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

GOES-18 EXIS XRS

L1b Provisional Maturity

presented: 17 November 2022

Presenter: Janet Machol - NOAA NCEI and U. Colorado CIRES

Contributors:

U. of Colorado LASP	Tom Eden, Don Woodraska, Frank Eparvier, Andrew Jones, Tyler Redick, Tom Woods, ...
NCEI/CIRES	Courtney Peck, Jamie Mothersbaugh, Ann Marie Mahon, Kevin Hallock, Stefan Codrescu, Laurel Rachmeler, ...
Other	Brooke Kotten, Jon Fulbright, Matt Garhart, Rodney Viereck, ...

Outline

Quick Summary

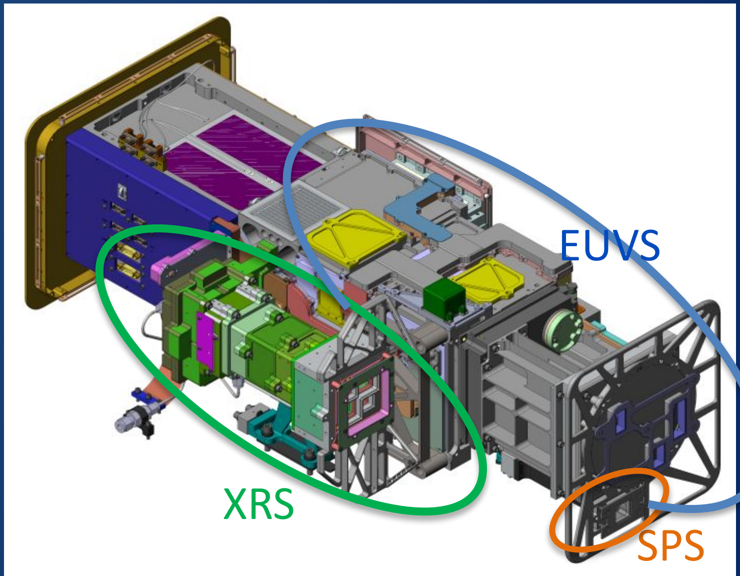
- Three types of data in presentation
  - operational L1b: NCEI-aggregated, GS-processed L1b
  - LASP-L0-processed: same calibration factors as L1b
  - operational L2: NCEI-processed and aggregated from operational L1b
- GOES-18 L1b good data: CDRL 79 Rev B LUTs
  - L1b data Rev B start date: July 15
  - bad data when reverted to Rev A: July 29 - Aug 9
  - L0 data missing: Sept 19 22:39 to Sept 23 16:38
- Cal values obtained via initial testing by LASP using L0 data
- GOES-18 behavior is similar to GOES-16 and -17. No surprises.
- Solar activity relatively high since launch: 1 X-class flare in Oct.
- GPA: 6 open ADRs, no GOES-18 specific issues
- All PLPT tests: PASSED
- Provisional Validation Product Maturity Assessment. PASSED

ADR = Algorithm Discrepancy Report
LUT = Look Up Table

EXIS

EUV and X-Ray Irradiance Sensors (EXIS)

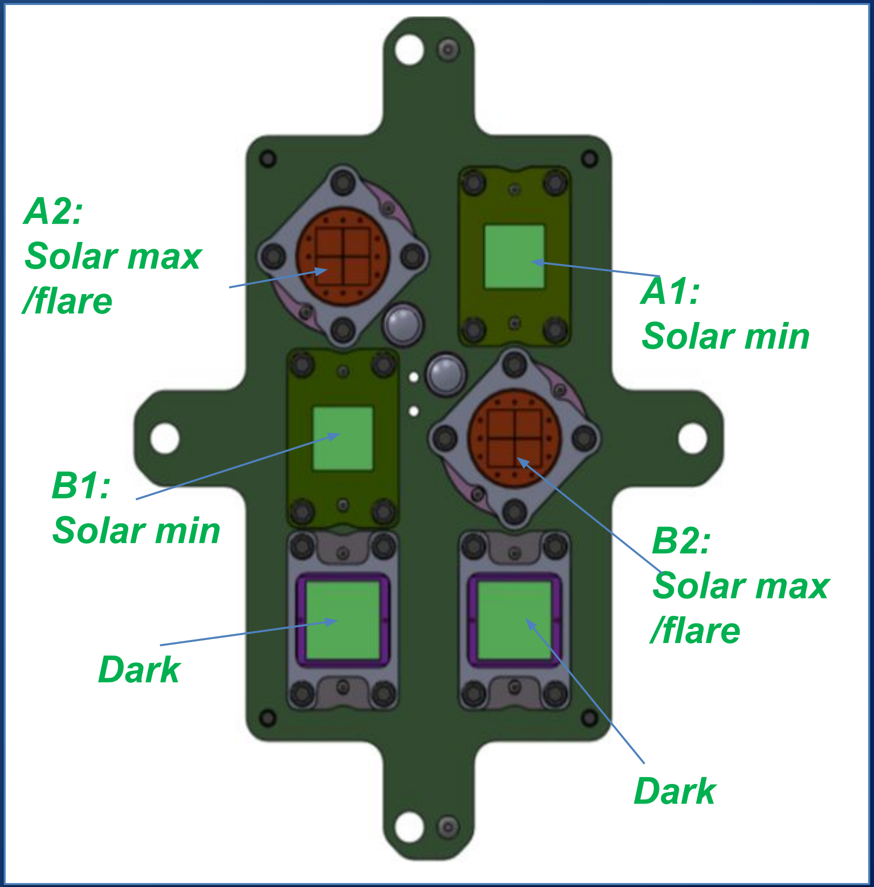
- X-Ray Sensor (XRS)
  - Monitor solar flares
    - Impacts communications and navigation
    - Warns of potential SEP events
- Extreme Ultraviolet Sensor (EUVS)
  - Measures ultraviolet irradiance which impacts upper atmosphere
- Sun Pointing Sensor (SPS)
  - Used for alignment (quad diode, 3.5° FOV)



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
  - A1, B1 - low solar activity
  - A2, B2 - solar max/flare
  - 2 dark diodes
  - Silicon photodiodes with Be filters
- L2 Products
  - 1-sec, 1-min averaged flux time series
  - flare event detection
  - flare location on the solar disk
  - daily background



SWPC 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)

L1B PRODUCT QUALITY ASSESSMENT

GPA Issues for Provisional Validation

- No current issues *impacting Provisional Validation.*

- 73 XRS-related ADRs have been closed since 2016.
  - Includes updates for routine LUT updates

Post-Launch Product Tests

PLPT tests as defined the EXIS RIMP*

Test ID	Test Title	Operator	Status	Criteria
08	XRS B1-B2 Crossover Threshold	LASP/NCEI	Pass	[1]
09	XRS A1-A2 Crossover Threshold	LASP	Pass	[1]
10	XRS Ratio – Threshold Assessment	LASP	Pass	[1]
11	NOAA XRS Scaling Factors	LASP	Pass	[1]
12	XRS L1b Uncertainties	LASP	Pass	[1]
13	XRS Flare Location Comparison (L1b)	NCEI	Pass	[2]
14	XRS/EUVS/Mg II Inter-Satellite Comparisons (L1b)	LASP/NCEI	Pass	[3]

Provisional Success Criteria:

[1] XRS L1b product data are available and analysis is complete.

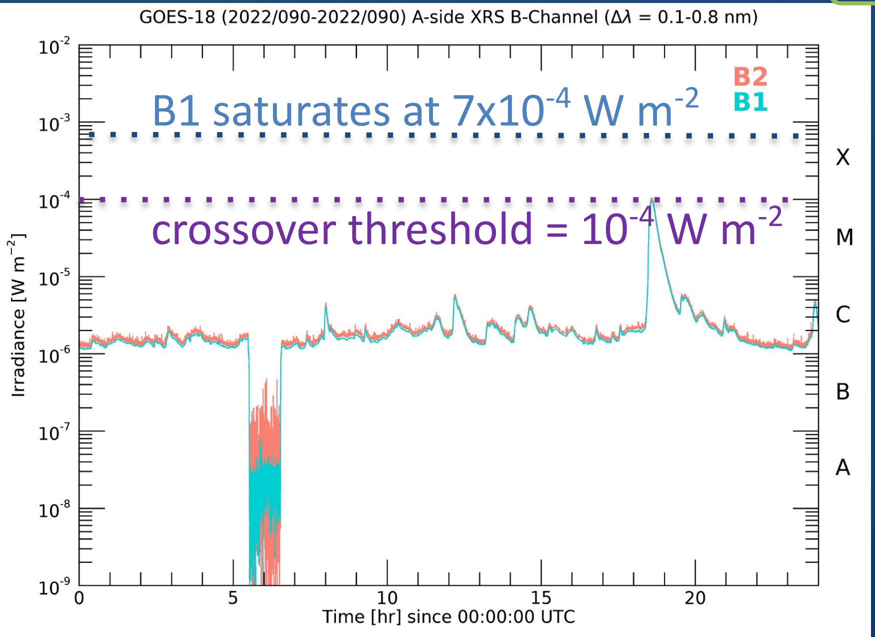
[2] Responses are observed in all 4 elements of the quad-diodes for an M-class flare.

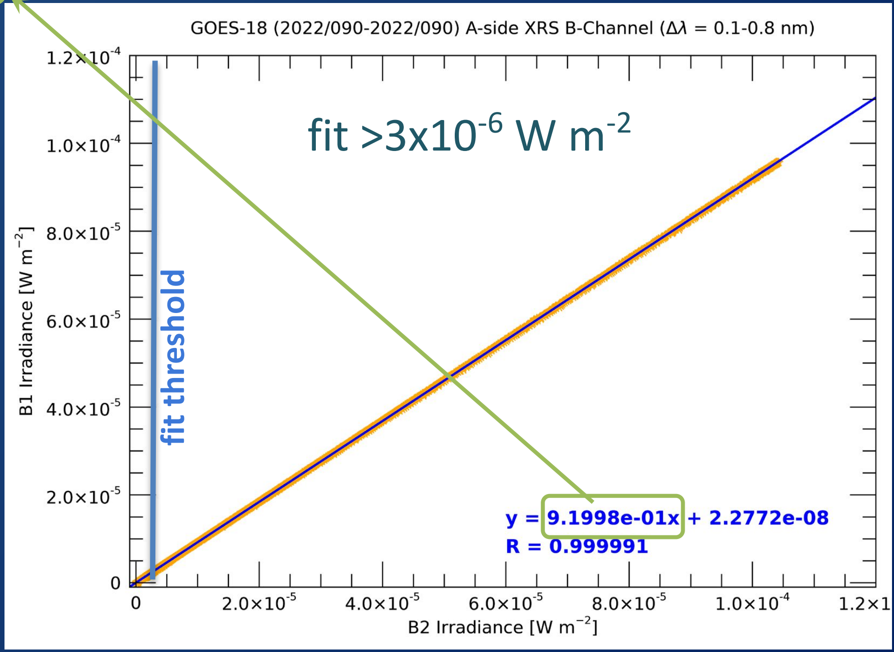
[3] There is no pass/fail on the result itself of this cross-comparison.

*Appendix A.2, pp 26 - 32, EXIS Readiness, Implementation, and Management Plan (RIMP v2; 410-R-RIMP-0316)

#8: XRS B1-B2 Crossover Threshold (1/2)

1. Select flux level for primary channel to switch from B1 to B2.
   - Chose same threshold as for GOES-16, -17: 10^{-4} W/m^2 (X1 class)
2. Scale B2 responsivity so that B1 and B2 fluxes match.
   - Important not to have jumps, for flare detection, etc.
   - B2 responsivity adjusted by 8%





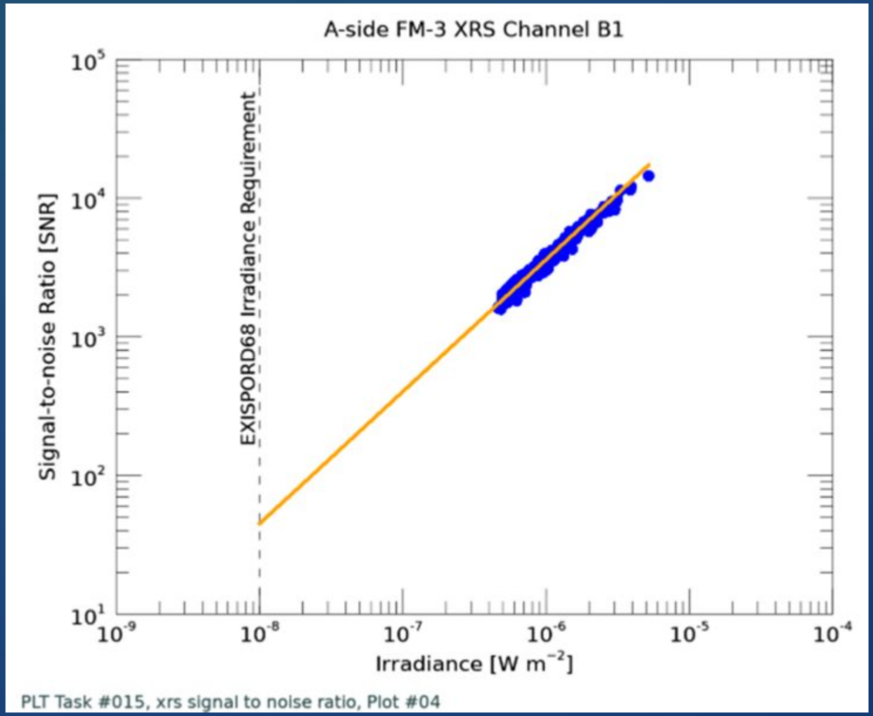
credit: Tom Eden, PLT 12, XRS Interchannel Comparison

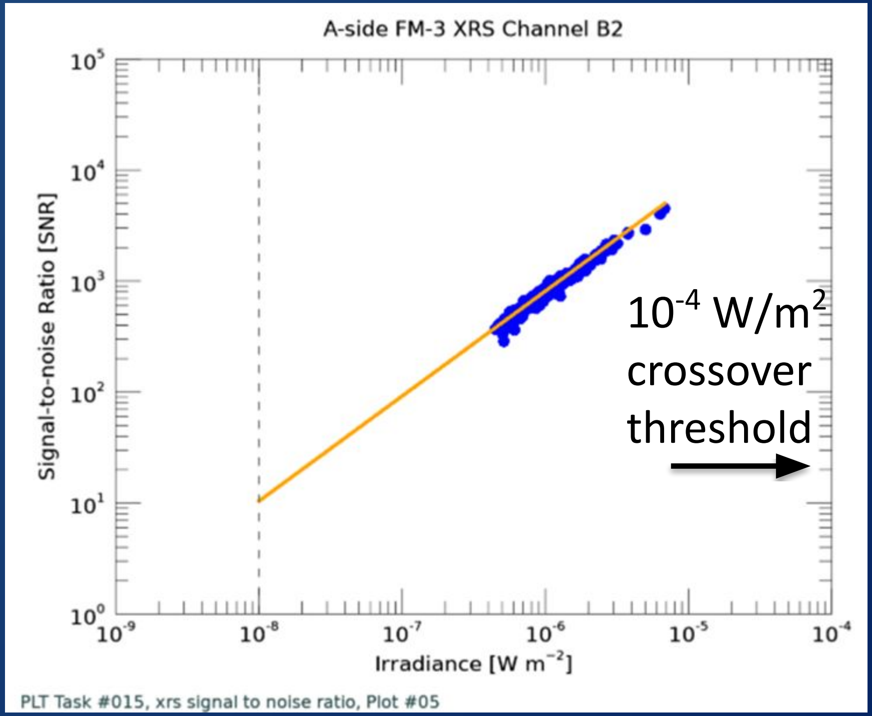
data: LASP-processed L1b

These GOES-18 data are preliminary, non-operational data and are undergoing testing.
Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.

#8: XRS B1-B2 Crossover Threshold (2/2)

3. Verify signal-to-noise ratio (SNR) is >1 relative to PORD requirement
   - SNR >>1 for XRS-B1 and -B2

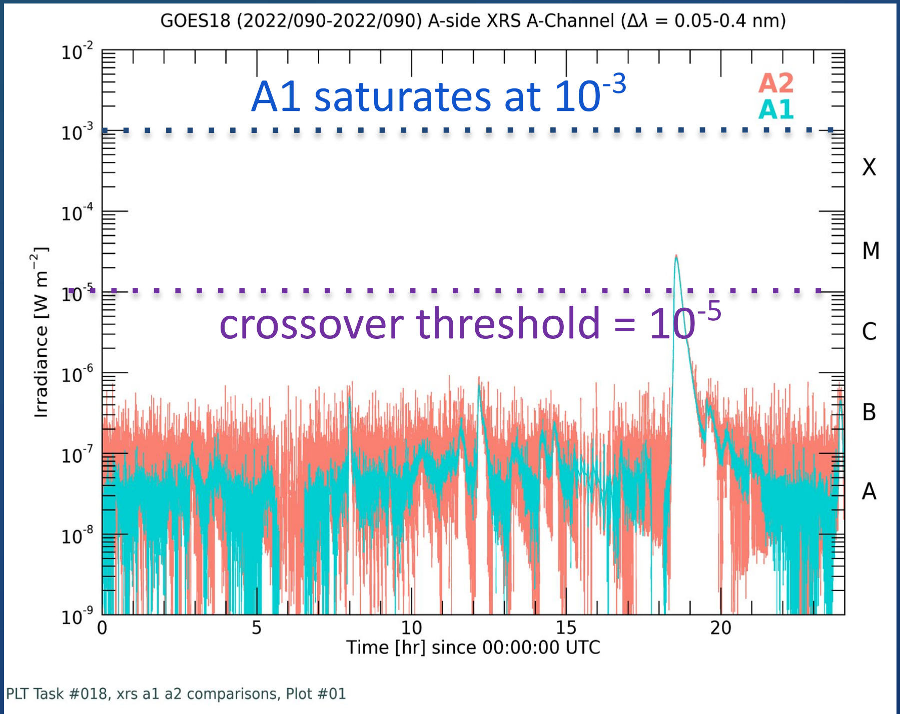


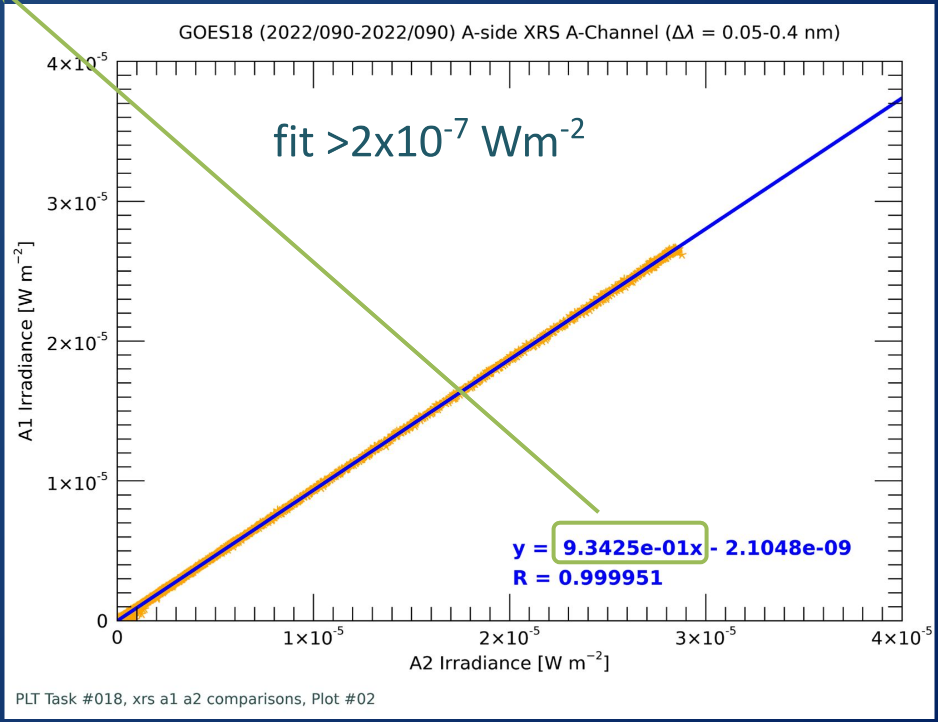


credit: Tom Eden, PLT 12, XRS Interchannel Comparison
data: LASP-processed L1b

#9: XRS A1-A2 Crossover Threshold (1/2)

1. Select flux level for primary channel to switch from A1 to A2.
   - Chose same threshold as for GOES-16, -17: 10^{-5} W/m^2 (corresponds to XRS-B X class flare)
2. Scale A2 responsivity so that A1 and A2 fluxes match.
   - A2 responsivity adjusted by 7%





credit: Tom Eden, PLT 10, XRS Interchannel Comparison
data: LASP-processed L1b

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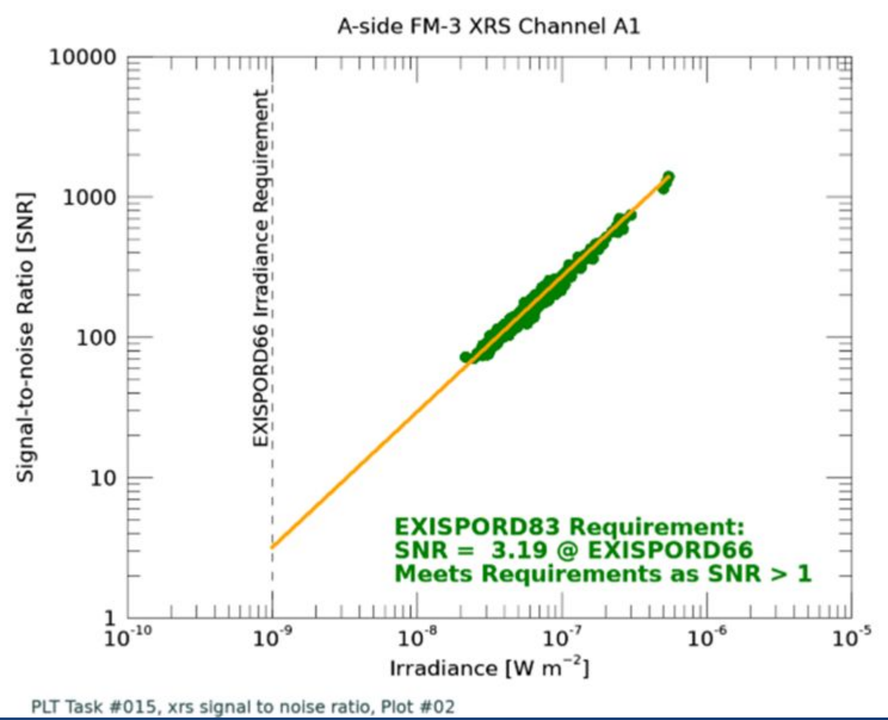
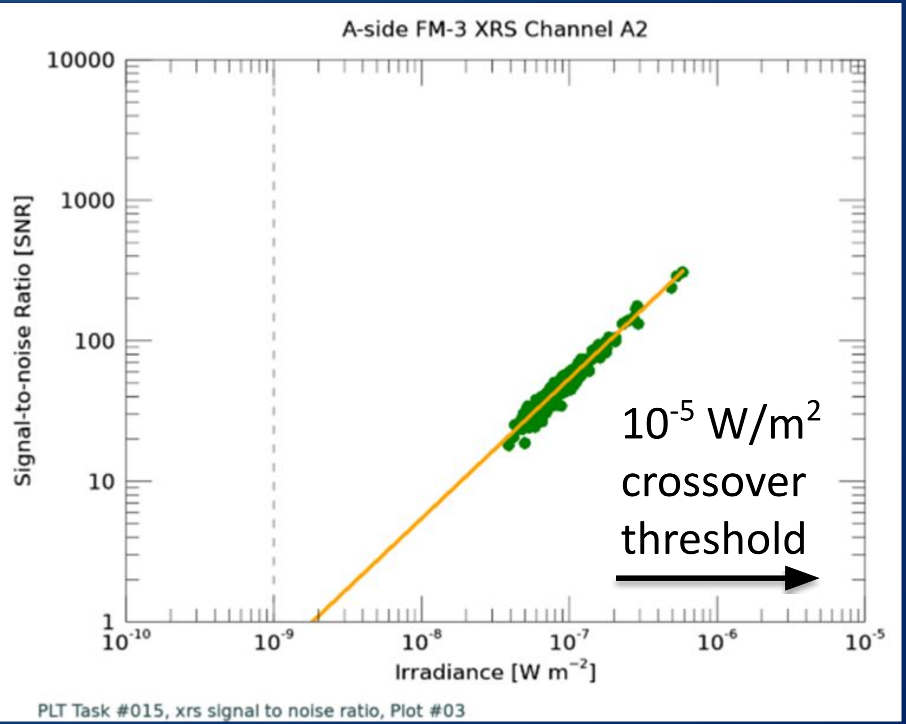
#9: XRS A1-A2 Crossover Threshold (2/2)

3. Verify signal-to-noise ratio (SNR) is >1 relative to PORD requirement
   - SNR >>1 for XRS-A1 and -A2





credit: Tom Eden, PLT 10, XRS Interchannel Comparison
data: LASP-processed L1b

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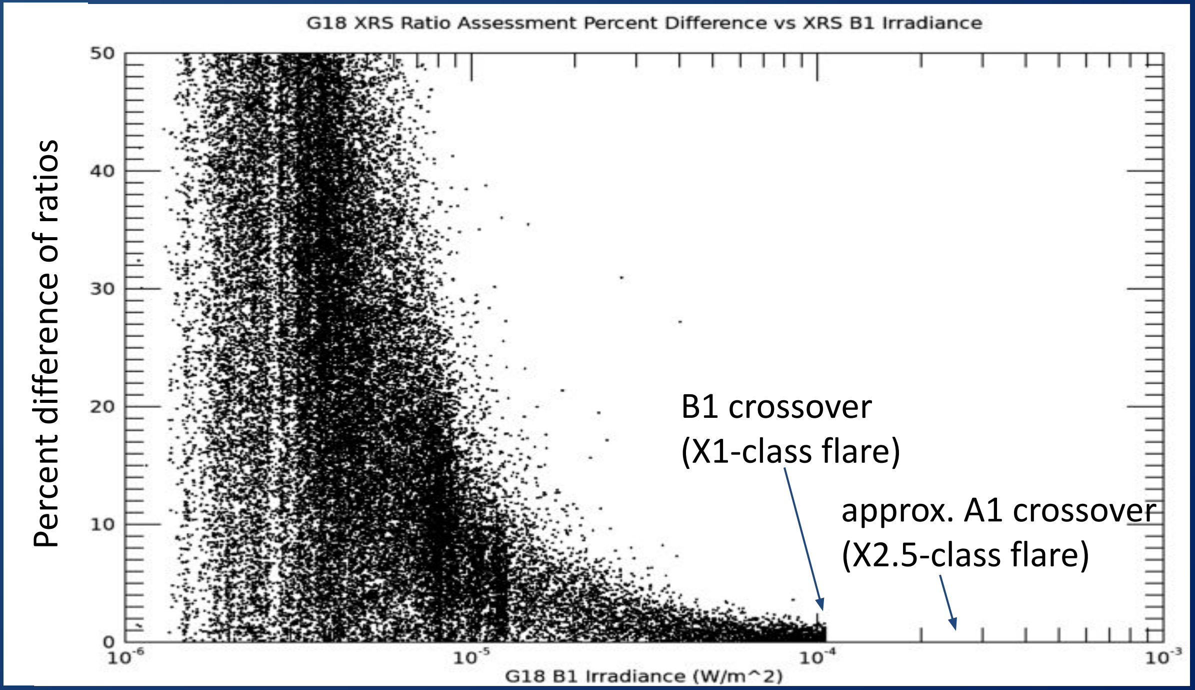
#10: XRS Ratio – Threshold Assessment

- SWPC operations mostly Level 2 1-minute averaged X-ray fluxes -- to define flares to trigger warnings and generation of other products.
  - During a flare, 1-s ratio is used to monitor flare increases. (L2)
- Objective: Find sensitivity of the XRS ratio to the XRS crossover thresholds.
- Plot for 2 Oct 2022 (2022275) with an X1-class flare.
- Result: Ratio is 2% at the B1 crossover and <2% at the A1 crossover.

Percent difference of ratios

$$\frac{A1/B1 - A2/B2}{A1/B1} \cdot 100\ [\%]$$



credit: Don Woodraska
data: LASP-processed L1b

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#12: XRS L1b Uncertainties (1/4)

- **Objective**: Determine the uncertainty in the XRS L1b fluxes.

- Irradiances examined on 3 May 2022 (doy 123).

- Results by flare class: *uncertainty / irradiance*
  - A1: B 9.6%, C 2.5%, M 2.2%
  - B1: **C** 2.6%, M 2.5%, X 2.5%

credit: Tom Eden
data: LASP-processed L1b

#12: XRS L1b Uncertainties (2/4)

Diode Current: $$C = \frac{g(S - S_0)}{\Delta t}$$

g = Diode gain (fC/DN)
S, S_0 = Diode, dark signal (DN)
Δt = Integration time (sec)

Relative uncertainty in current units:

$$\sigma_C = C\left[\left(\frac{\sigma_g}{g}\right)^2 + \left(\frac{\sigma_S}{S - S_0}\right)^2 + \left(\frac{\sigma_{S_0}}{S - S_0}\right)^2 + \left(\frac{\sigma_{\Delta t}}{\Delta t}\right)^2\right]^{1/2}$$

Flux: $$F = \frac{C}{R}$$

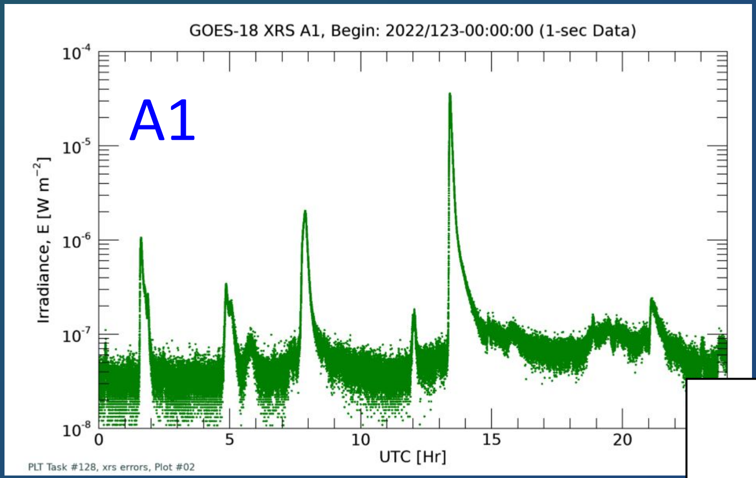
R = Diode Responsivity (A m^2 W^{-1})

Relative uncertainty in flux units:

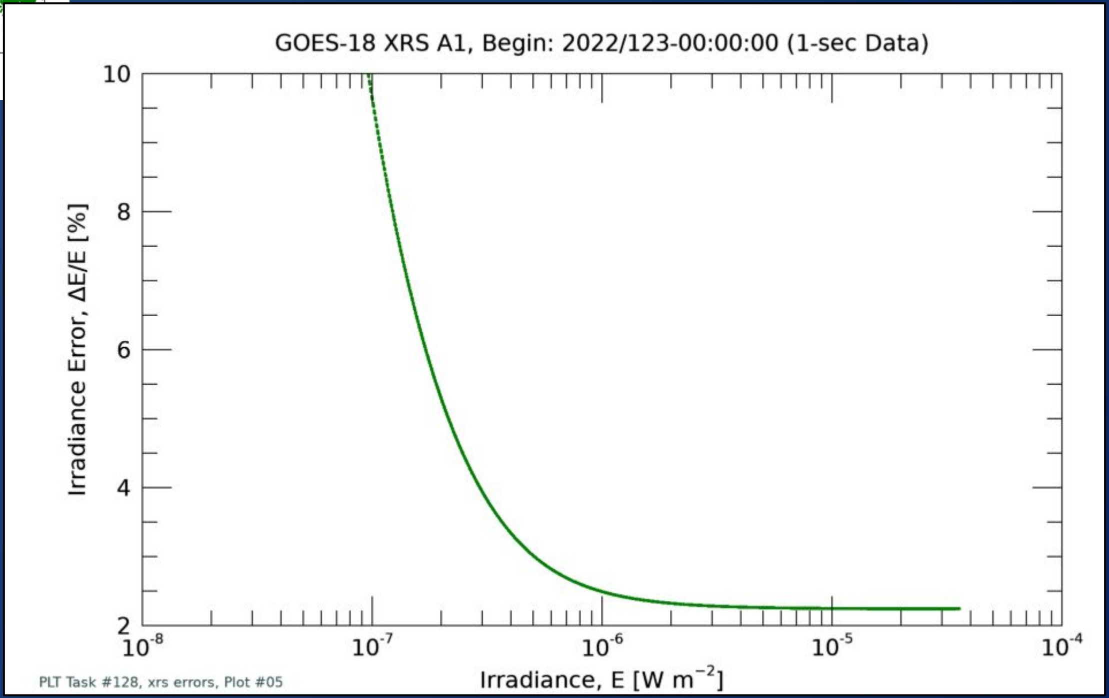
$$\sigma_F = F\left[\left(\frac{\sigma_C}{R}\right)^2 + \left(\frac{C\sigma_R}{R^2}\right)^2\right]^{1/2}$$

Not included: SURF systematic issues, FOV, degradation, ...

#12: XRS-A L1b Uncertainties (3/4)



Flux uncertainty as a function of flux.



credit: Tom Eden
data: LASP-processed L1b

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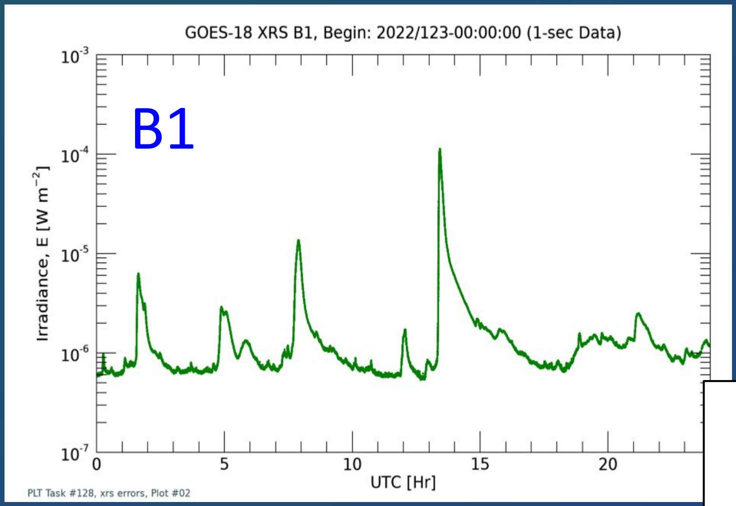
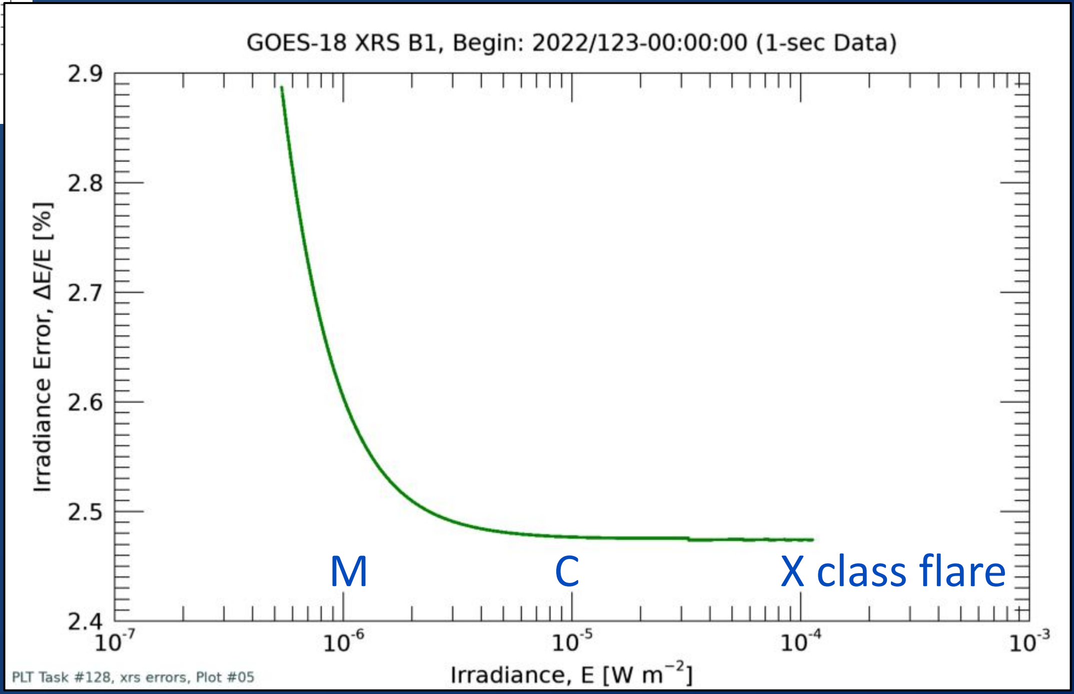
#12: XRS-B1 L1b Uncertainties (4/4)



Flux uncertainty as a function of flux.



credit: Tom Eden
data: LASP-processed L1b

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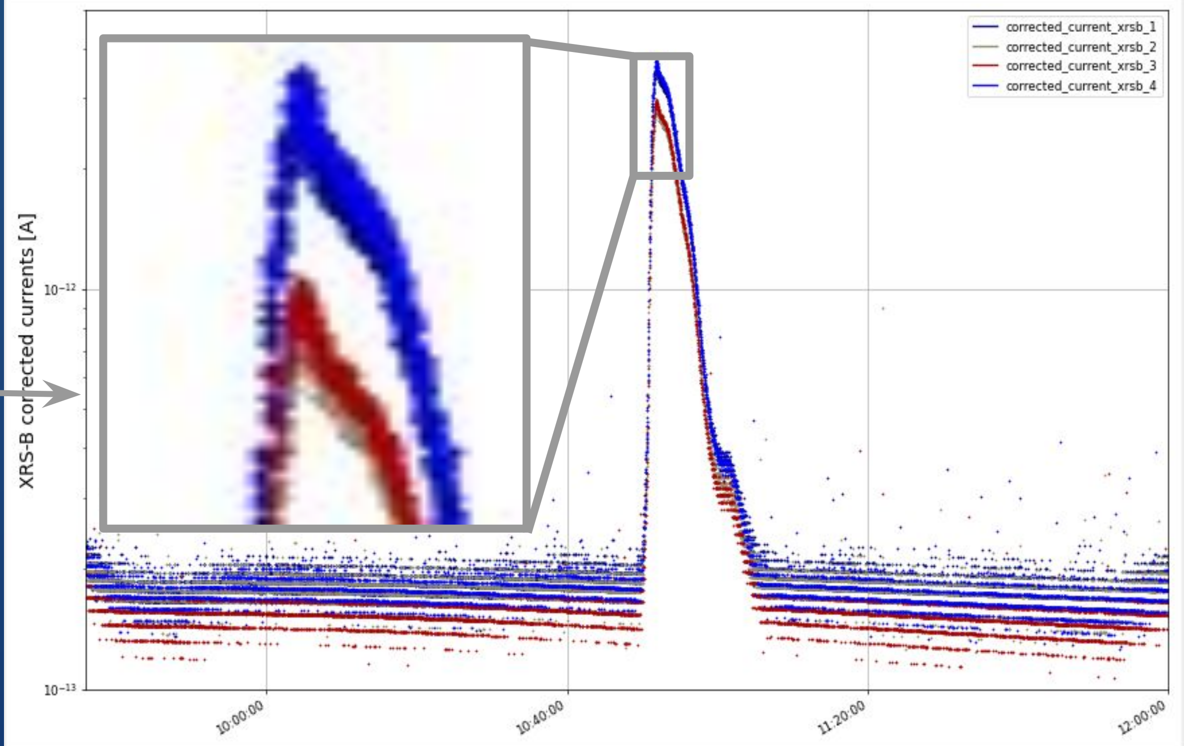
#13: XRS Flare Location Comparison (1/2)

- Objective: Observe solar flare response in all 4 quad-diodes.
- GOES-18 quad diode currents on a 1-sec cadence for 11 October 2022 shows that each diode observes am M-class flare.
- Coefficients for L2 Flare Algorithm have not yet been calculated for GOES-18.

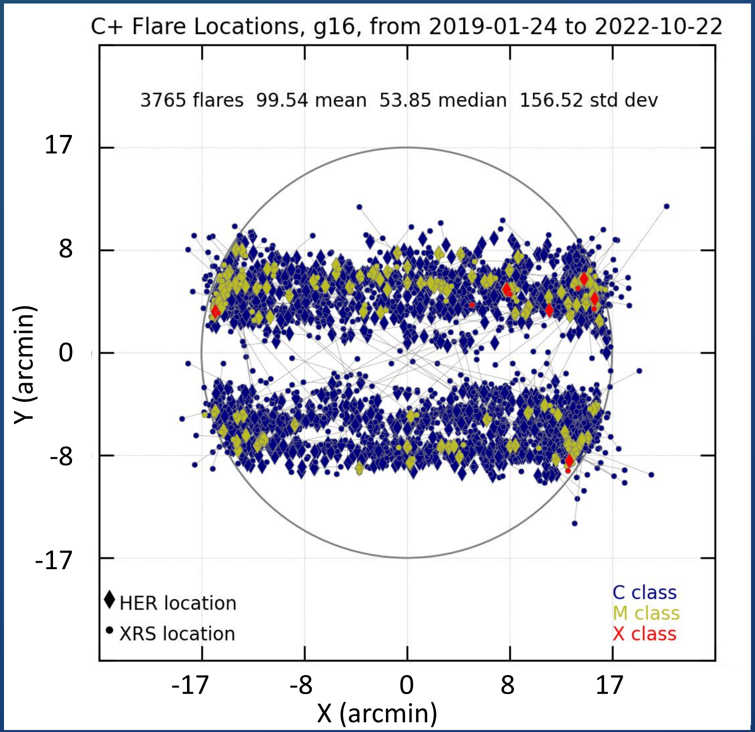
Some diodes measure very similar currents. Zoomed in image shows all 4 colors.



data: operational L1b

#13: XRS Flare Location Comparison (2/2)

- L2 Flare Location algorithm has been improved!
  - NSF Research Experiences for Undergraduates (REU) project
  - Results exceed requirement of <5 arcmin error for X-class flares
  - Revised product for GOES-16 and -17 to be released shortly
  - Further improvements in work



Statistics for GOES-16 Flare Location Algorithm*

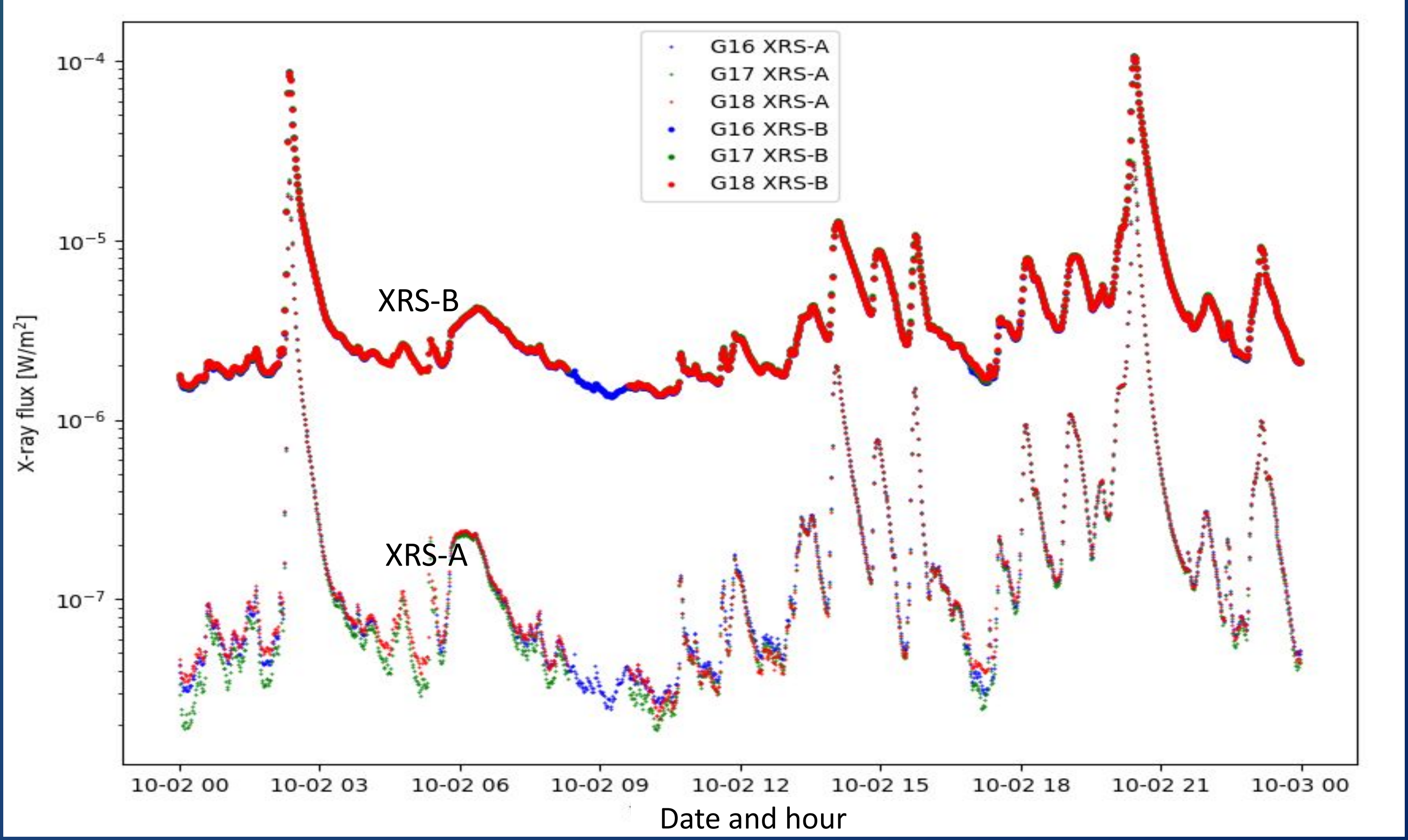
Flare Class	No. of Flares		Median Error [arcmin]		
	orig	revised	req'd	orig	revised
X	5	6	<5	1.54	**0.82**
M	40	133		1.58	**0.31**
C	267	1632		1.91	**0.97**
B	646	1994		3.44	**3.81**
All	958	3765		2.52	**2.00**

* orig = statistics at GOES-16 Full Validation PS-PVR in August 2020
revised = uses new algorithm and data from 2019-01-24 through 2022-10-22

credits: Courtney Peck, Brooke Kotten (student), Laurel Rachmeler
data: science-quality L2

#14: Inter-Satellite Comparisons (1/8)

- GOES-16, -17, and -18 comparisons for 1 day (2 Oct 2022)
- G18 electron contamination fix not implemented, but e- flux low on Oct 2



data: L2 1-minute operational averages

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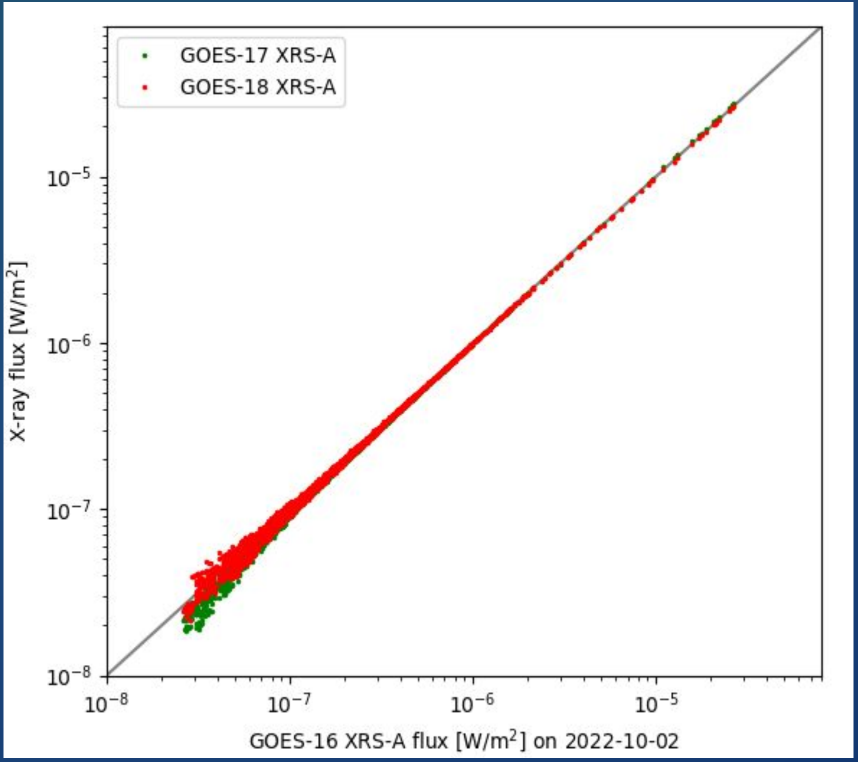
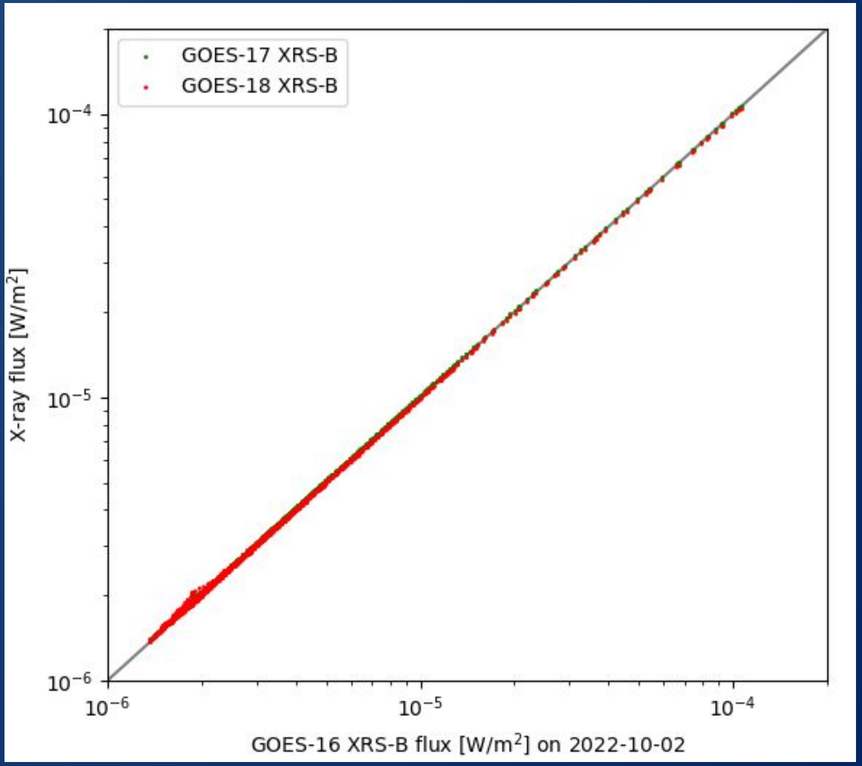
#14: Inter-Satellite Comparisons (2/8)

- Comparisons of GOES-17 and -18 to GOES-16 (2 Oct 2022).
- Linear behavior at higher fluxes as expected.





data: L2 1-minute operational averages

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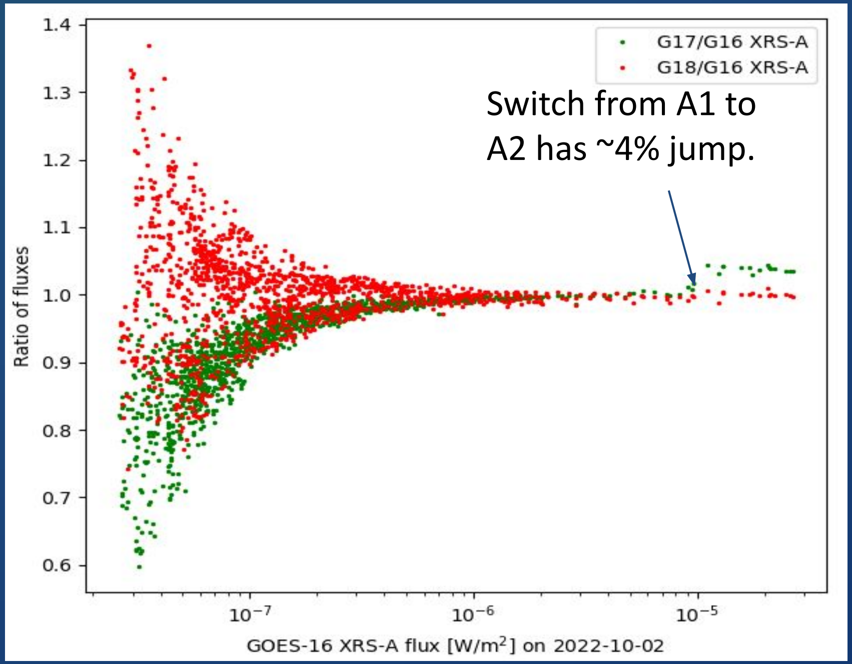
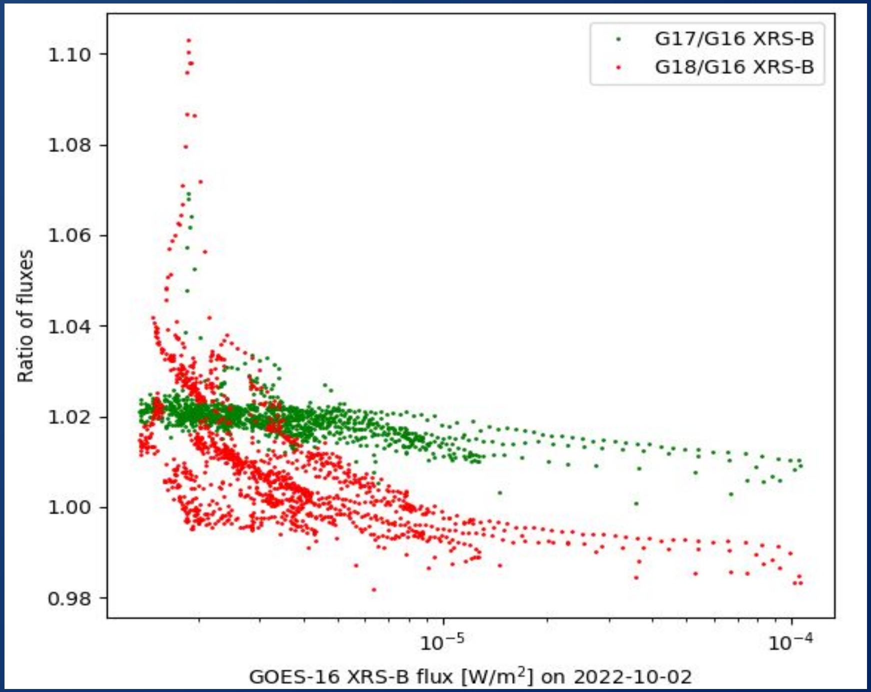
#14: Inter-Satellite Comparisons (3/8)

- Ratio of GOES-17 and -18 to GOES-16 (2 Oct 2022).
- Feature 1: GOES-17 jump in ratio when switch from A1 to A2
  - Cause: Incorrect scaling of GOES-17 XRS-A2 to -A1.
- Feature 2: Hysteresis like difference in XRS-B1 and -B2 during flares
  - Probable cause: Spectral changes during flare convolved with slight differences in filter transmissions for different satellite instruments.





data: L2 1-minute operational averages

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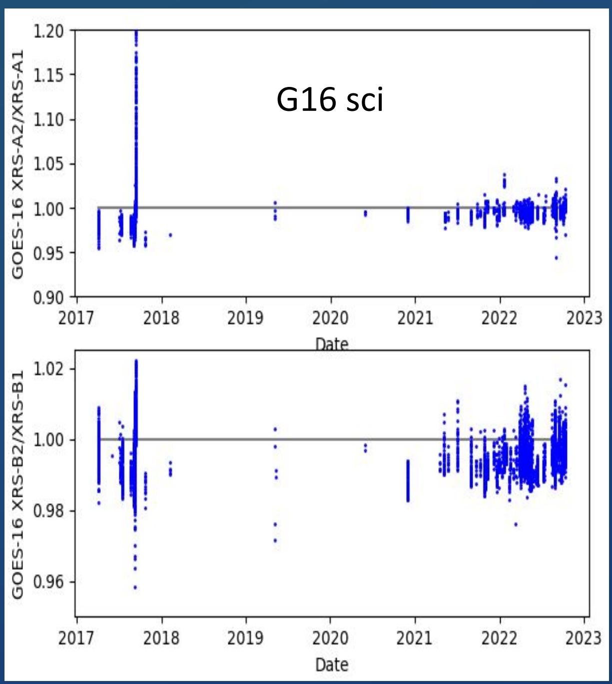
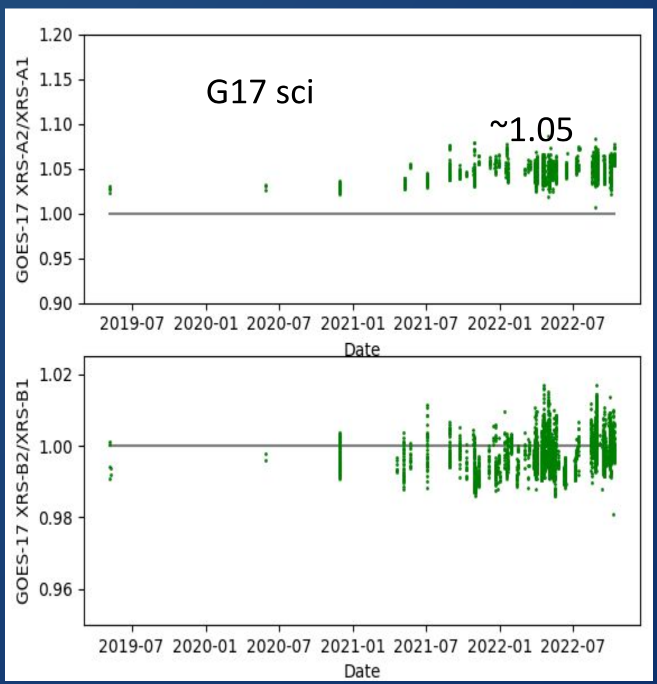
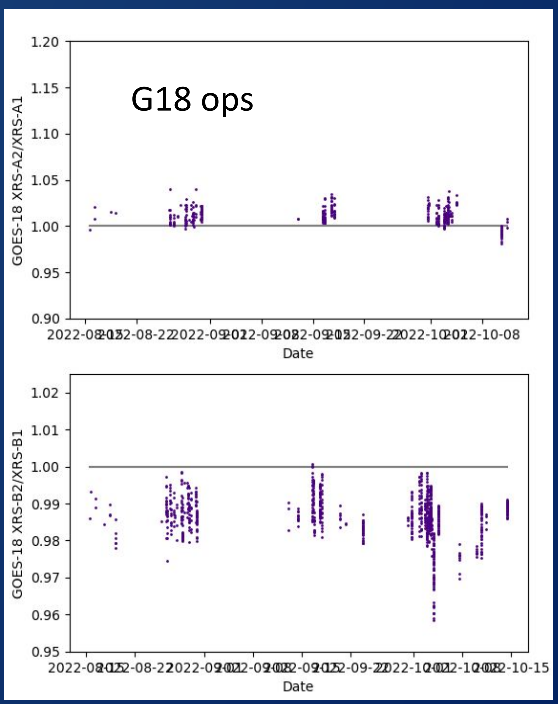
#14: Inter-Satellite Comparisons (4/8)

- Explore high vs low irradiance channel scaling
  - A2/A1 and B2/B1 time series for full mission
  - Included irradiance: XRS-A >2e-6 W/m^2, XRS-B: >1e-5 W/m^2
  - Plots: Different y-axes for XRS-A and -B
- Due to initial scaling with minimal data.
  - No clear trends with time, so not due to degradation







data: L2 1-minute averages: G16, G17 (science-quality), G18 (operational)

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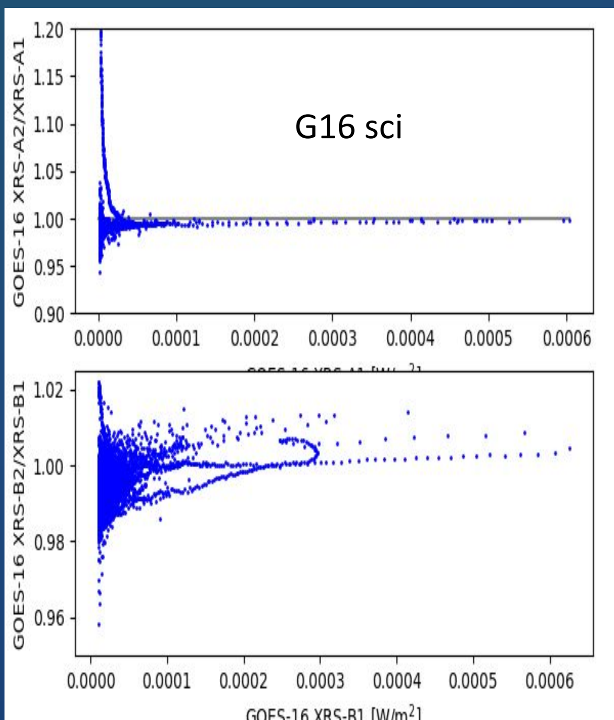
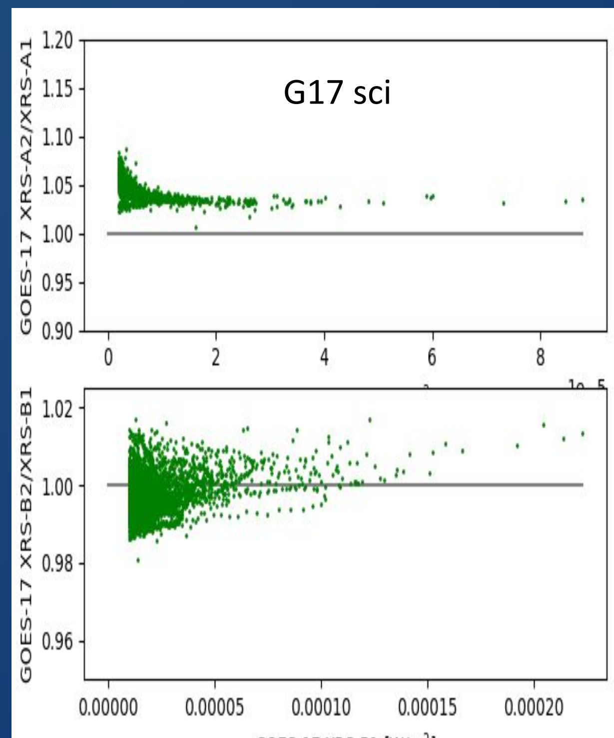
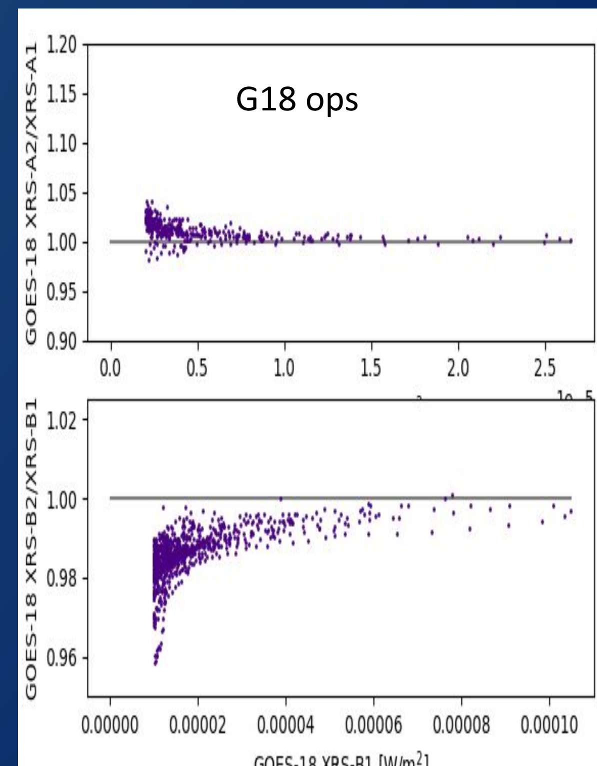
#14: Inter-Satellite Comparisons (5/8)

- A2 and B2 are rescaled early in the mission to A1 and B1
  - i.e., Set A2 / A1=1 and B2 / B1 =1
- Plots of A2/AI and B2/B1 vs irradiance below show offsets of 0.05 to 3.2%.
- Action: LASP and NCEI will redo XRS-A2, B2 scaling for all satellites.







data: L2 1-minute averages: G16, G17 (science-quality), G18 (operational)

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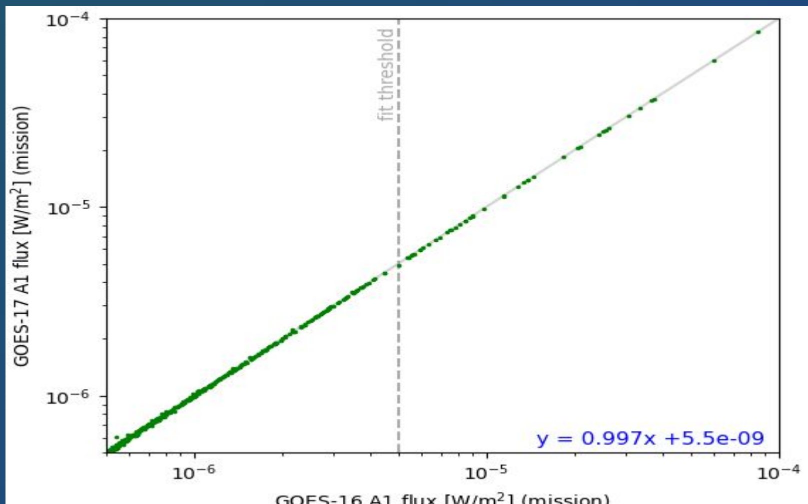
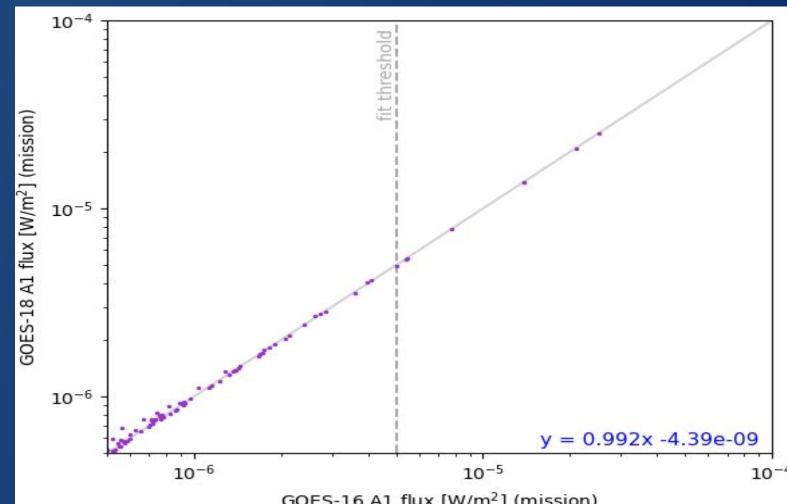
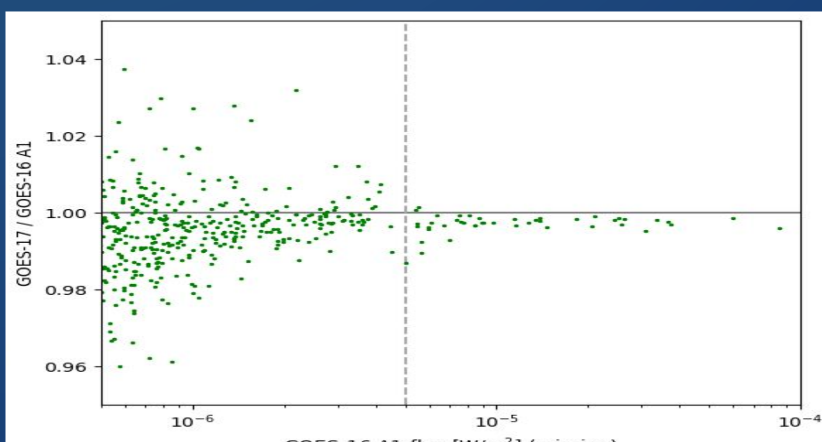
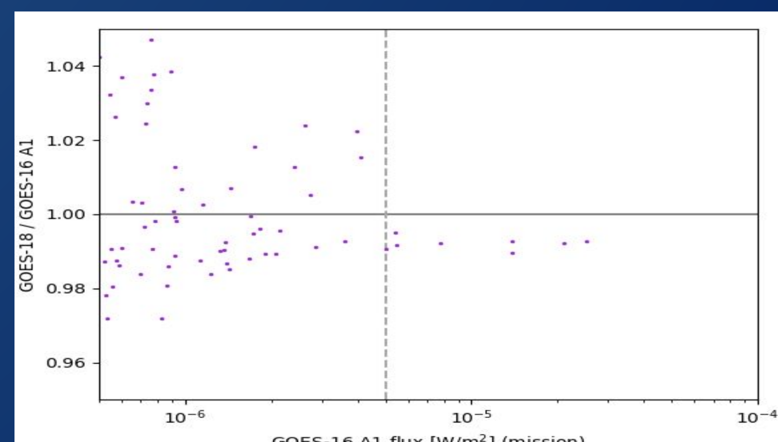
#14: Inter-Satellite Comparisons (6/8)

Calculate XRS-A1 ratios for different satellites using flare peak irradiances









data: L2 1-minute averages: G16, G17 (science-quality), G18 (operational)

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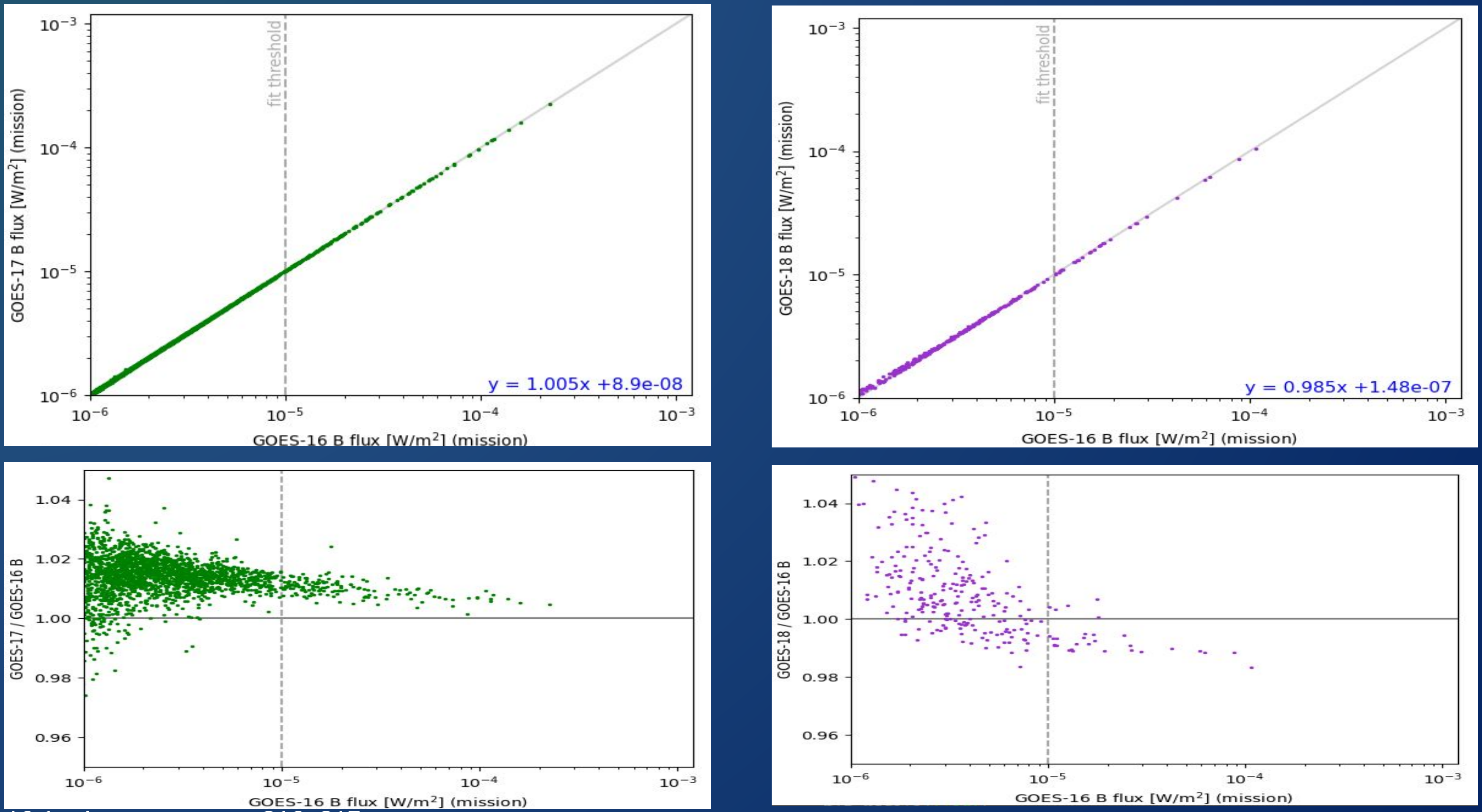
#14: Inter-Satellite Comparisons (7/8)

Calculate XRS-B1 ratios for different satellites using flare peak irradiances



data: L2 1-minute averages: G16, G17 (science-quality), G18 (operational)

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#14: Inter-Satellite Comparisons (8/8)
#11: NOAA XRS Scaling Factors

Approximate ratios between satellites

channel	ratio	at G17 PS-PVR (Aug 2020)	at G18 PS-PVR (Nov 2022)
A	G16/G15	1.37	
	G17/G15	1.32	
	G17/G16	0.99	1.00
	G18/G16		0.99 (XRS-A1)
B	G16/G15	1.07	
	G17/G15	1.10	
	G17/G16	1.02	1.01
	G18/G16		0.99

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XRS Ratios for Responsivity Adjustments

A by-product of this analysis was that we have determined needed adjustments to some of the high irradiance channel responsivities.

satellite + channel	m, b for fit: A2 = m ·A1 + b or B2 = m ·B1 + b	responsivity correction factor (1/m)	revise or review for next LUT
G16 A2	0.998, -7.52e-8	1.002	
G16 B2	1.010, -2.91e-7	0.990	X
G17 A2	1.033, +2.66e-8	0.968	X
G17 B2	1.009, -1.74e-7	0.991	X
G18 A2	0.999, +4.22e-8	1.001	X
G18 B2	0.998, -1.43e-7	1.002	X

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Instrument Issues

No significant new instrument issues.

COMPARISON TO PERFORMANCE BASELINE

Performance Baseline

MRD ID	Quantity	MRD Requirement	GOES-16	GOES-17	GOES-18*	Related PLPTs**	Status
2037	Measurement Range XRS A	$5x10^{-9}$ to $5x10^{-4}$ W/m^2	$1.20x10^{-10}$ to $8.12x10^{-3}$ W/m^2	$4.62x10^{-9}$ to $7.30x10^{-2}$ W/m^2	**$8.37x10^{-9}$ to $8.42x10^{-2}$ W/m^2**	#12	**PASS**
	Measurement Range XRS B	$2x10^{-8}$ to $2x10^{-3}$ W/m^2	$1.85x10^{-10}$ to $1.47x10^{-2}$ W/m^2	$6.13x10^{-9}$ to $4.40x10^{-2}$ W/m^2	**$7.54x10^{-9}$ to $5.26x10^{-2}$ W/m^2**		
2038	Measurement Accuracy XRS A	< 20% at 20X min flux	Not measured on orbit.			None	**PASS**
	Measurement Accuracy XRS B	< 20% at 20X min flux	Not measured on orbit.				
2041	Measurement Precision XRS A	2%	0.87%	0.69%	**0.71%**	#12	**PASS**
	Measurement Precision XRS B	2%	1.5%	0.23%	**0.46%**		
2042	Long-term Stability (over mission)	< ±5% or ability to track	Current trend is flat. Ability to track.			#14	**PASS**

* Calculations on following slides
** PLT-12 XRS L1b Uncertainties
PLT-14 XRS/EUVS/Mg II Inter-Satellite Comparisons (L1b)

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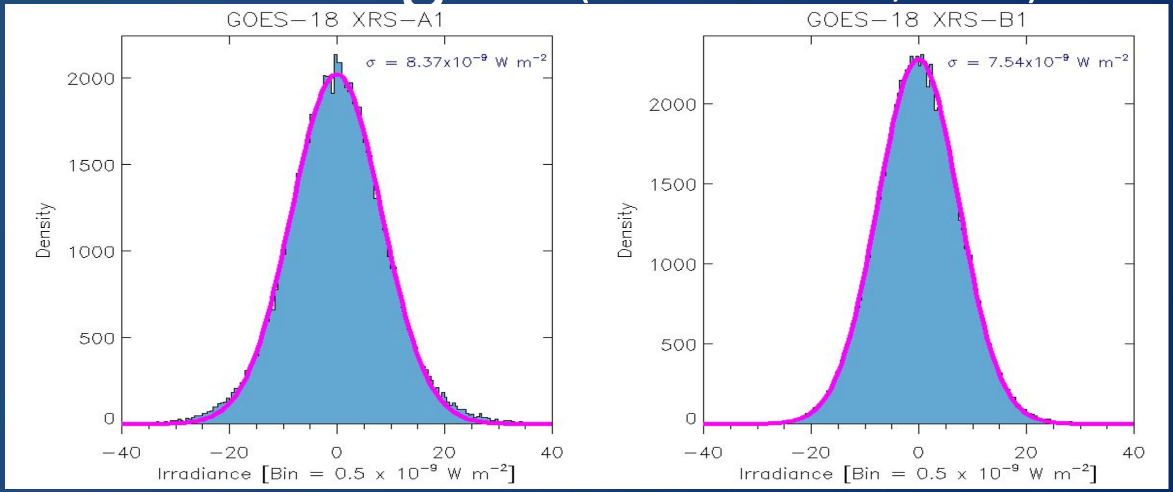
Performance Baseline

MRD ID	Description	Source of Values in Validation Table*
2037	XRS Product Measurement Range	Essentially no new values measured on orbit. Range minima are uncertainties due to noise for A1 and B1 Range maxima are: flux equivalent of 989,000 DN (ASIC counter saturation) for A2 and B2
2038	XRS Product Measurement Accuracy	Not measured on orbit. Validated pre-launch.
2041	XRS Product Measurement Precision	Essentially no new values measured on orbit. Percent precision = P/(20 x M)*100 P = Precision, M = MRD minimum measurable flux
2042	XRS Long-term Stability	Relative to GOES-16, XRS is currently stable. Future monitoring includes: (1) GOES-18 vs. other GOES satellites, (2) ASIC gain calibrations, (3) FOV mappings, and (4) cruciform scans.

* Details on next three slides

Uncertainties and Ranges (for MRD 2037, 2041)

Plots show noise distributions (with 1σ standard deviations) obtained by using high pass filter on **m**easurements.



Precision defined by equivalent irradiances for 1 DN at a typical temperature (14.139° C) on 2022/290.

A1: 1 DN = 1.188 x 10^{-9} W/m^2 B1: 1 DN = 7.001 x 10^{-10} W/m^2

A2: 1 DN = 8.516 x 10^{-8} W/m^2 B2: 1 DN = 5.314 x 10^{-8} W/m^2

Uncertainties for XRS-A1 and -B1 (from plot above)

σ_{A1} at 1 DN = 8.37 x 10^{-9} W/m^2 σ_{B1} at 1 DN = 7.54 x 10^{-9} W/m^2

Minimum irradiances are the larger of the 1-DN equivalent irradiances and uncertainties for A1 and B1.

A1 min: 8.37 x 10^{-9} W/m^2 B1 min: 7.54 x 10^{-9} W/m^2

Maximum irradiances are flux equivalents of 989,000 DN (ASIC counter saturation) for A2 and B2.

A1 max: 0.001175 W/m^2 B1 max: 6.924 x 10^{-4} W/m^2

A2 max: 0.08423 W/m^2 B2 max: 0.0526 W/m^2

credit: Tom Eden
data: LASP-processed L1b

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Percent Precision for XRS-A1 and -B1

(for MRD 2041)

Calculate percent precision at a very low MRD-defined irradiance level.
Percent precision at MRD-defined flux = P/(20 x M)*100 (Factor of 20 from MRD 2038).

P = Precision = 1 DN equivalent irradiances
A1: 1.19×10^{-9} W/m^2 B1: 7.00×10^{-10} W/m^2 (from previous slide)

M = MRD minimum measurable flux (from MRD2037)
A1: 8.37×10^{-9} W/m^2 B1: 7.54×10^{-9} W/m^2

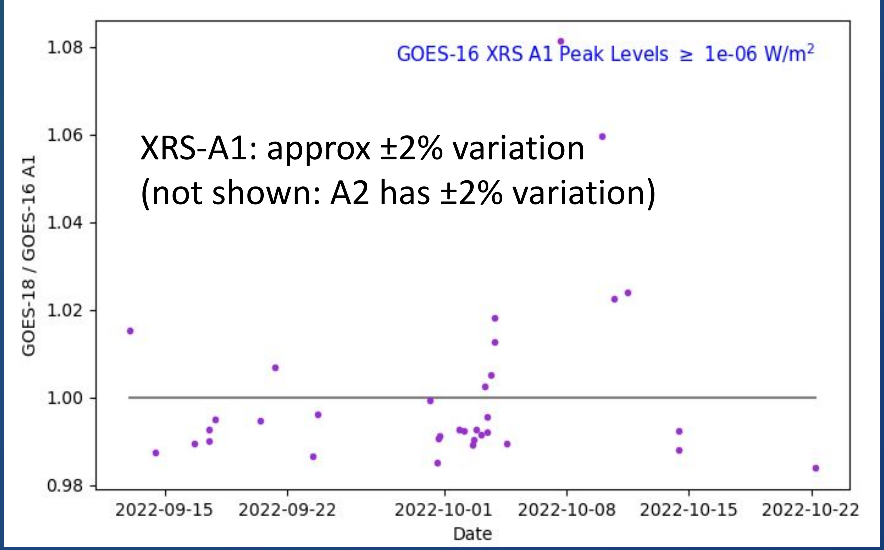
Measurement precision [%] = P/(20 x M)*100 (Factor of 20 from MRD 2038).
A1: 1.19×10^{-9} W/m^2 / ($20 \times 8.37 \times 10^{-9}$ W/m^2) x 100
B1: 7.00×10^{-10} W/m^2 / ($20 \times 7.54 \times 10^{-9}$ W/m^2) x 100

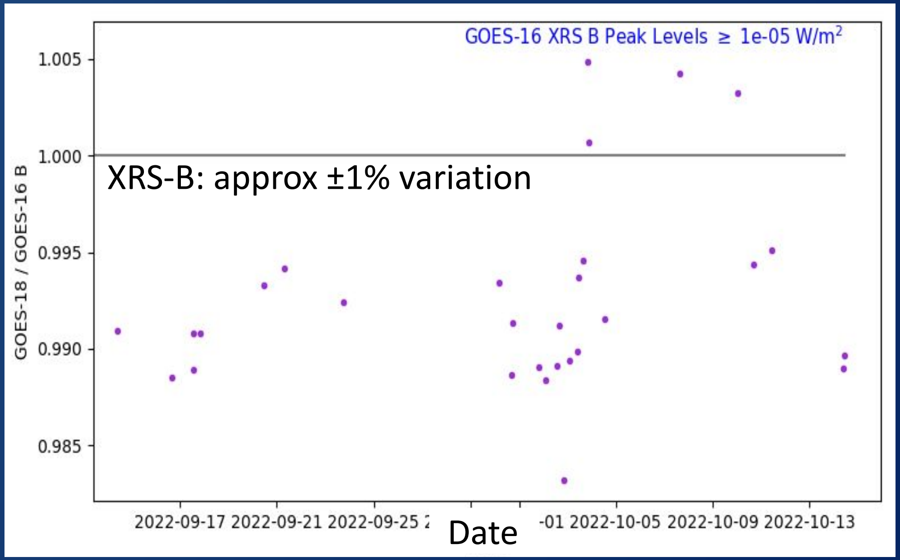
Percent precision: A1: 0.71%, B1: 0.46%

Stability of GOES-18 relative to GOES-16

(for MRD 2042)

- Examine ratios of peak irradiances for GOES-18 / GOES-16.
- Only used about a month of data.
- Irradiance appear stable and we will continue to monitor them.





data: L2 1-minute averages:
G16 (science-quality), G18 (operational)

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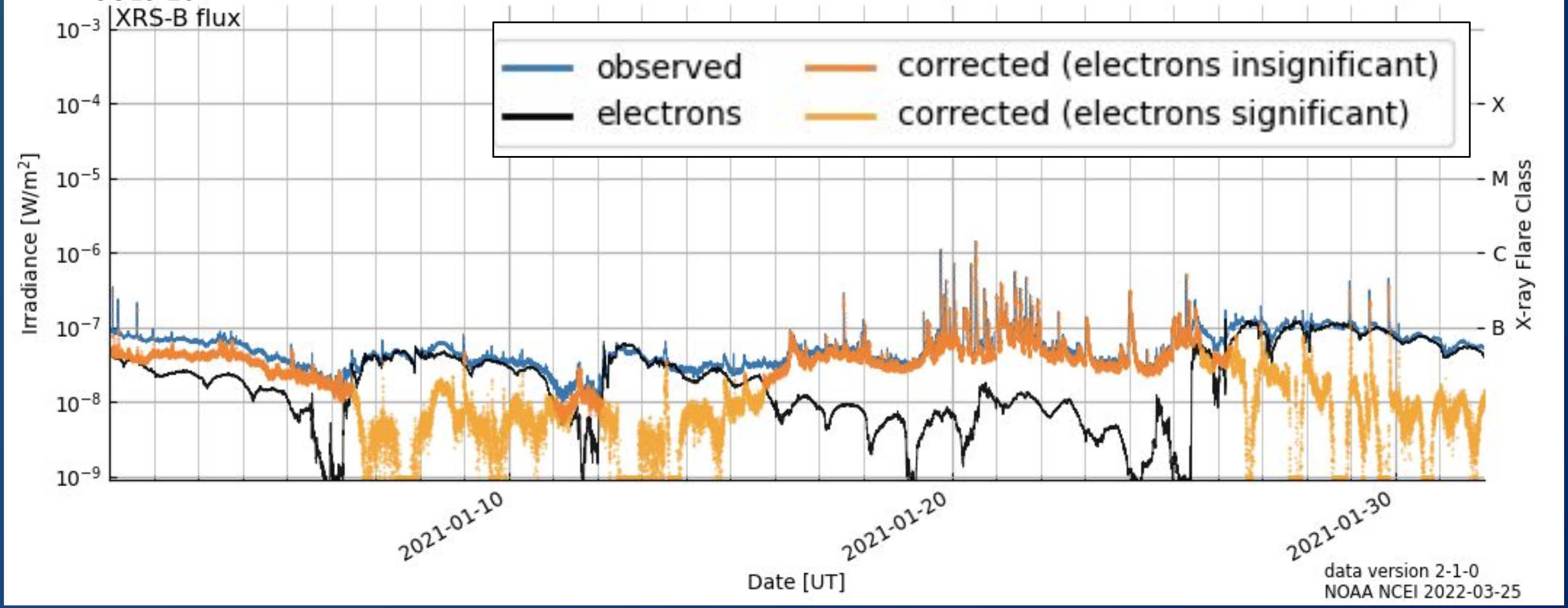
GOES-18 PORD Waiver for e- Flux (1/2)

- XRS signals artificially enhanced when electron fluxes are high.
- Corrected in L2 1-minute averaged data.

GOES-16



data: GOES-16 operational L2 1-minute averages

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GOES-18 PORD Waiver for e- Flux (2/2)

- XRS does not meet PORD requirements when e- fluxes are high and irradiance is low.
- PORD Waiver reduces electron fluxes defined as Worst-Case Electron Environment
  - Defined for GOES-16. Covers GOES-17 and -18. (LASP Waiver Request 161597revB)

	J(>E) (p/cm2/sec)							
E (MeV)	**0.3**	**0.45**	**1.05**	**1.9**				
EXISPORD Electron Fluxes in Assumed Worst-Case Electron Environment								
	2.0e7	7.0e6	7.0e5	1.5e5				
XRS-A Waiver Levels					**Scale factors applied to EXISPORD fluxes to get Waiver Values**			
G16	1.4e6	6.2e5	7.0e5	1.5e5	0.07	0.088	1	1
G17	1.6e6	8.5e5	7.0e5	1.5e5	0.082	0.122	1	1
G18	**2.4e6**	**1.1e6**	7.0e5	1.5e5	**0.122**	**0.158**	1	1
XRS-B Waiver Levels								
G16	3.4e6	1.3e06	7.0e5	1.5e5	0.17	0.19	1	1
G17	5.0e6	2.6e06	7.0e5	1.5e5	0.249	0.372	1	1
G18	**5.5e6**	**3.8e6**	7.0e5	1.5e5	**0.393**	**0.542**	1	1

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SUMMARY OF REMAINING ISSUES

Remaining XRS GPA Issues

- 6 ADRs for Full Validation

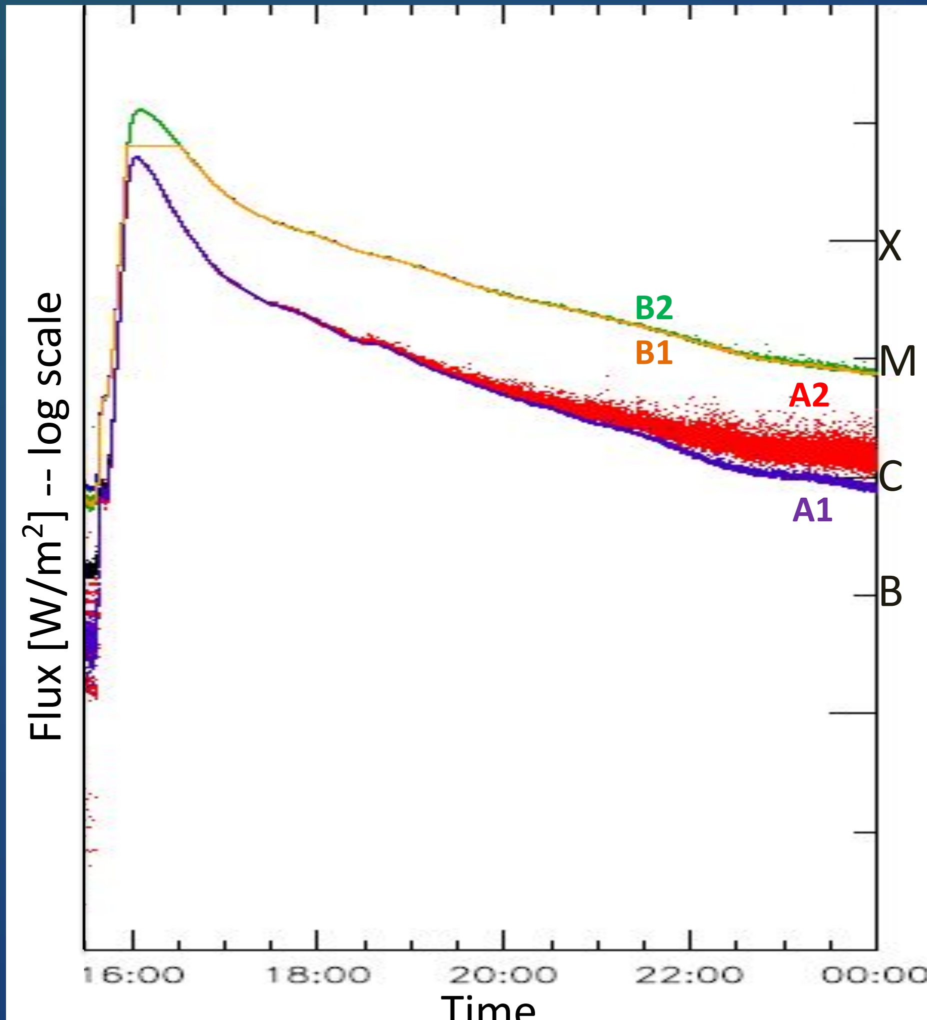
ADR	Issue	*	Description / Impacts	Delivery date
872	G17 solar array currents wrong			TBD
894	Output calculated dispersion and cross-dispersion angles during eclipses lunar transits (instead of fill values)			DO.12
1130	SPS_roll_angle revise variable name and change long_name and comment			DO.12
1161	EXIS penumbra flag		Impacts flare detection (detailed in GOES-17 EUVS Full Validation PS-PVR)	TBD
1171	ECEF_Z range needs to be increased		impacts all SWx instr.	DO 12.00
1272	XRS L1b sc_power_side mismatch between flag value & meaning			TBD

* Impact on status: Minor Impact | Moderate Impact | Major Impact

Remaining Instrument XRS Issues

#	Issue	Description	Comments to Users
1	XRS-A is larger GOES-R than on GOES-15.	XRS-A: GOES-17/GOES-15 = 1.32	The source of this discrepancy is unknown and is under investigation. The fluxes from GOES-8 through -15 have all agreed, and the GOES-R satellites all agree with each other. We will use newly available solar X-Ray spectral measurements from other satellites we will try to resolve.
2	Dark radiation coefficients need to be determined.	The dark radiation coefficient is used to correct the signal for proton contamination during SEP events. It is currently not being applied (and set to 0).	Analysis to determine this term is in progress. Signals will be artificially high during SEP events, especially in the A2 and B2 channels.
3	Dark counts	Improve dark counts with values from periods of lowest electron fluxes.	Until XRS LUT is updated, impact will be to slightly increase fluxes, but this will only be noticeable for the lowest fluxes.
4	Electron contamination fit coefficients.	L2 electron contamination correction requires coefficients for SEISS MPSHI telescopes and energy bands.	The L2 algorithm coefficients need to be determined for GOES-18 . A new machine-learning based method is being tested as well.

Instrument Issue: Dark Radiation Coefficients



data: G16 operational L1b

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

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PROVISIONAL MATURITY ASSESSMENT

Provisional Validation (1/2)

Preparation Activities	Assessment
Validation activities are ongoing and the general research community is now encouraged to participate.	Validation activities are ongoing. Results have been discussed with SWPC. Release of data by NCEI will enable research community participation.
Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.	There are no severe algorithm anomalies.
Incremental product improvements may still be occurring.	Product improvements will result from the resolution to issues given on the slides titled "Remaining XRS GPA Issues" and "Remaining Instrument XRS Issues"

Provisional Validation (2/2)

End State	Assessment
Product performance has been demonstrated through analysis of a small number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts.	XRS flux measurements have been compared with measurements from GOES-15, -16, and -17. Instrument was calibrated at NIST.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Yes, product performance will be communicated to users via the Readme.
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	The Readme will summarize remaining issues and strategies. Strategies have been discussed with SWPC and agreed to by them.
Testing has been fully documented.	Tests are documented in this presentation and PLT reports.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	See SWPC assessment.

Summary and Recommendations

- All sensors are performing very well.
- Calibration LUTs have been updated. Further updates will occur.
- Observed issues are similar to those for GOES-16, -17.
- Promising paths toward diagnoses and fixes of issues have been identified.

NCEI-CO recommends that FM3 XRS L1b data be transitioned to Provisional status at this time.

PATH TO FULL VALIDATION

Path to Full Validation

- Analyze daily, weekly and quarterly calibrations.
  - Next XRS LUT (early December) will have revised dark counts and XRS-A2 and -B2 responsivities.
- Identify and resolve instrument issues including those listed in the Summary of Remaining Issues slides.
  - Data analysis with L1b, L2, and locally processed L0 data.
  - Need X-Class flare and SEP events.
- A Determine L2 LUT values by operational date of 4 Jan 2023.
  - spike correction
  - electron contamination coefficients
  - flare location parameters
- NCEI will create pipeline for reprocessed science-quality data.
- Verify L1b revisions for ADR fixes.
- Complete electron contamination waiver submission process.

Risks for Full Validation Status

Issue	*	Notes
New issues found during continued monitoring and analysis for issue resolution.	Possible	

BACKUP SLIDES

EXIS Calibrations

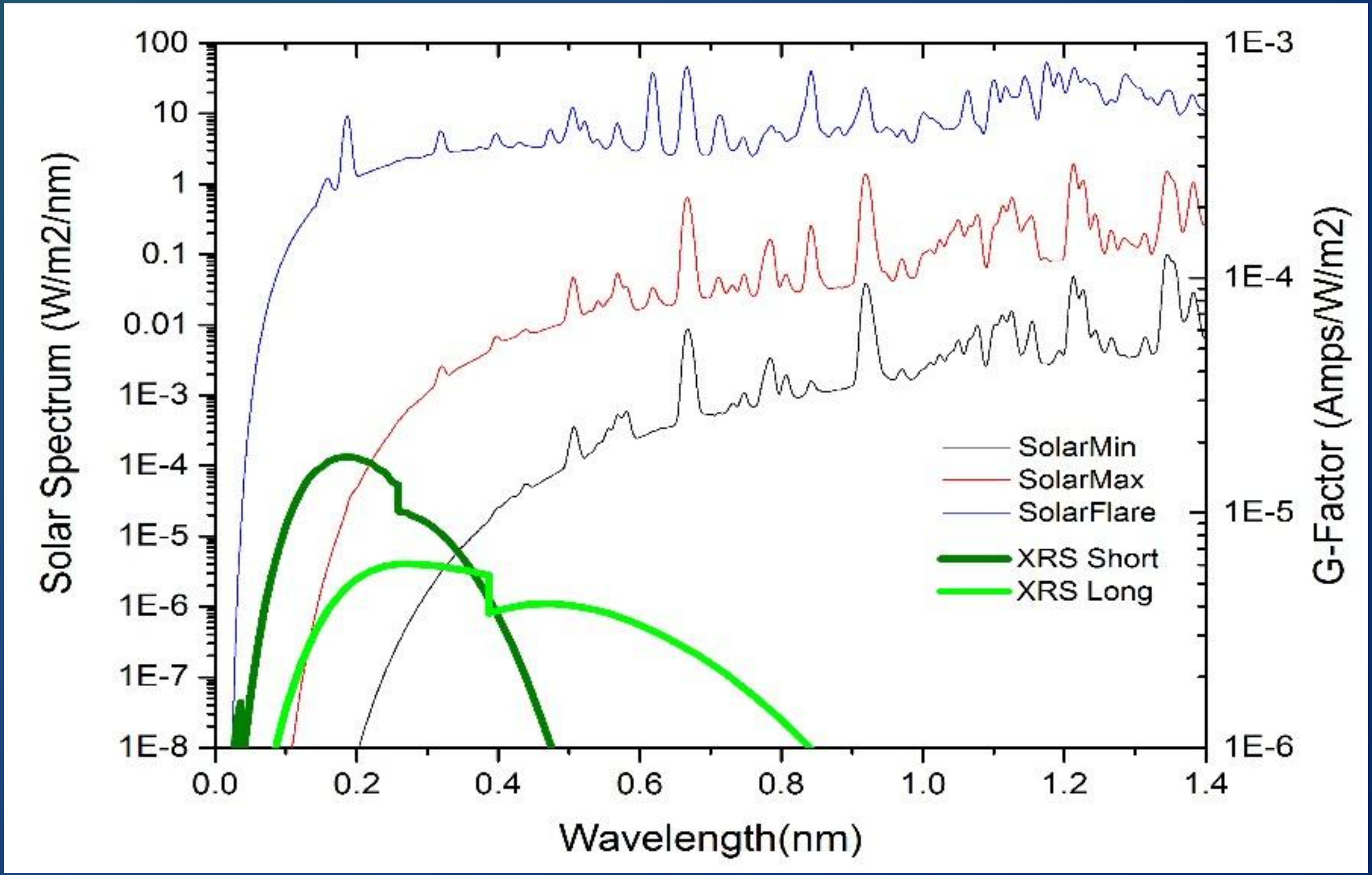
- Nominal Weekly - 90 s comparison with secondary
  - EUVS - A, -B Measure and trend darks and gain.
  - EUVS-A Measure and trend primary filter changes.
  - EUVS - A, -B, -C Measure and trend flatfield.
  - EUVS -C Measure and trend primary channel offset.
- Quarterly cruciform
  - XRS, EUVS-A, -B, -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

FM3 LUTs as of 2020-11-01:

SPS_Cal_INR(fm3_CDRL79revB).h5
XRS_Cal_INR(fm3_CDRL79revB).h5
Yearly_1AU_Correction_Table(2022).h5

XRS Responsivity and Solar Spectra



Provisional Maturity Definition

- Validation activities are ongoing and the general research community is now encouraged to participate.
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.
- Incremental product improvements may still be occurring.
- Product performance has been demonstrated through analysis of a small number of independent measurements obtained from other satellites.
- Product analysis is sufficient to establish product performance relative to expectations (Performance Baseline).
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, and tested.
- Testing has been fully documented.
- Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.