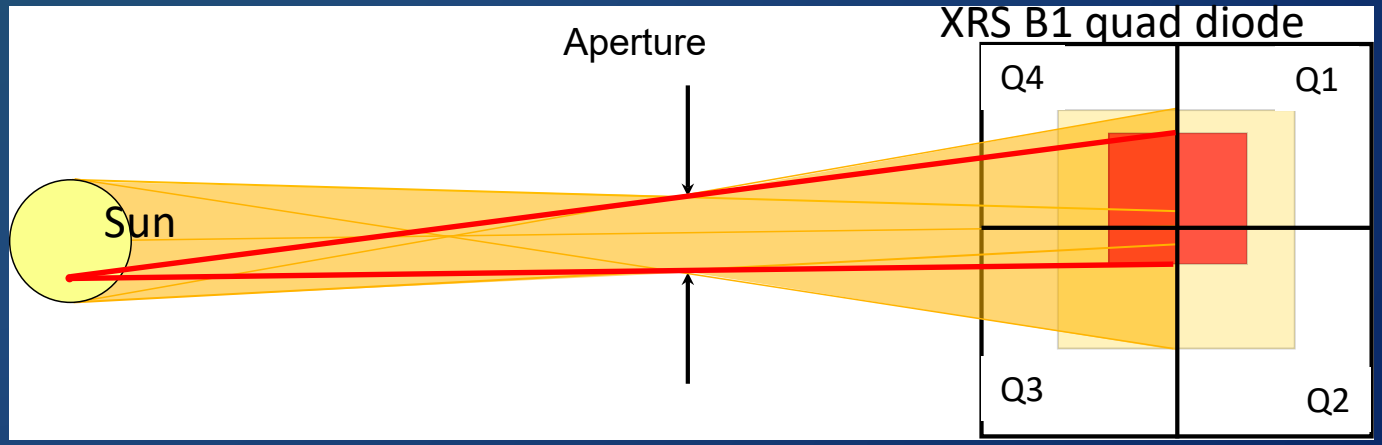
Data analysis performed with L1b and L2 data, both from GPA and locally processed L0 data.

* Test plans and procedures are described in Appendix A.3 in the EXIS Readiness, Implementation, and Management Plan (RIMP v1.1; 416-R-RIMP-0316)

#13: XRS Flare Location Validation (1/5)

Objective: Validate flare location algorithm

Accuracy Requirement: 5 arcmin for X-class flares (EXISPORD 313, MRD 2036)
Preliminary results meet requirement.



X = [(Q1 + Q2) - (Q3 + Q4)] / Qsum
Y = [(Q1 + Q4) - (Q2 + Q3)] / Qsum
where Q1 to Q4 are background-subtracted corrected currents
and Qsum = Q1 + Q2 + Q3 + Q4

#13: XRS Flare Location Validation (2/5)

Objective: Validate flare location algorithm

Accuracy Requirement:

- 5 arcmin for X-class flares (EXISPORD 313, MRD 2036)
- Sun has a diameter of 32 arcmin.

Preliminary results meet requirement.

Flare Location Algorithm

- L2 inputs: XRS-B2 (quad diode) 1-min averages, XRS Event Summary
- Adjustments
  - XRS FOV ±77 arcmin
  - *10° rotation for GOES-17 (not understood yet)*
  - x and y offsets, SPP angle (future additions)

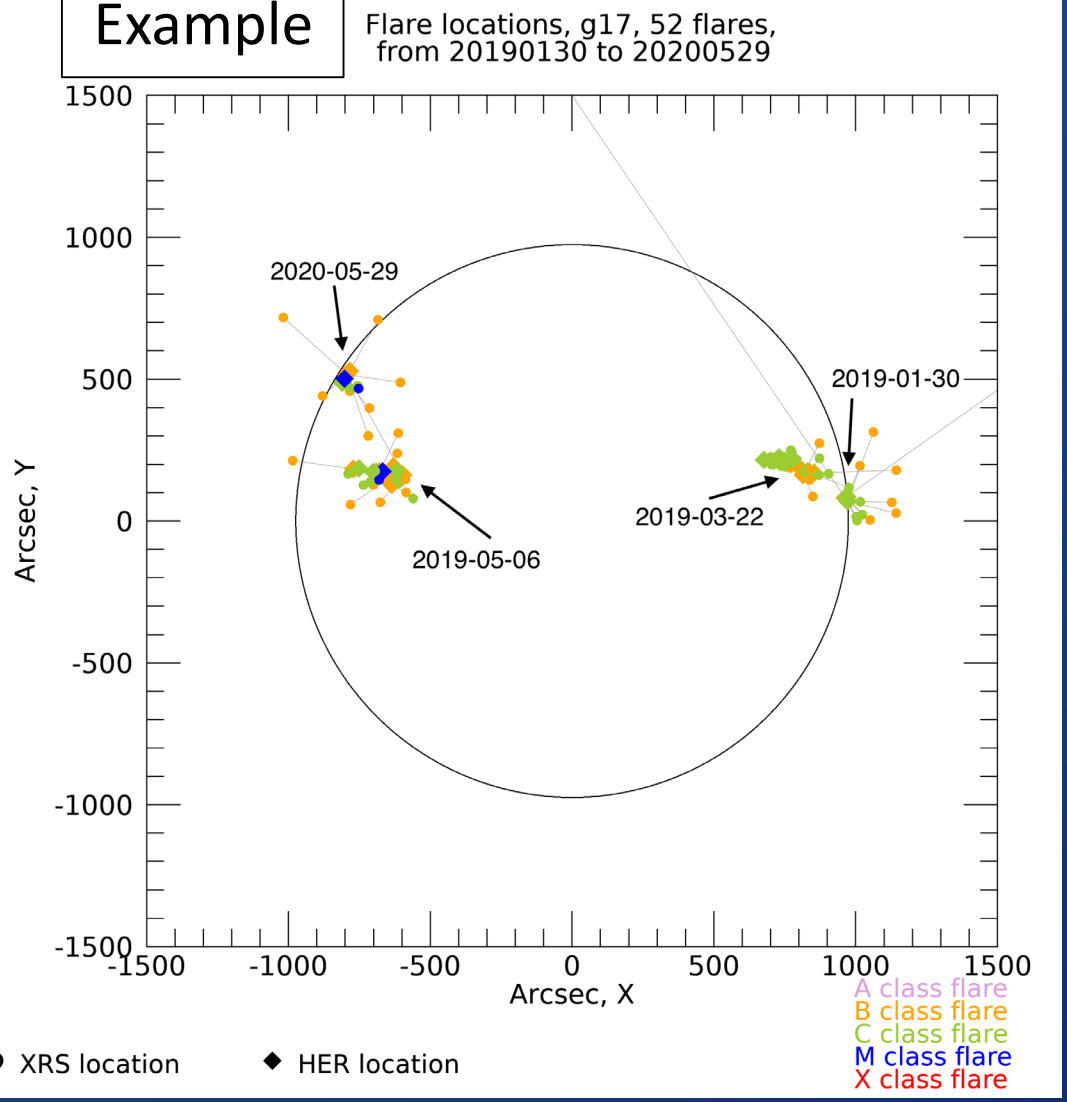
'True' Location for Comparisons

- Heliophysics Event Registry (HER) database* (AIA difference images)

*https://www.lmsal.com/solarsoft/latest_events/

#13: XRS Flare Location Validation (4/5)

Example



Preliminary Statistics

1 June 2018 to 18 Aug 2020

Flare Class	# of flares	Median Error [arcmin]
X	0	---
M	3	1.00
C	49	1.35
B	205	4.51
All	257	3.86

plot from L. Rachmeler

#13: XRS Flare Location Validation (5/5)

Future steps

Determine reason for 10° rotation for GOES-17

Adjust x and y offsets and radial scaling (small impacts)

SPP_to_Sun_roll_angle

- Add to calculation.
- Use yaw flip and telemetry value GNC_AR_SUVI_ROLL_ANG_ERR
- Still working to understand definitions.

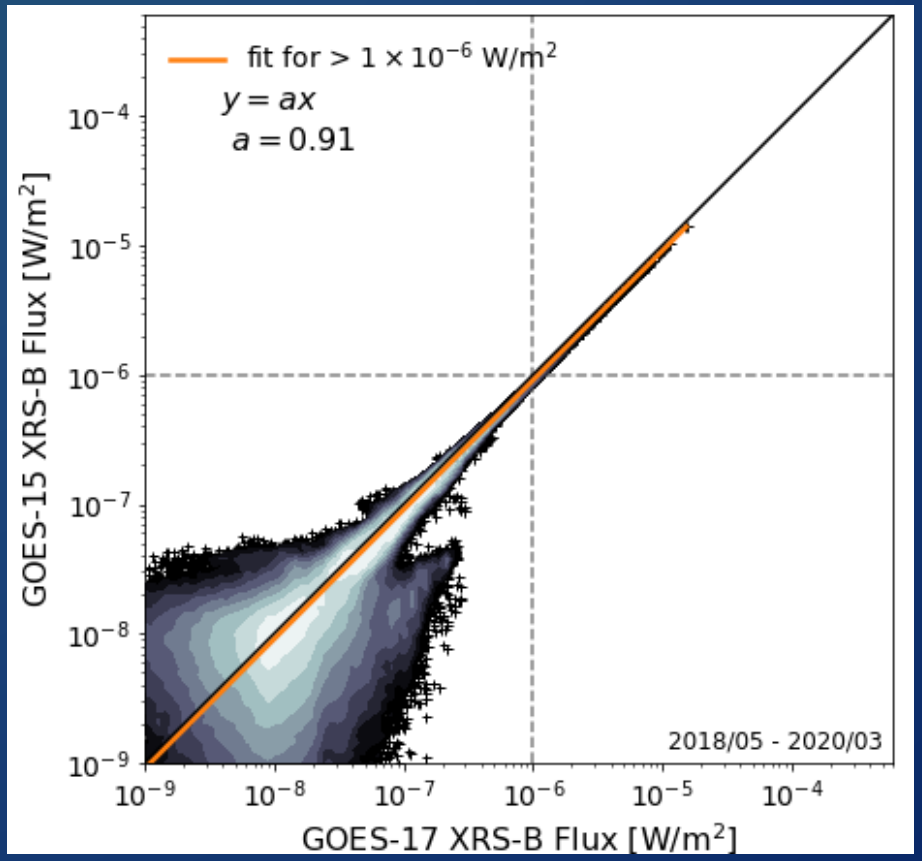
ADR: redefine long_name (and name?) for SPP_to_Sun_roll_angle

- Angle to celestial (Earth) north instead of solar north

#14: Inter-Satellite Comparisons (1/3)

XRS-B: GOES-15 and -17 Full Mission Comparison

- Reprocessed science-quality data (no SWPC scaling factor)
- GOES-17 fluxes corrected for electron contamination
- Linear behavior at higher fluxes

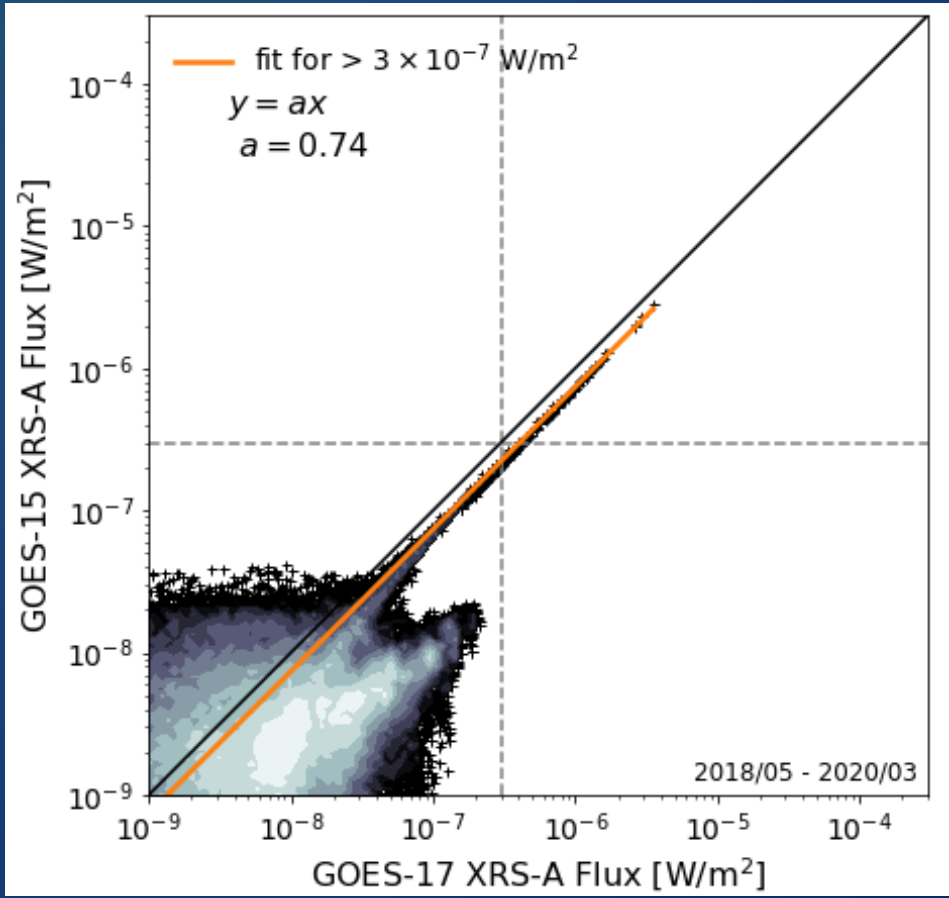


Plots from E. Zetterlund

#14: Inter-Satellite Comparisons (2/3)

GOES-15 and -17 XRS-A Full Mission Comparison

- Same data as XRS-A comparison
- 30% difference is not yet understood.

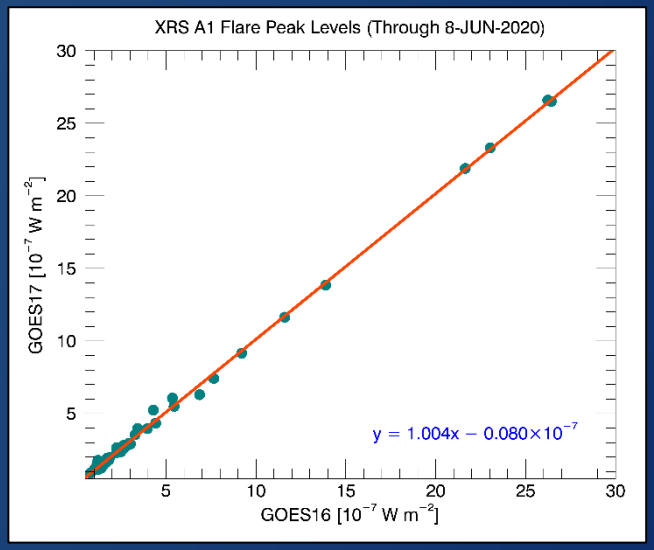


Plot from E. Zetterlund

#14: Inter-Satellite Comparisons (3/3)

GOES 17 vs GOES 16 Peaks

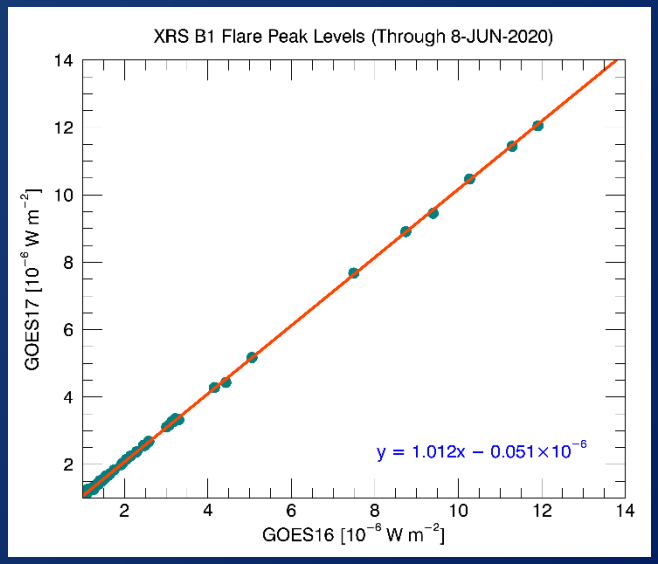
Slopes of ~1 demonstrate that XRS sensors respond similarly to these flares.



Approximate channel ratios

channel B G16/G15 =1.09
G17/G15 = 1.11
G17/G16 = 1.012

channel A G16/G15 = 1.41
G17/G15 = 1.40
G17/G16 = 1.004



Plots from Tom Eden

Performance Baseline Comparison

Assessment from Provisional PS-PVR: All requirements are met.
At Full PS-PVR: All requirements continue to be met.

MRD ID	Quantity	MRD Requirement	MIT/LL Predicted Performance	NCEI Value at Provisional	Requirement Met
2037	Measurement Range XRS A	$5x10^{-9}$ to $5x10^{-4}$ W/m^2	$5x10^{-10}$ to $5x10^{-2}$ W/m^2	$4.62x10^{-9}$ to $7.30x10^{-2}$ W/m^2	pass
	Measurement Range XRS B	$2x10^{-8}$ to $2x10^{-3}$ W/m^2	$2x10^{-10}$ to $1x10^{-2}$ W/m^2	$6.13x10^{-9}$ to $4.40x10^{-2}$ W/m^2	pass
2038	Measurement Accuracy XRS A	< 20% at 20X min flux	A1: < 2.5% (BOL) A2: < 2.2% (BOL)	Not measured on orbit.	pass
	Measurement Accuracy XRS B	< 20% at 20X min flux	B1: < 2.4% (BOL) B2: < 2.3% (BOL)	Not measured on orbit.	pass
2041	Measurement Precision XRS A	2%	1.5%	0.69%	pass
	Measurement Precision XRS B	2%		0.23%	pass
2042	Long-term Stability (over mission)	< ±5% or ability to track	Track changes. Estimated response change is <3% over life of mission	Current trend is flat. Ability to track.	pass

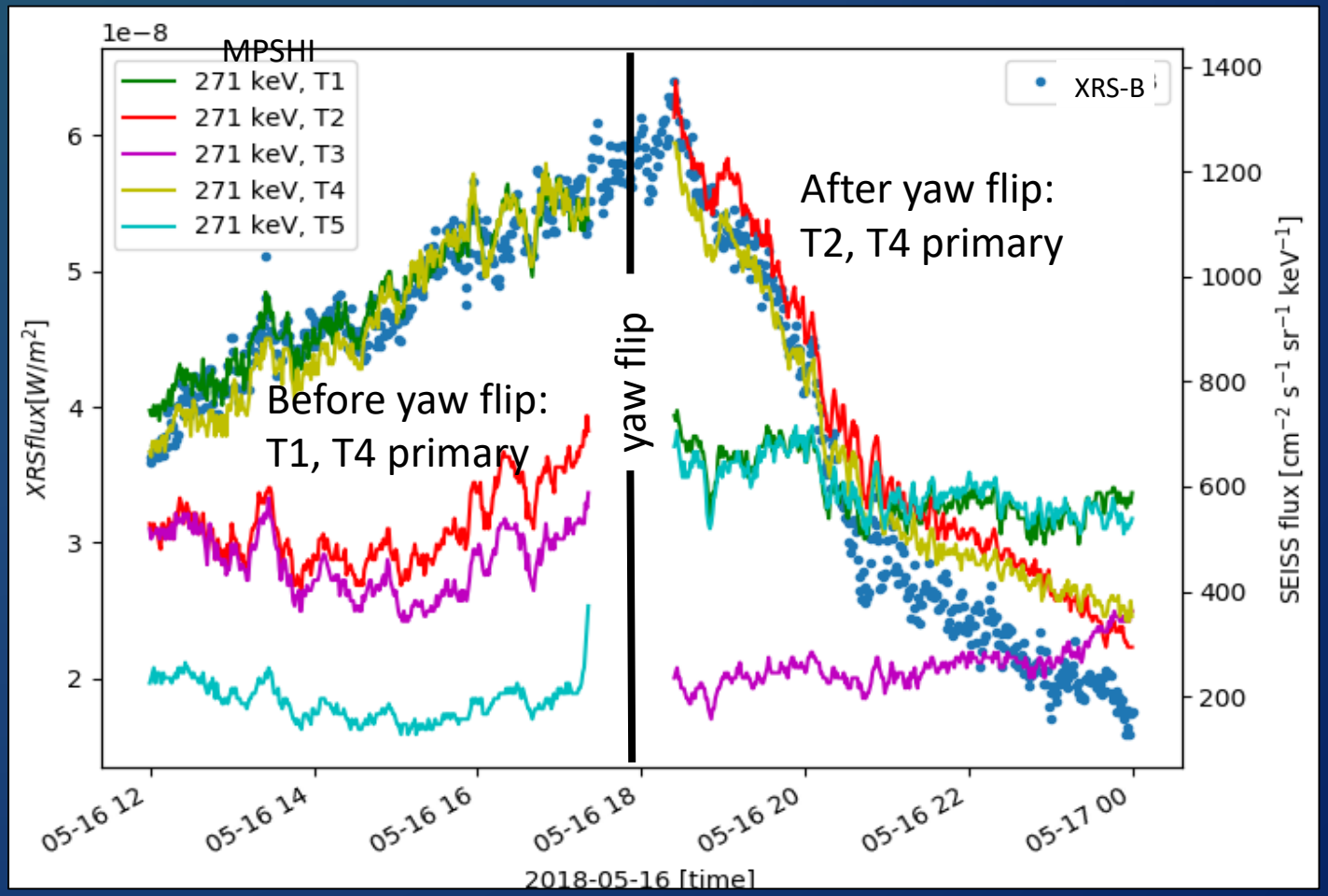
Remaining Instrument Issues

#	Issue	Description	Comments to Users
1	XRS-A is larger for GOES-R than for GOES-NOP.	XRS-A: GOES-R/GOES-15 ≈ 1.41	The source of this discrepancy is unknown and is under investigation.
2	Dark radiation coefficients are set to 0	The L1b dark radiation coefficient is used to correct the signal for proton contamination during SEP events. It is currently not being applied.	Analysis to determine this term is in progress. Signals will be artificially high during SEP events, especially in the A2 and B2 channels. [Slide 39]
3	Dark counts	Improve dark counts with values from periods of lowest electron fluxes. Applies to all channels except B1.	Impact will be to slightly increase fluxes, but this will only be noticeable for the lowest XRS-A fluxes. (LUTs to be submitted in September 2020. More of an issue for GOES-16).
4	Electron contamination fit coefficients.	L2 electron contamination correction uses parameters based on SEISS MPSHI differential electron fluxes.	The final coefficients are still being determined. [Slides 28 and 29]
5	Flare location algorithm	L2 algorithm needs further analysis.	Product should be released soon from revised algorithm code. [Slides 16 -20]

Electron Contamination Correction (1/2)

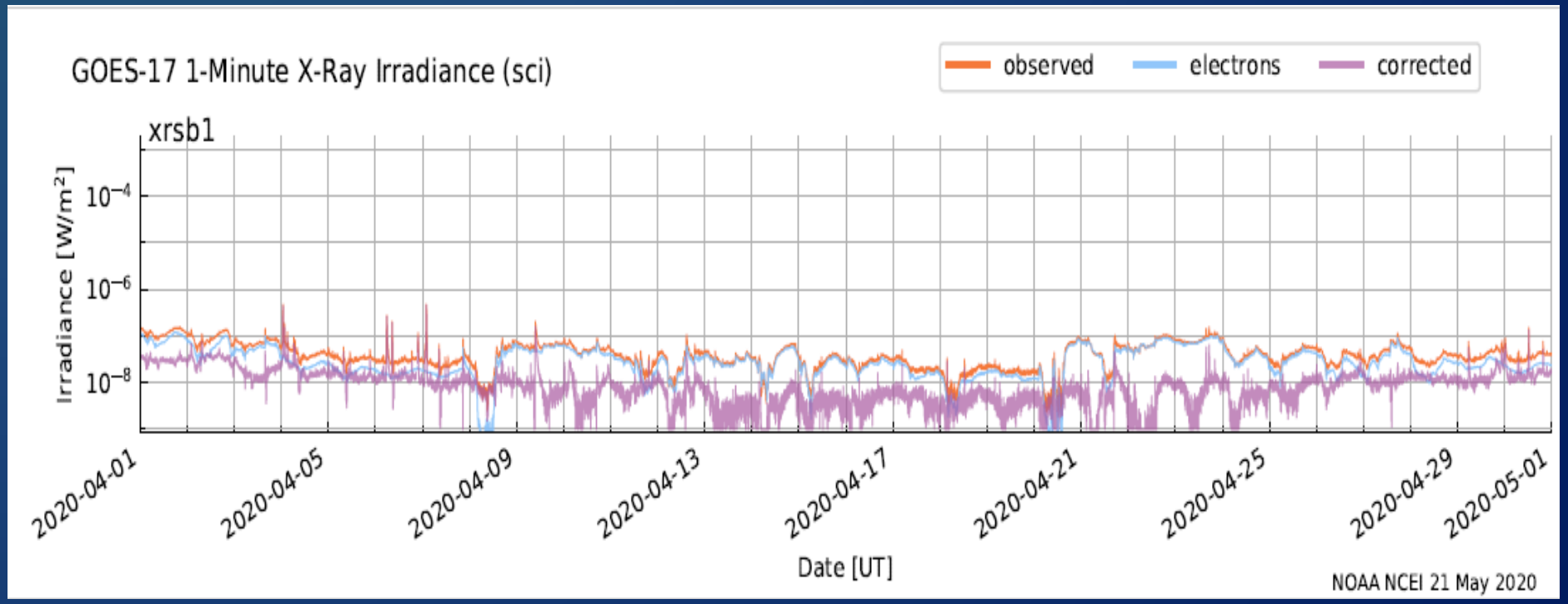
Objective: Remove electron contamination from fluxes

- Data impacts when X-ray fluxes are low, e^- fluxes are high



Electron Contamination Correction (2/2)

- Correction is implemented in L2 data.
- Based on fit to SEISS MPSHI differential electron flux
  - uses 5 telescopes and 7 energy bands.
- With more data, fit parameters are being refined.



OTHER UPDATES

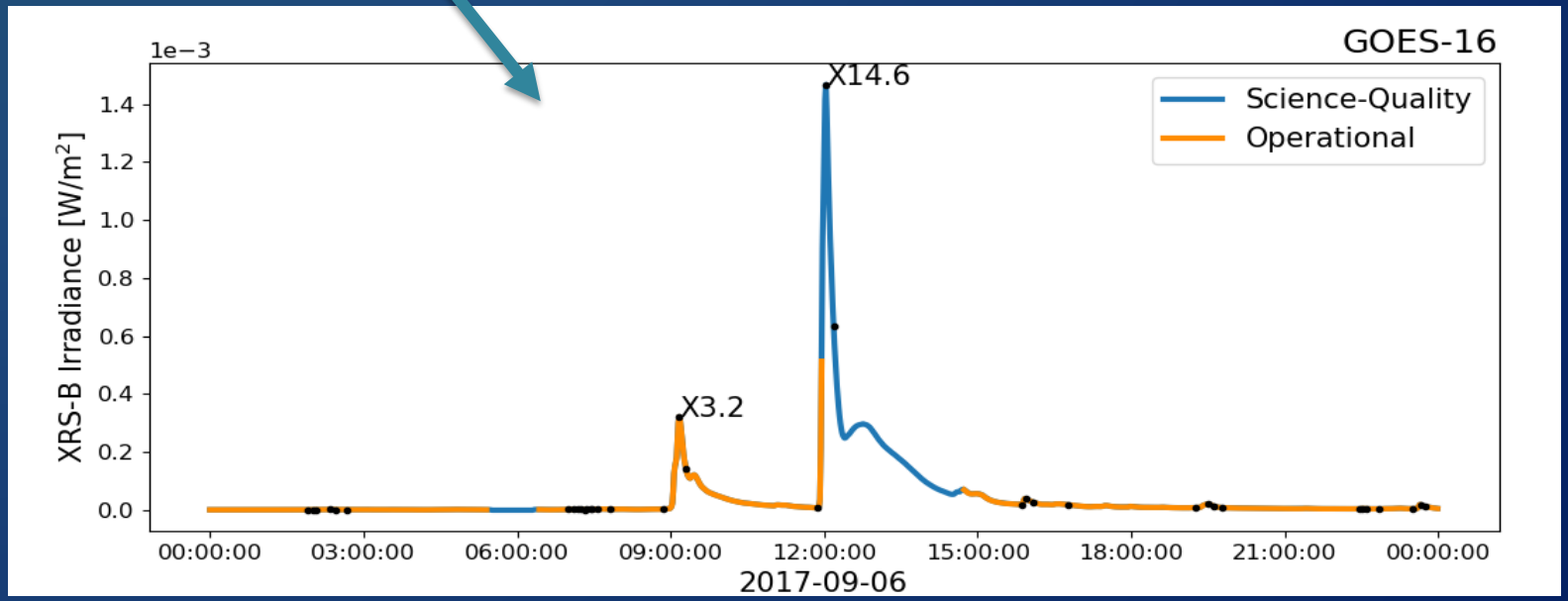
XRS Science-Quality L1b and L2 Data

GOES-16,-17

- Reprocessed daily files from L0 (uses codes from LASP and NCEI)
- Uses latest LUTs and fixes back to start of mission
- Production lags ops by several days – fills data gaps

GOES 13-15

- Revised on-orbit calibrations and quality flags
- Same format as GOES-R
- Used for validation.



plot from C. Peck

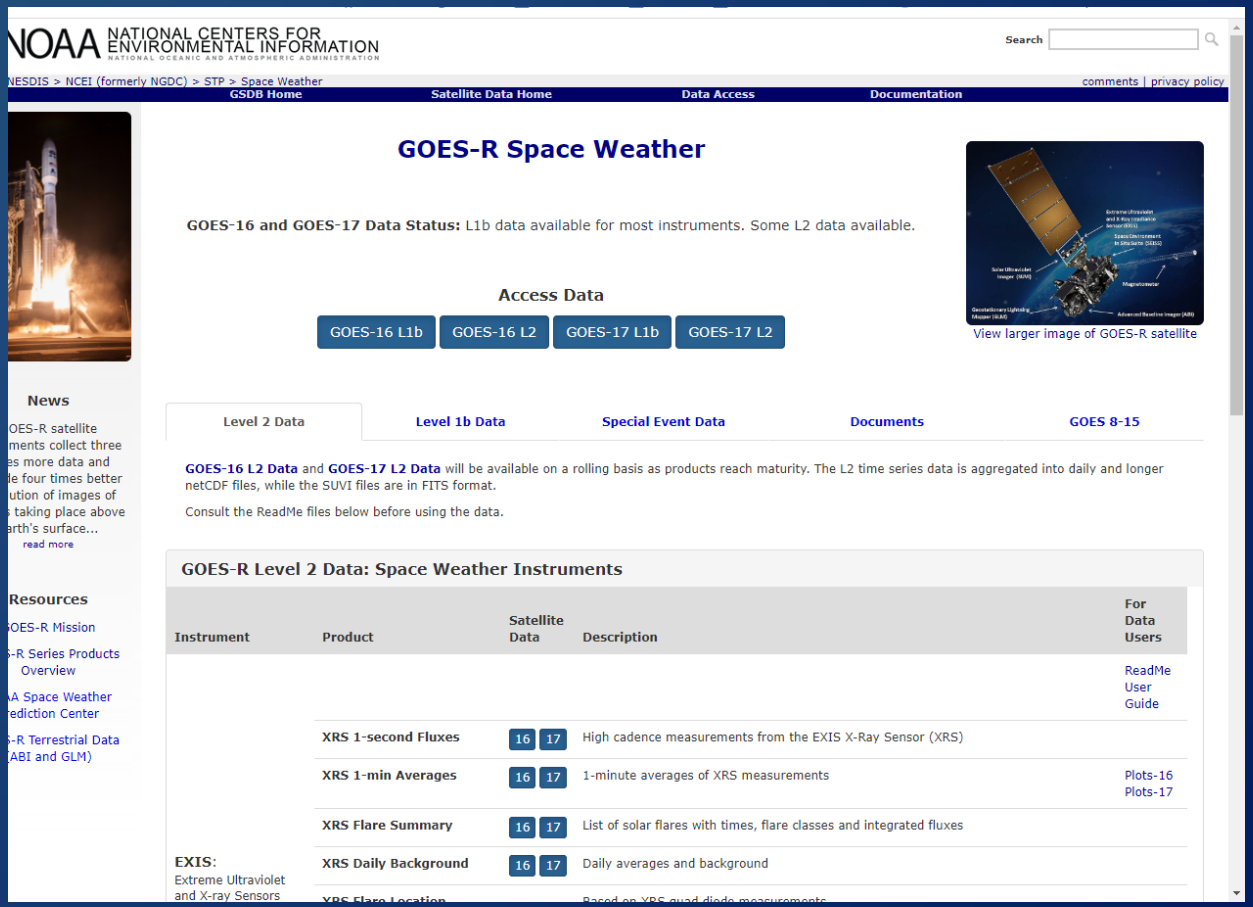
XRS Data at NCEI-CO Portal

NCEI GOES-R Web Portal https://www.ngdc.noaa.gov/stp/satellite/goes-r.html

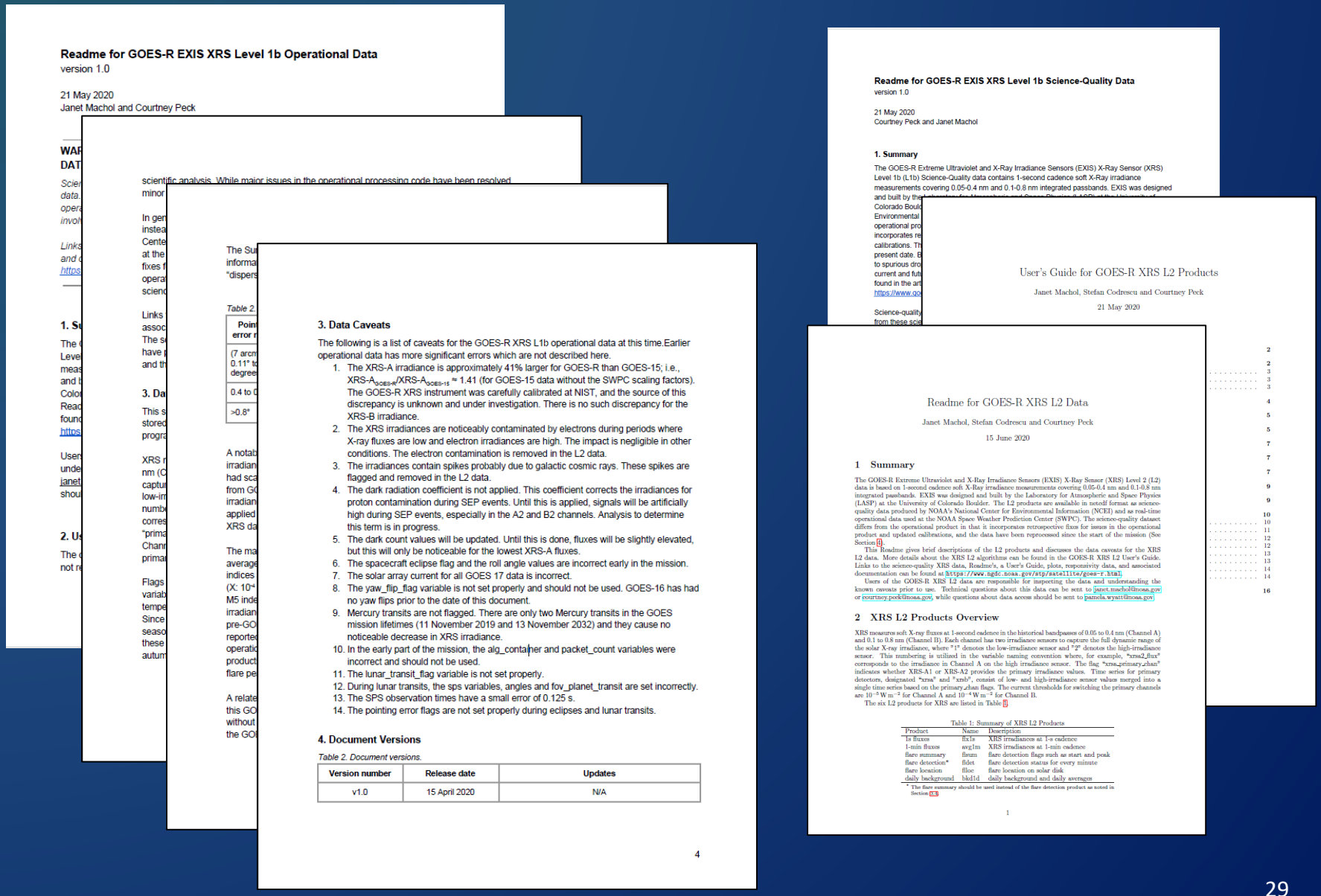
- Operational and science-quality L1b and L2 data
- Documents
- Plots

Data releases announced in solar newsletters and to mailing list of ~100 people.

SWPC provides JSON files of L2 data with <2-min latency. (Not releasing netcdf to match NCEI)



XRS L1b Documentation



Readme for GOES-R EXIS XRS Level 1b Operational Data
version 1.0

21 May 2020
Janet Machol and Courtney Peck

Readme for GOES-R EXIS XRS Level 1b Science-Quality Data
version 1.0

21 May 2020
Courtney Peck and Janet Machol

1. Summary

The GOES-R Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS) X-Ray Sensor (XRS) Level 1b (L1b) Science-Quality data contains 1-second cadence soft X-Ray irradiance measurements covering 0.05-0.4 nm and 0.1-0.8 nm integrated passbands. EXIS was designed and built by the

User's Guide for GOES-R XRS L2 Products

Janet Machol, Stefan Codrescu and Courtney Peck

21 May 2020

Readme for GOES-R XRS L2 Data

Janet Machol, Stefan Codrescu and Courtney Peck

15 June 2020

1 Summary

The GOES-R Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS) X-Ray Sensor (XRS) Level 2 (L2) data is based on 1-second cadence soft X-Ray irradiance measurements covering 0.05-0.4 nm and 0.1-0.8 nm integrated passbands. EXIS was designed and built by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado Boulder. The L2 products are available in netcdf format as science-quality data produced by NOAA's National Center for Environmental Information (NCEI) and as real-time operational data used at the NOAA Space Weather Prediction Center (SWPC). The science-quality dataset differs from the operational product in that it incorporates retrospective fixes for issues in the operational product and updated calibrations, and the data have been reprocessed since the start of the mission (See Section 6).

This Readme gives brief descriptions of the L2 products and discusses the data caveats for the XRS L2 data. More details about the XRS L2 algorithms can be found in the GOES-R XRS L2 User's Guide. Links to the science-quality XRS data, Readme's, a User's Guide, plots, responsivity data, and associated documentation can be found at https://www.ngdc.noaa.gov/stp/satellite/goes-r.html.

Users of the GOES-R XRS L2 data are responsible for inspecting the data and understanding the known caveats prior to use. Technical questions about this data can be sent to janet.machol@noaa.gov or courtney.peck@noaa.gov, while questions about data access should be sent to pamela.wyatt@noaa.gov.

2 XRS L2 Products Overview

XRS measures soft X-ray fluxes at 1-second cadence in the historical bandpasses of 0.05 to 0.4 nm (Channel A) and 0.1 to 0.8 nm (Channel B). Each channel has two irradiance sensors to capture the full dynamic range of the solar X-ray irradiance, where "1" denotes the low-irradiance sensor and "2" denotes the high-irradiance sensor. This numbering is utilized in the variable naming convention where, for example, "xrsa2_flux" corresponds to the irradiance in Channel A on the high irradiance sensor. The flag "xrsa_primary_chan" indicates whether XRS-A1 or XRS-A2 provides the primary irradiance values. Time series for primary detectors, designated "xrsa" and "xrsb", consist of low- and high-irradiance sensor values merged into a single time series based on the primary_chan flags. The current thresholds for switching the primary channels are 10^{-5} W m^{-2} for Channel A and 10^{-4} W m^{-2} for Channel B.

The six L2 products for XRS are listed in Table 1.

Table 1: Summary of XRS L2 Products

Product	Name	Description
1s fluxes	flx1s	XRS irradiances at 1-s cadence
1-min fluxes	avg1m	XRS irradiances at 1-min cadence
flare summary	flsum	flare detection flags such as start and peak
flare detection*	fldet	flare detection status for every minute
flare location	floc	flare location on solar disk
daily background	bkd1d	daily background and daily averages

* The flare summary should be used instead of the flare detection product as noted in Section 6.3.

1

3. Data Caveats

The following is a list of caveats for the GOES-R XRS L1b operational data at this time.Earlier operational data has more significant errors which are not described here.

1. The XRS-A irradiance is approximately 41% larger for GOES-R than GOES-15; i.e., XRS-$A_{GOES\text{-}R}$/XRS-$A_{GOES\text{-}15}$ ≈ 1.41 (for GOES-15 data without the SWPC scaling factors). The GOES-R XRS instrument was carefully calibrated at NIST, and the source of this discrepancy is unknown and under investigation. There is no such discrepancy for the XRS-B irradiance.
2. The XRS irradiances are noticeably contaminated by electrons during periods where X-ray fluxes are low and electron irradiances are high. The impact is negligible in other conditions. The electron contamination is removed in the L2 data.
3. The irradiances contain spikes probably due to galactic cosmic rays. These spikes are flagged and removed in the L2 data.
4. The dark radiation coefficient is not applied. This coefficient corrects the irradiances for proton contamination during SEP events. Until this is applied, signals will be artificially high during SEP events, especially in the A2 and B2 channels. Analysis to determine this term is in progress.
5. The dark count values will be updated. Until this is done, fluxes will be slightly elevated, but this will only be noticeable for the lowest XRS-A fluxes.
6. The spacecraft eclipse flag and the roll angle values are incorrect early in the mission.
7. The solar array current for all GOES 17 data is incorrect.
8. The yaw_flip_flag variable is not set properly and should not be used. GOES-16 has had no yaw flips prior to the date of this document.
9. Mercury transits are not flagged. There are only two Mercury transits in the GOES mission lifetimes (11 November 2019 and 13 November 2032) and they cause no noticeable decrease in XRS irradiance.
10. In the early part of the mission, the alg_container and packet_count variables were incorrect and should not be used.
11. The lunar_transit_flag variable is not set properly.
12. During lunar transits, the sps variables, angles and fov_planet_transit are set incorrectly.
13. The SPS observation times have a small error of 0.125 s.
14. The pointing error flags are not set properly during eclipses and lunar transits.

4. Document Versions

Table 2. Document versions.

Version number	Release date	Updates
v1.0	15 April 2020	N/A

4

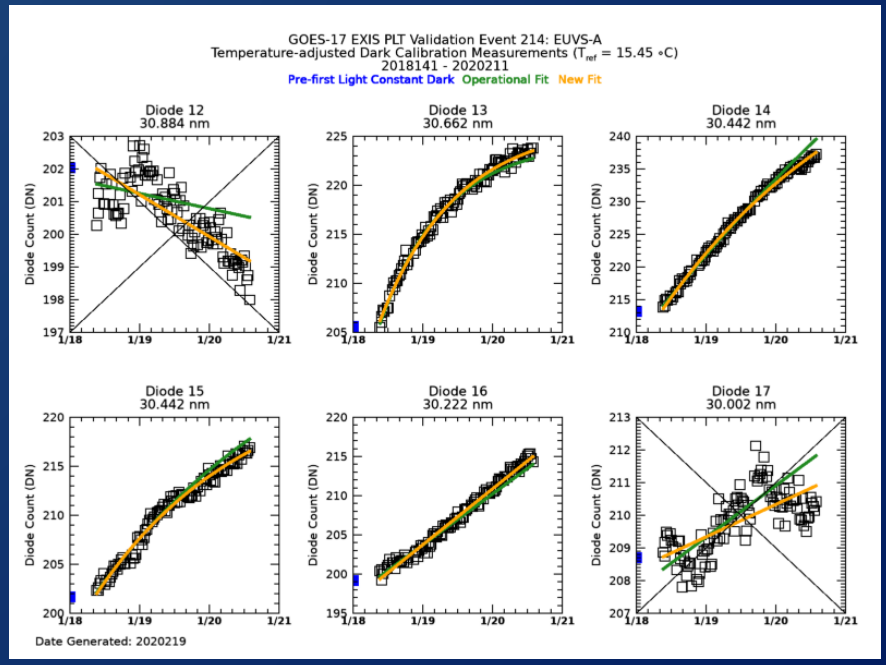
EXIS Calibration Tools and LUT Deliveries

Software for On-Orbit EXIS Calibrations

- LASP provided tools and training to NCEI in spring
- Implemented at NCEI with some upgrades

GOES-16 and -17 LUT deliveries by NCEI

- NCEI analysis: 3 calibration codes x 2 sats x (1 or 2) channels x 24 diodes
- Verified results with LASP
- Will submit LUTs shortly
  - In OE on September 2
  - Will fix low EUVS alarms



Example calibration: dark drift correction for 6 of the 24 EUVS-A diodes.

FULL MATURITY ASSESSMENT

Full Validation
Definition and Prior Activities

Preparation Activities	Assessment
Validation, quality assessment, and anomaly resolution activities are ongoing.	Validation activities are ongoing. Results have been discussed with SWPC. Release of data by NCEI has enabled research community participation.
Incremental product improvements may still be occurring.	Product improvements will result from the resolution to issues given on the slides titled "GPA Issues" and "Remaining Instrument Issues"
Users are engaged and user feedback is assessed.	Discussions with SWPC and the science community are ongoing.

Full Validation Assessment

Status after Full Validation

End State	Assessment
Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground truth and validation efforts.	XRS flux measurements from GOES-15, -16 and -17 have been inter-compared. Instrument was calibrated at NIST. Products are documented in Readmes and User Guides.
Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.	Except as described on the slide titled "Remaining Instrument Issues“, the products are operationally optimized. Regular monitoring, on-orbit calibrations and LUT updates will maintain this optimization.
All known product *anomalies are documented and shared* with the user community.	Anomalies are listed in the caveats section in the L1b Readmes at the NCEI GOES-R web site.
Product is operational.	GOES-16 XRS L1b available real-time for operations. L2 products operational at SWPC: 1-s fluxes, 1 minute averages, flare detection, flare summary, daily background L2 product to be operational soon: flare location GOES-17 XRS Available operationally soon at SWPC.

Next Steps for XRS

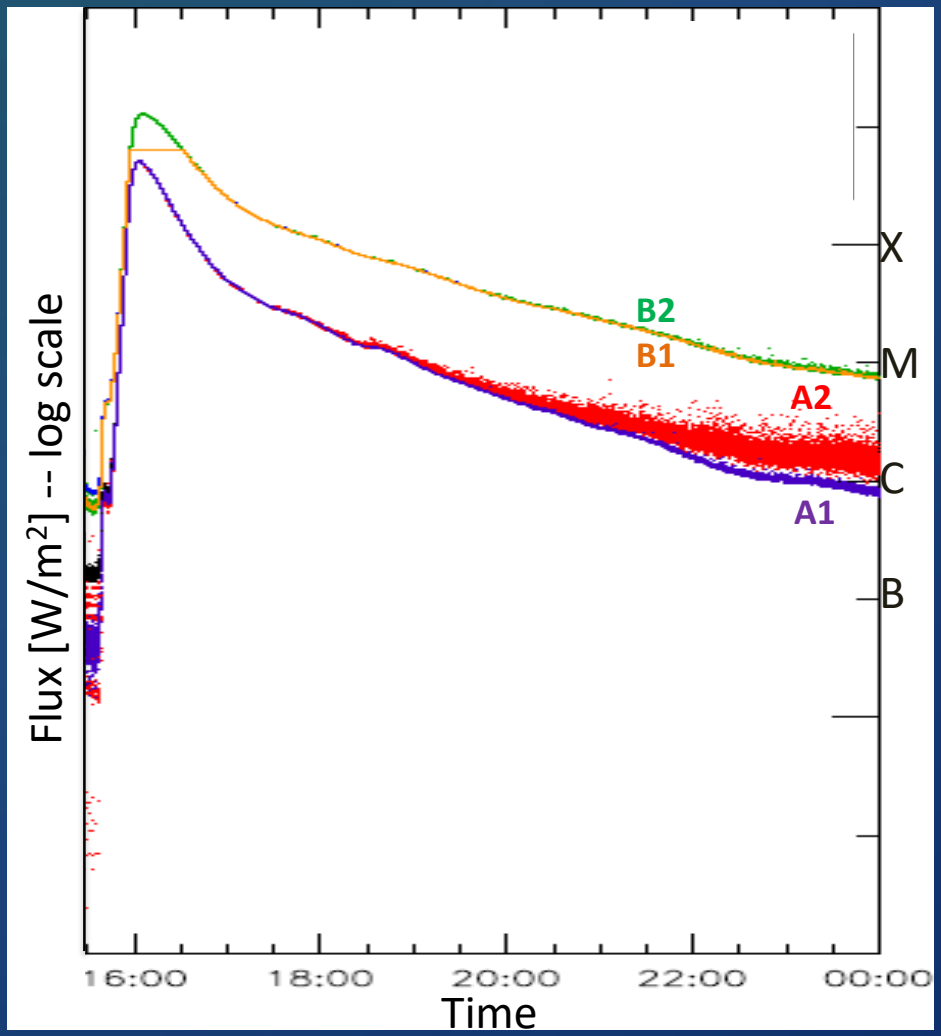
- Continue analysis of instrument issues [Slide 27]
  - Produce updated electron contamination correction.
  - Produce flare location product. (PLPT 13)
  - Need X-class flare and SEP events for some tests.
- Calibrations
  - Further work on calibration tools.
  - Analyze daily, weekly and quarterly calibrations.
  - Provide updated calibration tables.
    - LUTs for EUVS-A and –B submitted yesterday (ADRs 1115, 1116)
    - Further LUT updates to be submitted early September (XRS, EUVS-B)
    - LUT updates after each eclipse season and at other times
  - Develop regular monitoring of data
- Verify ADR fixes
  - Current ADRs [Slide 14]
  - ADR 445
    - data outage when XRS-B1 detector saturates
    - code fixed and ADR closed, but not tested operationally, requires large X-class flare

Summary and Recommendations

- All GOES-16 and -17 XRS sensors are performing very well.
- Observed issues are similar for GOES-16 and 17
- Promising paths toward diagnoses and fixes of issues have been identified.
- Fixes for remaining ADRs need to be implemented to provide good data at all times.
- Continued data monitoring and updates to on-orbit LUTs are required. New LUTs will be implemented in the coming weeks.
- Further algorithm review will be required after large SEP events.

BACKUP SLIDES

Instrument Issue: Dark Radiation Coefficients



Signal is higher in A2 than A1 in SEP event.

CDRL 80 flux equation has a correction terms to account for SEPs; e.g.:

$C_{rad,\ A1} = k_{A1} \langle C_{Dark,\ rad} \rangle$

Need to determine k_i

EXIS Calibrations

- Nominal Weekly - 90 s comparison with secondary
  - EUVS - A, -B — Measure and trend darks and gain.
  - EUVS-A — Measure and trend primary filter changes.
  - EUVS - A, -B, -C — Measure and trend flatfield.
  - EUVS -C — Measure and trend primary channel offset.
- Quarterly cruciform
  - XRS, EUVS-A, -B, -C — Measure and trend FOV map
  - XRS, SPS — Measure and trend internal gain, dark
- Quarterly other
  - XRS, EUVS-A, -B — Measure radiation k factors
  - SPS — Check for radiation sensitivity
  - EUVS-C — Check radiation filtering, Mg II scaling.
  - XRS — Find cross-over thresholds for A1-A2 and B1-B2. Check impact on ratios.
  - XRS — Determine NOAA scaling, L1b uncertainties.
  - EUVS — L1b model baseline and uncertainties.
  - EUVS — Check for bootstrap relationships and degradations.
- Longterm comparisons
  - XRS — Compare flare locations from XRS and SUVI
  - XRS, EUVS — Compare measurements with other satellites

XRS LUTs

XRS_Cal_INR(xxx)-xxx.h5

SPS_Cal_INR(xxx)-xxx.h5

Yearly_1AU_Correction_Table(20xx)-xxx.h5