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

GOES-19 EXIS XRS L1b Provisional Maturity

11 March 2025

Presenters: Janet Machol, Jimmy Negus - NOAA NCEI and U. Colorado CIRES

Contributors:

U. of Colorado LASP	Tom Eden, Don Woodraska, Tom Woods, Frank Eparvier, Andrew Jones, Tyler Redick, ...
NCEI/CIRES	Ann Marie Mahon, Jamie Mothersbaugh, Stefan Codrescu, Kevin Hallock, Josh Riley, Pamela Wyatt, Laurel Rachmeler, Elysia Lucas, Andrew Wilson...
Other	Jon Fulbright, Liz Kline, Nick Carrasco, Randy Race, ...

Outline

Quick Summary

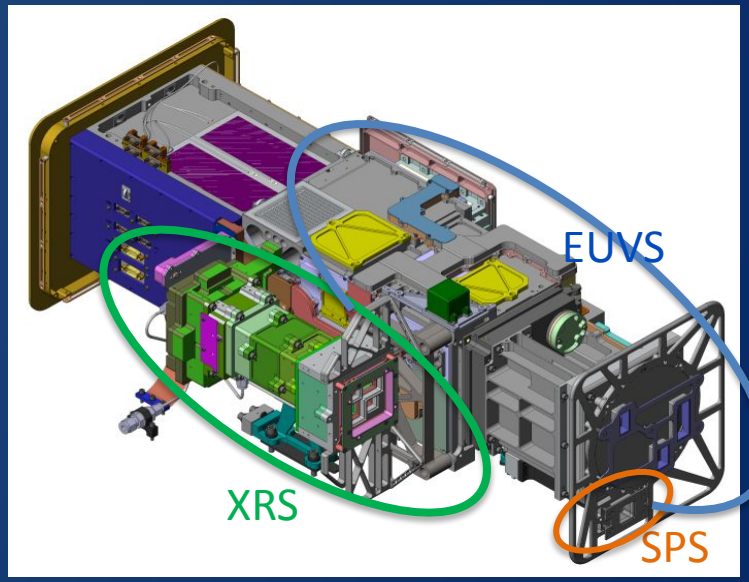
- Three types of data in presentation
  - Operational L1b: NCEI-aggregated, Ground System-processed L1b
  - LASP-L0-processed: same calibration factors as L1b
  - NCEI-L0-processed science-quality L1b, L2:
    - mission duration for GOES-19 data: 2024-07-24 to 2025-03-03
- GOES-19 Operational L1b: CDRL 79 Rev C LUTs
  - Rev C install date: 28 Jan 2025
  - Rev D (in March): revised A2, B2 responsivities and dark current
- Reprocessed data is essential to the analysis, so that we can verify the calibration parameters over much of the mission, instead of since late January. Science-quality data is between Rev C and D.
- GOES-19 behavior is similar to GOES-16 and -18. No surprises.
- Solar activity high: ~24 X-class flares since 2024-07-24
- GPA: 3 open ADRs, many closed, no GOES-19 specific issues
- All PLPT tests: PASSED
- Provisional Validation Product Maturity Assessment. PASSED

ADR = Algorithm Discrepancy Report
LUT = Look Up Table
GPA = Ground Processing Algorithm

EXIS

EUV and X-Ray Irradiance Sensors (EXIS)

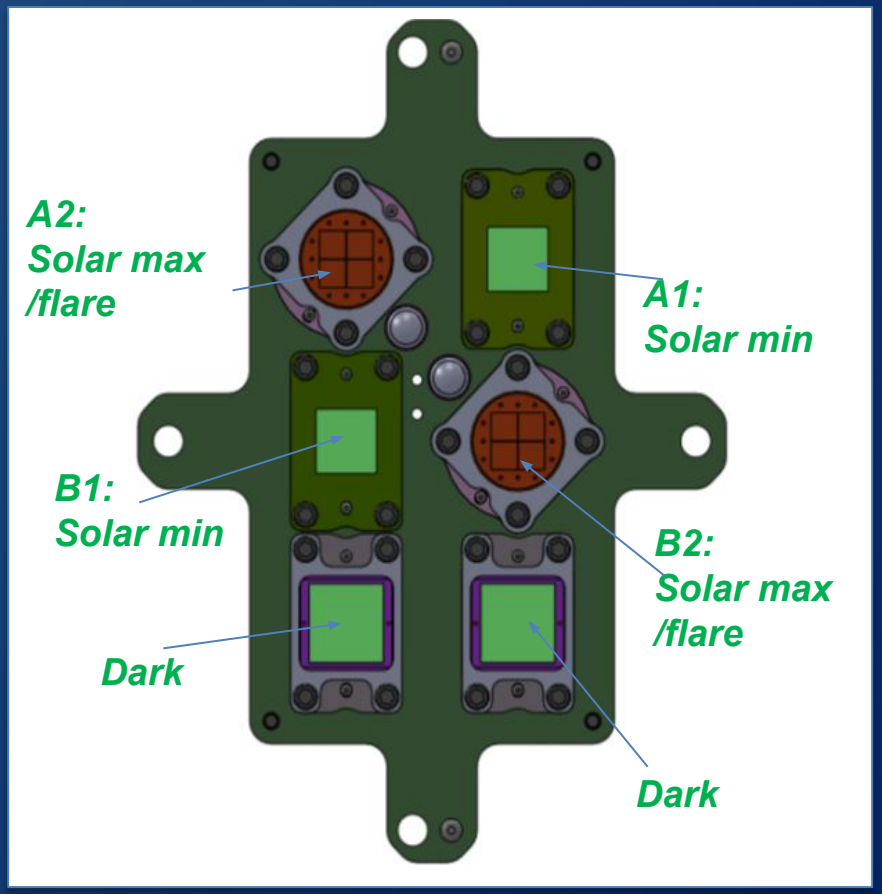
- X-Ray Sensor (XRS)
  - Monitor solar flares
    - Impacts communications and navigation
    - Warns of potential solar energetic particle events
- Extreme Ultraviolet Sensor (EUVS)
  - Measures solar ultraviolet irradiance which impacts upper atmosphere
- Sun Pointing Sensor (SPS)
  - Used for alignment (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 - quadrant, solar flare
  - 2 dark diodes
  - Silicon photodiodes with Be filters
- L2 Products
  - 1-sec averaged irradiances
  - 1-min averaged irradiances
  - flare summary
  - flare location on the solar disk
  - daily averages and background
  - composite flare report (new)



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.*
- Closed XRS-related ADRs (includes routine LUT updates)
  - 85 closed since 2016.
  - 10 closed since GOES-18 Full Validation in Dec 2023. (Shown in table.)
- Open ADRs: 3 (See slide 42)

Closed ADRs	Issue (Routine LUT updates in grey font)	WRs	Build
872	G17 solar array currents wrong	6600, 6780	DO.12.01.00
894 1087	Output dispersion and cross-dispersion angles during eclipses, lunar transits (instead of fill values)	6902 7796 8161 8323	DO.12.00.00
1130	SPS_roll_angle revise variable name and change long_name and comment	8263	DO.12.00.00
1171	ECEF_Z range needs to be increased	9326	DO.12.00.00
1272	XRS L1b sc_power_side mismatch between flag value & meaning	n/a	PR.12.05.00
1394	GOES-16 EUVS-A/B CDRL 79 Rev T LUT Updates	n/a	PR.13.01.05
1400	GOES-U EXIS CDRL79 RevA for PLT	n/a	PR.13.07.00
1456	GOES-16 EXIS EUVS-A and EUVS-B RevU LUT Updates	n/a	PR.13.07.02
1459	GOES-18 EXIS EUVS-A and EUVS-B RevI LUT Updates	n/a	PR.13.07.02
1499	G19 EXIS CDRL 79 revB	n/a	PR.13.10.01
1524	GOES-16 EXIS EUVS-A and EUVS-B Rev V LUT Updates	n/a	PR.14.00.08
1527	GOES-18 EXIS EUVS-A and EUVS-B Rev J LUT Updates	n/a	PR.14.00.08
1533	G19 EXIS CDRL 79 revB	n/a	PR.14.00.08
1538	Update FM4 (GOES-19) EUVS Bandpasses in OMAS	n/a	PR.14.00.08

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.

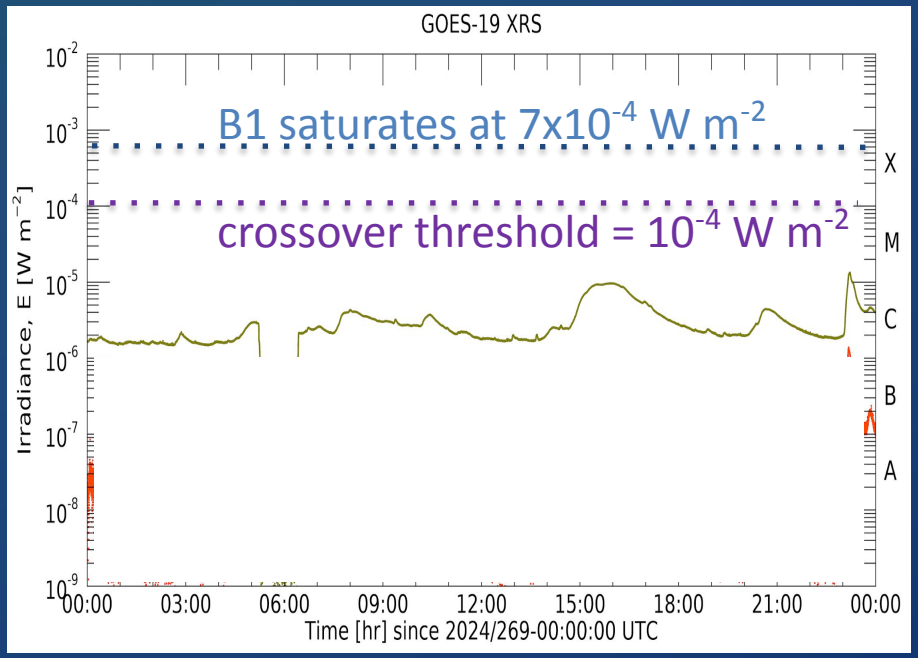
*Appendix A.2, pp 26 - 32, EXIS Readiness, Implementation, and Management Plan (RIMP v2; 410-R-RIMP-0316)

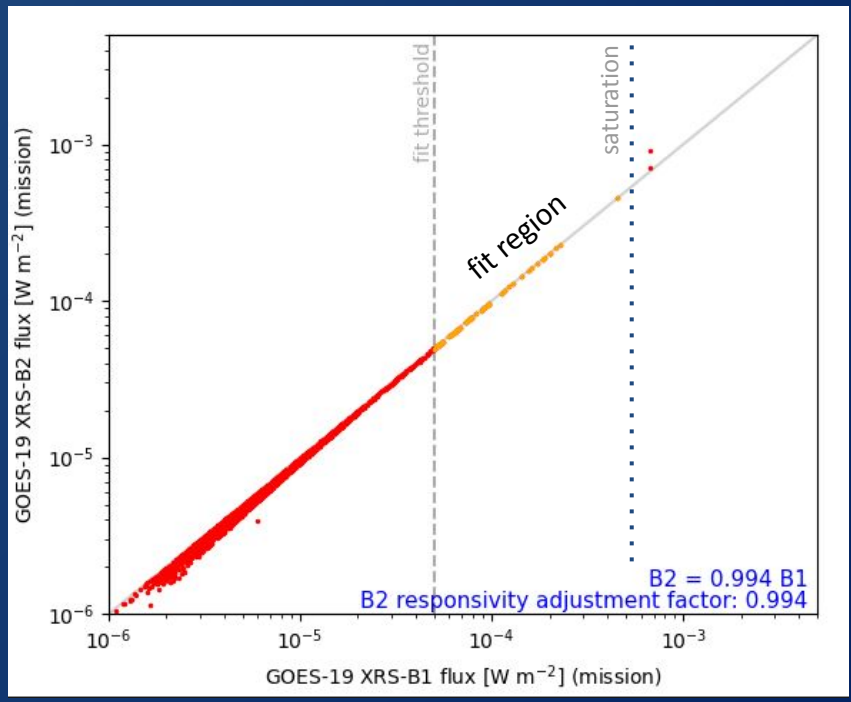
Status of XRS Data

- Science-quality data is required for much of the PS-PVR analysis.
- Code for science-quality data for analysis is undergoing fixes.
- Space CADAT: Cloud Algorithm Development and Test
  - new NCEI L0--> L1b reprocessing code (for sci quality data)
  - Major improvements: Python, runs fast
  - L1b algorithm changes: time-dependent dark counts
  - L2 algorithm changes: interpolation of missing points, flare location update
  - Implementation delayed (outside of our control)
  - Full testing of results to determine recalibration began a week ago.
- Current status at PS-PVR
  - Still only have "test" data. Used "preliminary science-quality" L2 data.
  - Updates needed for <u>all</u> satellites: responsivities, time-dependent dark correction, spike removal, electron contamination, flare location.
  - Will be corrected in coming weeks in new data version.
  - Goal: final L1b and L2 calibration coefficients before GOES-19 becomes operational on 4 April 2025.

#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, -18: 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.



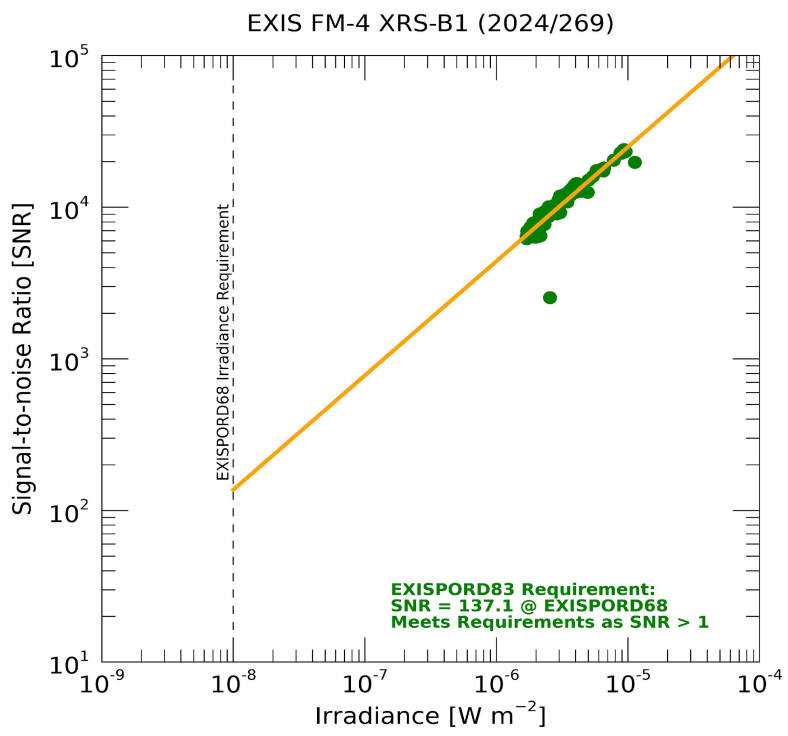


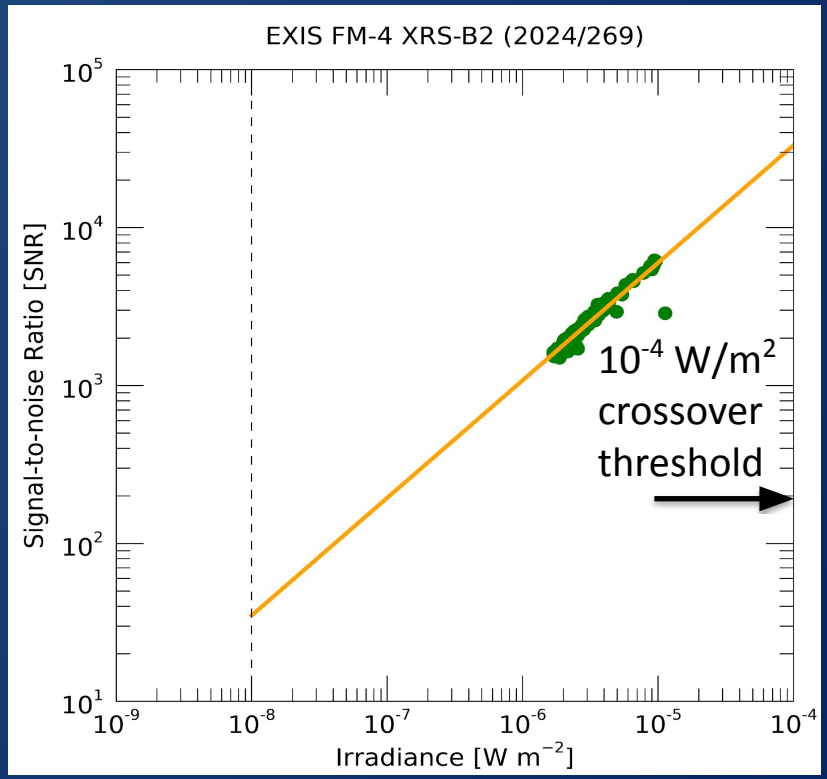
credit: Tom Eden, PLT 12, XRS Interchannel Comparison
data: LASP-processed L1b and preliminary science-quality L2 flare summary

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

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

Result: SNR >>1 for XRS-B1 (and -B2), easily satisfying PORD requirement

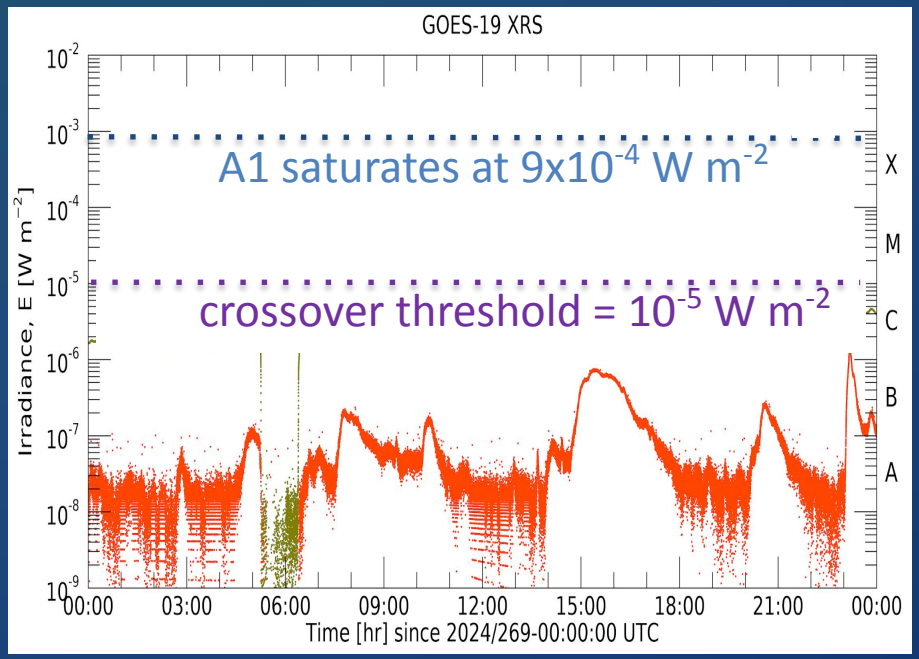


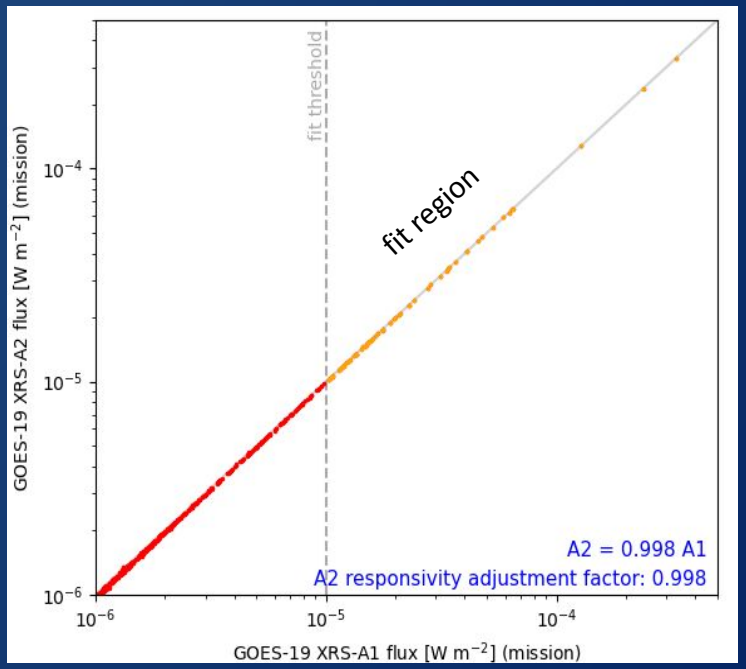


credit: Tom Eden, PLT 12, XRS Signal-to-Noise Ratio
data: LASP-processed L1b

#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, -18: 10^{-5} W/m^2 (approximately an XRS-B X1 flare)
2. Scale A2 responsivity so that A1 and A2 fluxes match.



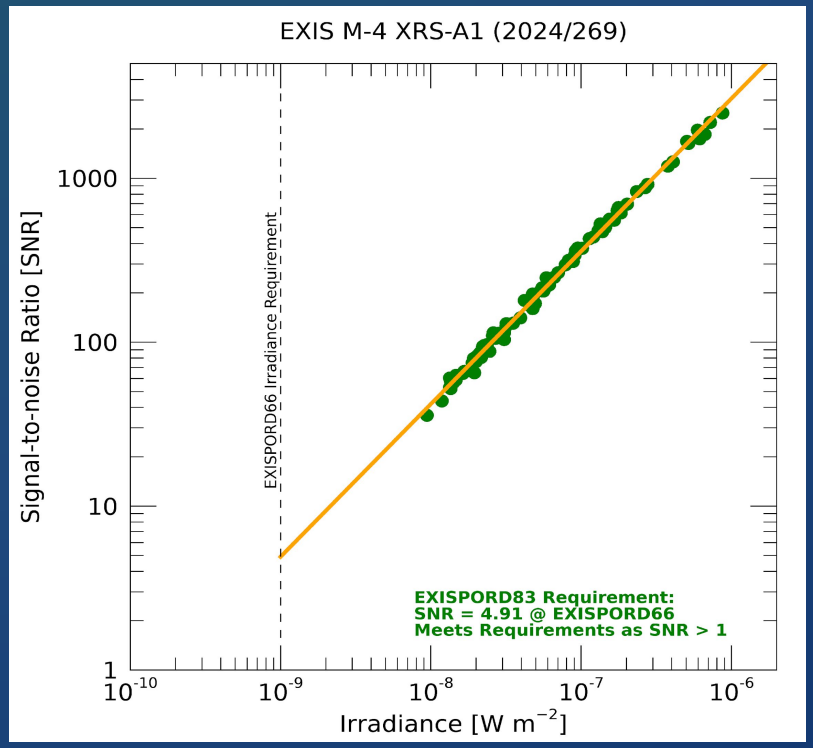


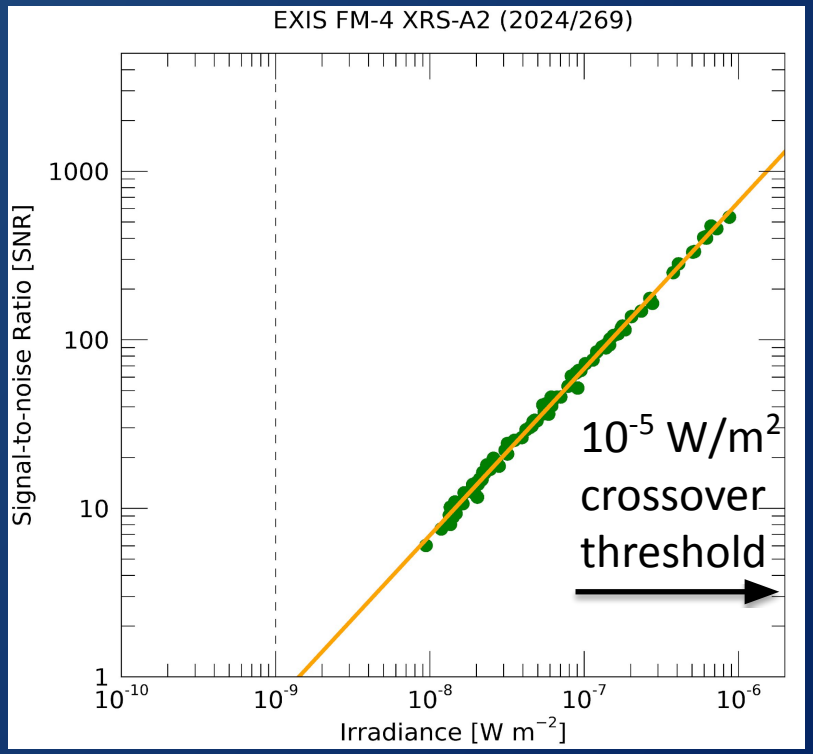
credit: Tom Eden, PLT 12, XRS Signal-to-Noise Ratio
data: LASP-processed L1b and preliminary science-quality L2 flare summary

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

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

Result: SNR >>1 for XRS-A1 (and -A2), easily satisfying PORD requirement





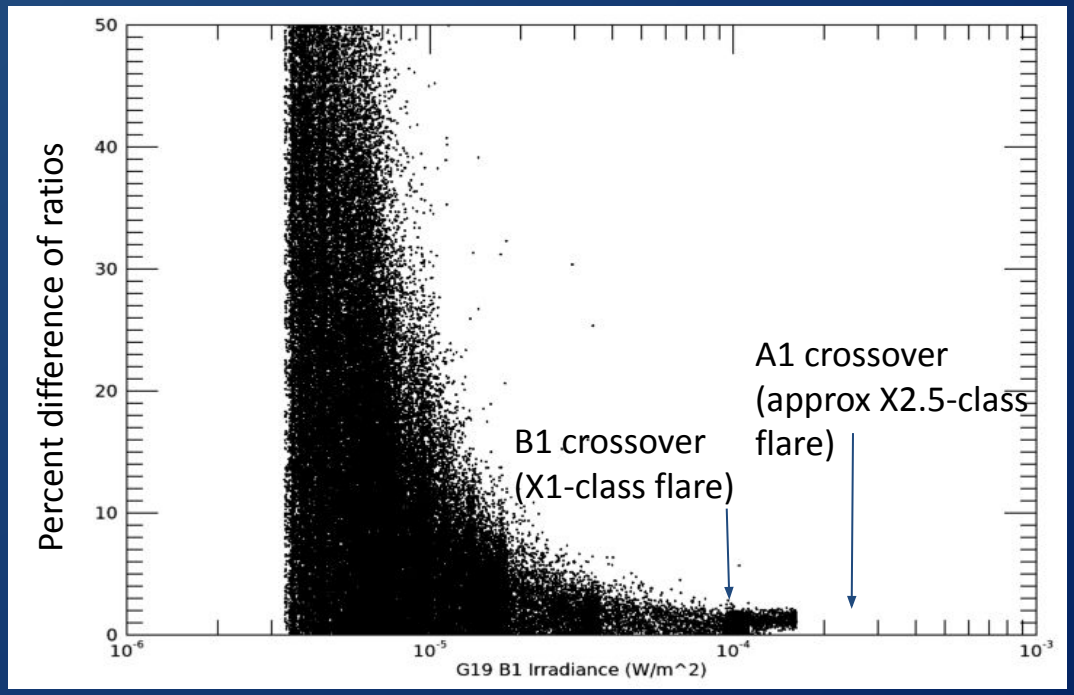
credit: Tom Eden, PLT 12, XRS Signal-to-Noise Ratio
data: LASP-processed L1b

#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 30 Dec 2024 (doy 365) with an X1-class flare.
- Result: Ratio is 2% at the B1 crossover and (presumably at the A1 crossover).

$$\text{Percent difference of ratios}$$

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



credit: Don Woodraska
data: LASP-processed L1b

#12: XRS L1b Uncertainties (1/4)

- **Objective**: Determine the uncertainty in the XRS L1b fluxes.
- Irradiances examined on 2024 doy 281.
- Results by flare class: *uncertainty / irradiance*
  - A1: <2.5% for flares above 10^{-6} W/m^2
  - B1: <2.5% for flares above 10^{-5} W/m^2

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

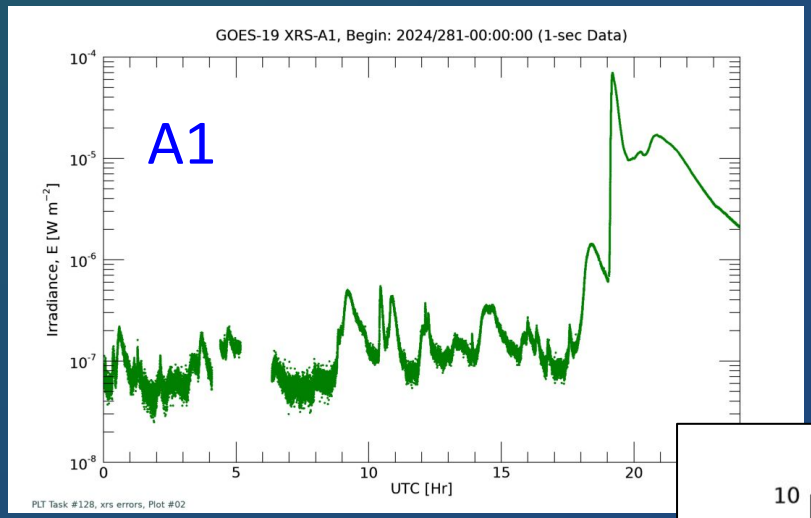
R = Diode Responsivity (A m^2 W^{-1})

Relative uncertainty in flux units: $\sigma_F = F\left[\left(\frac{\sigma_C}{R}\right)^2 + \left(\frac{C\sigma_R}{R^2}\right)^2\right]^{1/2}$

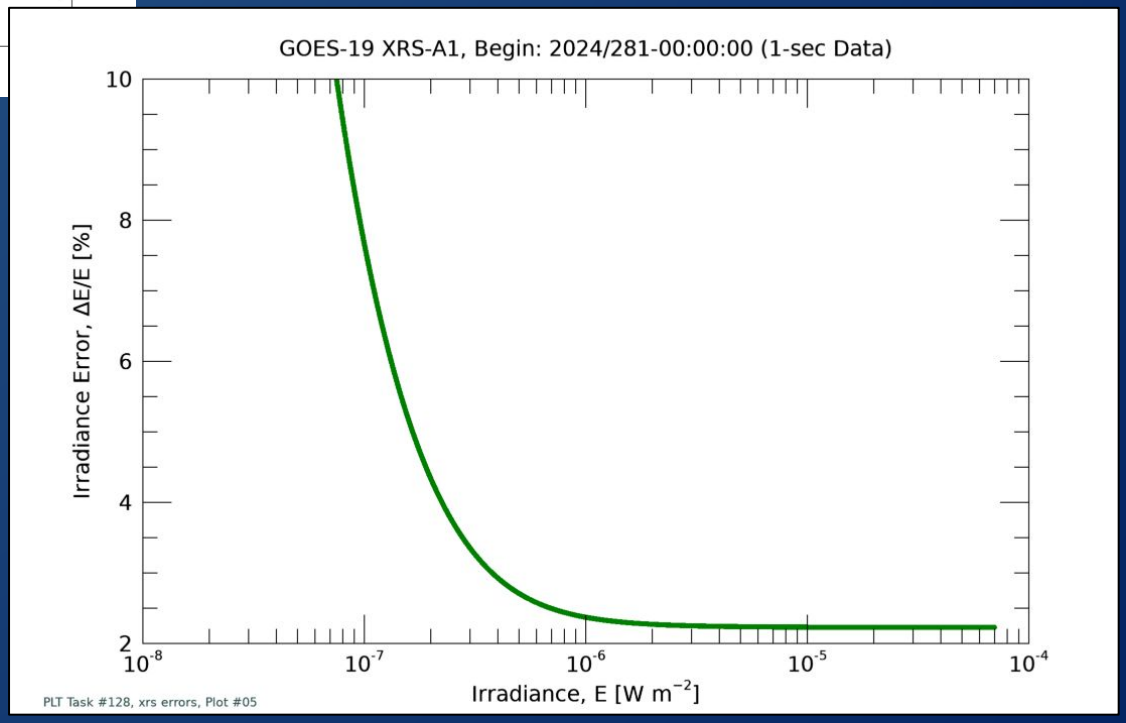
Not included: SURF systematic issues, FOV, degradation, ...

credit: Tom Eden

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

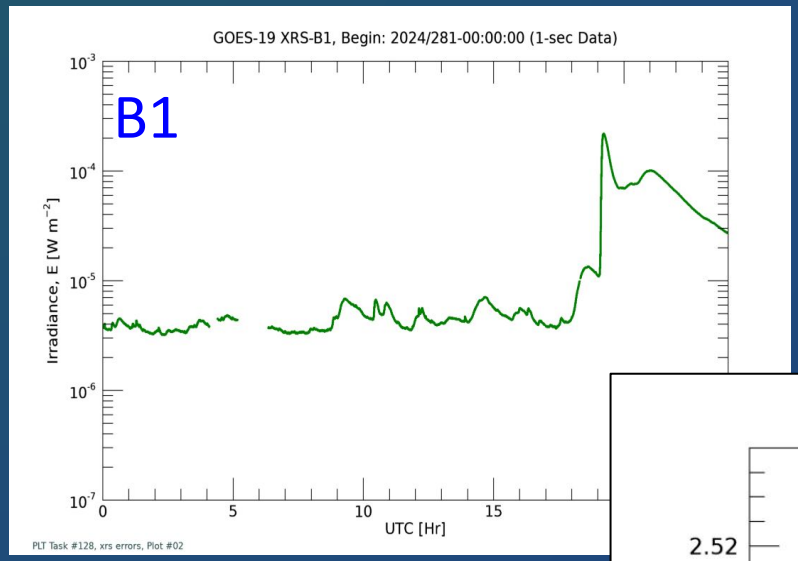


Flux uncertainty as a function of flux.

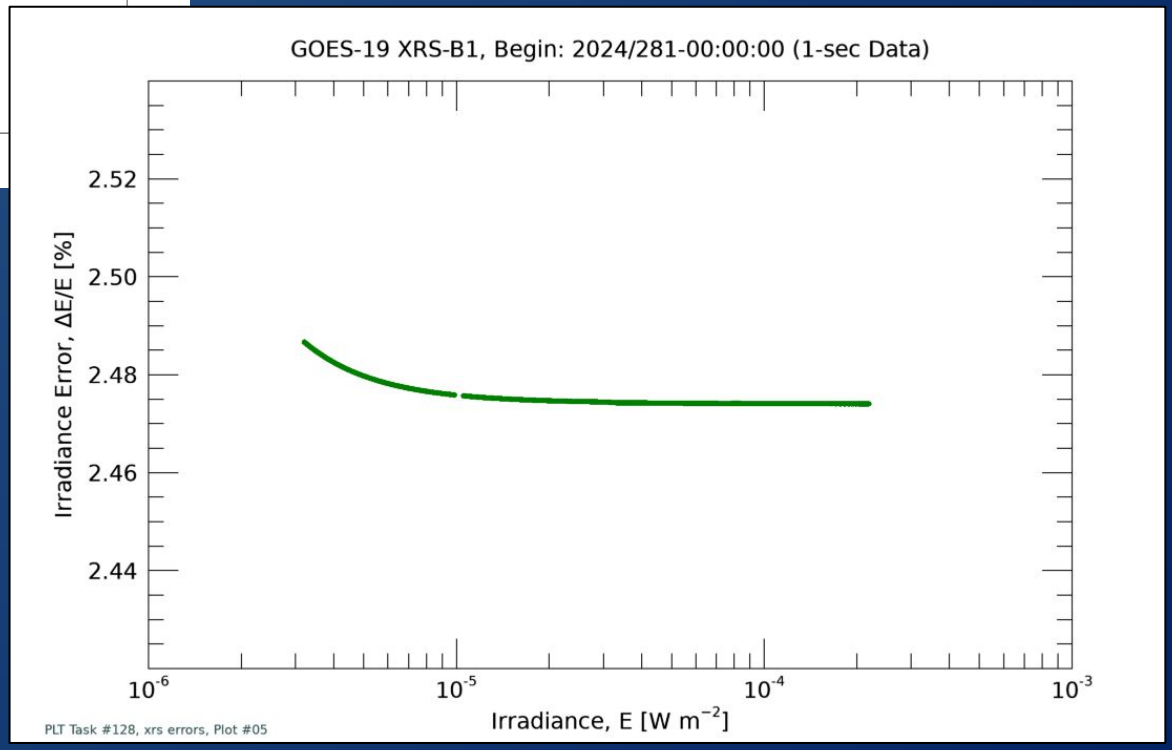


credit: Tom Eden
data: LASP-processed L1b

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



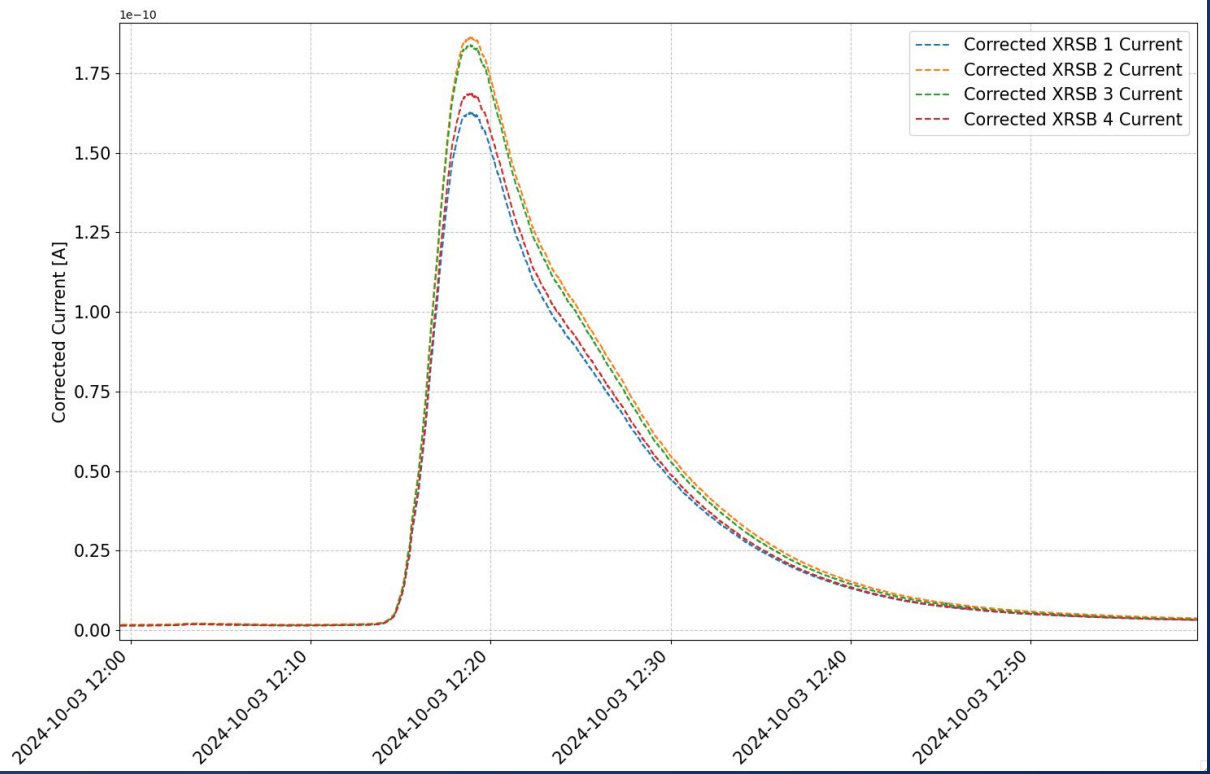
Flux uncertainty as a function of flux.



credit: Tom Eden
data: LASP-processed L1b

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

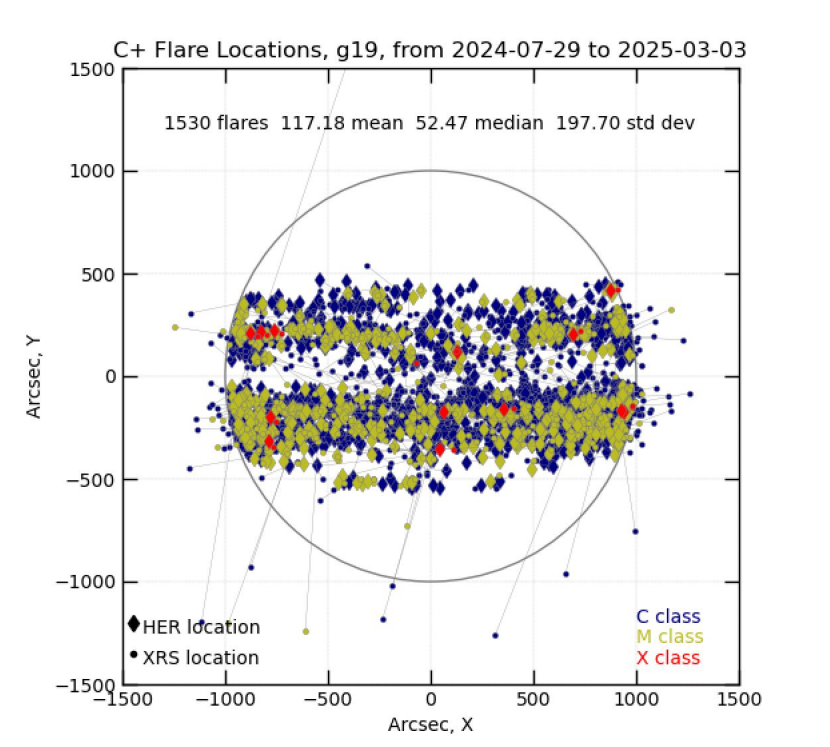
- Objective: Observe solar flare response in all 4 quad-diodes.
- GOES-19 quad diode currents on a 1-sec cadence for 3 October 2024 shows that each diode observes an X9-class flare.
- Preliminary coefficients for L2 Flare Algorithm have been calculated for GOES-19.



data: preliminary science_quality 1s L1b

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

- L2 Flare Location Algorithm:
  - Improved XRS Flare Location Algorithm
  - Comparisons with simultaneous flares observed by Solar Dynamics Observatory's Atmospheric Imaging Assembly (94Å and 131Å)
  - Data accessed from the Heliophysics Event Registry (HER)
  - Results meet requirement of < 5 arcmin error for all flares



Statistics for GOES-19 Flare Location Algorithm

Flare Class	No. of Flares	Median Error [arcmin] Required (< 5 arcmin)
X	17	**0.65**
M	447	**0.62**
C	1223	**1.08**
All	1687	**0.94**

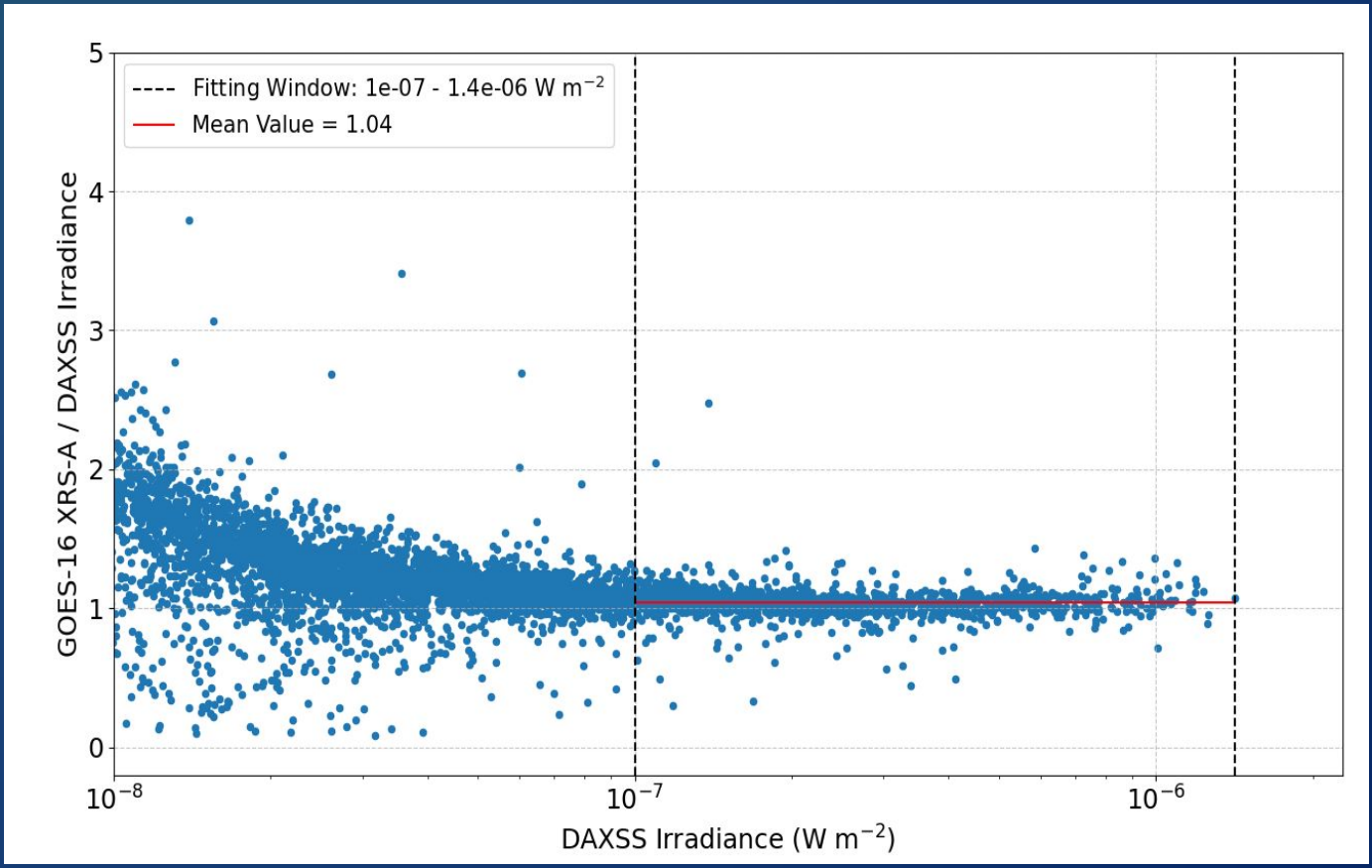
data: preliminary science-quality L2 flare location

Interlude: XRS-A Calibrations

- Why are XRS-A irradiances larger on GOES-R than on GOES-15?
  - Example: for XRS-A, GOES-17/GOES-15 = 1.3
  - Irradiances for GOES-8 through GOES-12 are consistent
  - Irradiances for GOES-R satellites are consistent
  - Long standing instrument issue at XRS PS-PVRs
  - GOES-R has better calibration. So, discrepancy is highly likely to be in GOES-8 through GOES-12 XRS-A
  - Future analysis with future satellite measurements will confirm.

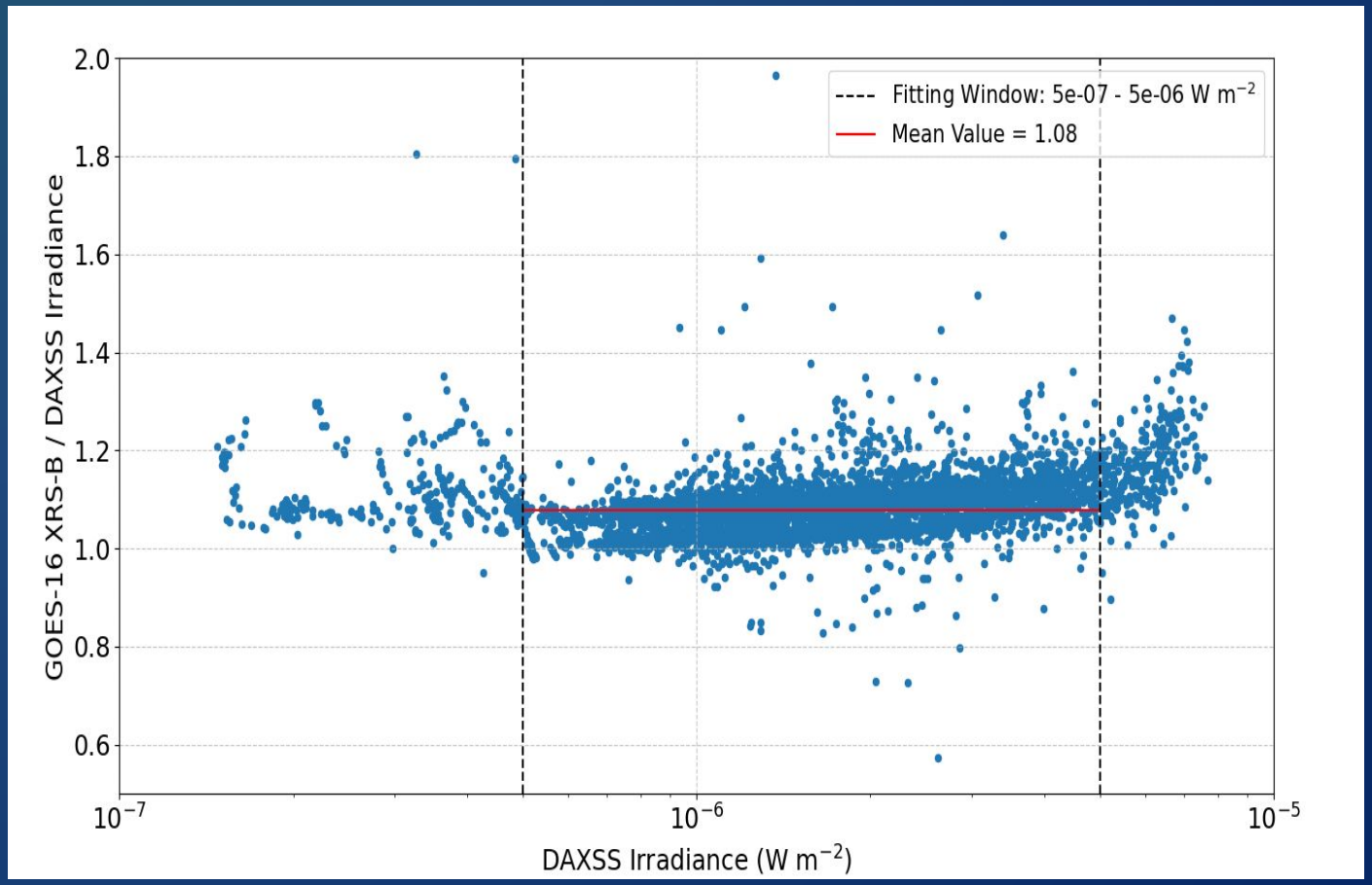
Interlude: XRS-A Calibrations

- Dual-zone Aperture X-ray solar Spectrometer (DAXSS)
- DAXSS spectral range: 0.5 keV to 20 keV (0.06–2.5 nm)
- Overlapping observational window: 28 February 2022 - 25 October 2023
- DAXSS data agrees well with GOES-R XRS-A channel.



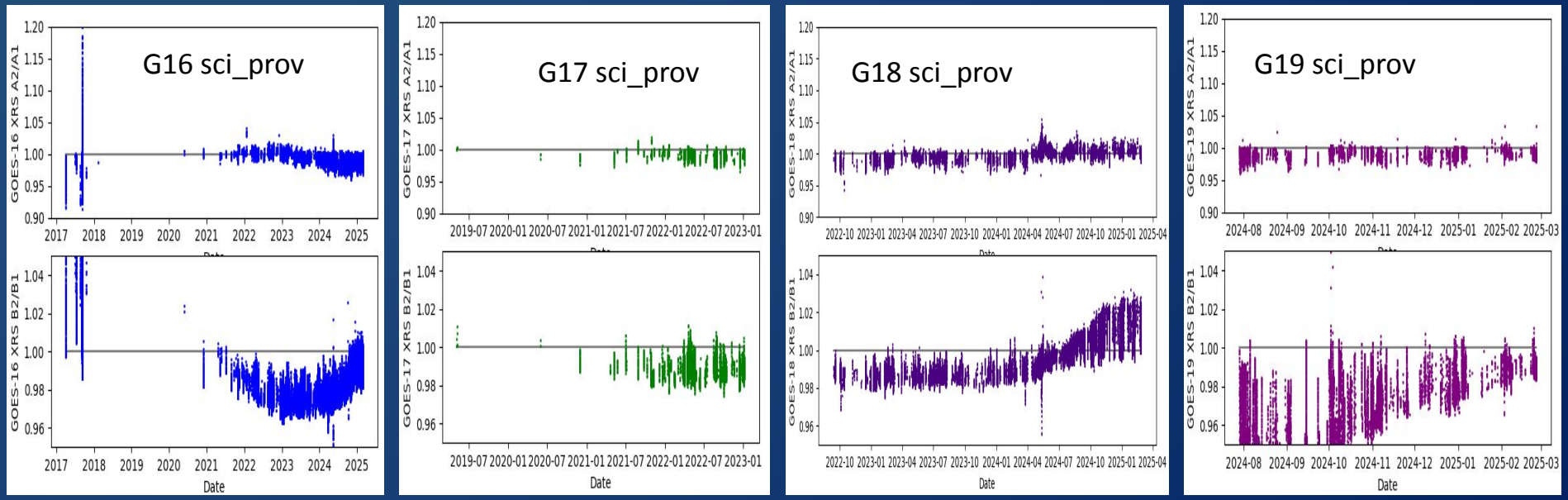
Interlude: XRS-A Calibrations

DAXSS data agrees well with GOES-R for XRS-B channel



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

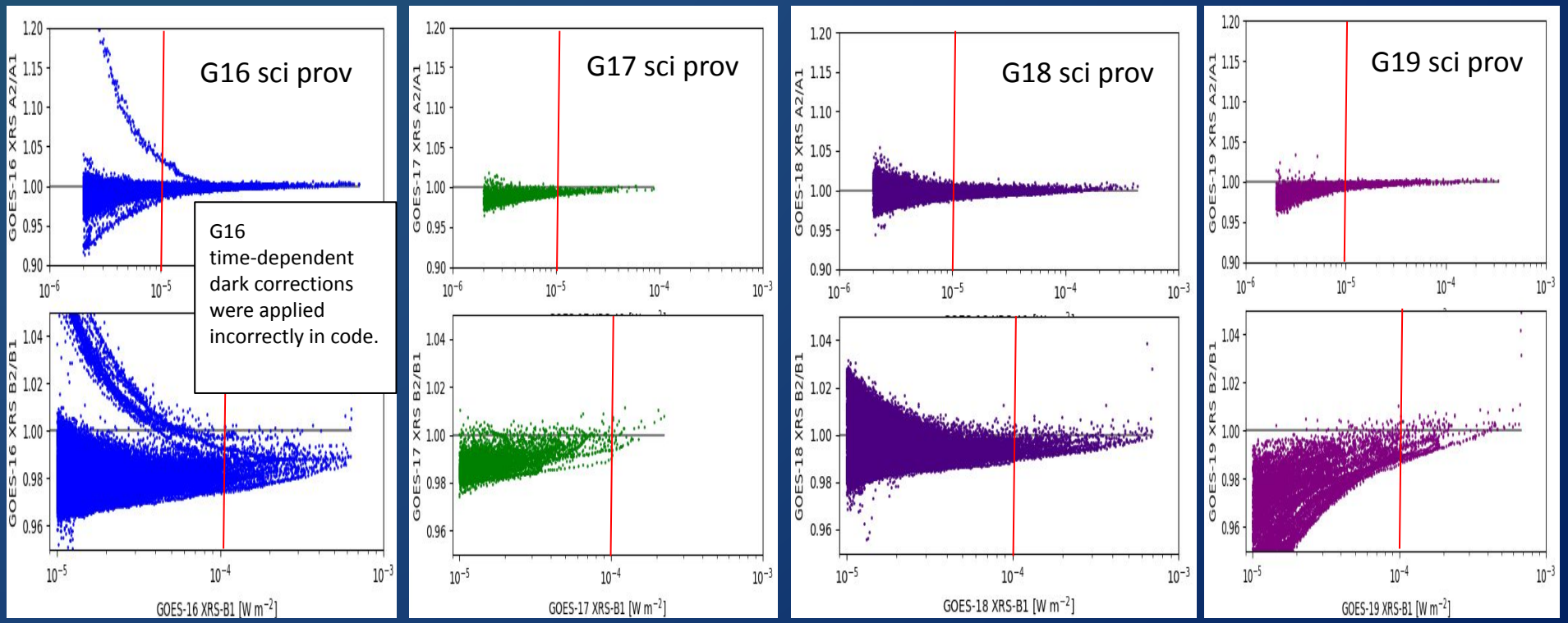
- Explore high vs low irradiance channel scaling <u>for mission time period.</u>
  - A2/A1 and B2/B1 time series for full mission <u>for individual satellites</u>.
  - Included irradiance: XRS-A >2e-6 W/m^2, XRS-B: >1e-5 W/m^2 for full mission.
  - Plots: Different y-axes for XRS-A and -B
- Errors of 1-4%.
- Next version of data will fix...
  - trends with time: dark count time-dependent corrections
  - offsets: scaling of A1 to A2, B1 to B2



data: preliminary science-quality L2 1-minute averages

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

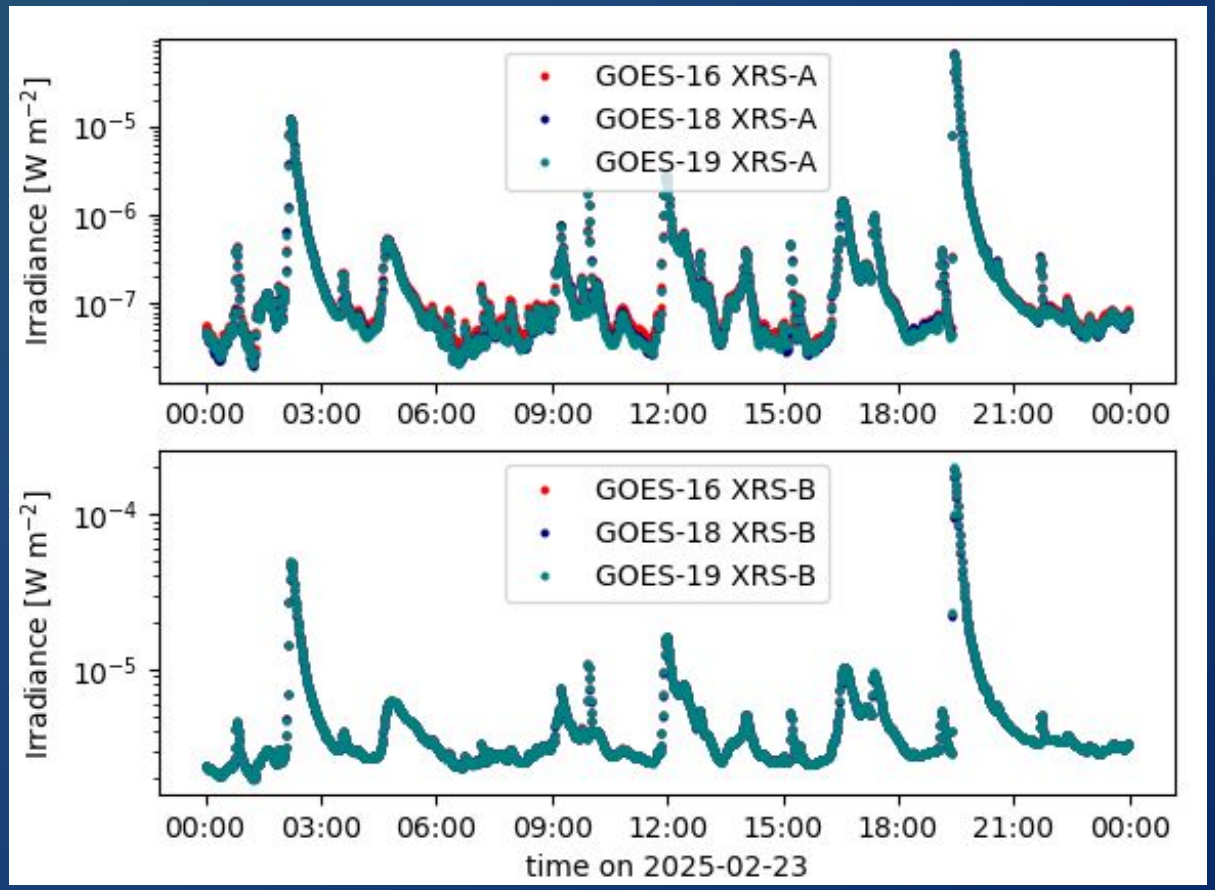
- Plots are for full mission for individual satellites.
- Need to rescale A2 and B2 to A1 and B1 to correct offsets
  - Set A2 / A1=1 and B2 / B1 =1 at channel switch thresholds (red lines)
  - Time-dependent dark correction must be completed first.



data: preliminary science-quality L2 1-minute averages

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

- GOES-16, -18, and -19 comparisons for 1 day (23 February 2025)
- GOES-19 electron contamination not implemented, but e- flux low on Feb 23

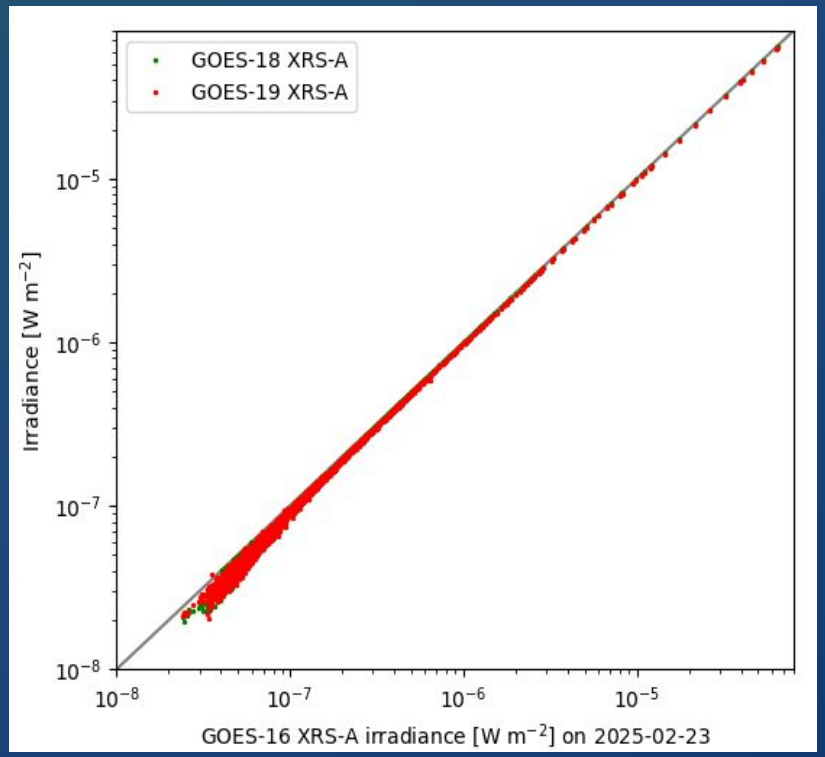


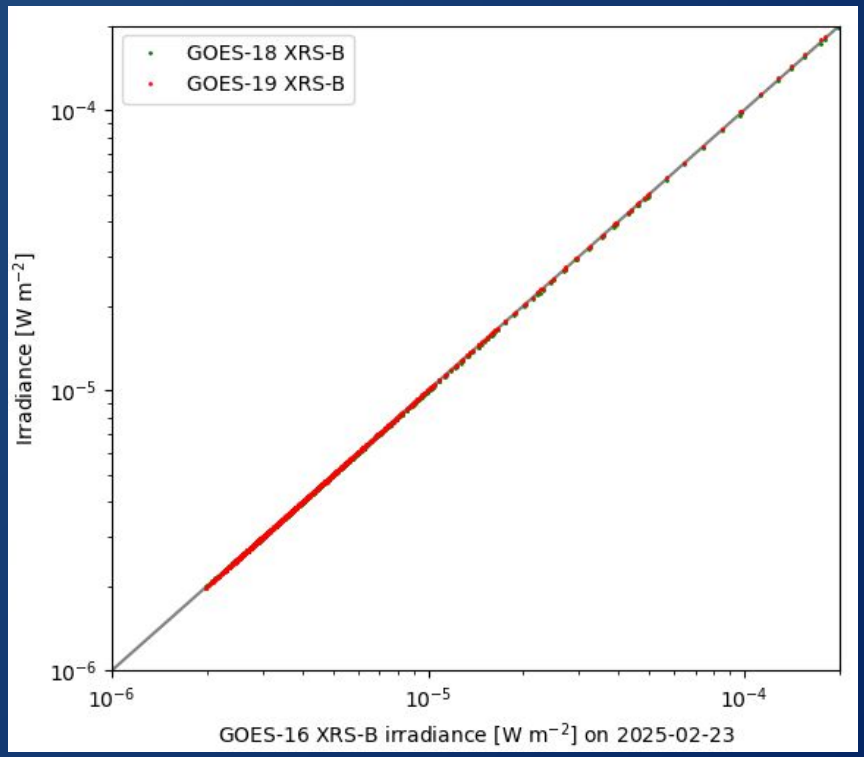
data: preliminary science-quality L2 1-minute averages

These GOES-19 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.

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

- Comparisons of GOES-16 and -18 to GOES-19 (23 Feb 2025).
- Linear behavior at higher fluxes as expected.

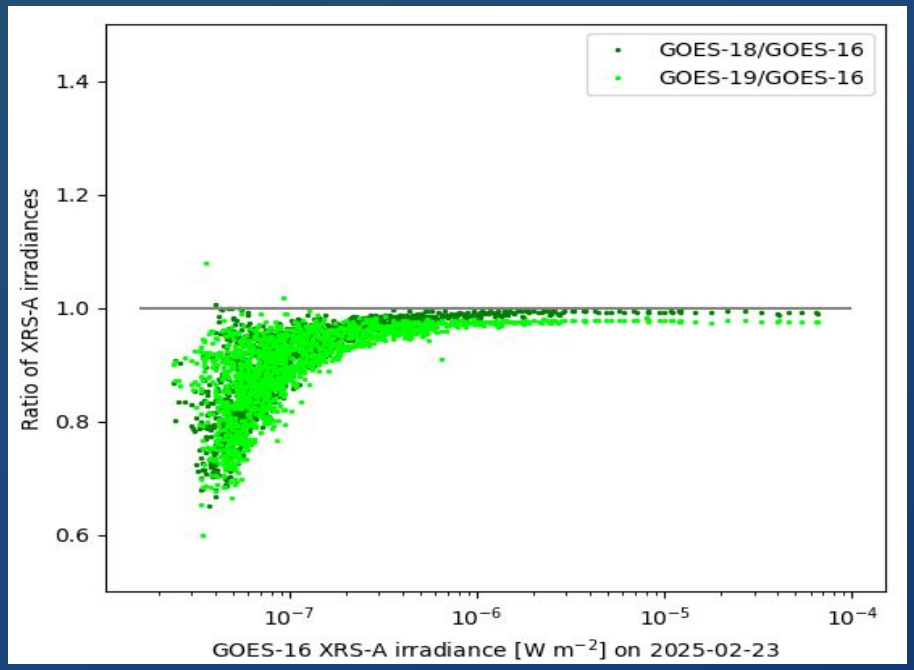


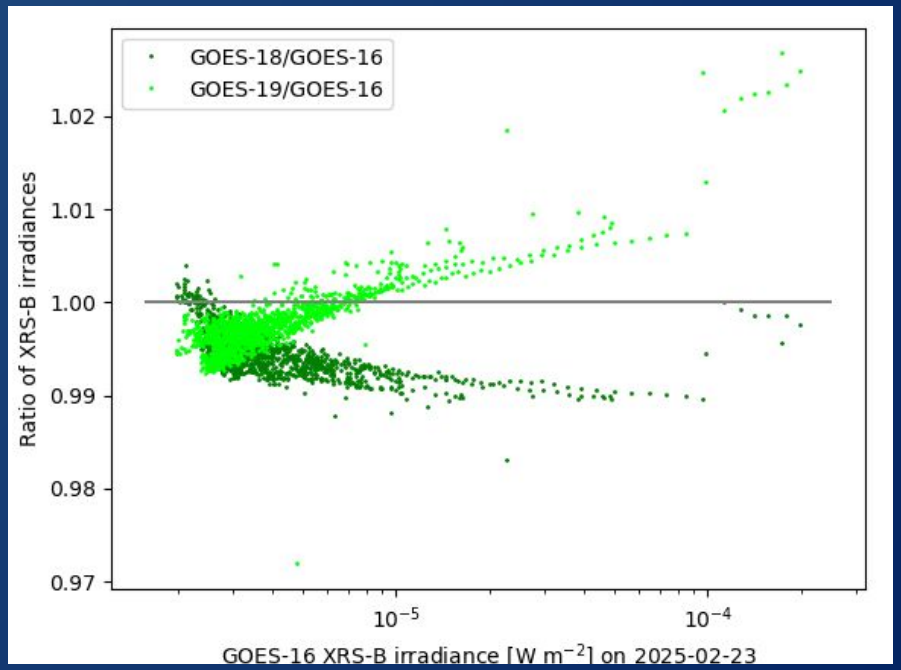


data: preliminary science-quality L2 1-minute averages

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

- Ratios of GOES-18 and -19 to GOES-16 (23 February 2025).
- Trends and offsets at least partially due to use of the preliminary data.



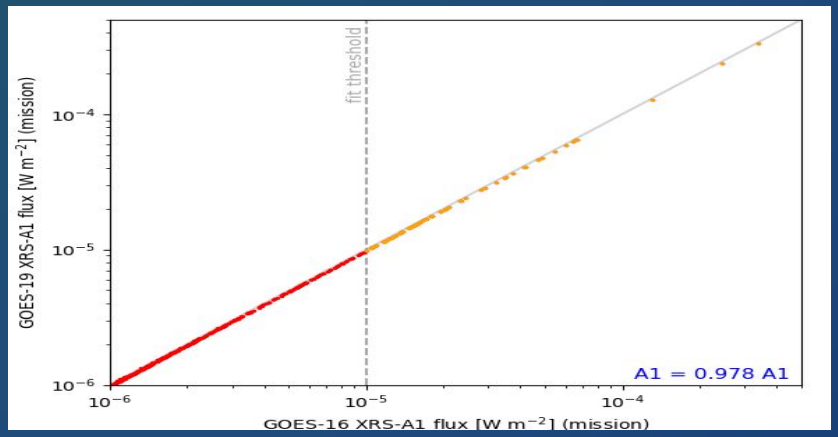


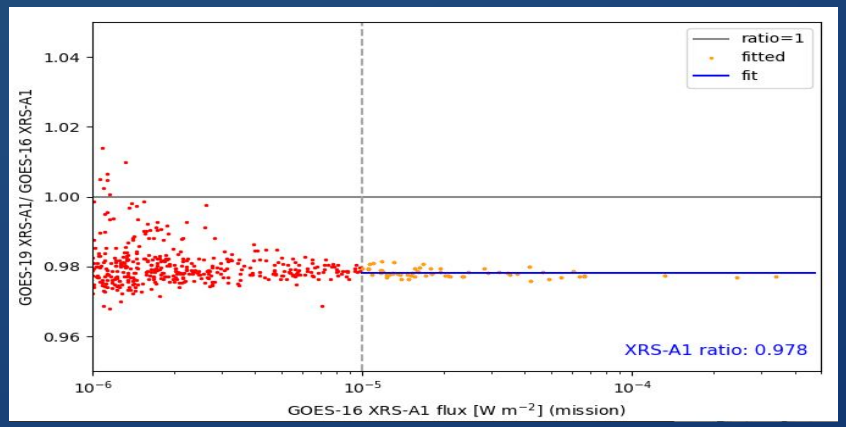
data: preliminary science-quality L2 1-minute averages

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

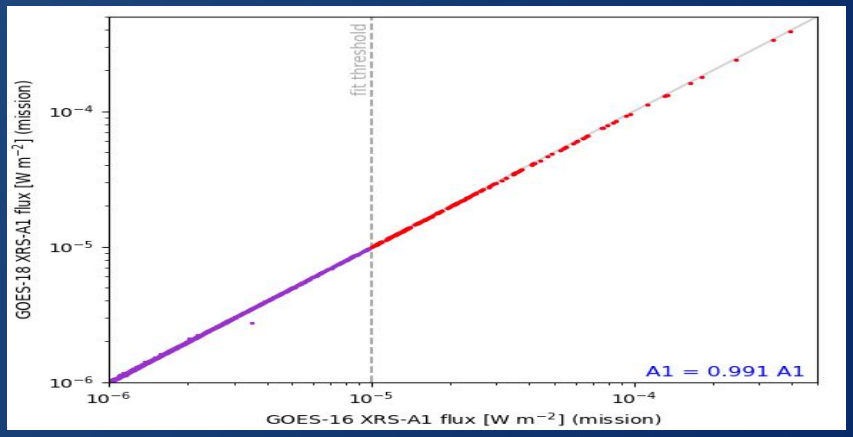
Calculate XRS-A1 ratios for different satellites for mission using flare peak irradiances

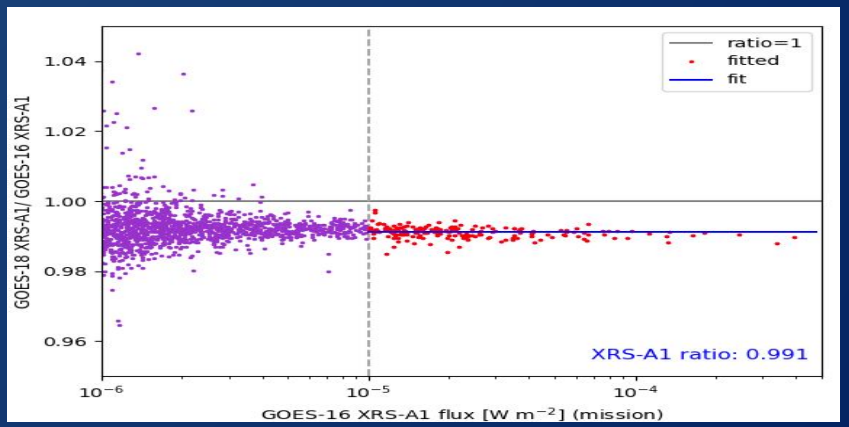
GOES-19 vs GOES-16





GOES-18 vs GOES-16





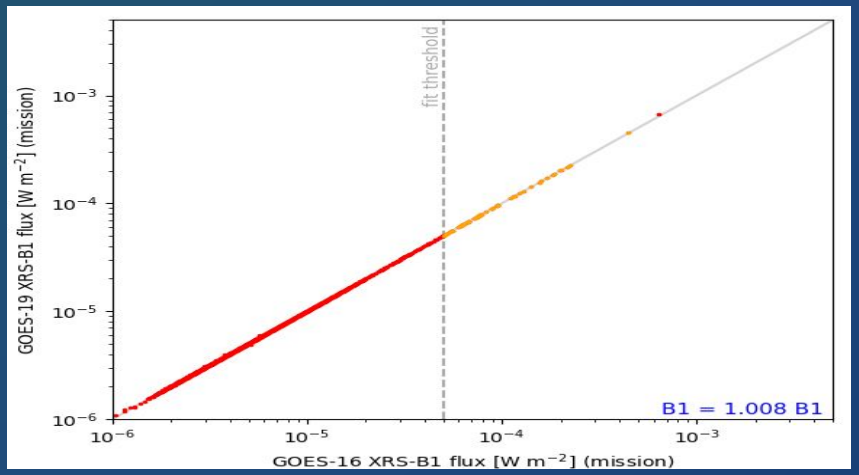
data: preliminary science-quality L2 flare summary

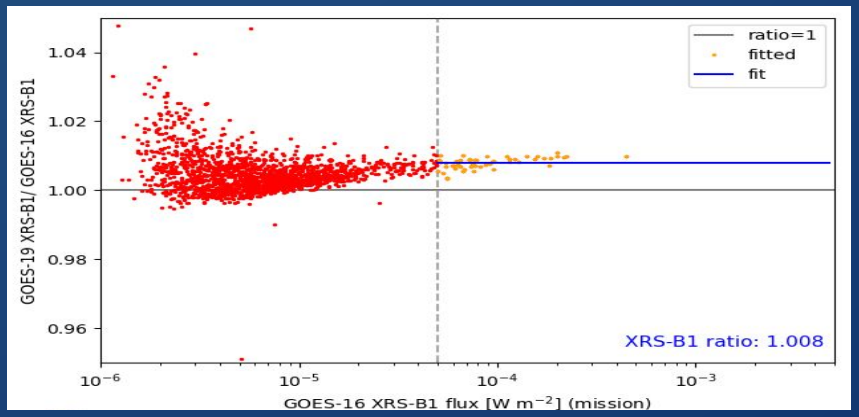
These GOES-19 data are preliminary, non-operational data and are undergoing testing.
Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.

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

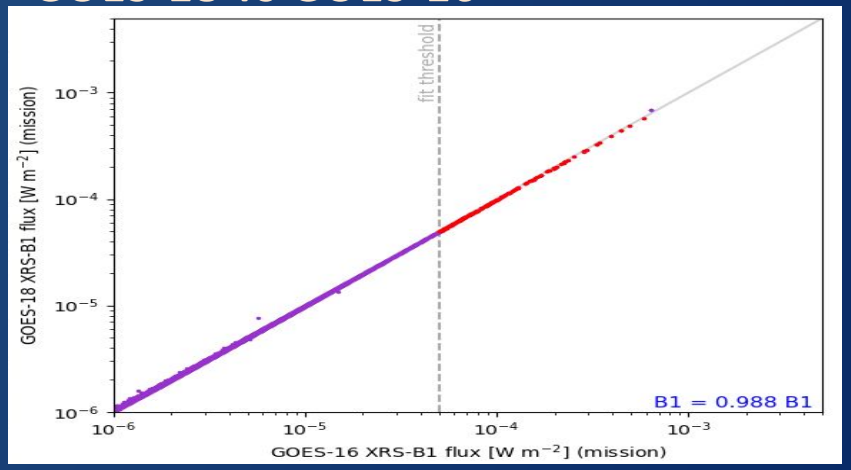
Calculate XRS-B1 ratios for different satellites for mission using flare peak irradiances

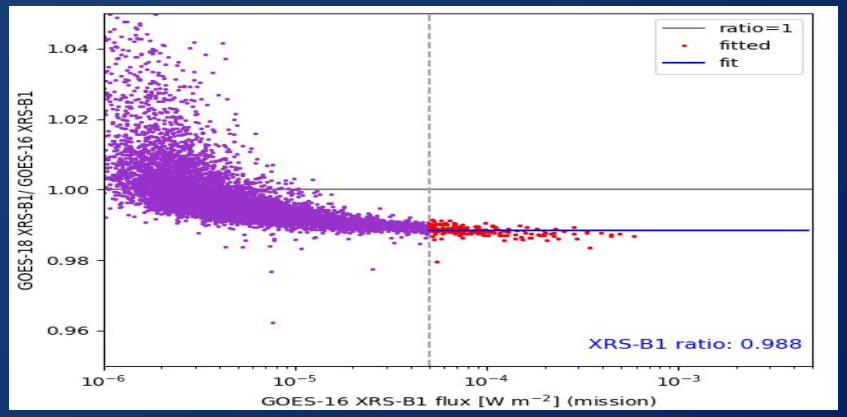
GOES-19 vs GOES-16





GOES-18 vs GOES-16





data: preliminary science-quality L2 flare summary

These GOES-19 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.

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

Approximate (not final!) ratios between satellites [1]

Channel	Satellites	Ratio .
A	G16/G15	1.3 [2]
	G17/G16	0.99
	G18/G16	0.99
	G19/G16	0.98
	G19/G18	0.98
B	G16/G15	1.08
	G17/G16	1.01
	G18/G16	0.99
	G19/G16	1.01
	G19/G18	1.02

[1] Ratios will change (and be improved) in upcoming new data version.
[2] Discrepancy between GOES-R and -15 XRS-A is likely due to GOES-15 calibration errors. See "Interlude" Slide.

data: preliminary science-quality L2 flare summary

Instrument Issues

No significant new instrument issues.

COMPARISON TO PERFORMANCE BASELINE

Performance Baseline

MRD ID	Quantity	MRD Requirement	GOES-16	GOES-17	GOES-18	GOES-19*	PLPTs**	Status
2037	Measurement Range XRS-A	$5x10^{-9}$ to $5x10^{-4}$ W/m^2	$4.47x10^{-9}$ to 0.0739 W/m^2	$4.62x10^{-9}$ to 0.0730 W/m^2	$8.37x10^{-9}$ to 0.0842 W/m^2	**$6.62 x 10^{-9}$ to 0.0680 W/m^2**	#12	**PASS**
	Measurement Range XRS-B	$2x10^{-8}$ to $2x10^{-3}$ W/m^2	$5.84x10^{-9}$ to 0.0510 W/m^2	$6.13x10^{-9}$ to 0.0440 W/m^2	$7.54x10^{-9}$ to 0.0526 W/m^2	**$7.25x10^{-9}$ to 0.0493 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%	**0.56%**	#12	**PASS**
	Measurement Precision XRS-B	2%	1.5%	0.23%	0.46%	**0.45%**		
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)

These GOES-19 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.

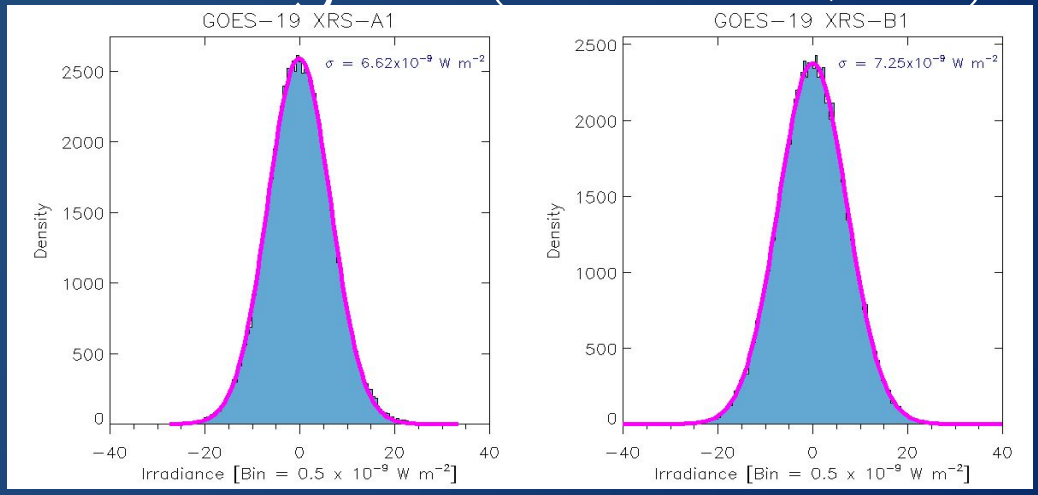
Performance Baseline

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 and -18, XRS is currently stable. Future monitoring includes: (1) GOES-19 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 (14.215° C) on 2024/284.

A1: 1 DN = 9.4898 x 10^{-10} W/m^2 B1: 1 DN = 6.8205 x 10^{-10} W/m^2

A2: 1 DN = 6.8790 x 10^{-8} W/m^2 B2: 1 DN = 4.9871 x 10^{-8} W/m^2

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

σ_{A1} at 1 DN = 6.62 x 10^{-9} W/m^2 σ_{B1} at 1 DN = 7.25 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: 6.62 x 10^{-9} W/m^2 B1 min: 7.25 x 10^{-9} W/m^2

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

A1 max: 9.39 x 10^{-4} W/m^2 B1 max: 6.75 x 10^{-4} W/m^2

A2 max: 0.0680 W/m^2 B2 max: 0.0493 W/m^2

credit: Tom Eden
data: LASP-processed L1b

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: 9.4898×10^{-10} W/m^2 B1: 6.8205×10^{-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).

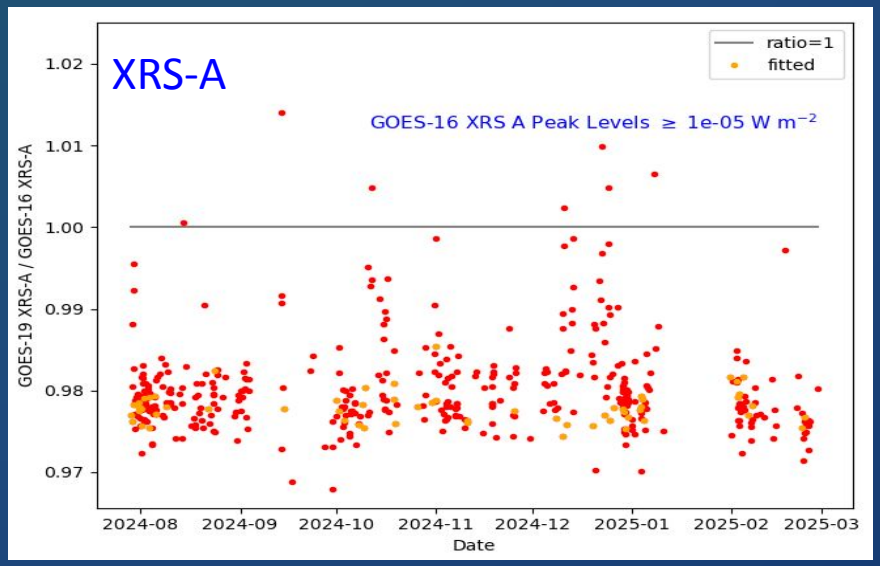
A1: 9.4898×10^{-10} W/m^2 / ($20 \times 8.37 \times 10^{-9}$ W/m^2) x 100

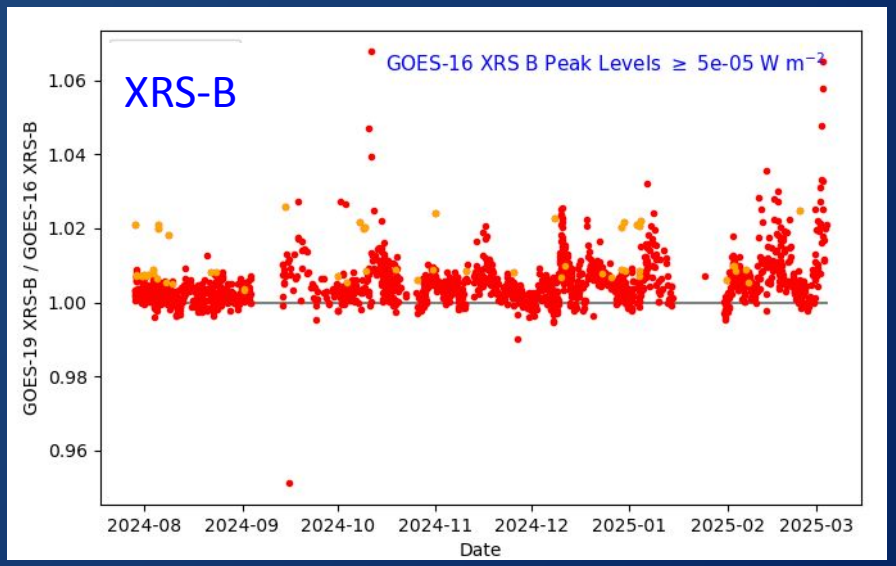
B1: 6.8205×10^{-10} W/m^2 / ($20 \times 7.54 \times 10^{-9}$ W/m^2) x 100

Percent precision: A1: 0.56%, B1: 0.45%

Stability of GOES-19 relative to GOES-16 (for MRD 2042)

- Examine ratios of peak irradiances for GOES-19 / GOES-16.
- Irradiances appear stable (i.e., no trend) and we will continue to monitor them.

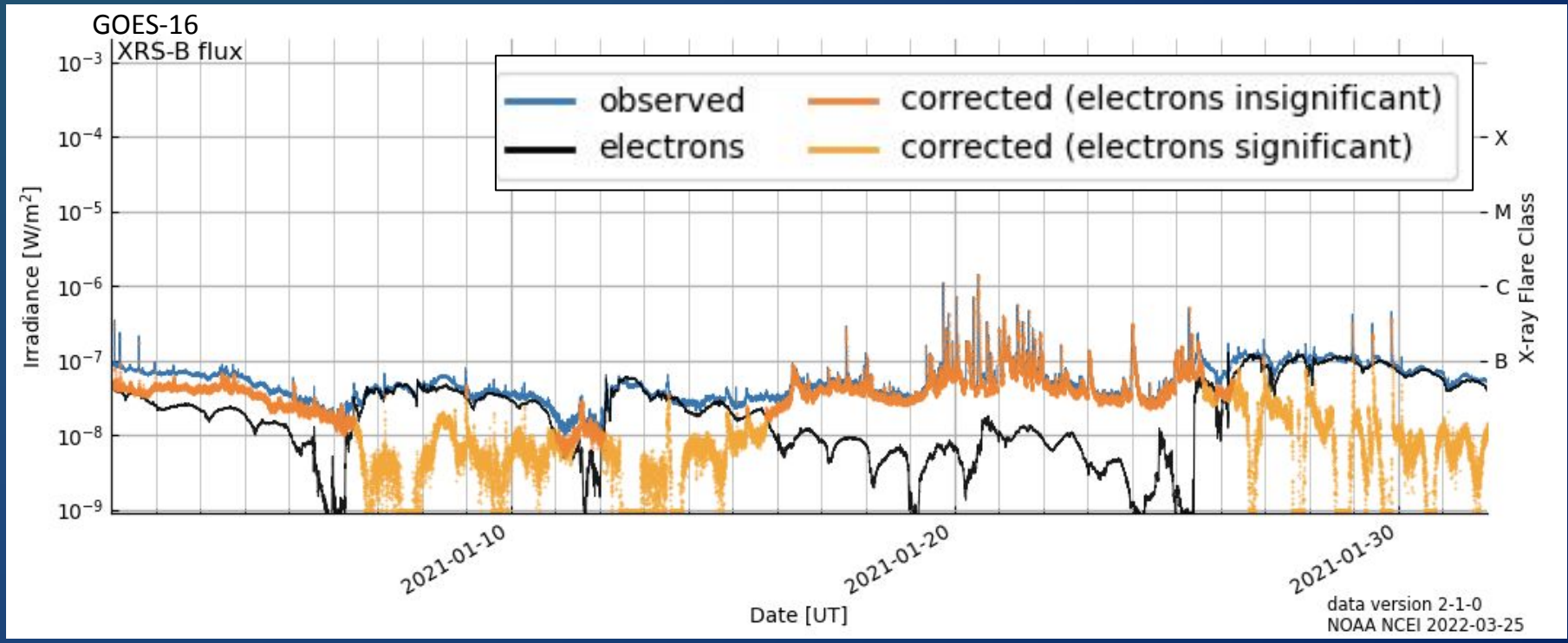




data: preliminary science-quality L2 flare summary

GOES-19 PORD Waiver for e- Flux (1/2)

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



data: GOES-16 operational L2 1-minute averages

These GOES-19 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.

GOES-19 PORD Waiver for e- Flux (2/2)

- XRS does not meet PORD requirements when e- fluxes are high and irradiance is low.
- THe PORD Waiver reduces electron fluxes defined as Worst-Case Electron Environment
  - Defined for GOES-16. Covers GOES-17, -18, -19. (LASP Waiver Request 161597revD)
- Evaluation with *estimated electrons = XRS-{A/B}1 -XRS{A/B}2* and MPSHI data.
- GOES-19 XRS-B: high solar activity --> no periods where electrons signal violated PORD
- To complete waiver for XRS-B, GOES-16 values were assumed for GOES-19.

	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 to be applied to EXISPORD Electron 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
G19	**3.0e5**	**3.5e4**	7.0e5	1.0e5	**0.015**	**0.005**	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
G19	**3.4e6***	**1.3e06***	7.0e5	1.5e5	**0.17***	**0.19***	1	1

* GOES-19 XRS-B1 uses corresponding GOES-16 values.

credit: Tom Eden

data: LASP-processed L1b

SUMMARY OF REMAINING ISSUES

Remaining XRS GPA Issues

- 3 ADRs for Full Validation

ADR	WR	Issue	*	Description / Impacts	Build
1144	8764 10165	EXIS during eclipse or lunar transit		XRS correction part of ADR is ready to go into operation.	DO.16.00.00
1161	8762 8837 10071	Add EXIS penumbra flag		Impacts flare detection (detailed in GOES-17 EUVS Full Validation PS-PVR)	MM.14.00.00
1437	10106	EXIS LZSSc monitoring and backfill		Impacts all space weather instruments. A partial fix has been implemented.	PR.14.00.02

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

Remaining Instrument XRS Issues

#	Issue	Description	Comments to Users
1	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. More SEP events are probably required to perform full fix. (See Backup Slide 52.)
2	Update L1b calibration coefficients	Update dark counts and responsivities. Time-dependent dark count offsets are now used in the science-quality data. For operational LUTs, static offsets are derived from the science-quality functions.	The L1b algorithm calibration coefficients will be revised for GOES-16 through -19 in March 2025.
3	Update L2 calibration coefficients	Update parameters for 1s spike removal, electron contamination and flare location.	The L2 algorithm calibration coefficients will be revised for GOES-16 through -19 in March 2025.

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, -17 and -18. 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.	Product is ready for operational use and further cal/val activities.

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 and -18.
- Promising paths toward diagnoses and fixes of issues have been identified.

NCEI-CO recommends that FM4 XRS L1b data be transitioned to Provisional status at this time.

PATH TO FULL VALIDATION

Path to Full Validation

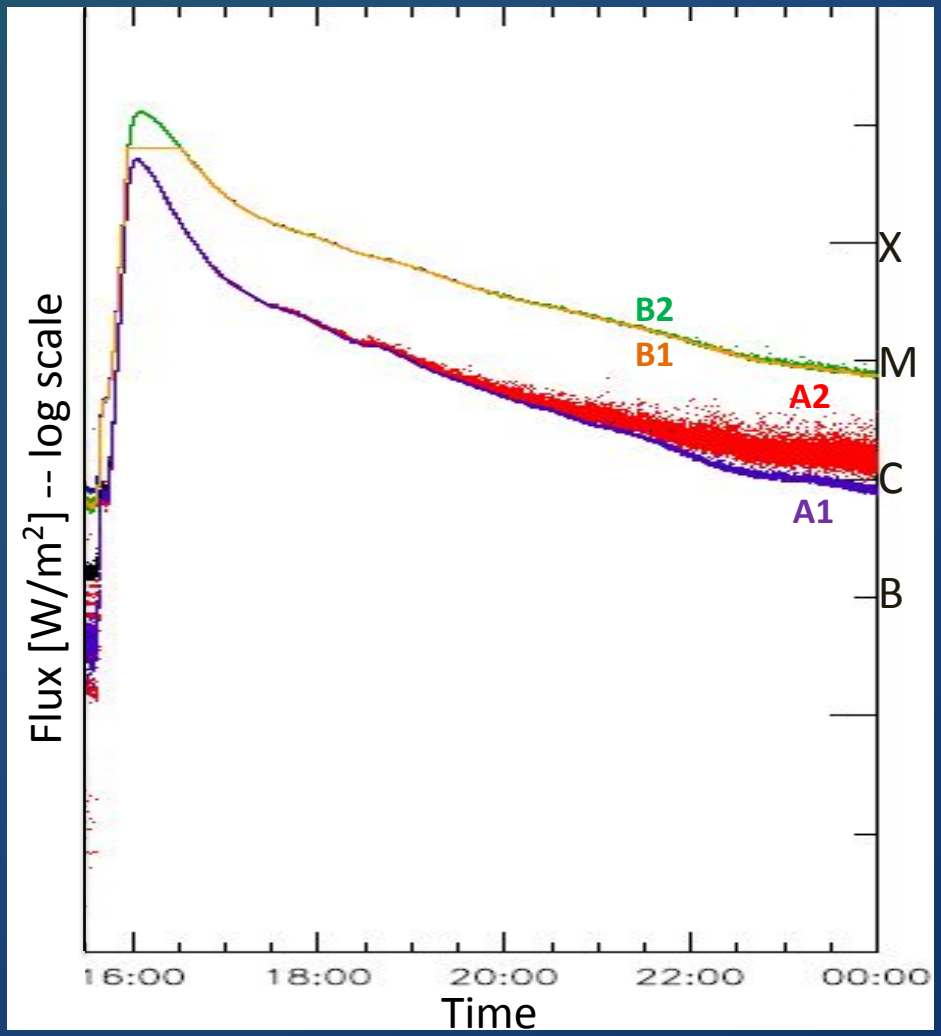
- Analyze daily, weekly and quarterly calibrations.
  - Next XRS LUT (March 2025) will have revised dark counts and XRS-A2 and -B2 responsivities.
- Identify and resolve instrument issues including those listed in the Summary of Remaining Issues slides.
  - Data analysis with L1b, L2, and locally processed L0 data.
  - Need major SEP events.
- Update L1b and L2 LUT values before the GOES-19 operational date of 4 April 2025.
- Verify L1b revisions for ADR fixes.
- Complete electron contamination waiver submission process.

Risks for Full Validation Status

Issue	Impact	Notes
New issues found during continued monitoring and analysis for issue resolution.	Possible moderate impact	
Uncertain funding for vendor (LASP) to assist with analyzing anomalous issues and operational under special circumstances.	Possible moderate impact	

ADDITIONAL INFORMATION

Instrument Issue: Dark Radiation Coefficients



data: GOES-16 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

EXIS Calibrations

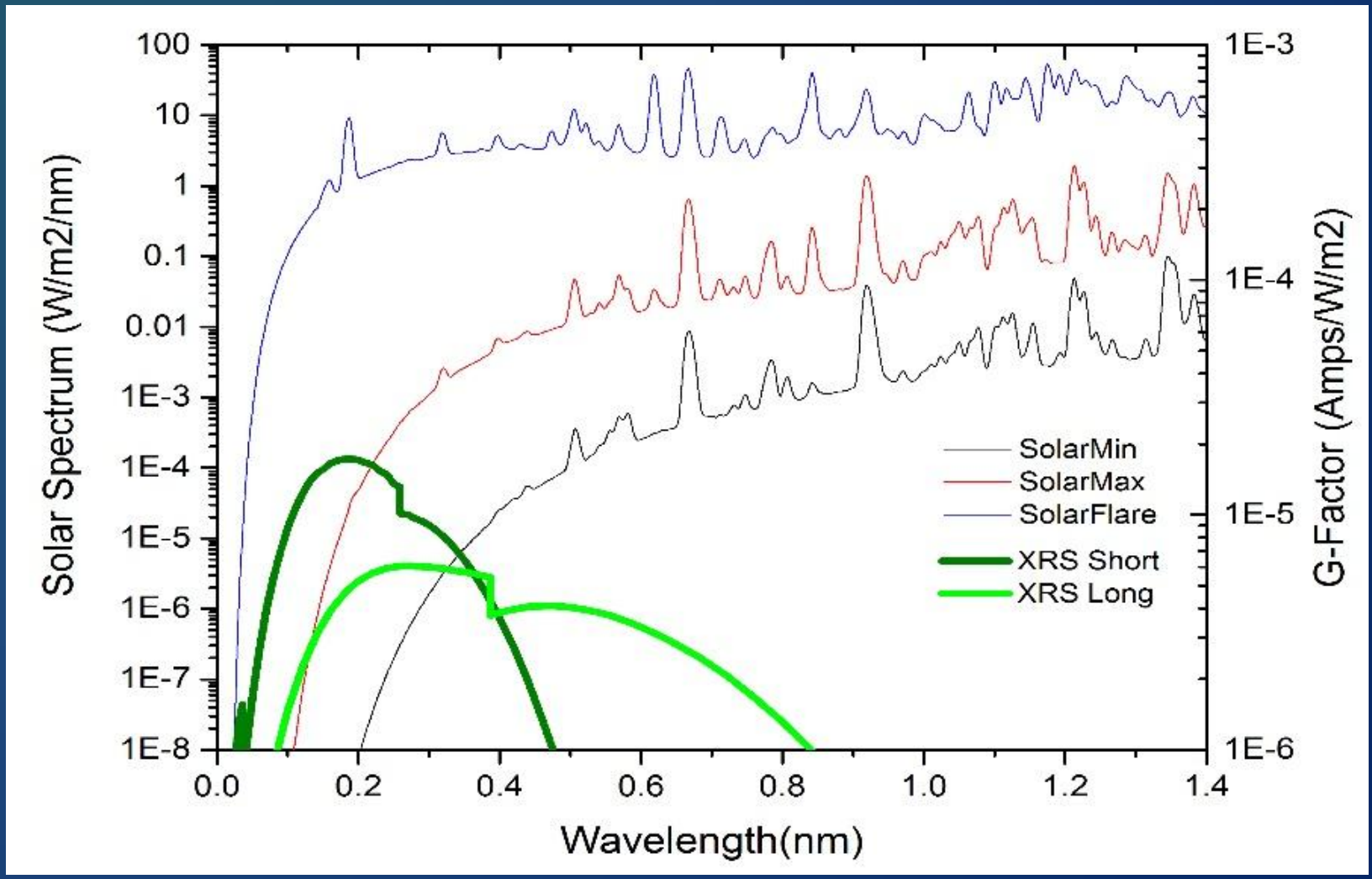
- Nominal Weekly - 90 s comparison with secondary
  - EUVS - A, -B Measure and trend darks and gain.
  - EUVS-A Measure and trend primary filter changes.
  - EUVS - A, -B, -C Measure and trend flatfield.
  - EUVS -C Measure and trend primary channel offset.
- Quarterly cruciform
  - XRS, EUVS-A, -B,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

FM4 LUTs as of 2025-03-07:

SPS_Cal_INR(fm4_CDRL79revC).h5
XRS_Cal_INR(fm4_CDRL79revC).h5
Yearly_1AU_Correction_Table(2025).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.