GOES-19 EXIS EUVS L1b Provisional Maturity Peer Stakeholder-Product Validation Review (PS-PVR)

March 11, 2025

Presenter

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Contributors

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Summary

- GOES-19 EUVS performance is similar to GOES-16, GOES-17, and GOES-18.
- The EXIS-EUVS instrument vendor, Laboratory for Atmospheric and Space Physics (LASP, University of Colorado), conducted GOES-19 PLT operations.
- ECI observations were done using the GOES-19 satellite on January 14-30 2025. The data measured during ECI cannot be used for provisional maturity analysis.
- RevC LUTs installed in operational processing on January 30 2025. This is the start of operational-quality L1b and L2 data. The RevA and RevB LUTs were installed during PLT, and did not have finalized calibrations.
- Due to ECI and the date of the RevC LUT installation, this presentation uses data from January 31-March 9 2025.
- This presentation contains science-quality L2 data for GOES-16 and GOES-18, and operational L2 and L1b data for GOES-19.
- GPA: Many ADRs have been submitted and resolved. 4 ADRs are currently open.
- All PLPTs: **PASSED**
- Provisional Validation Product Maturity Assessment: **PASSED**

ECI = Extended Coronal Imaging
PLPT = Post-Launch Product Test
GPA = Ground Processing Algorithm
ADR = Algorithm Discrepancy Report
LUT = Look Up Table

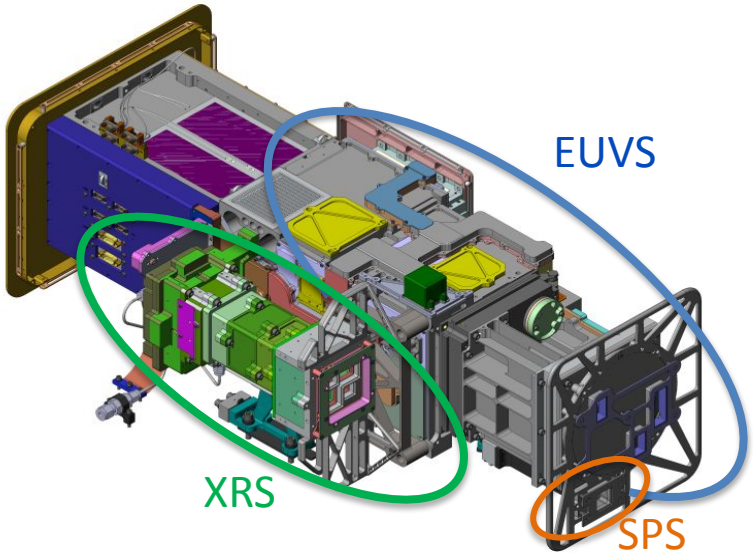
Disclaimer for PASS Status

- Due to ECI and RevC LUT installation date, GOES-19 has only 5 weeks of valid operational data
- GOES-19 EUVS-A and EUVS-B degradation are scaled to GOES-16. This is a temporary method used at the start of the mission and is *not* the standard degradation correction method.
- GOES-18 EUVS-A has a known incorrect scaling. This will be fixed with a new LUT in March 2025.
- GOES-19 LUT updates are significantly affected by the GOES-19 schedule. No data will be taken from March 21-April 1 while GOES-19 is drifting to its operational position. This period covers the middle of the spring 2025 eclipse season; data taken during the middle of the eclipse season is necessary for updating the temperature, dark drift and degradation corrections.
  - I don't know if I can use the fall 2024 eclipse season data, or develop a work-around. This will require additional thinking.
- Rodney Viereck (SWPC) will discuss during his presentation

EXIS Overview

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)



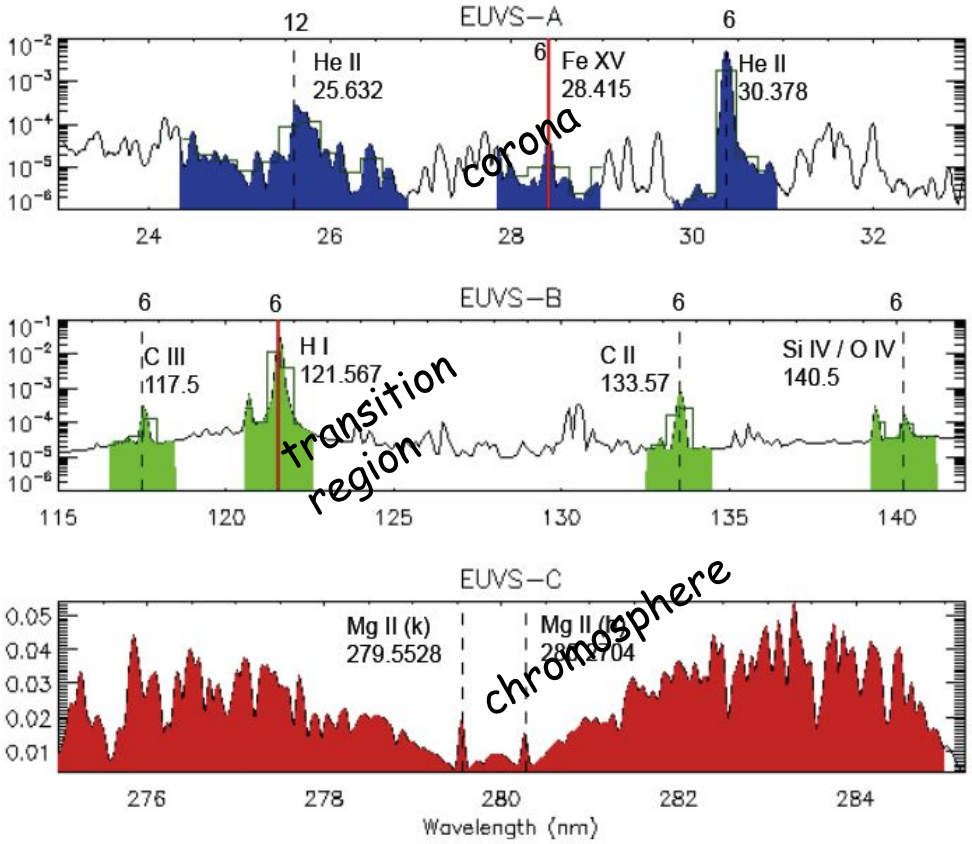
EXIS was designed, built and tested by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado

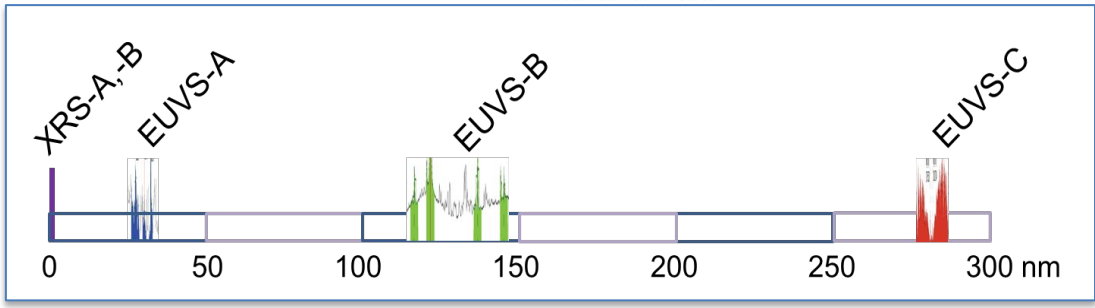
Extreme Ultraviolet Sensor (EUVS)

- Requirements
  - ≤30 s cadence
  - ≤20% accuracy
  - Spectral model (5-127 nm)

- 3 Grating Spectrographs
- EUVS-A: 24 diode array, filter wheel
- EUVS-B: 24 diode array
- EUVS-C: 512 diode array

- L1b Products
  - 7 solar lines
  - Mg II index
  - Spectral model (5-127 nm)
  - High-resolution data (L2)





Why Measure EUV Variability?

- Air Force High Accuracy Satellite Drag Model (HASDM)
  - Calculates and predicts neutral density and satellite position for collision avoidance
  - Users: DOD, NASA, NOAA, every satellite operator in the US

- Variations in solar EUV by up to a factor of 10 increase have major impacts for satellites in low Earth orbit (LEO)
  - More EUV irradiance causes more heating in the thermosphere, which causes the atmospheric layer to expand
  - Satellite drag can increase by a factor of 10 and operators must correct orbit calculations

- More EUV irradiance modifies the ionosphere, which impacts radio communications and GPS navigation

Why Measure EUV Variability?

- NOAA Whole Atmosphere Model – Ionosphere Plasmasphere with Electrodynamics (WAM-IPE based on the GFS weather model)
  - Specify and predict ionosphere conditions for radio communication and satellite navigation.
  - Specify and predict neutral density for satellite orbit predictions and collision avoidance.
  - Customers: DOD, DHS/FEMA, FAA, ICAO, Satellites, Construction, Agriculture, Mineral Exploration, etc.
  - Status: Currently developing the appropriate interface between the GOES EUVS data and the operational WAM-IPE model

- The recently formed DOC **Office of Space Commerce** will eventually include civil **Space Traffic Management** and **Space Situational Awareness.** This office will likely manage satellite drag models which will require solar EUV input from GOES to improve model performance.

L1B PRODUCT QUALITY ASSESSMENT

Post-Launch Product Tests

PLPT	Test Title	Operator	Status	Criteria
01	EUVS-C Mg II Scaling	LASP	Pass	[1]
02	EUVS L1b Model Baseline	LASP	Pass	[1]
03	EUVS L1b Uncertainties	LASP	Pass	[1]
14	XRS/EUVS/Mg II Inter-Satellite Comparisons (L1b)	NCEI	Pass	None
15	Degradation Trending for EUVS-A	NCEI	Pass	[1]
16	Degradation Trending for EUVS-B	NCEI	Pass	[1]
17	Degradation Trending for EUVS-C	NCEI	Pass	[1]

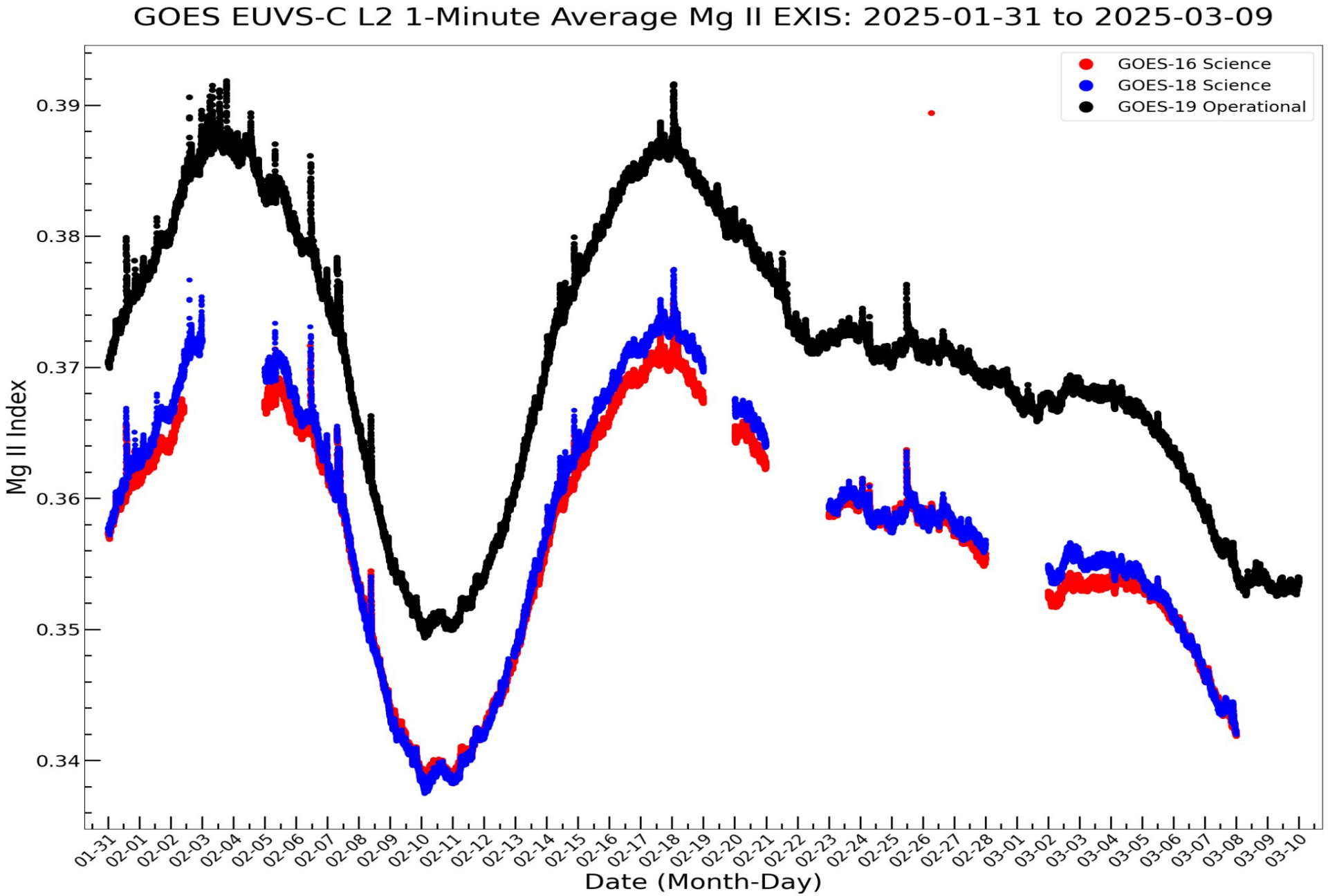
- Test Plans and Procedures are from the RIMP*
- Some PLPT tests use LASP-processed L0 data
  - PLPTs for calibrations need unprocessed data
- Ground System OE L1b and L2 data used for considerable ADR testing and some PLPT #14 analysis
- [1] RIMP Provisional Success Criteria: "EUVS L1b product data are available and analysis is completed."

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

PLPT #1: EUVS-C Mg II Scaling

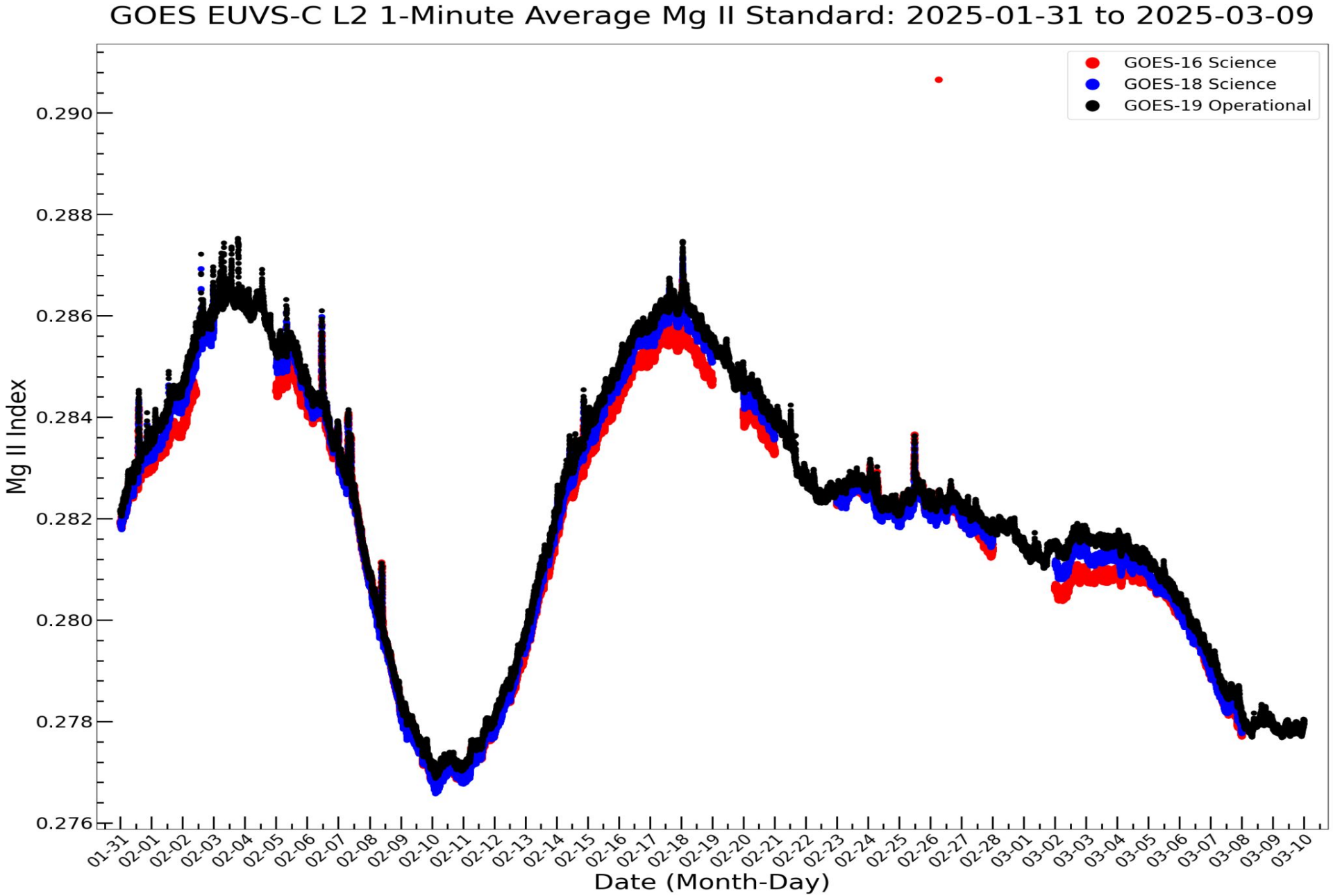
- Determine the NOAA Mg II scaling factors needed for historical continuity
- Scaling is to a standard spectral resolution as described in:
  - A Revised Magnesium II Core-to-Wing Ratio From SORCE SOLSTICE. *Earth and Space Science*, 6(11), 2106-2114. https://doi.org/10.1029/2019EA000652. M. Snow, et al.
- New factors: $MgII_{NOAA} = a + b \cdot MgII_{EXIS}$
  - GOES 16: a = 0.18461750 b = 0.27230353
  - GOES-17: a = 0.18653062 b = 0.25803610
  - GOES-18: a = 0.18745964 b = 0.26407333
  - GOES-19: a = 0.18934246 b = 0.25057585
- The scaling is linear, so the difference between satellites is reduced in the standard Mg II index
- The scaled Mg II value is called "Mg II NOAA" in L1b data and "Mg II Standard" in L2 data

- EUVS-C MgII_EXIS index. The indices from each satellite are NOT yet scaled.



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.

- EUVS-C MgII_standard index. The indices from each satellite are now scaled and show agreement.



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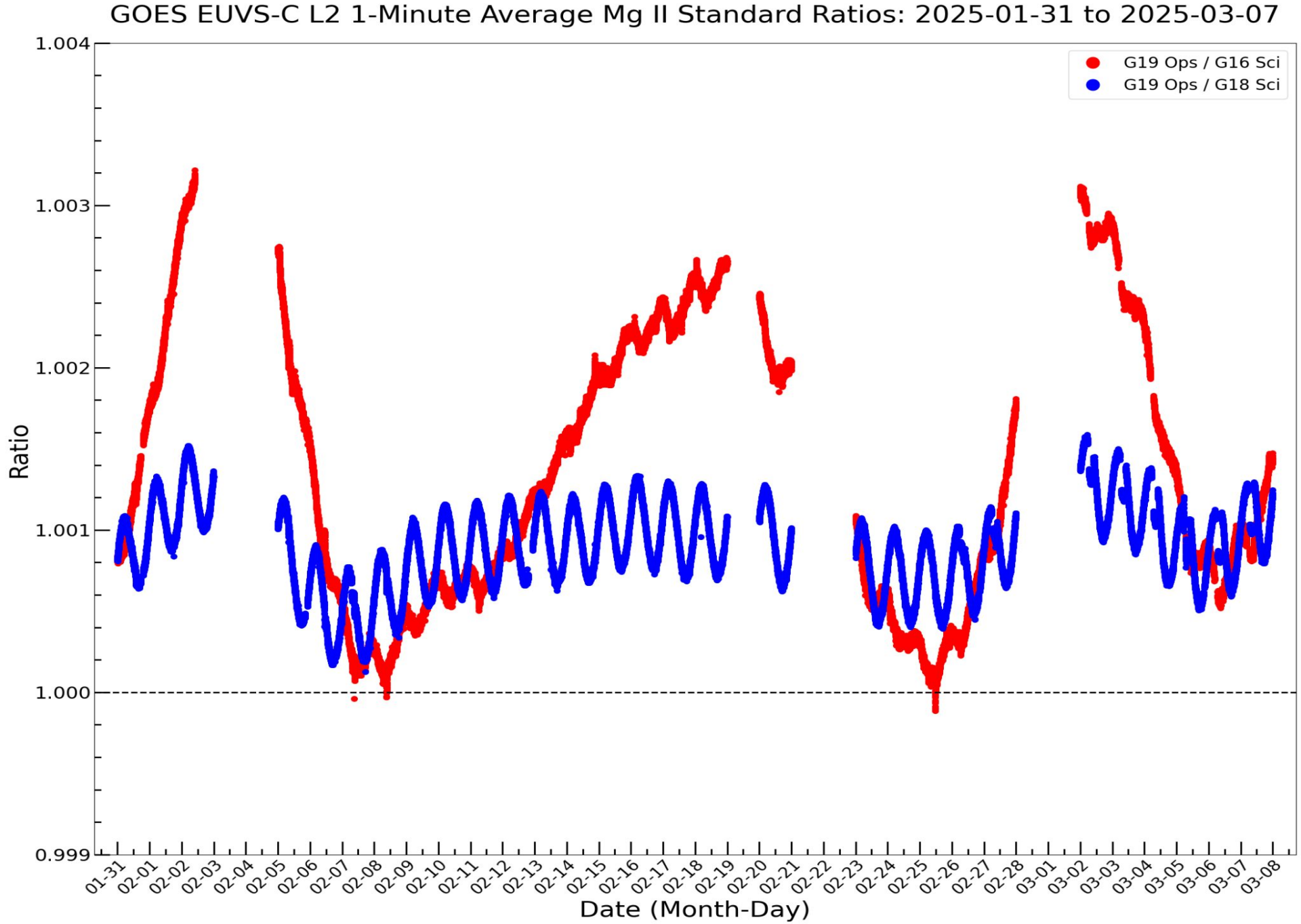

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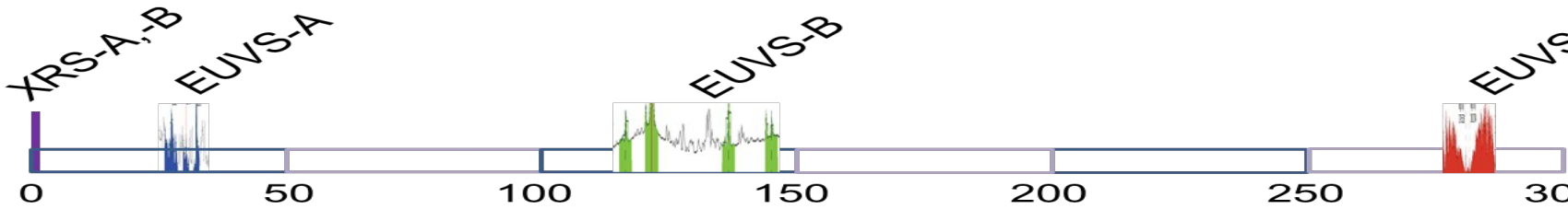
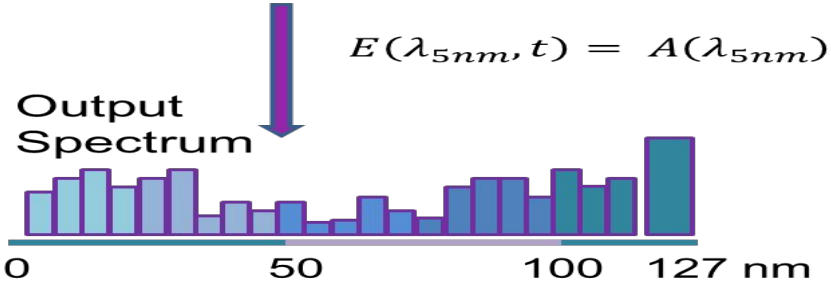
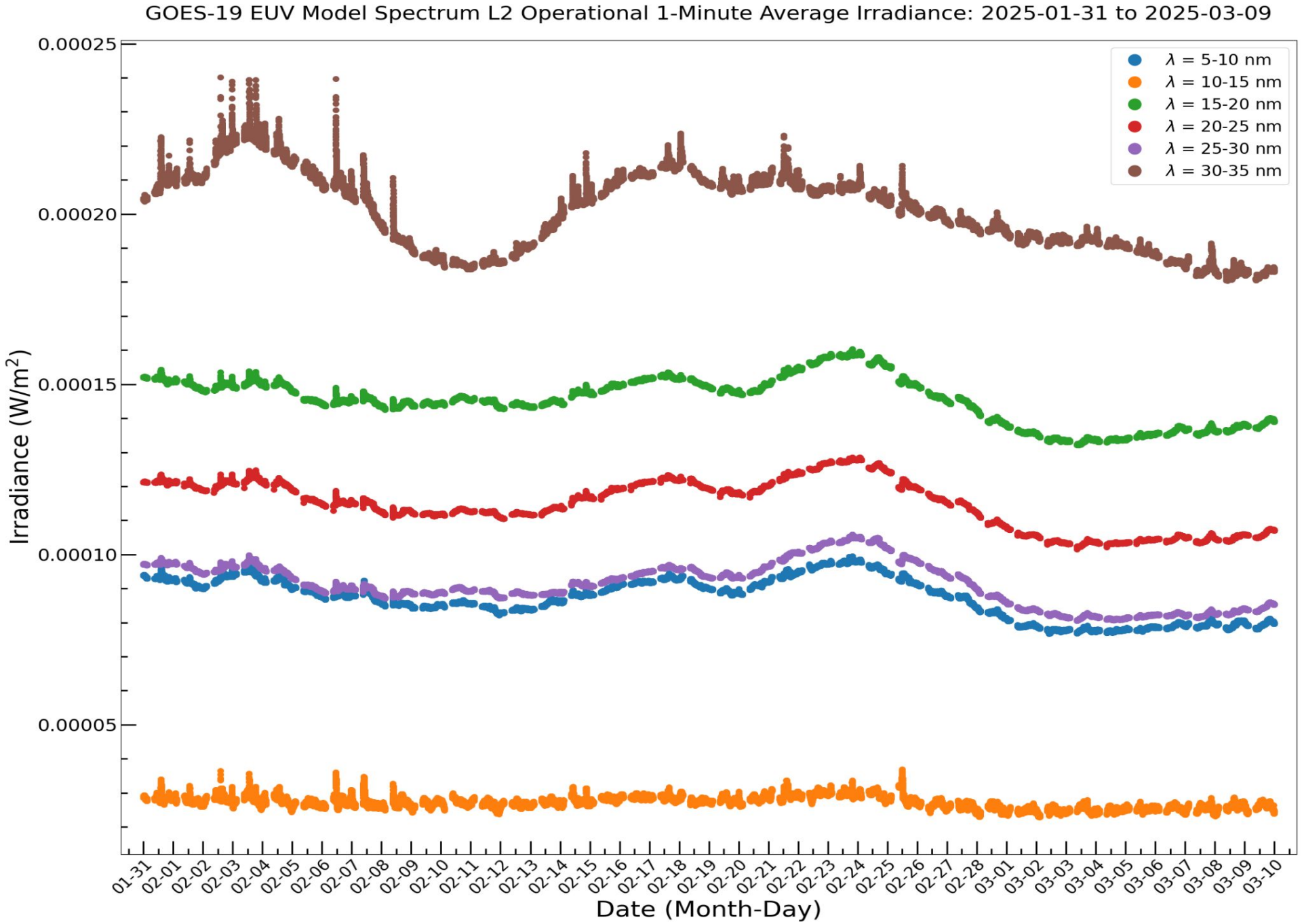
PLPT #2: EUVS L1b Model Baseline

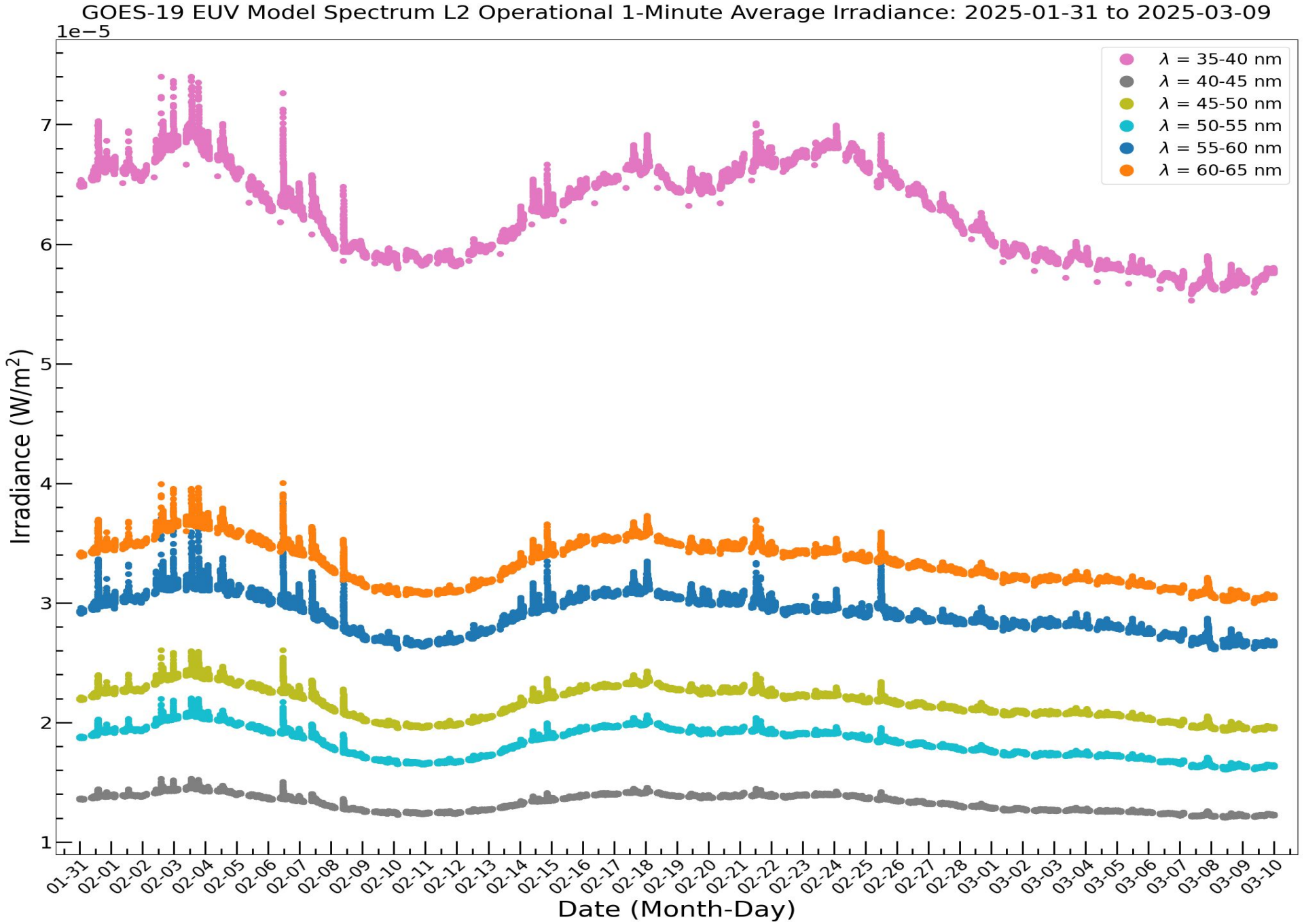
- **Objective**: Determine if coefficient parameter updates are needed for the EUVS proxy model.
- The same model spectrum coefficients are in use for all 4 satellites (GOES-16, GOES-17, GOES-18, GOES-19)
- Plots show G19 irradiance vs. time in each of the 23 wavelength bins
- Model described in:
  - The GOES-R EUVS Model for EUV Irradiance Variability, E.M.B. Thiemann, et al., J. Space Weather and Space Climate, 2019.

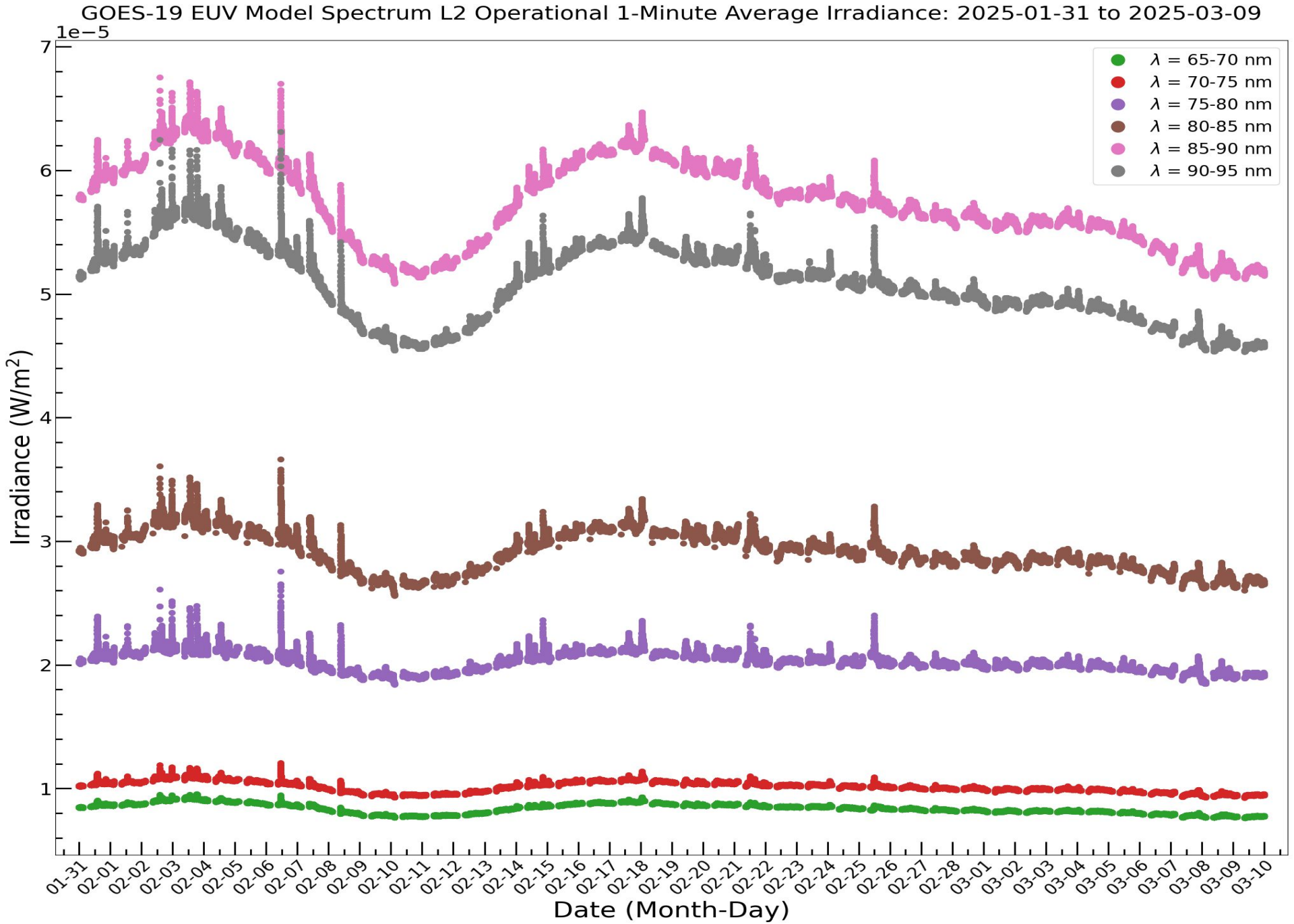


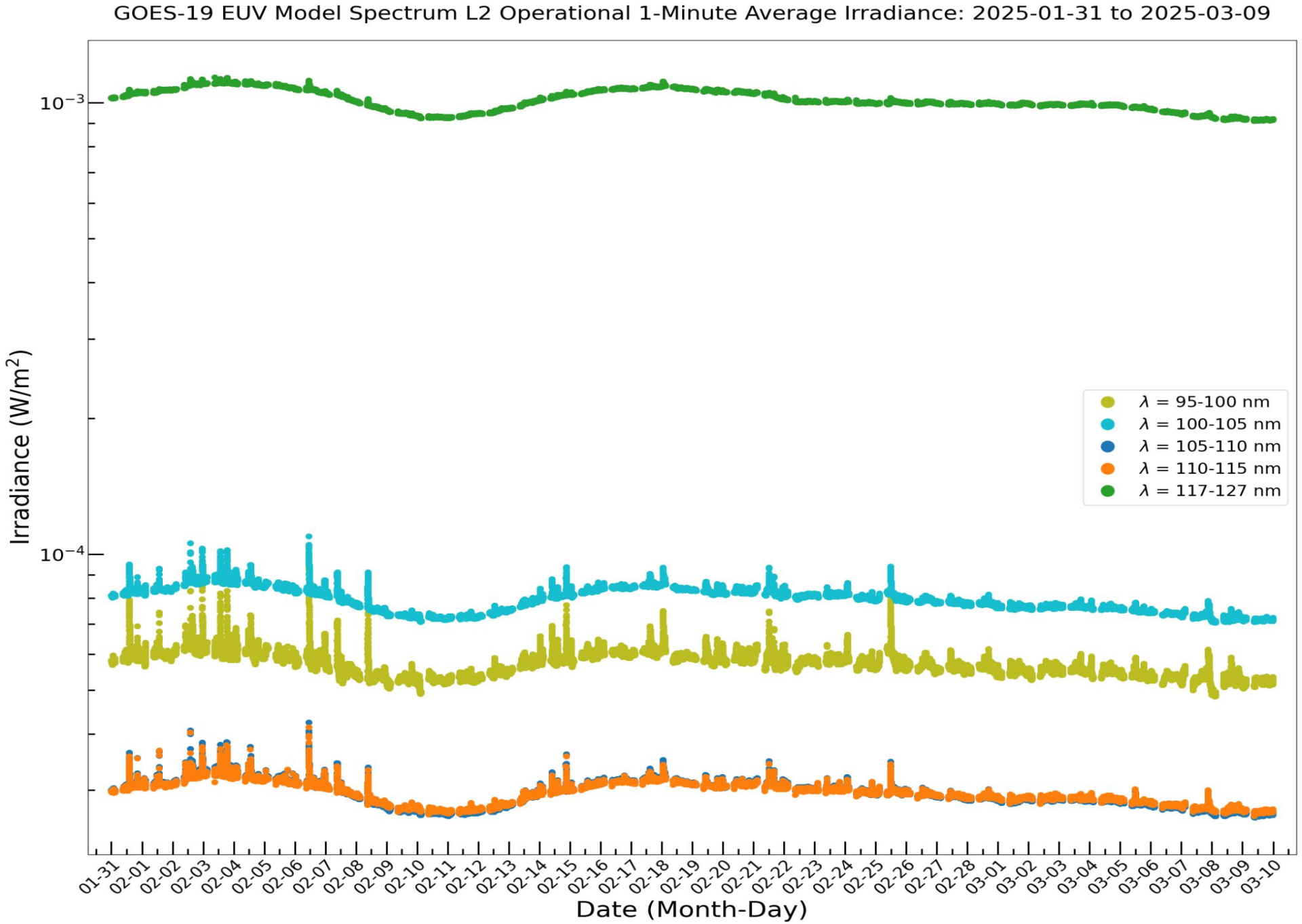
$$E(\lambda_{5nm}, t) = A(\lambda_{5nm}) + \sum_{i=1}^{10} j_i(\lambda_{5nm})\, P_i^{m_i}(t) + \sum_{i=1}^{10} k_i(\lambda_{5nm})\, Q_i^{n_i}(t)$$





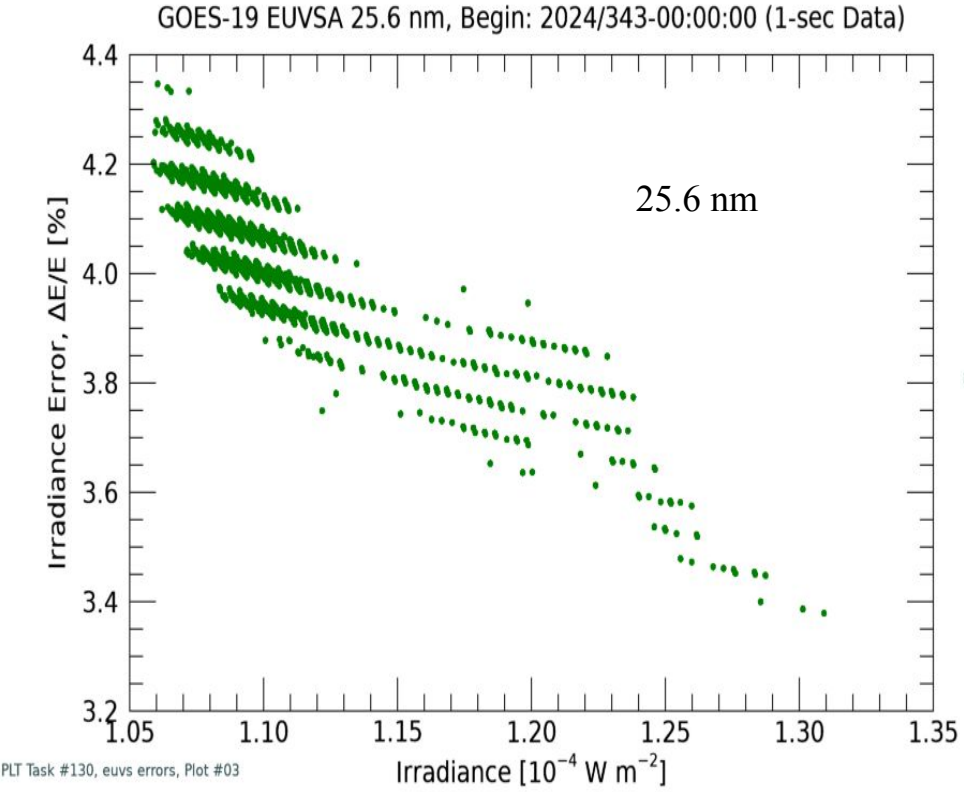


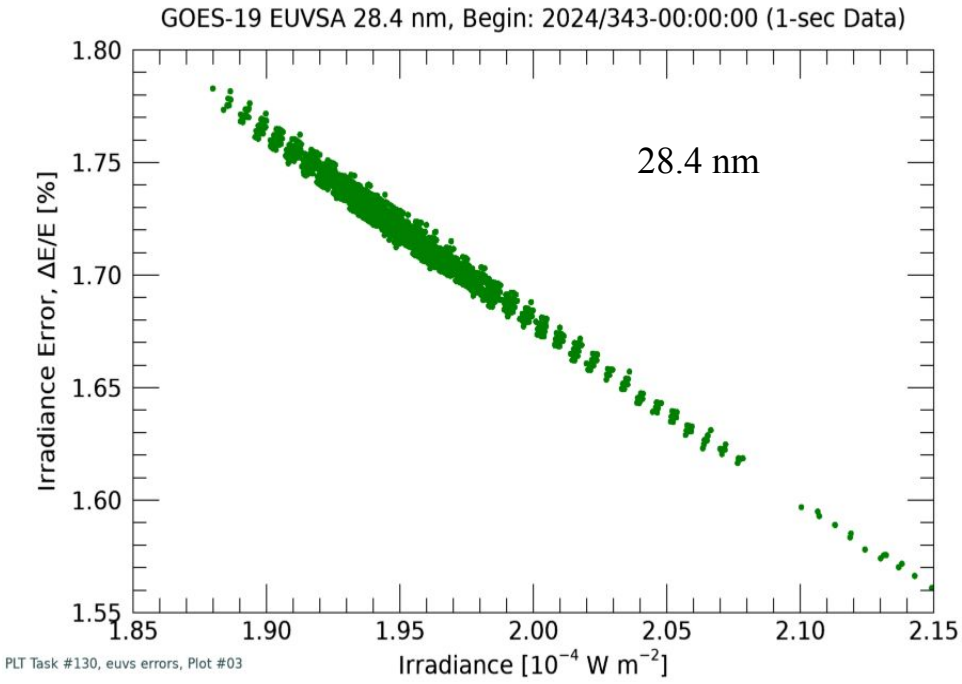


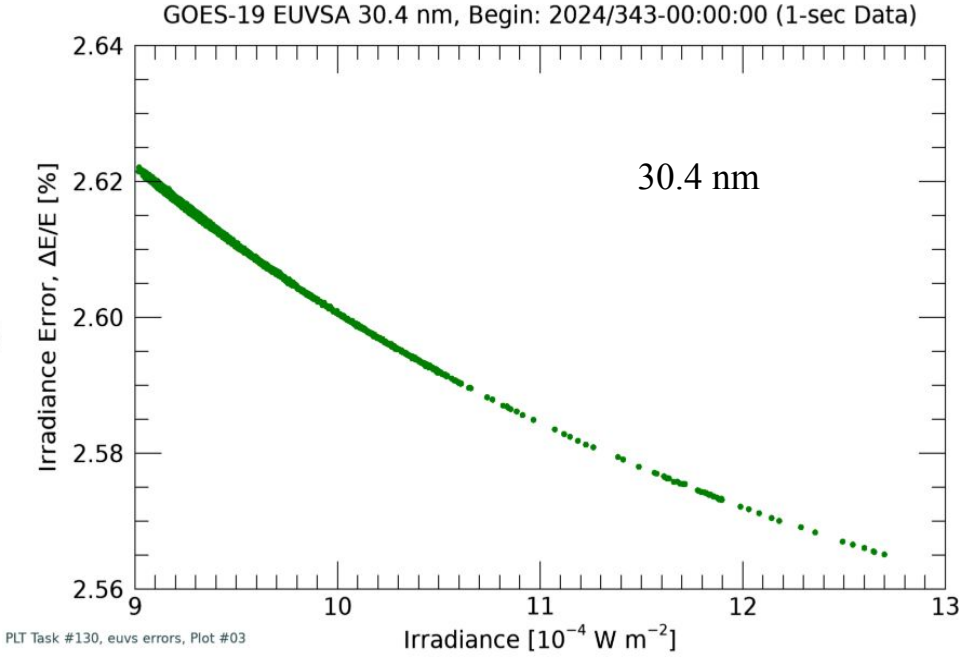


PLPT #3: EUVS L1b Uncertainties

- EUVS-A and EUVS-B uncertainties calculated on 2024343 (December 8 2024)
- There was an X2.2 flare on this day. Large flares cause large signals in the EUVS wavelength bands, making the uncertainties easier to calculate.
- Systematic effects (steps) in the data are caused by low signal and temperature thermistor quantization (affects dark and gain measurements)
- Data has a 1-second cadence
- EUVS-C has such a strong signal that the errors are insignificant; it is not shown here







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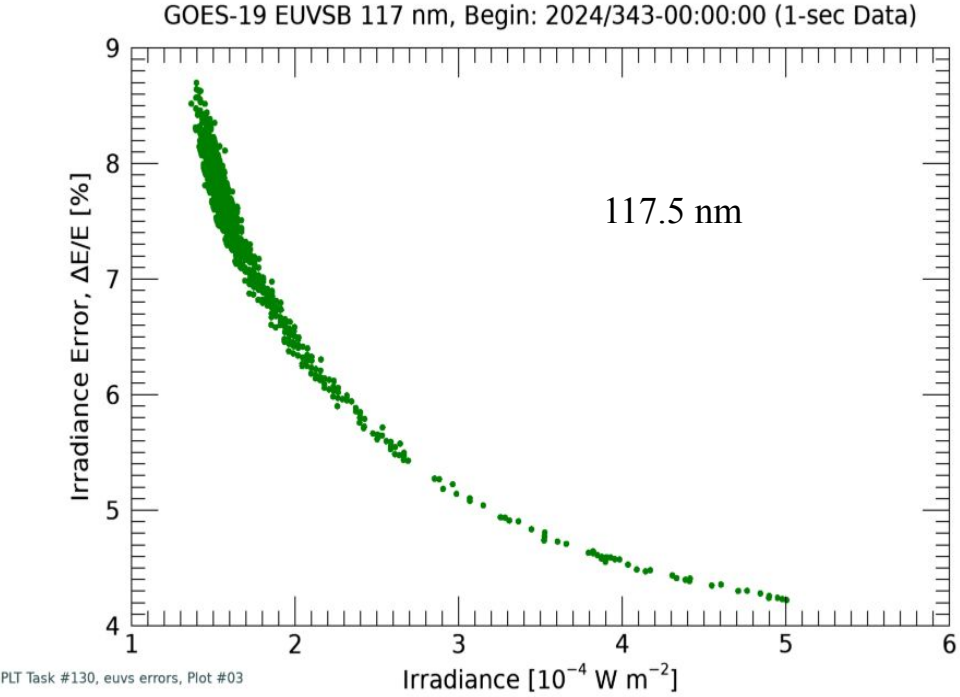

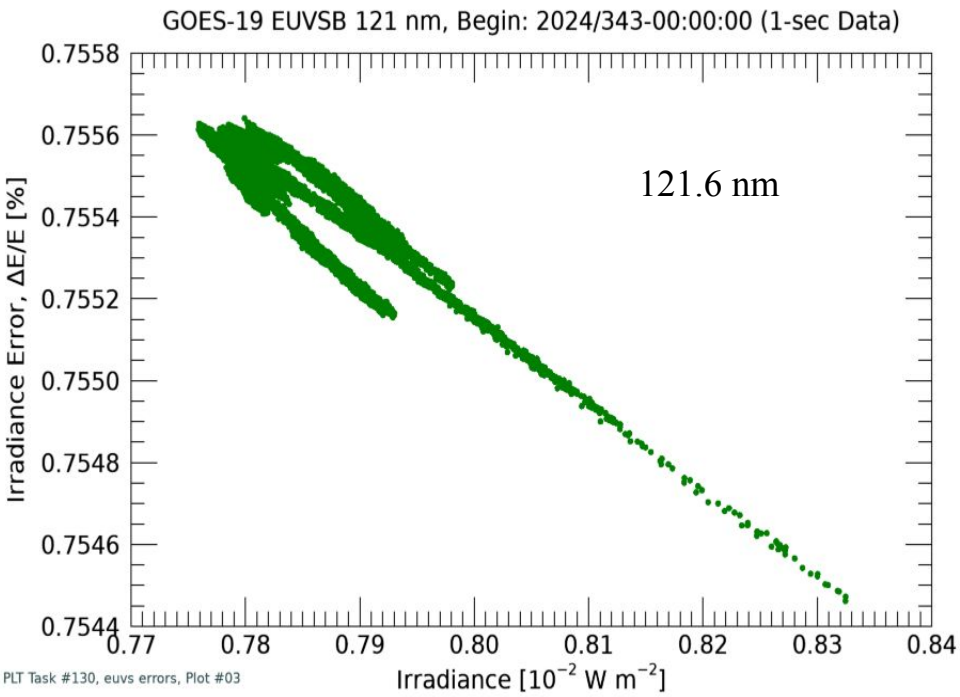

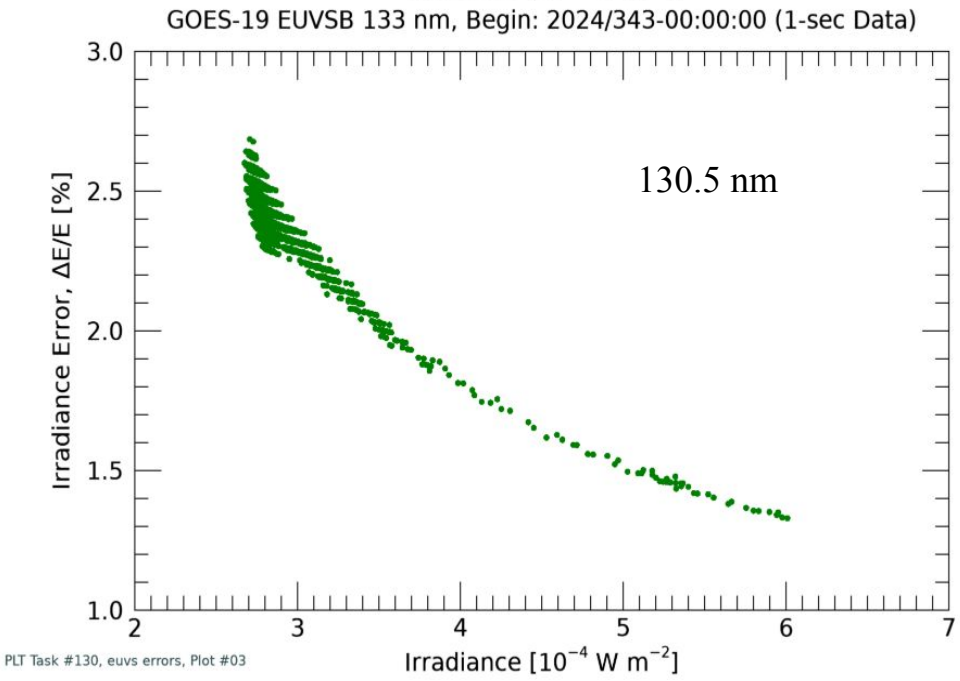

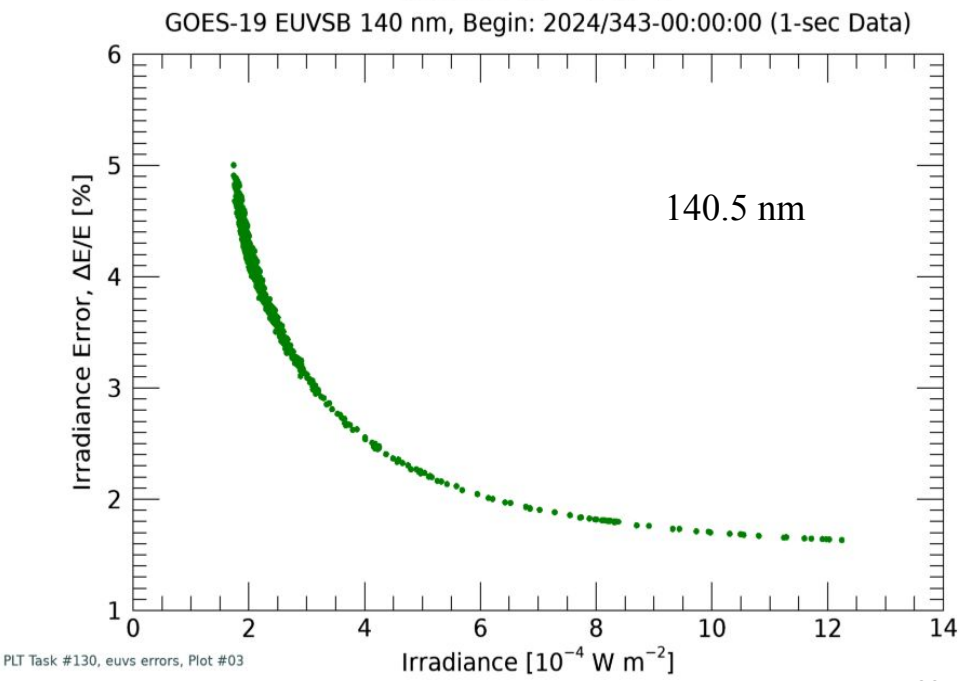

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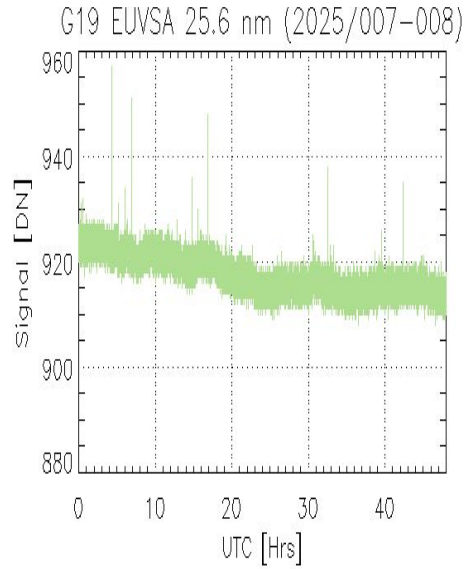
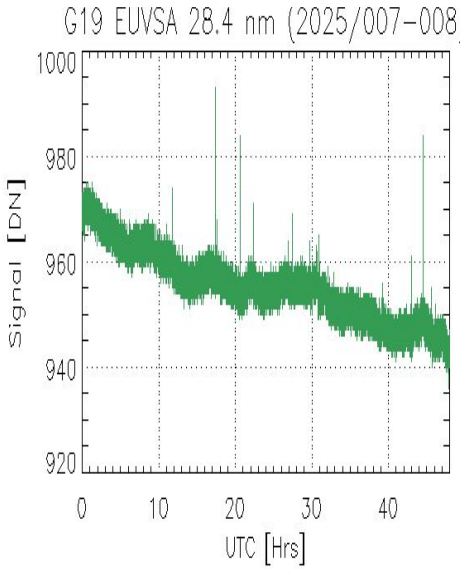
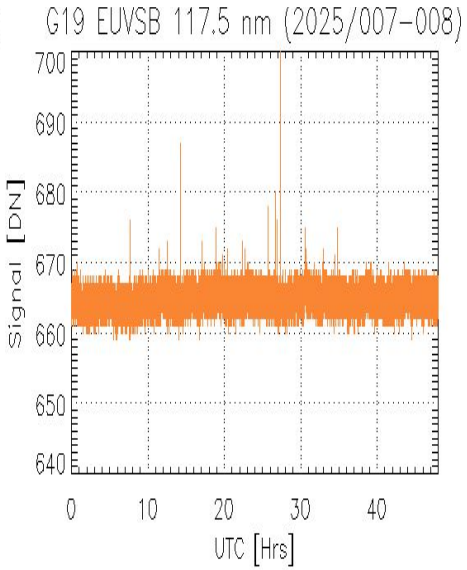
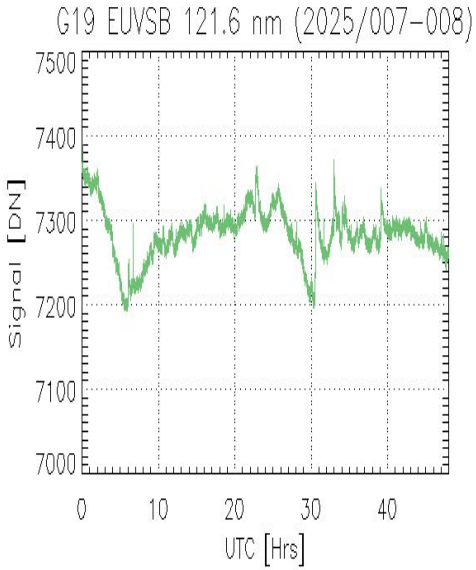
Uncertainty Statistical Analysis

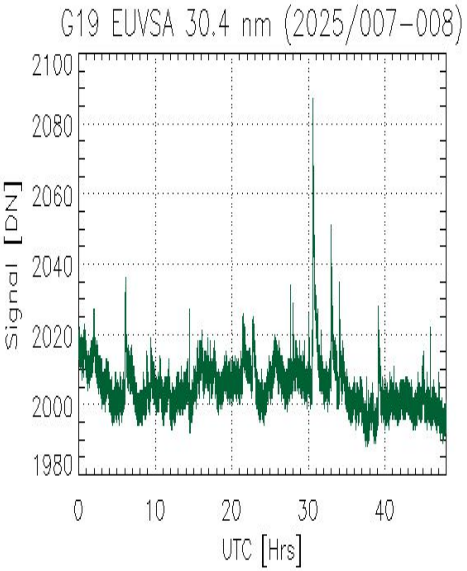
Step 1: Start with raw signal at 1-second cadence

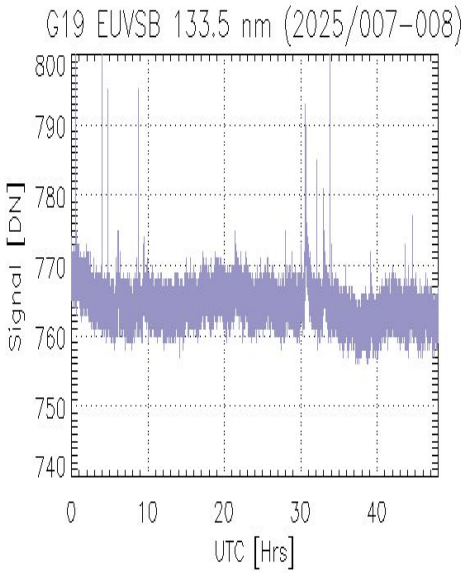


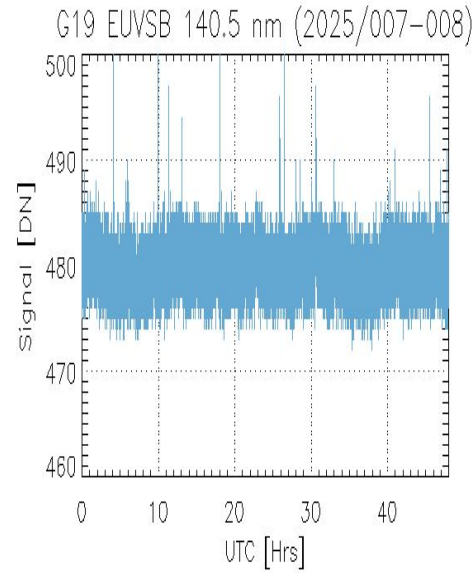












Credit: Tom Eden

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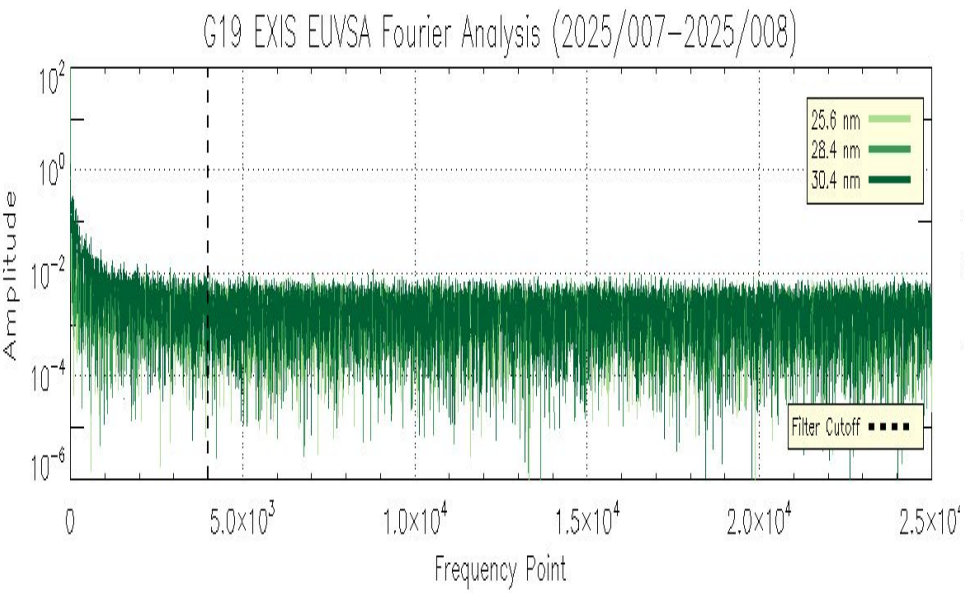
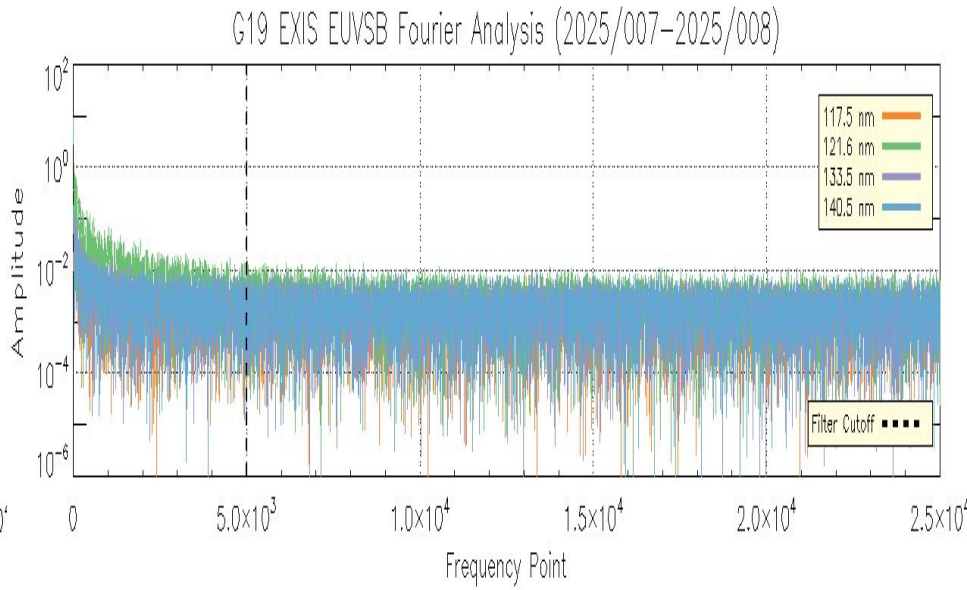
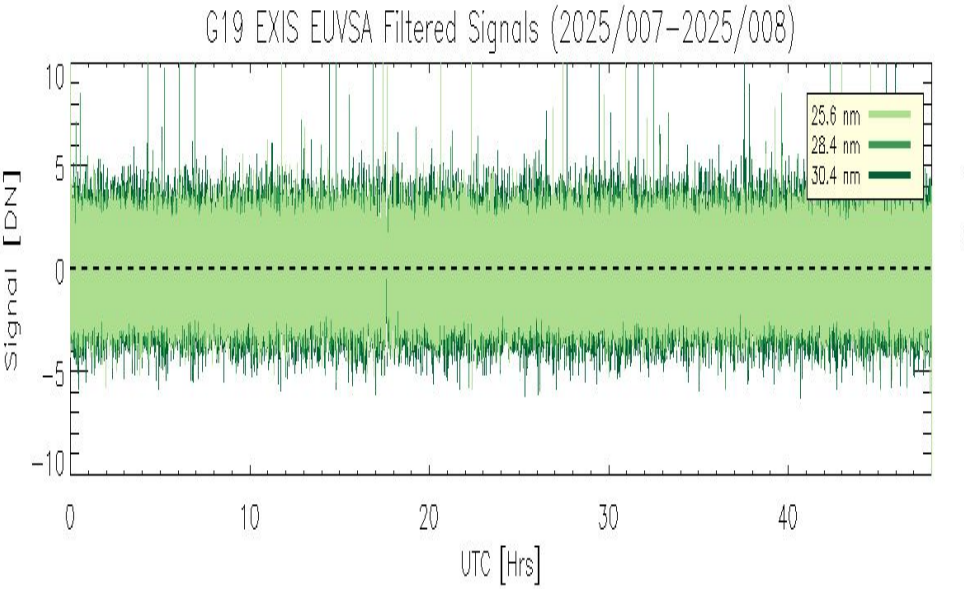
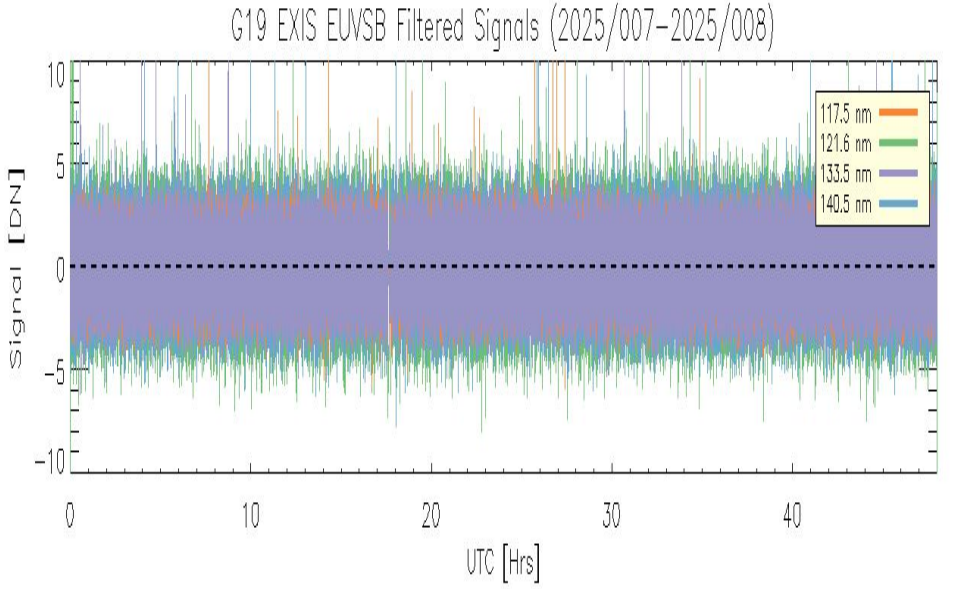
Step 2: Perform FFT of raw signal and choose appropriate cut-off frequency for high-pass filtering









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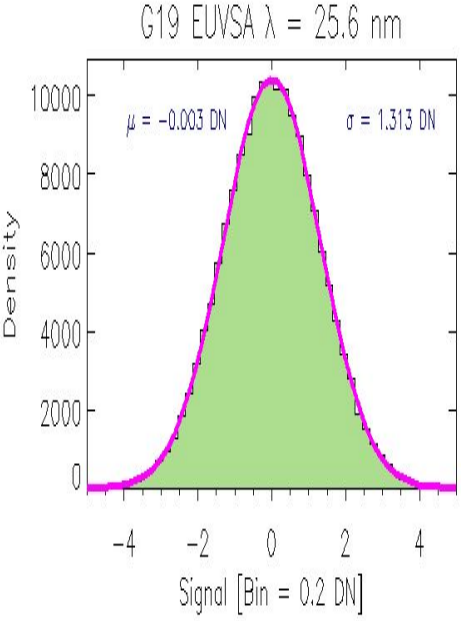
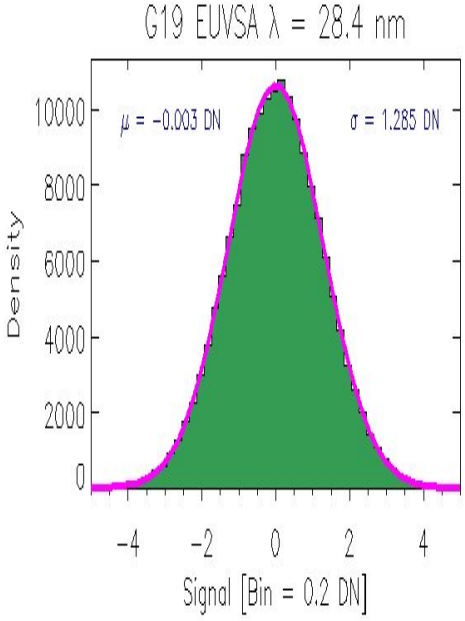
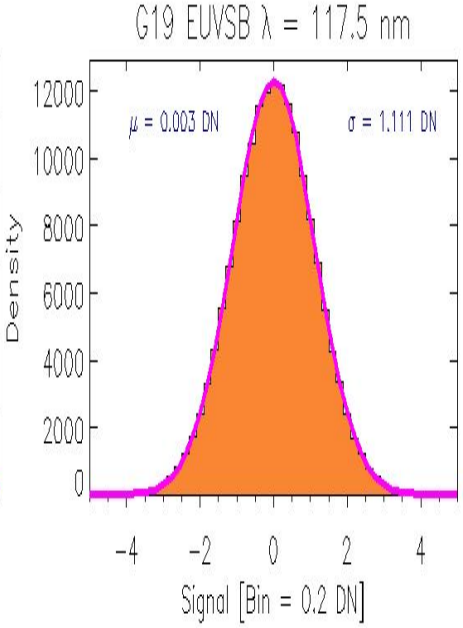
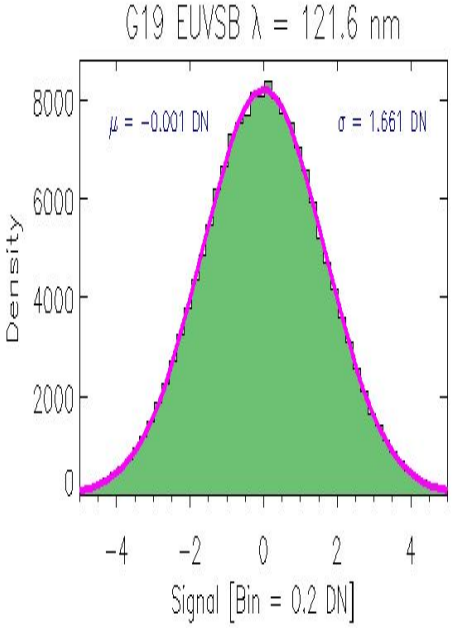
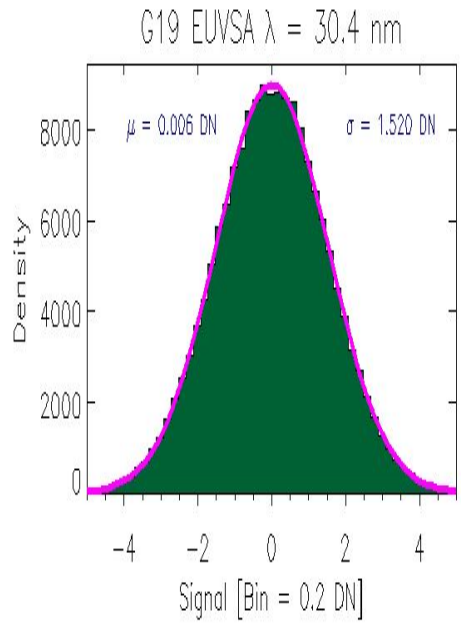
Step 3: Find 1-σ from distribution of high pass filtered data

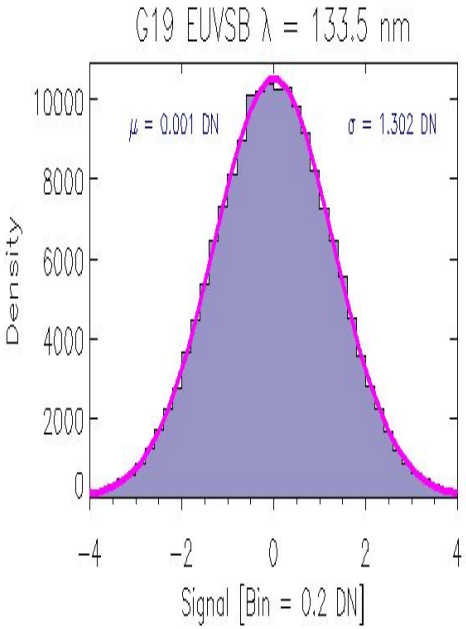


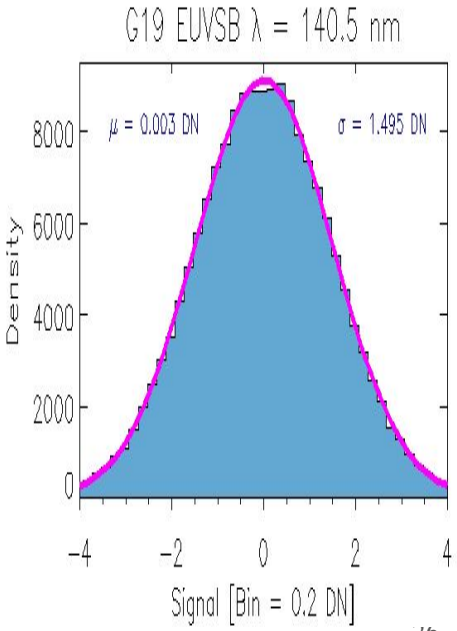












Credit: Tom Eden

- 1 DN equivalent irradiances define the precision
- Minimum irradiances are the larger of the 1 DN equivalent irradiances and the uncertainties
- Maximum irradiances are flux equivalents of 989,000 DN (ASIC counter saturation)
- Measurement precision as defined by MRD 2028 is found by: Precision_% = (Precision / (Minimum_Irrad * 20)) * 100

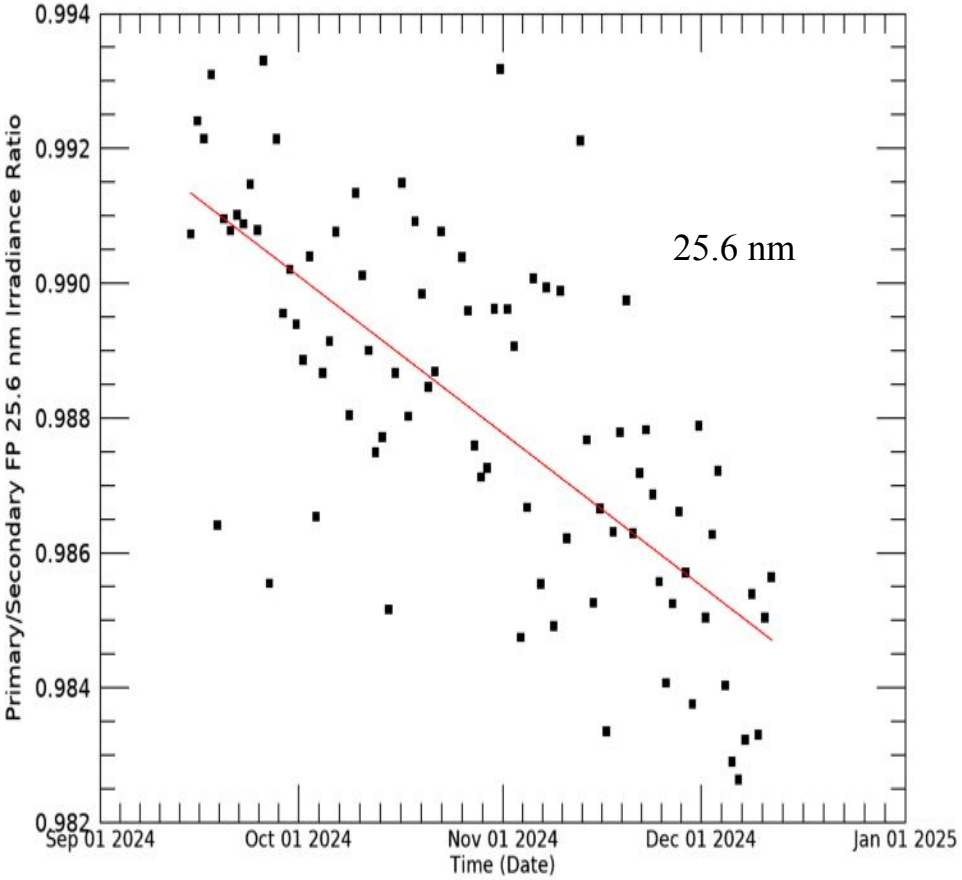
Wavelength (nm)	1-DN Irradiance (W/m^2)*	Uncertainty (DN)	Uncertainty (W/m^2)	Minimum Irradiance (W/m^2)	Maximum Irradiance (W/m^2)	% Precision
EUVS-A: 25.6	2.198e-6	1.313	2.8860e-6	2.8860e-6	2.1738	**3.8080**
EUVS-A: 28.4	1.865e-6	1.285	2.3965e-6	2.3965e-6	1.8445	**3.8911**
EUVS-A: 30.4	2.348e-6	1.520	3.5690e-6	3.5690e-6	2.3222	**3.2894**
EUVS-B: 117.5	7.320e-6	1.111	8.1325e-6	8.1325e-6	7.2395	**4.5005**
EUVS-B: 121.6	4.291e-6	1.661	7.1274e-6	7.1274e-6	4.2438	**3.0102**
EUVS-B: 133.5	3.251e-6	1.302	4.2328e-6	4.2328e-6	3.2152	**3.8402**
EUVS-B: 140.5	4.703e-6	1.495	7.0310e-6	7.0310e-6	4.6513	**3.3445**

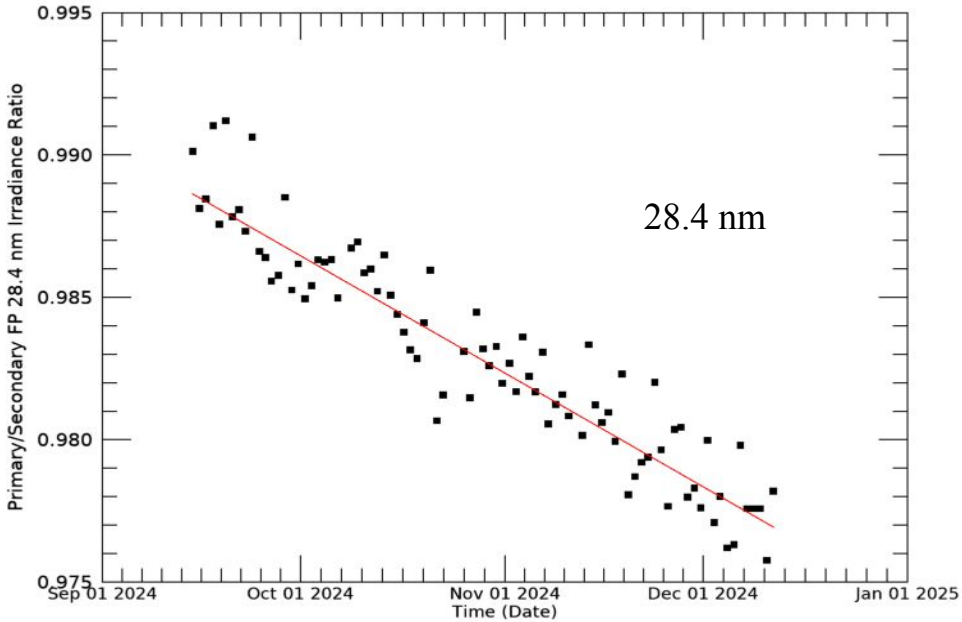
*Mean ASIC Temperatures: EUVS-A = 15.749 C, EUVS-B = 18.032 C. 1 DN equivalent irradiances from January 20 2025 (2025020).

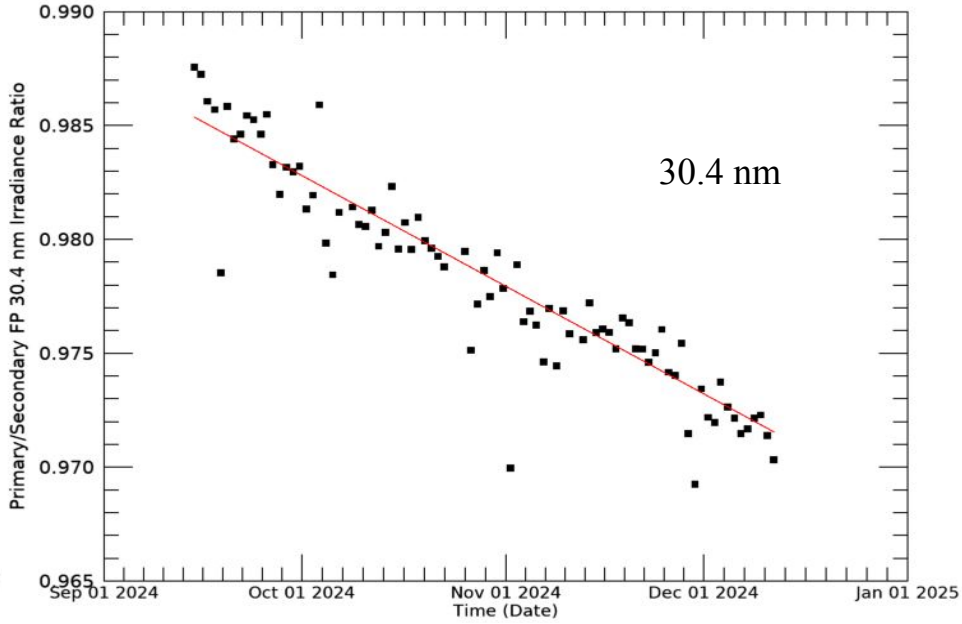
- Precision for all wavelengths is < 4.6%. This is well with the requirement of MRD 2031 (<20%).

PLPT #15: EUVS-A Degradation Trending

- Red lines are fits to degradation. The degradation correction is applied to the irradiance in L1b processing.
- Fit uncertainties are ≤1.5% and depend on signal strength
- EUVS-A degradation is routinely updated after each eclipse season (2x per year) with new temperature and dark count corrections. Line segments are re-fit to provide a more accurate model of the degradation.







Credit: Don Woodraska

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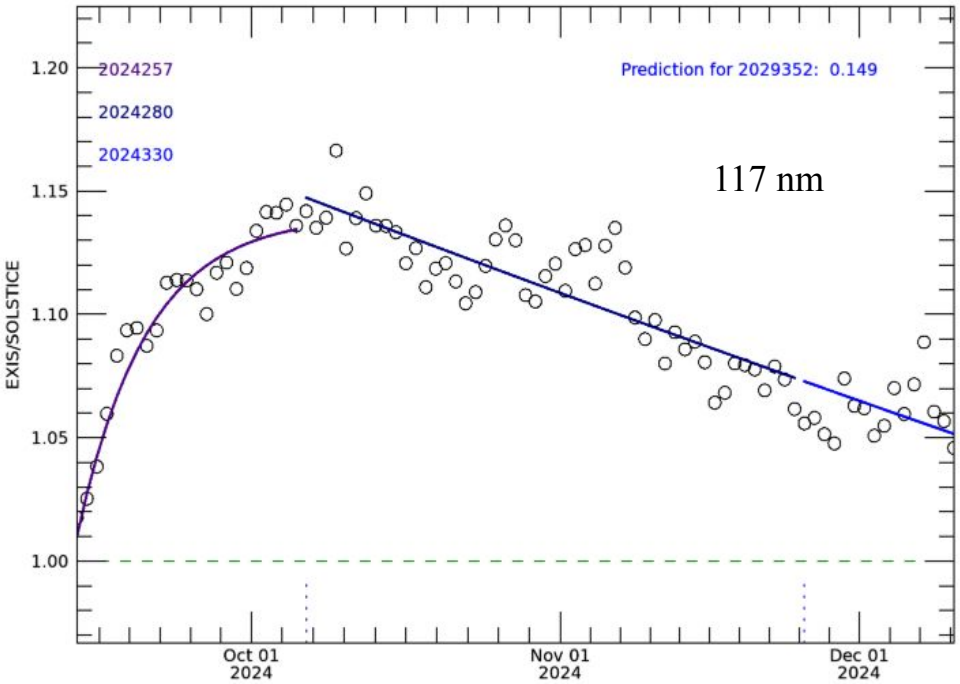
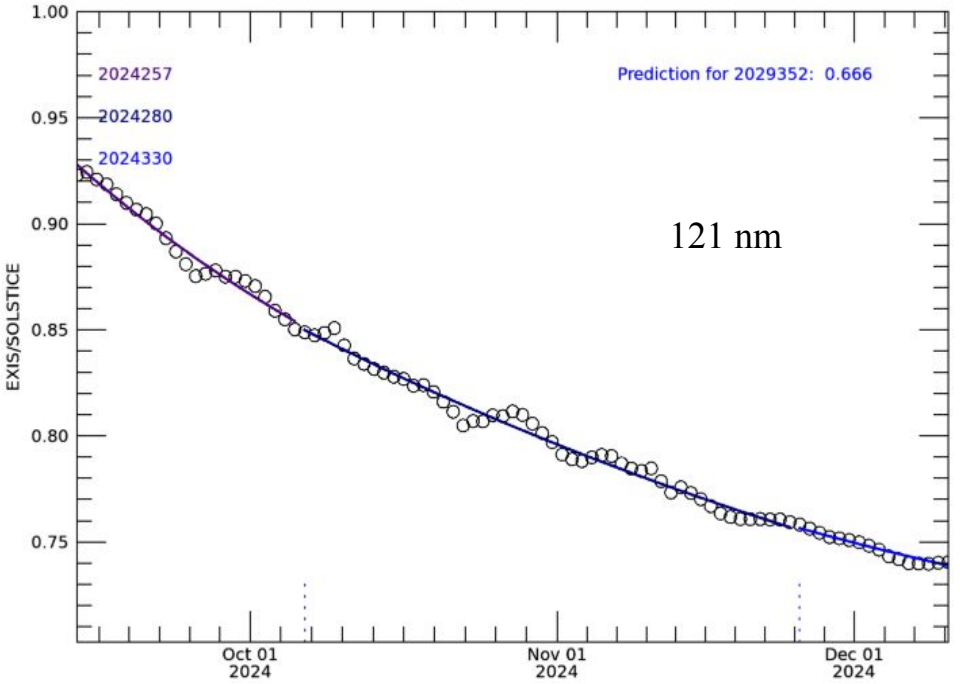
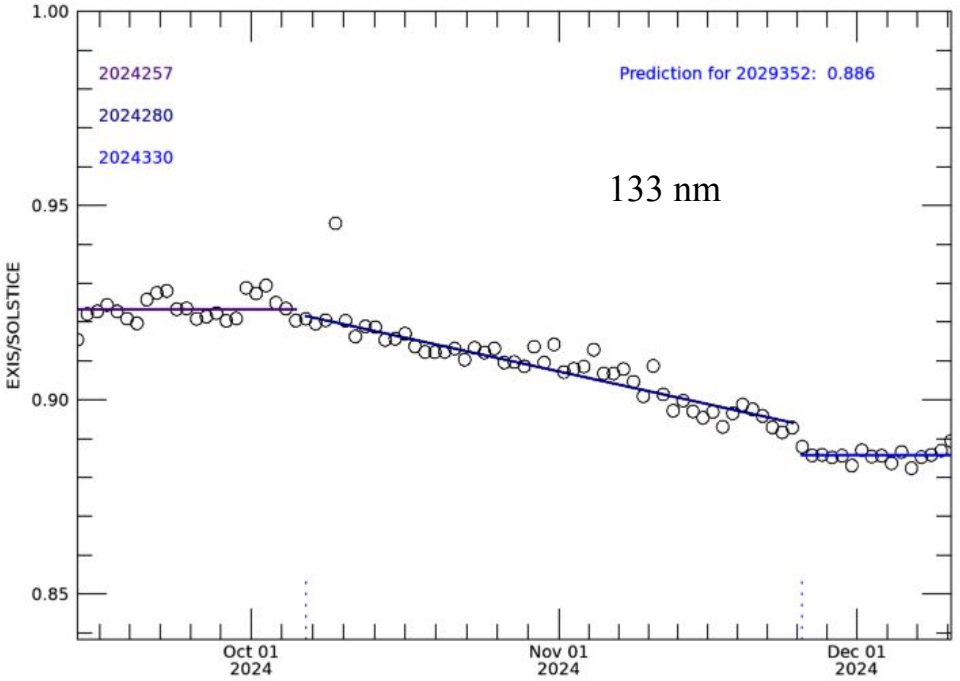
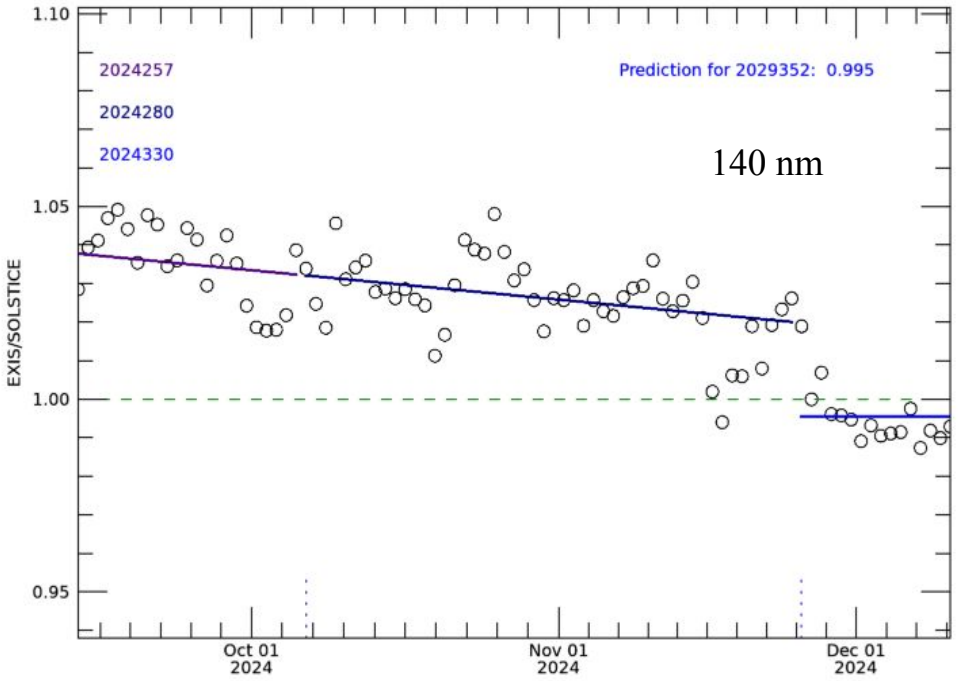
PLPT #16: EUVS-B Degradation Trending

- EUVS-B wavelengths are 117.5 nm, 121.6 nm, 133.5 nm and 140.5 nm
- Degradation determined by ratio with Mg II data
  - Distinct fits over different time intervals
  - Mg II replaces SORCE SOLSTICE (SORCE mission ended February 2020)
- EUV degradation rates tend to start high and decrease in time
- The degradation correction is applied to the irradiance during L1b processing
- Contributions to irregular behavior:
  - Possible degradation rate changes with solar variability and ops changes
  - Limited GOES-19 data makes current projection of long-term degradation trends difficult
  - Early in the mission, trends and corrections change frequently and are significantly influenced by lack of stable data







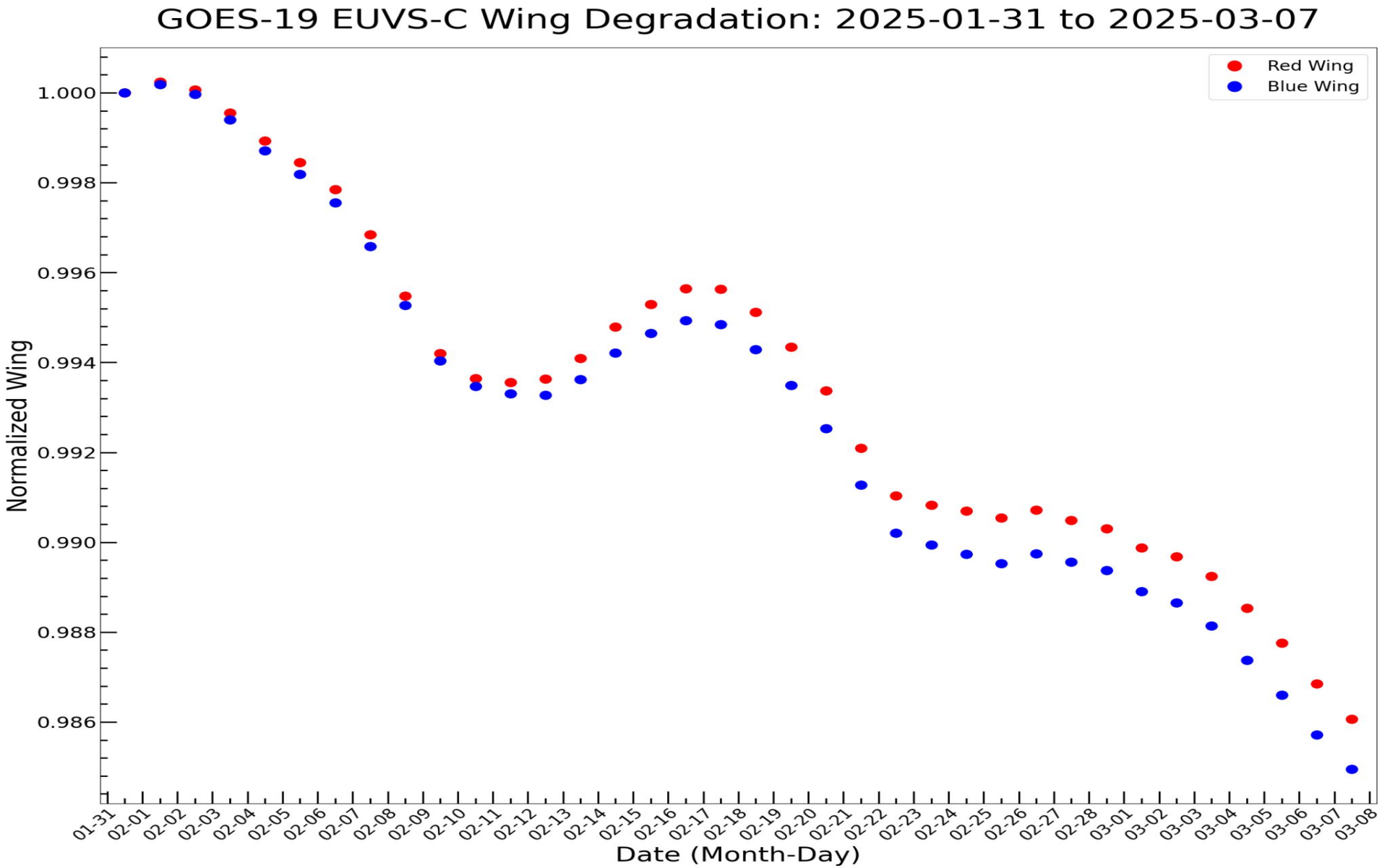


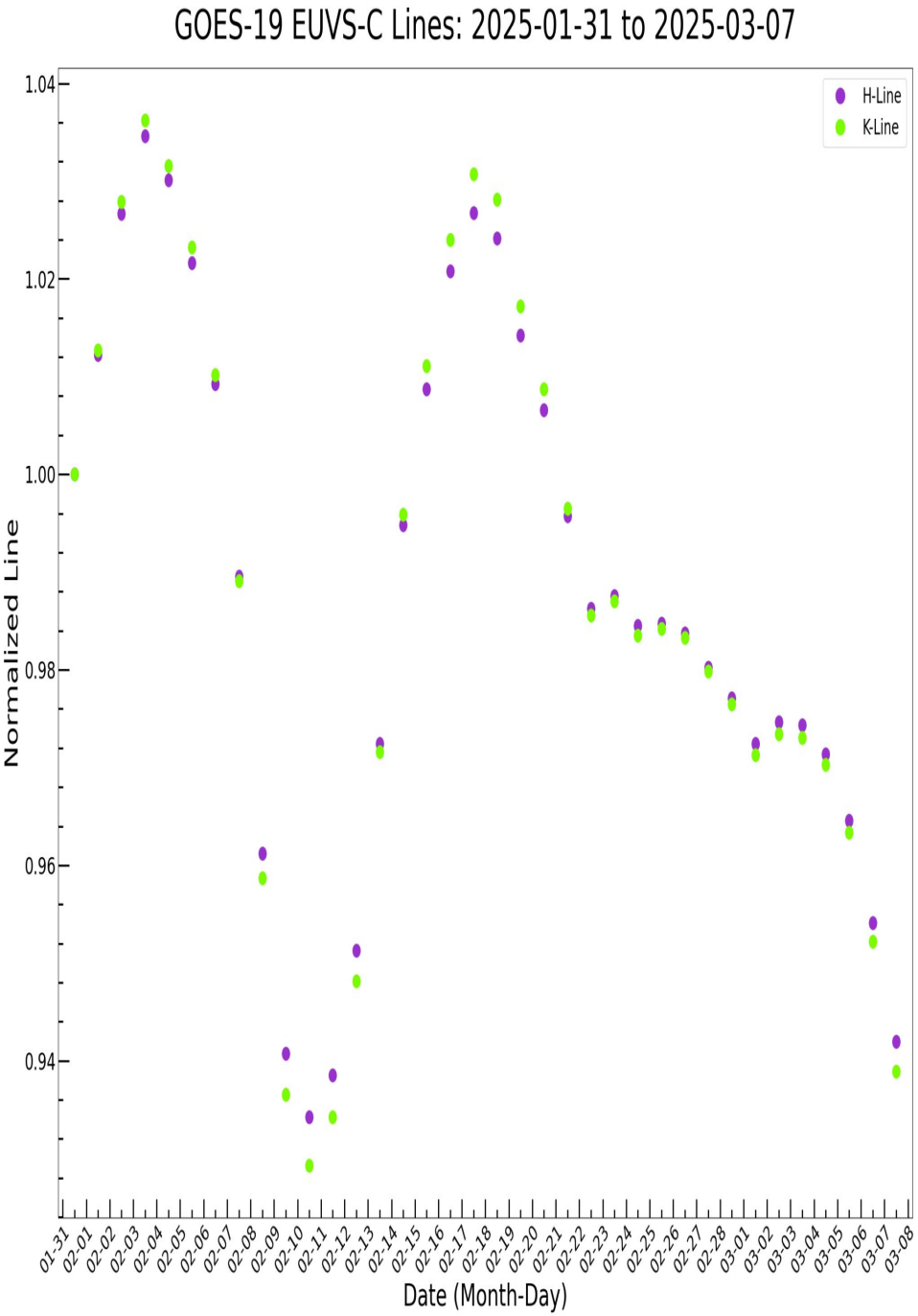
- EUVS-B degradation is routinely updated after each eclipse season (2x per year) with new temperature and dark count corrections. Line segments are re-fit to provide a more accurate model of the degradation.
- These results are preliminary and will change in subsequent LUT updates
- The degradation trend for both EUVS-A and EUVS-B is impacted by the ECI observations
- Additionally, GOES-19 will drift to its operational orbit position in March 2025, during the spring eclipse season, and will not take data during the drift. This will delay analysis of the most recent changes in the EUVS degradation trend.

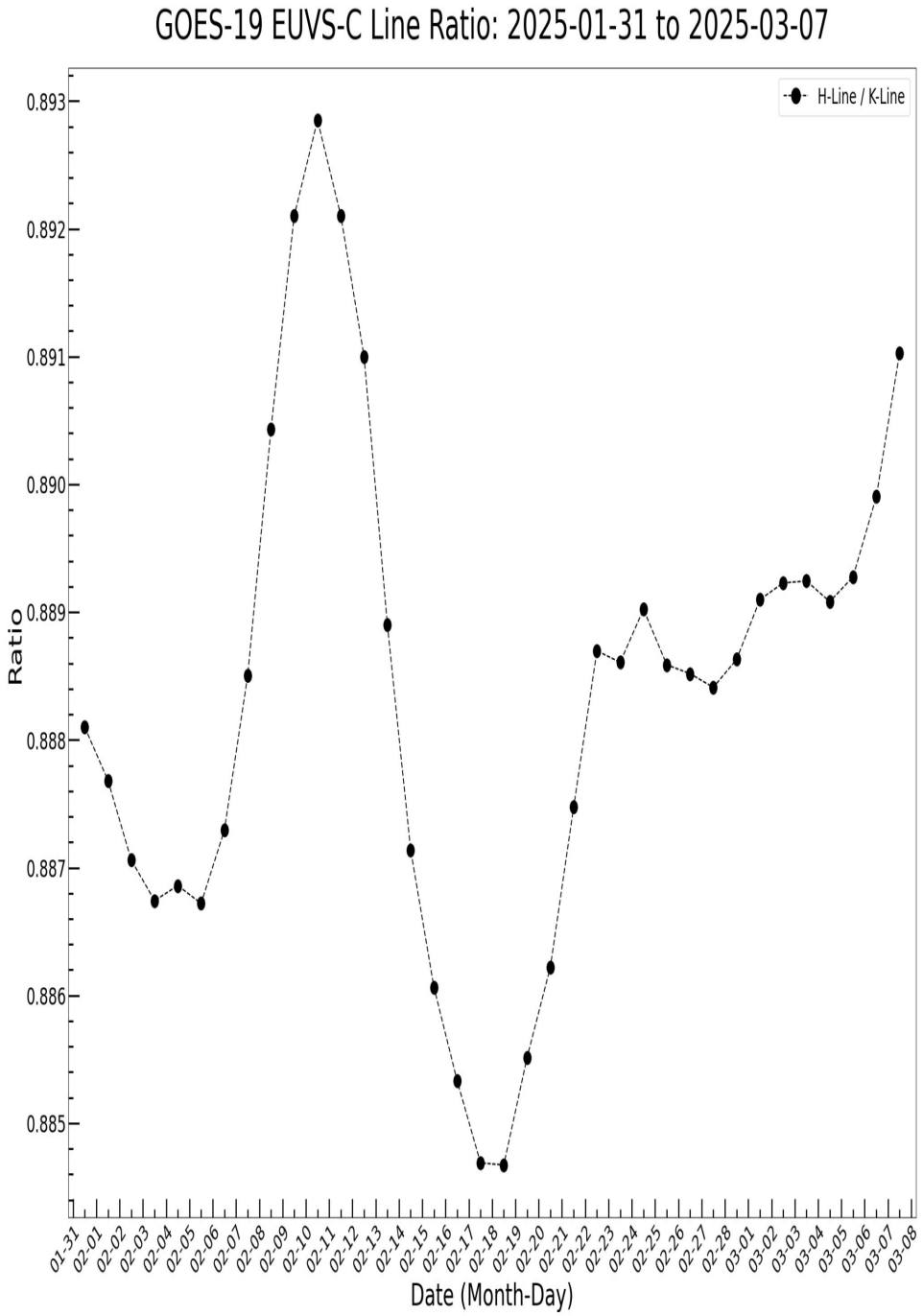
Degradation %	**Launch Date = June 25 2024; 2024177**
Wavelength (nm)	**Projected Degradation on 2029352**
117	0.149
121	0.666
133	0.886
140	0.995

PLPT #17: EUVS-C Degradation Trending

- Data is normalized to the first data point. Degraded data is then measured from this initial normalization.







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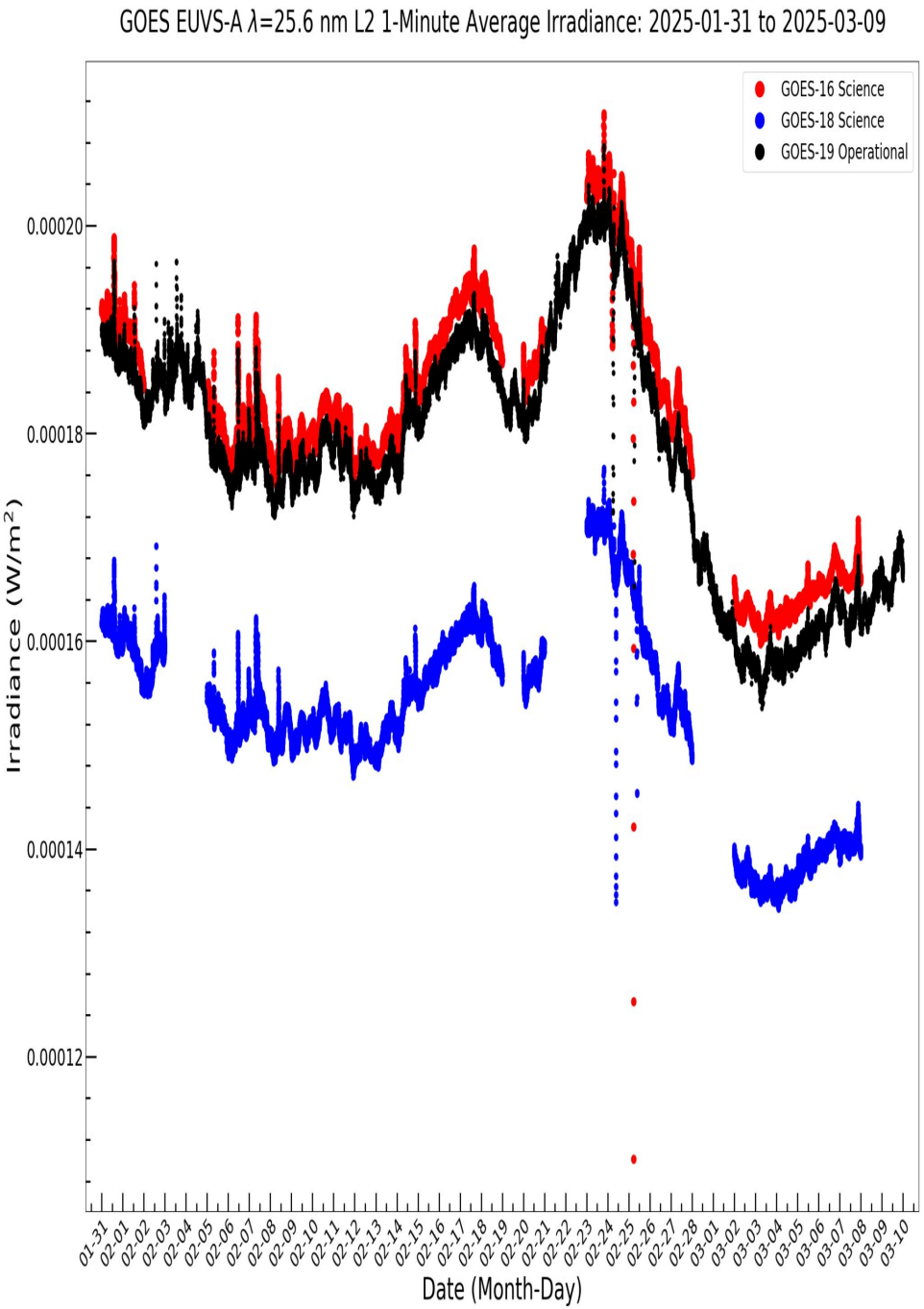
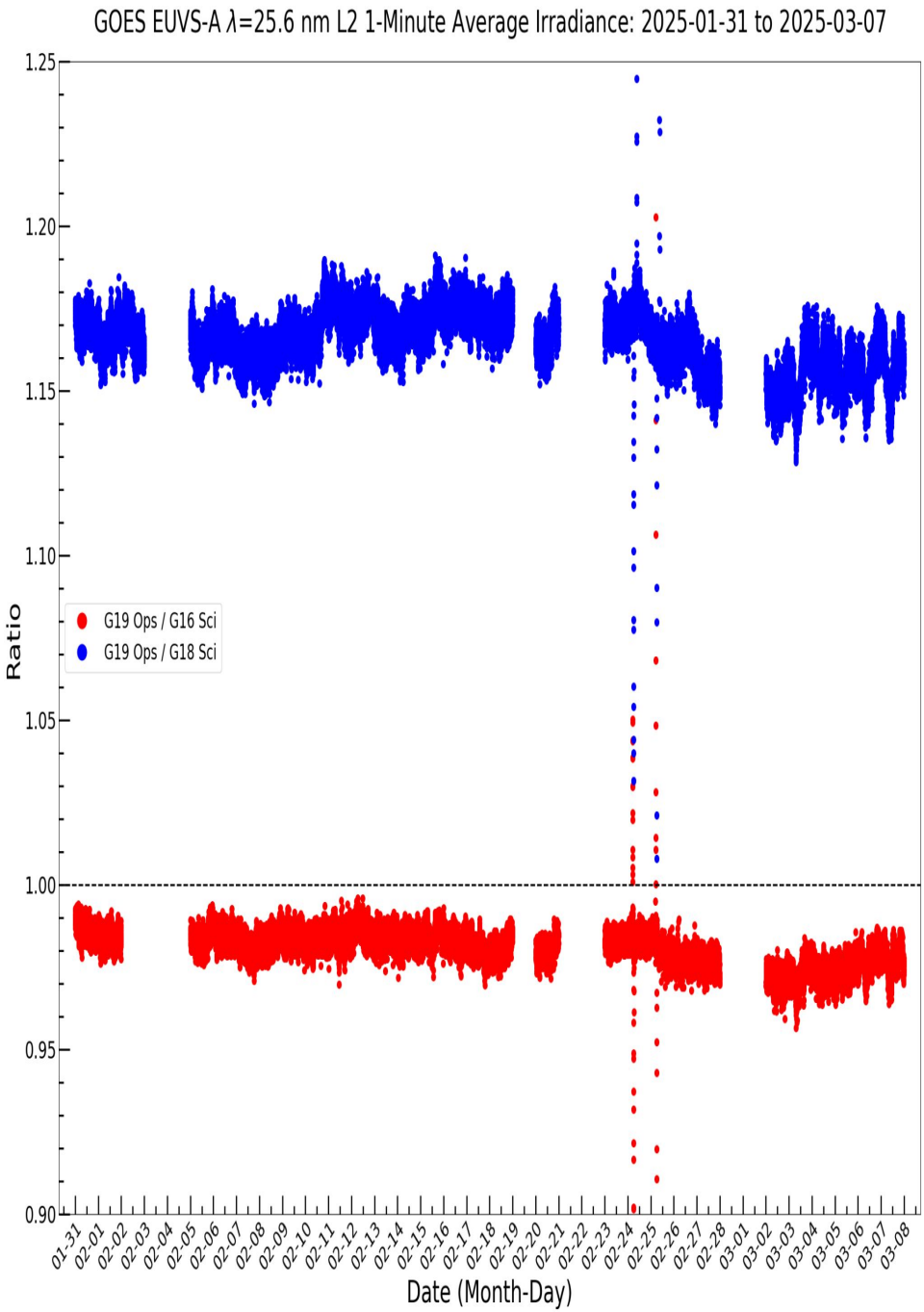
PLPT #14: EUVS-A and EUVS-B Inter-Satellite Comparisons

- Plots show G19 L2 1-minute average operational data and G16 & G18 L2 1-minute average science data. L2 data is made from 30-second L1b operational data.
- Plots show the following:
  - Line irradiances and their ratios (G19/G16, G19/G18)
  - Linear fits to G19 vs. G16 and G19 vs. G18 line irradiances
- The EUVS-A plots on slides 35-40 show a discrepancy in the GOES-18 irradiance. This issue is discussed in further detail on slides 61-65 and will be fixed in 2025.





25.6 nm

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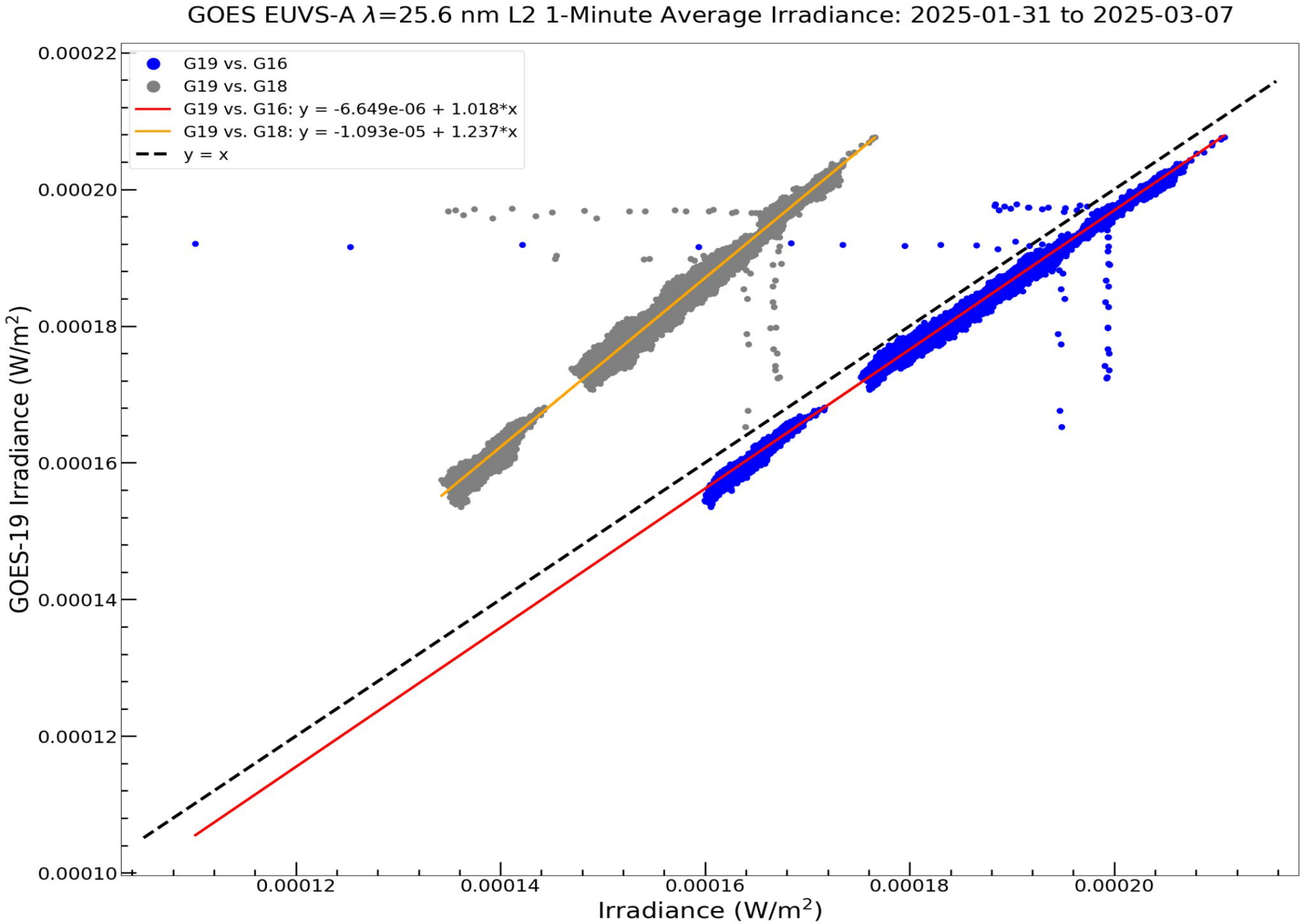
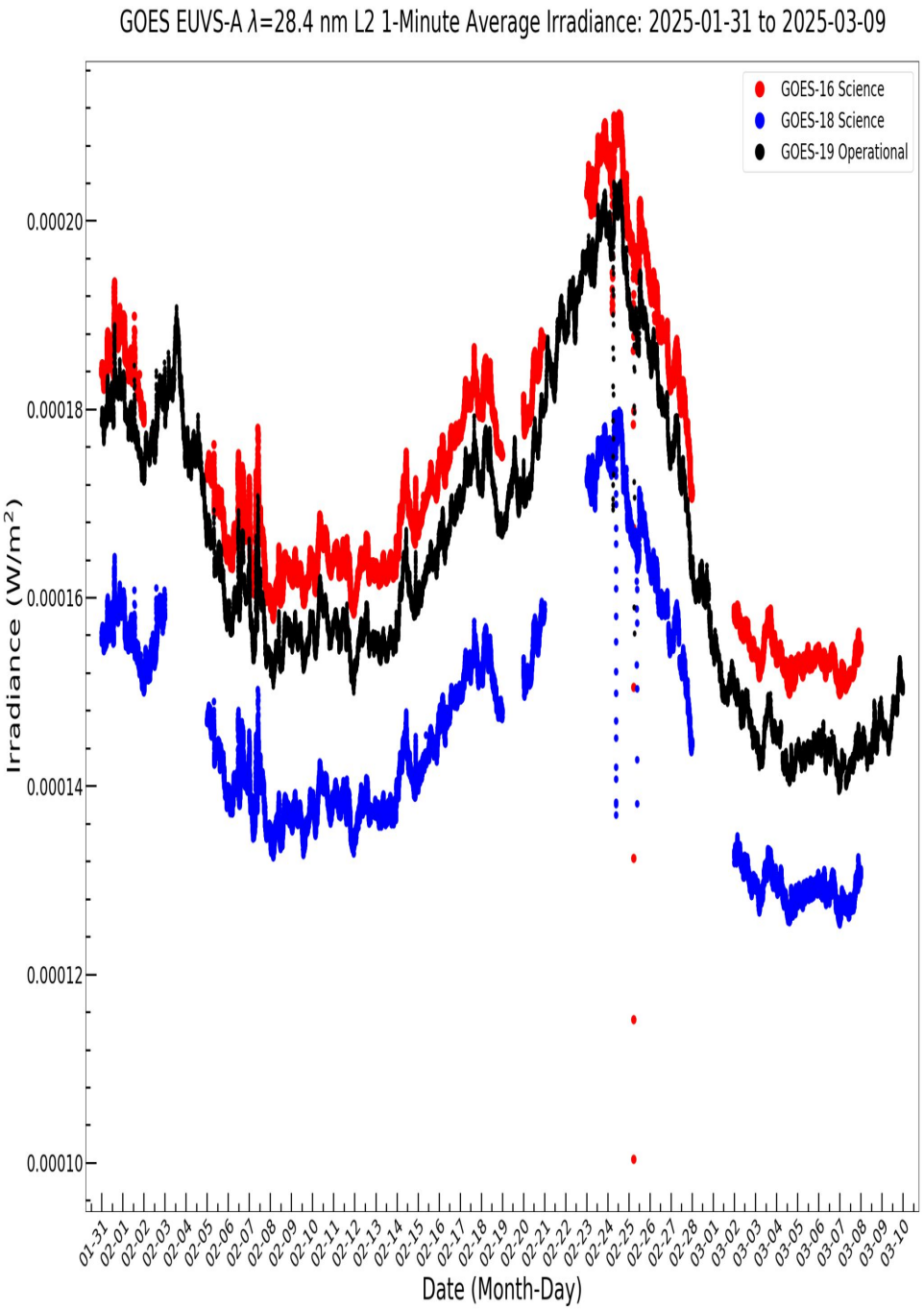
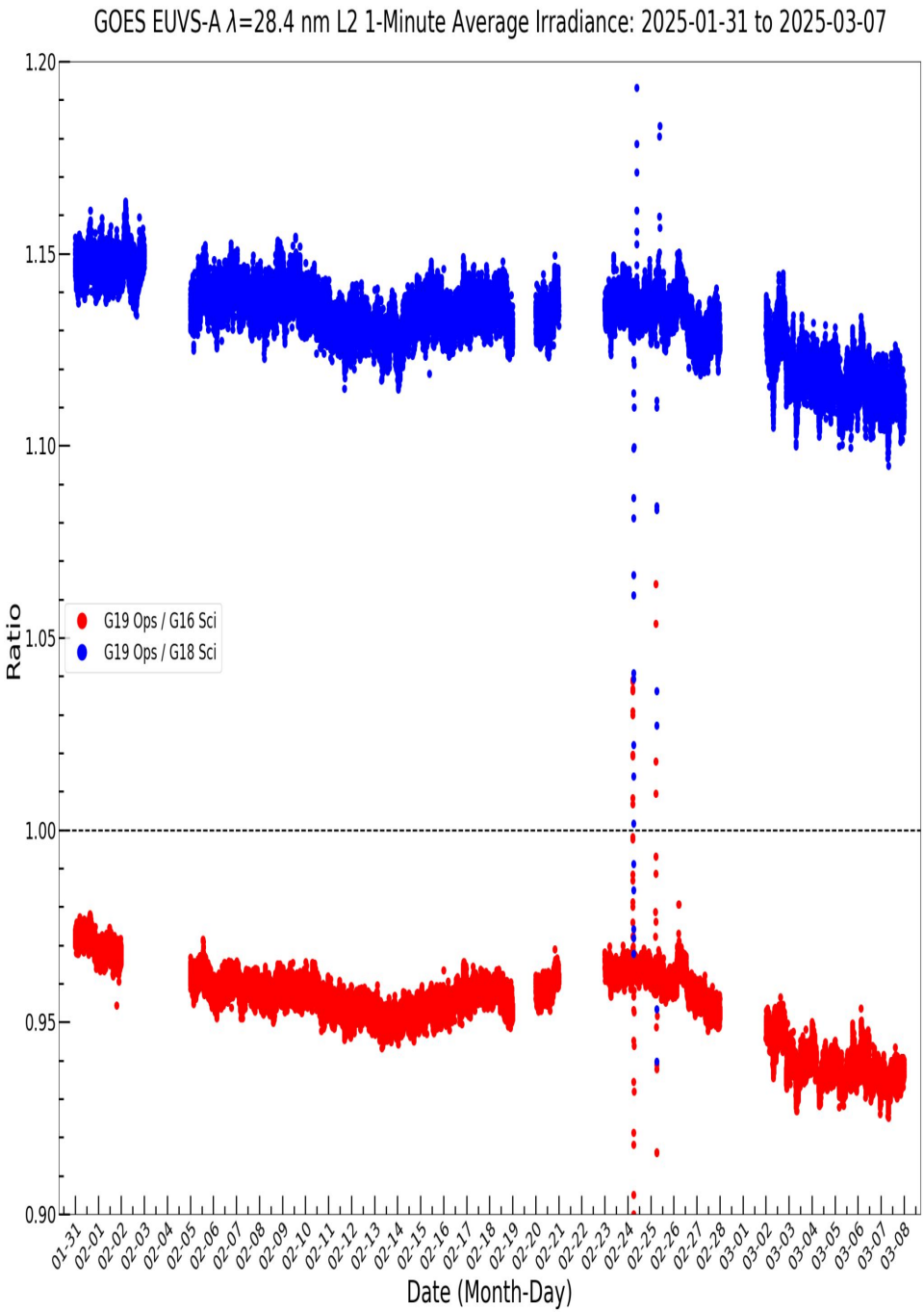


25.6 nm





28.4 nm

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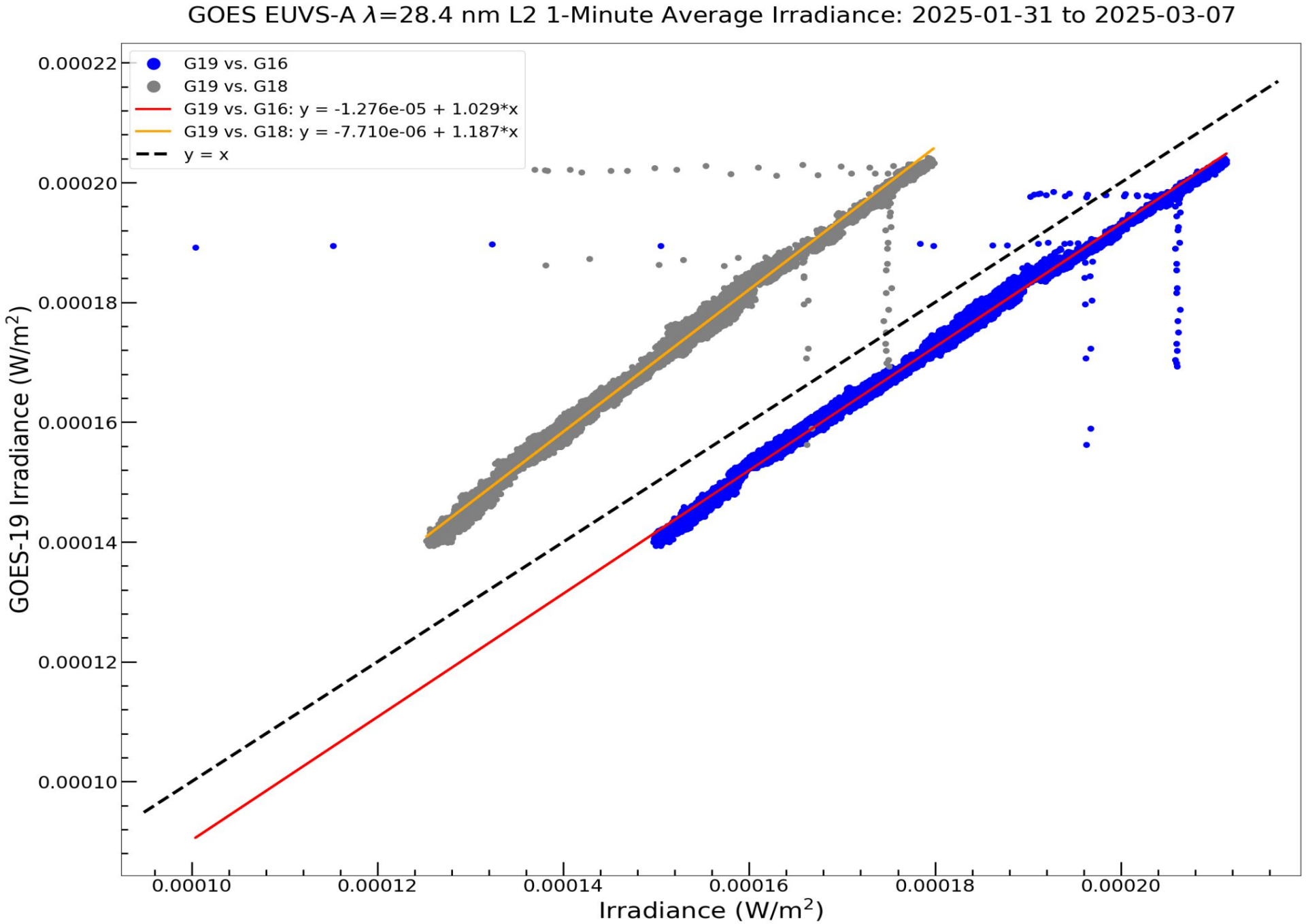

28.4 nm

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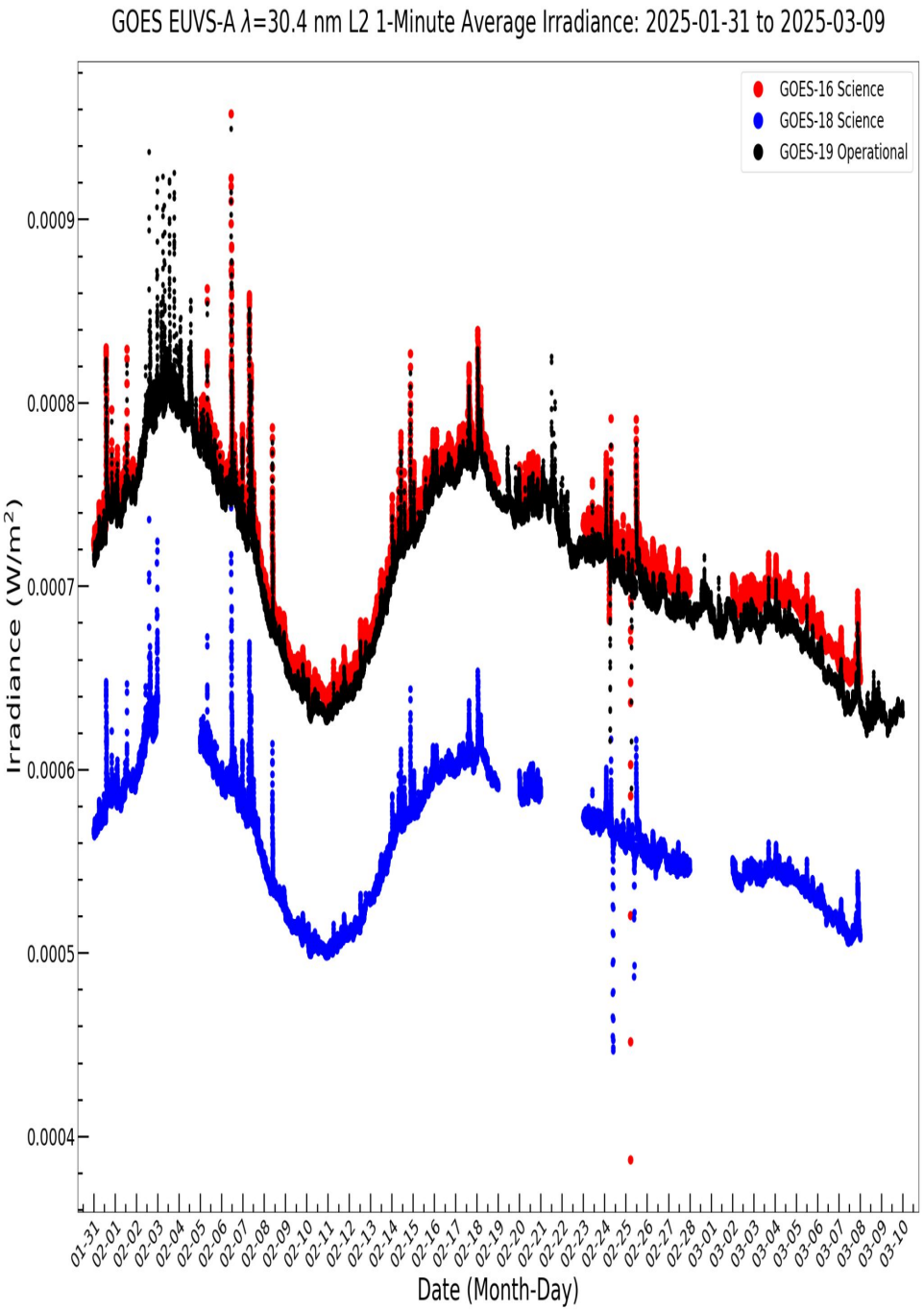

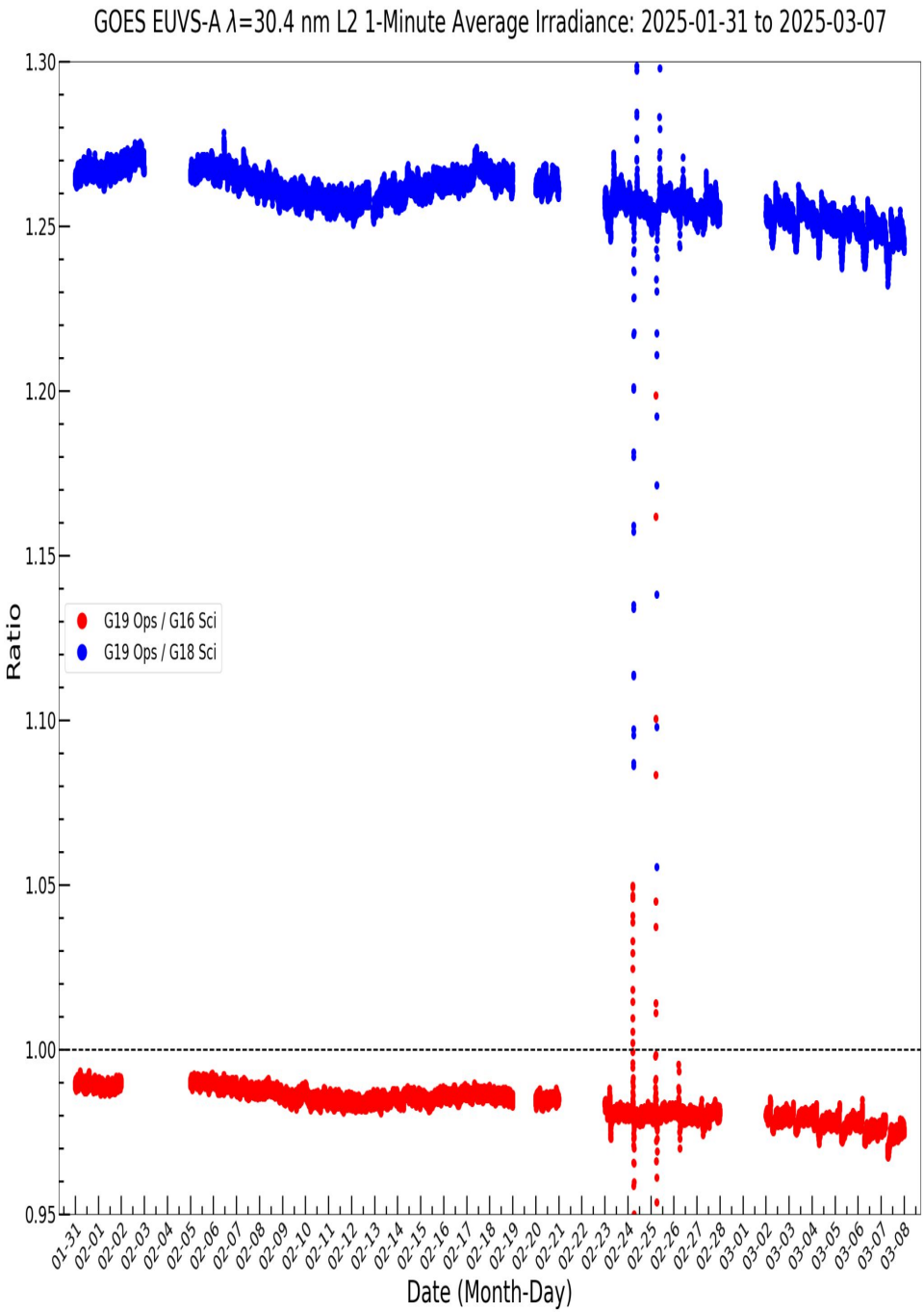

30.4 nm

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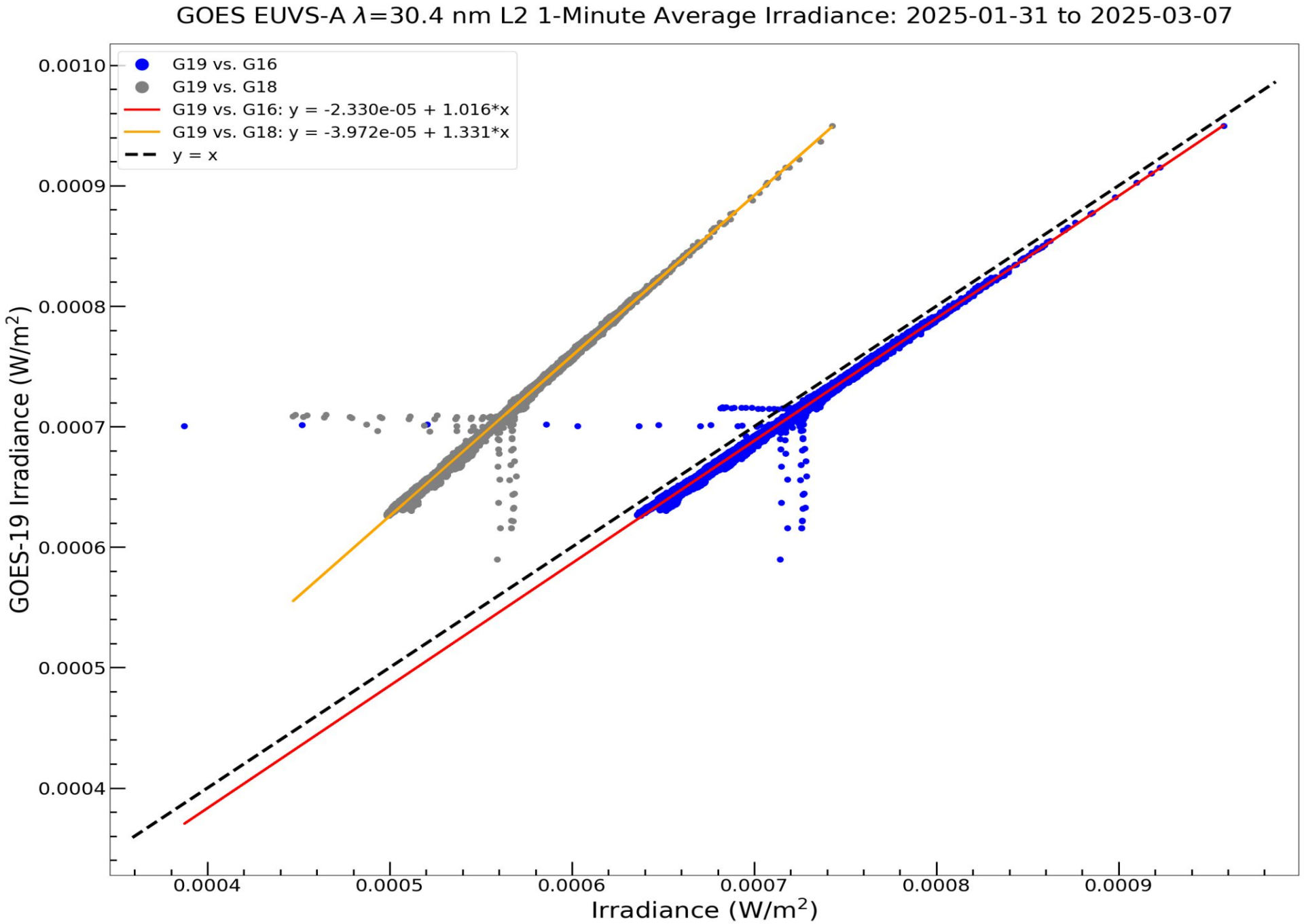
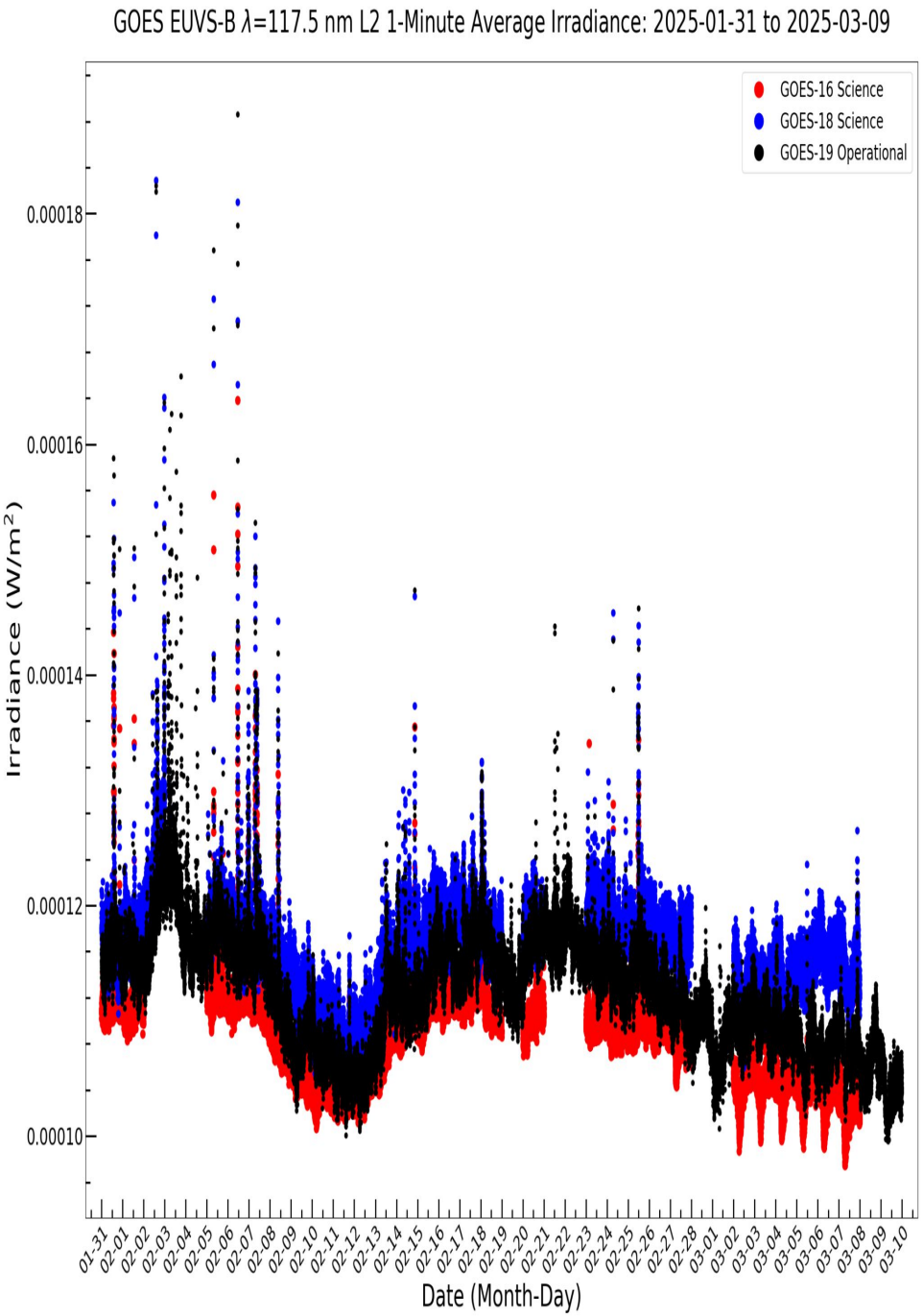
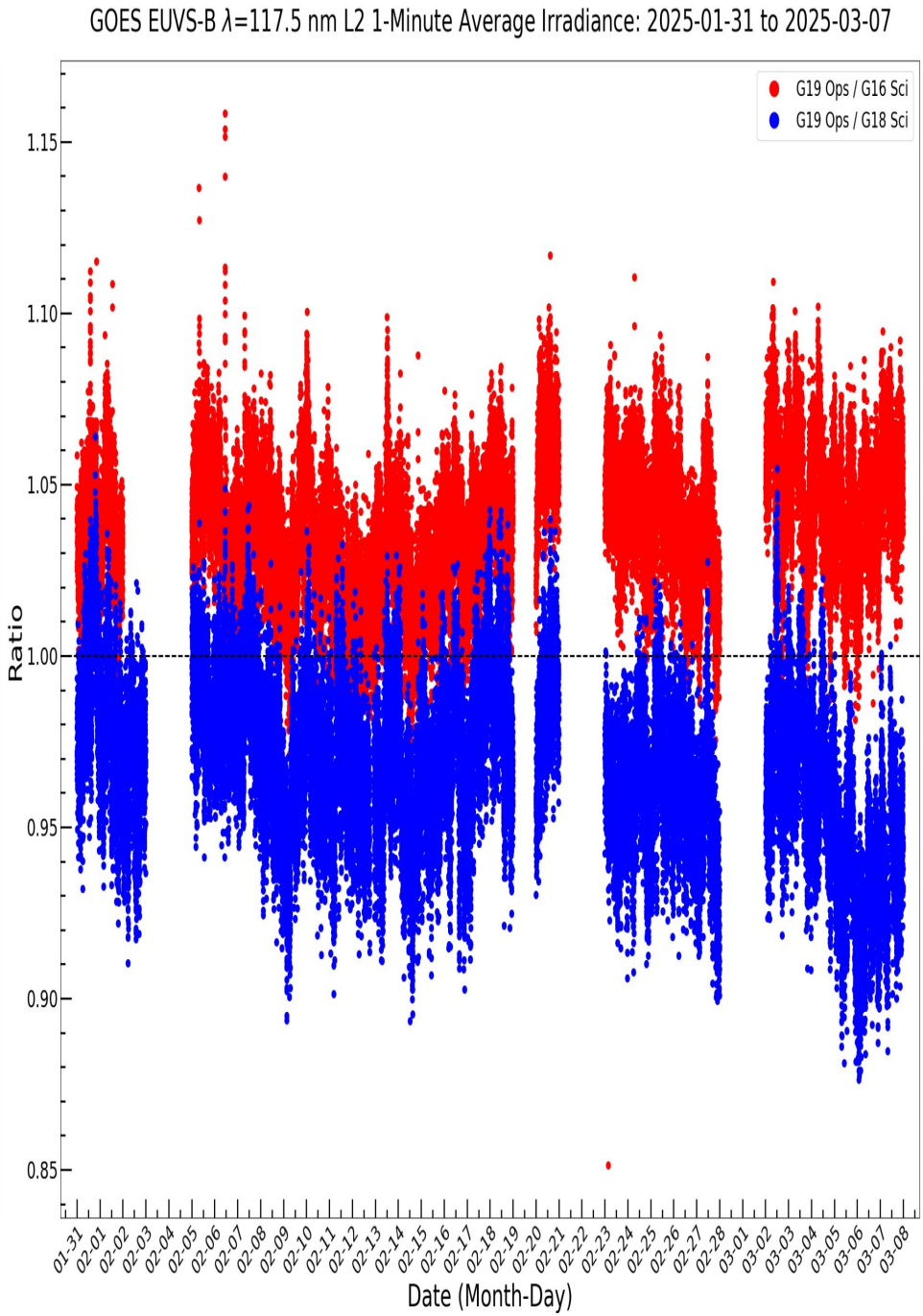


30.4 nm





117.5 nm

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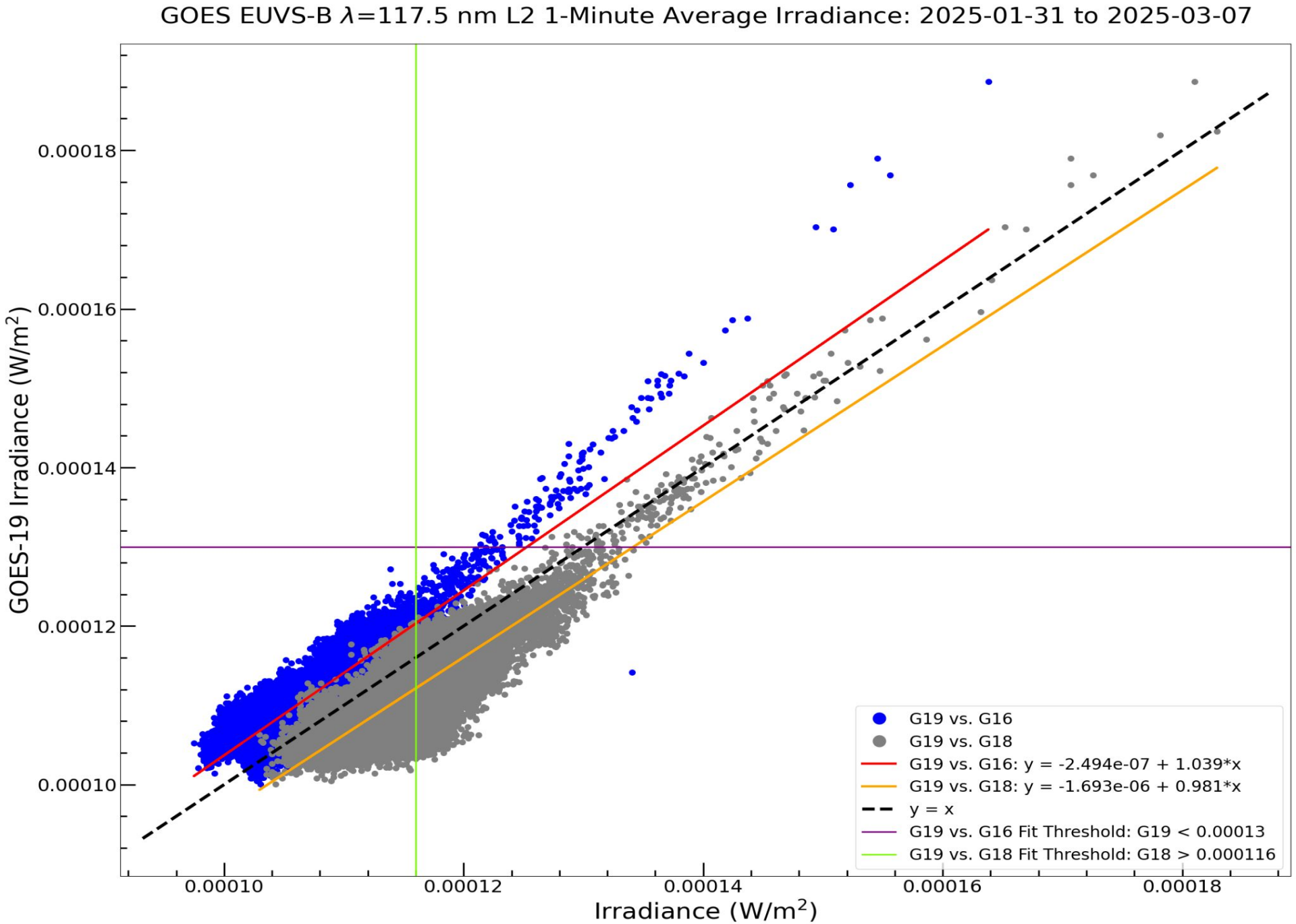
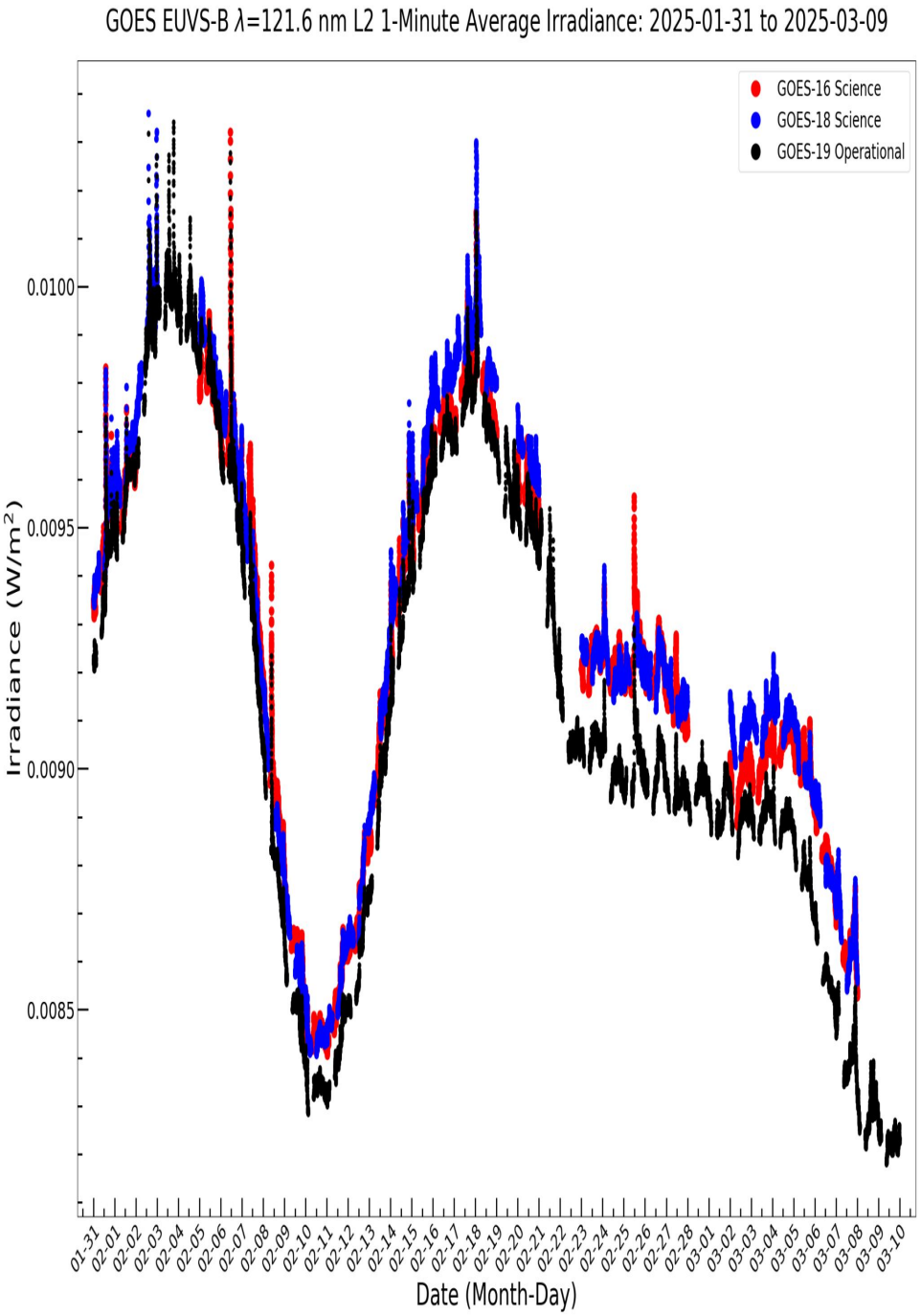
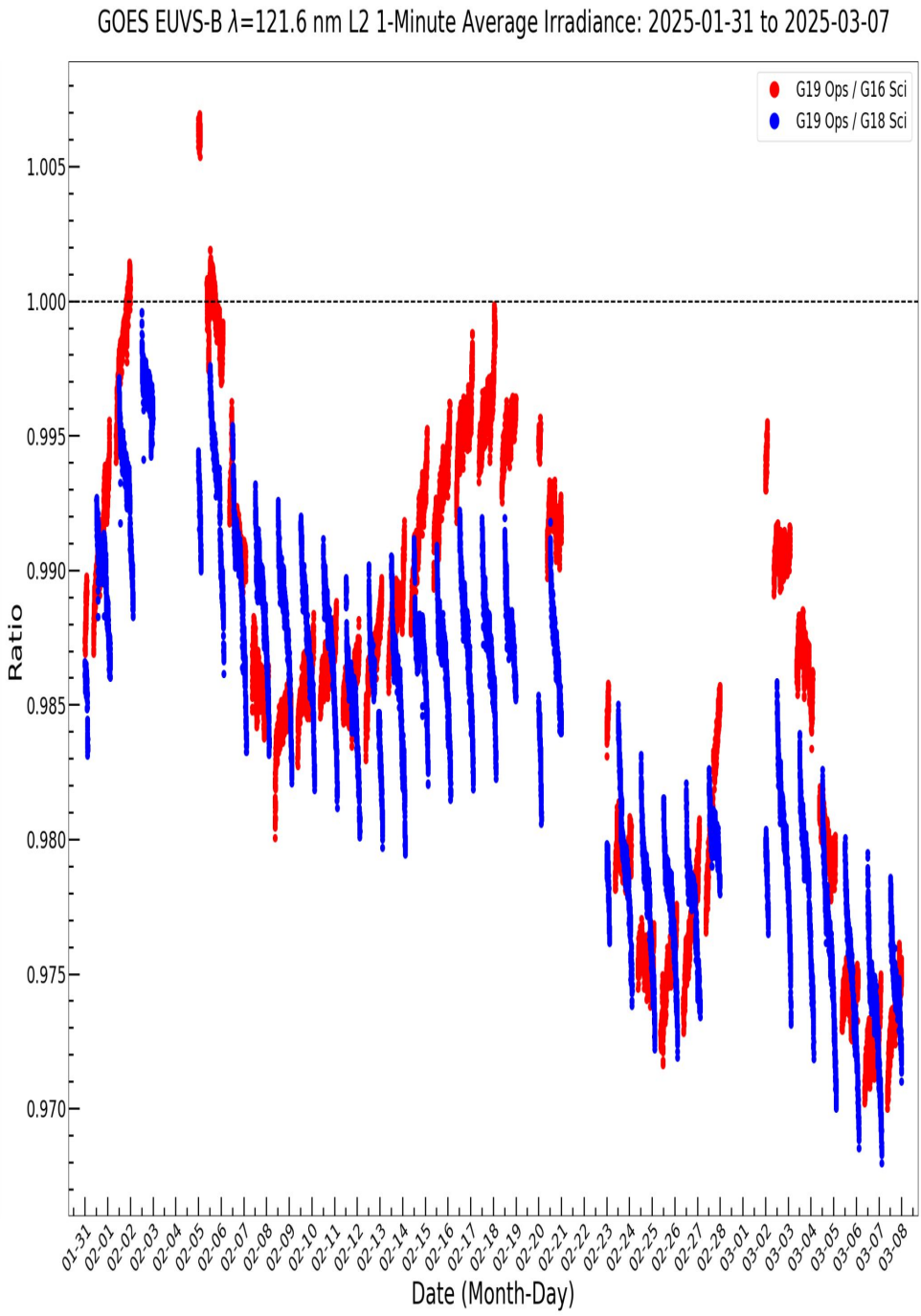


117.5 nm





121.6 nm

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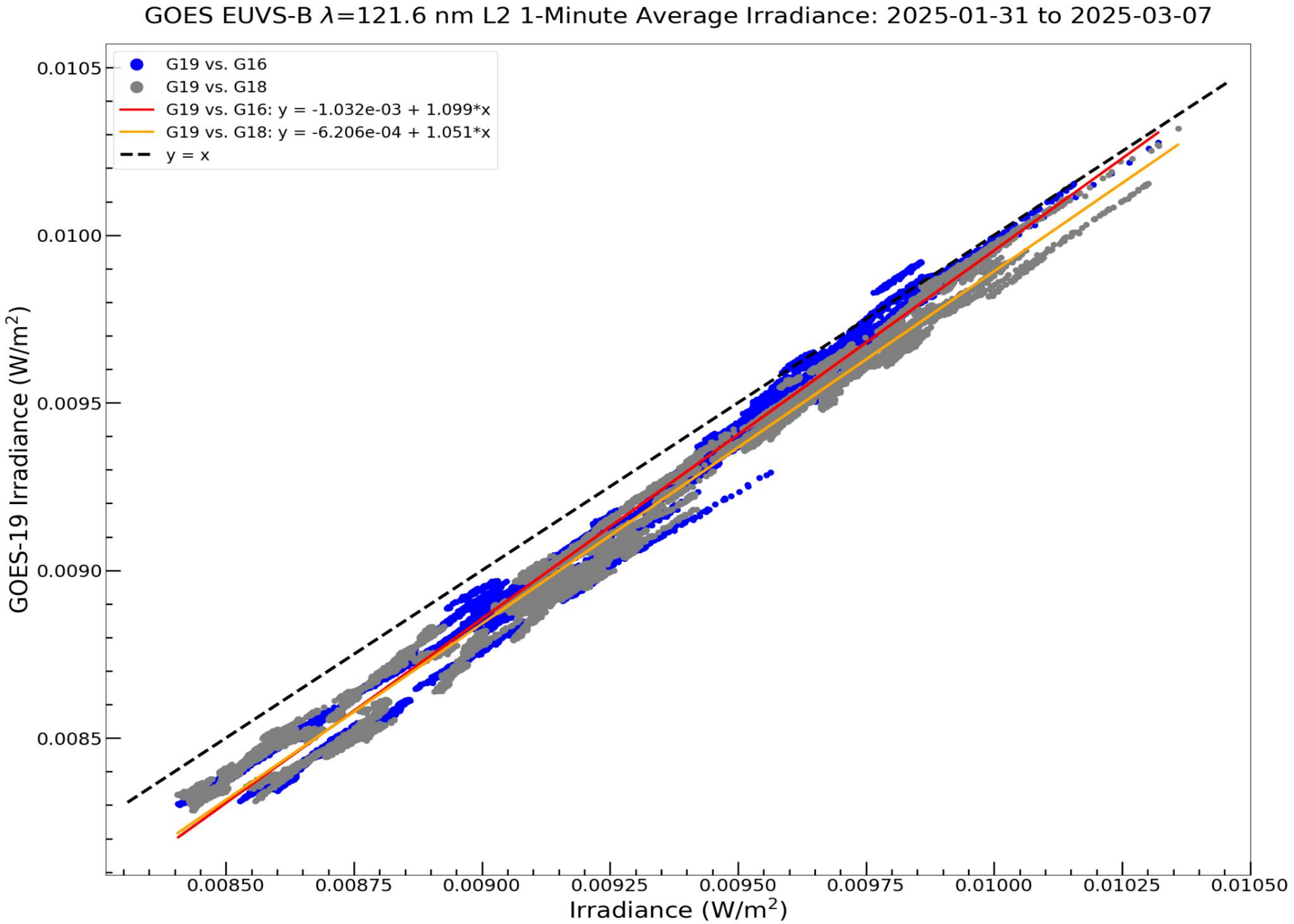
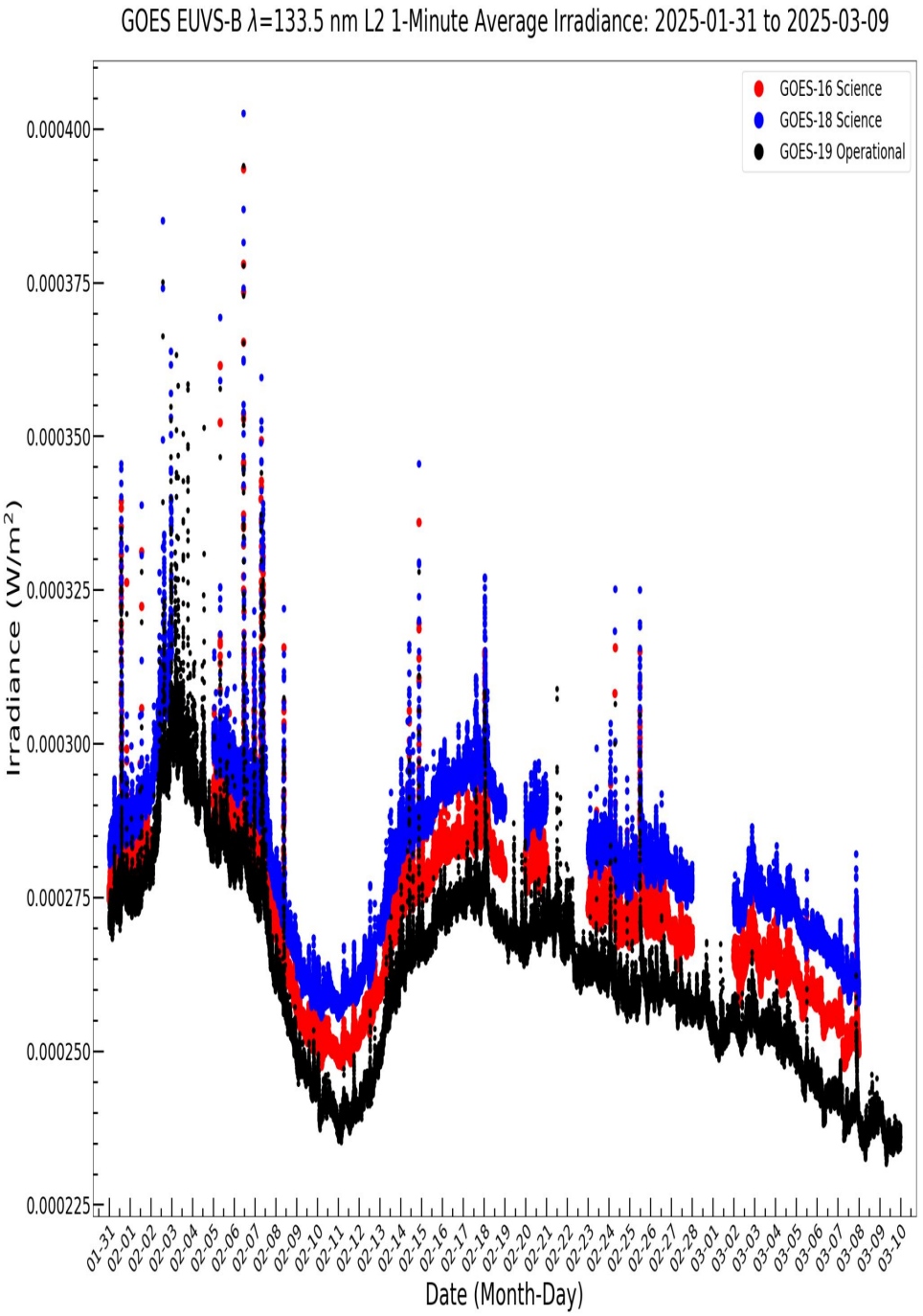
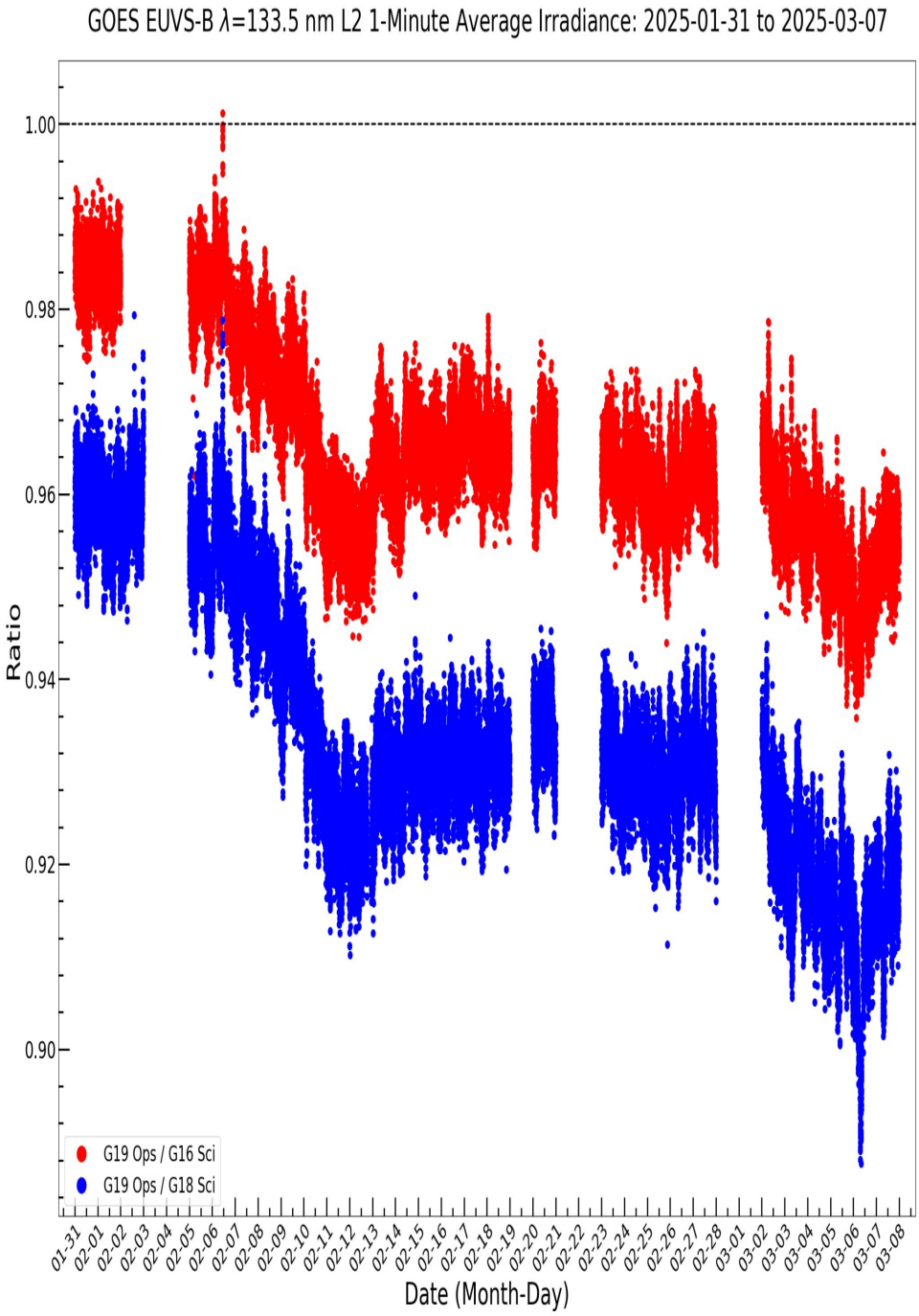


121.6 nm





133.5 nm

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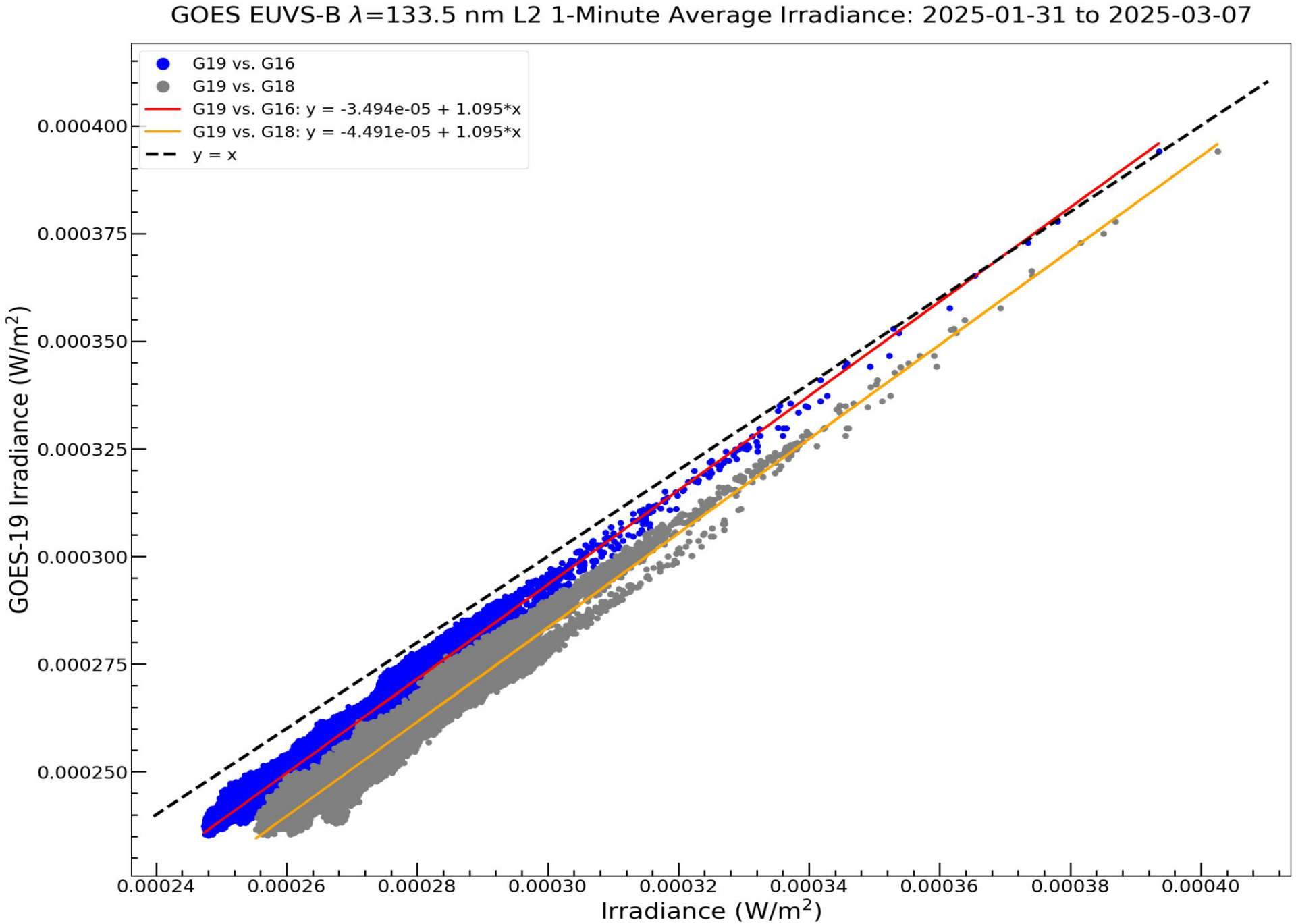
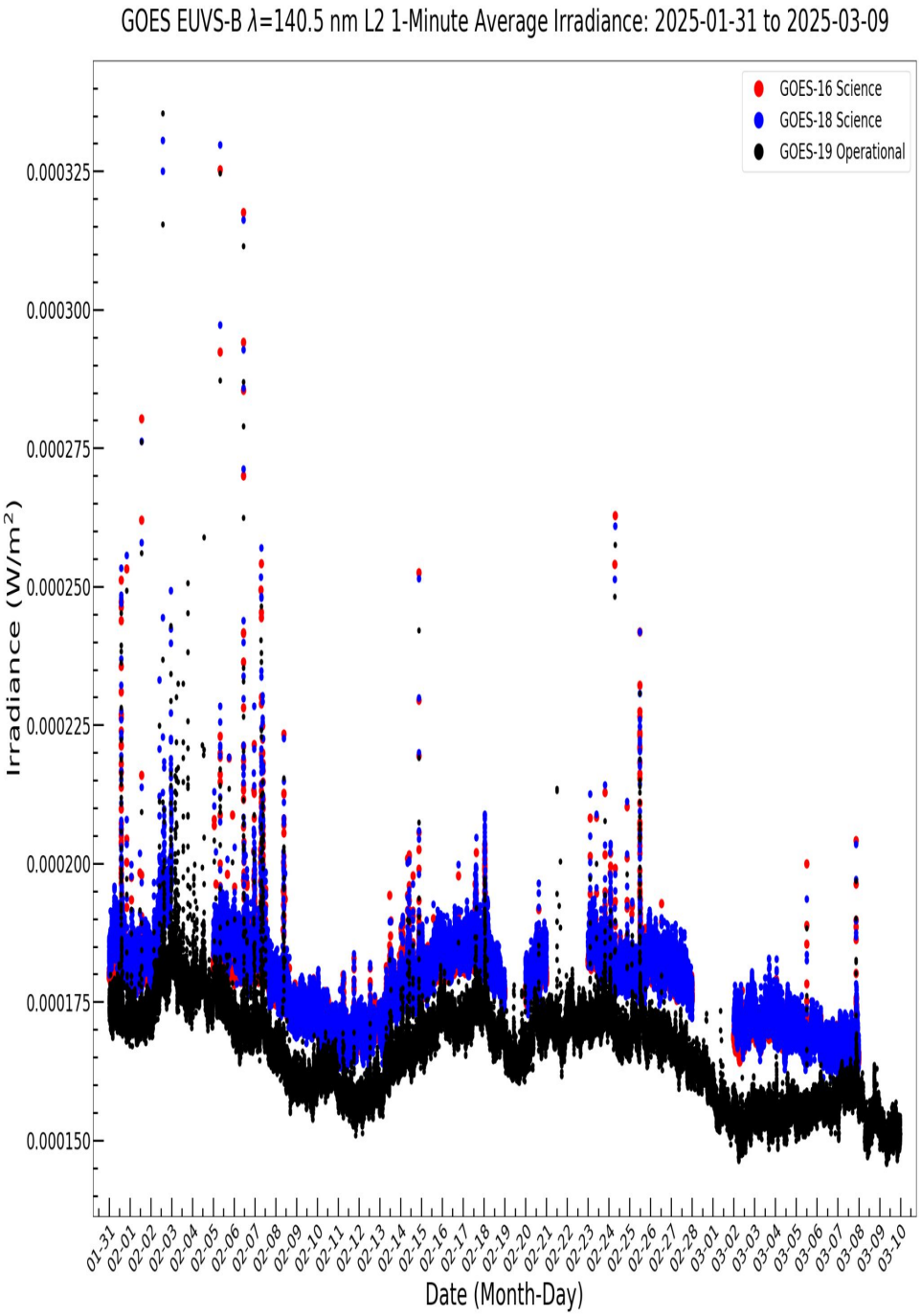
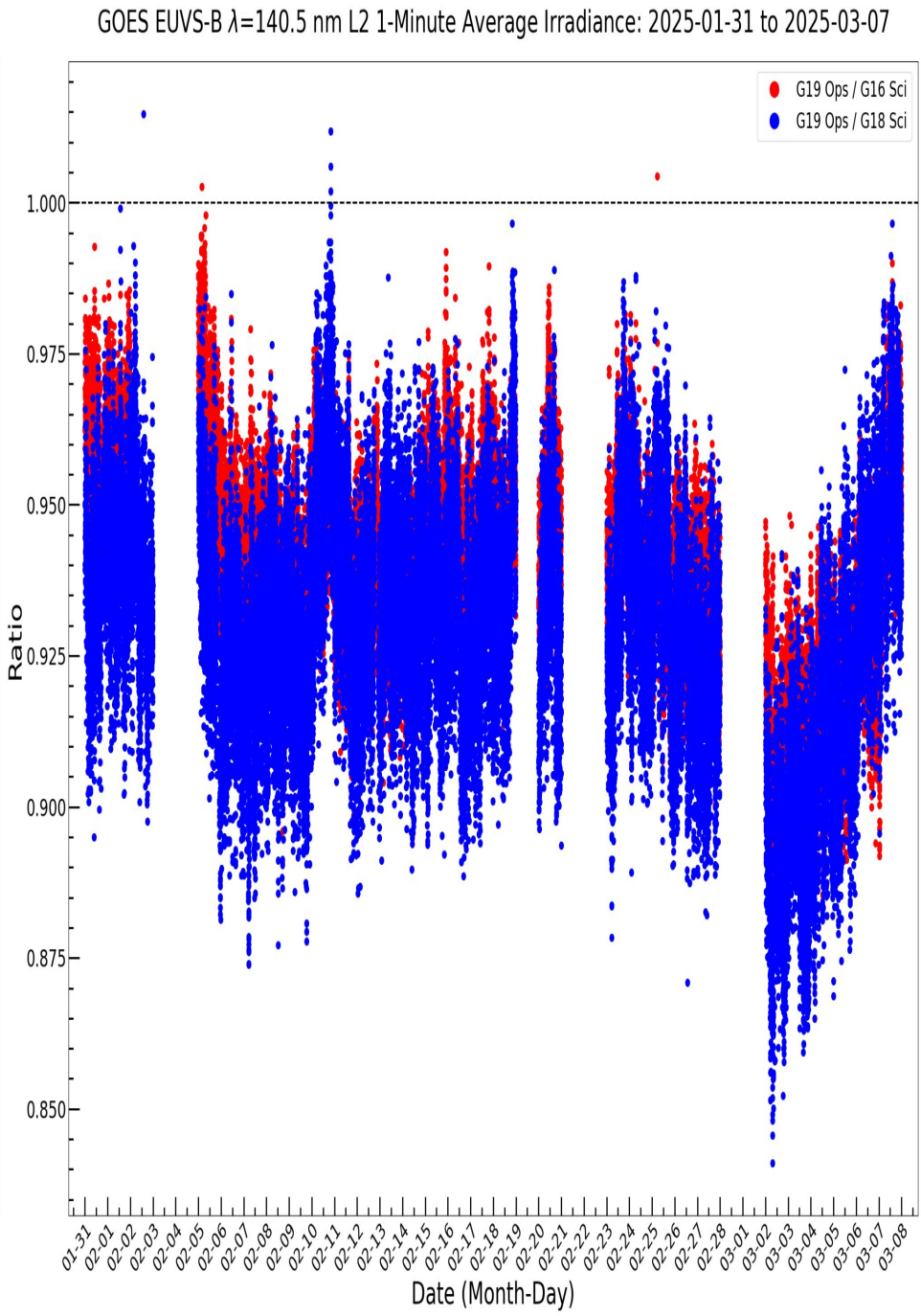


133.5 nm





140.5 nm

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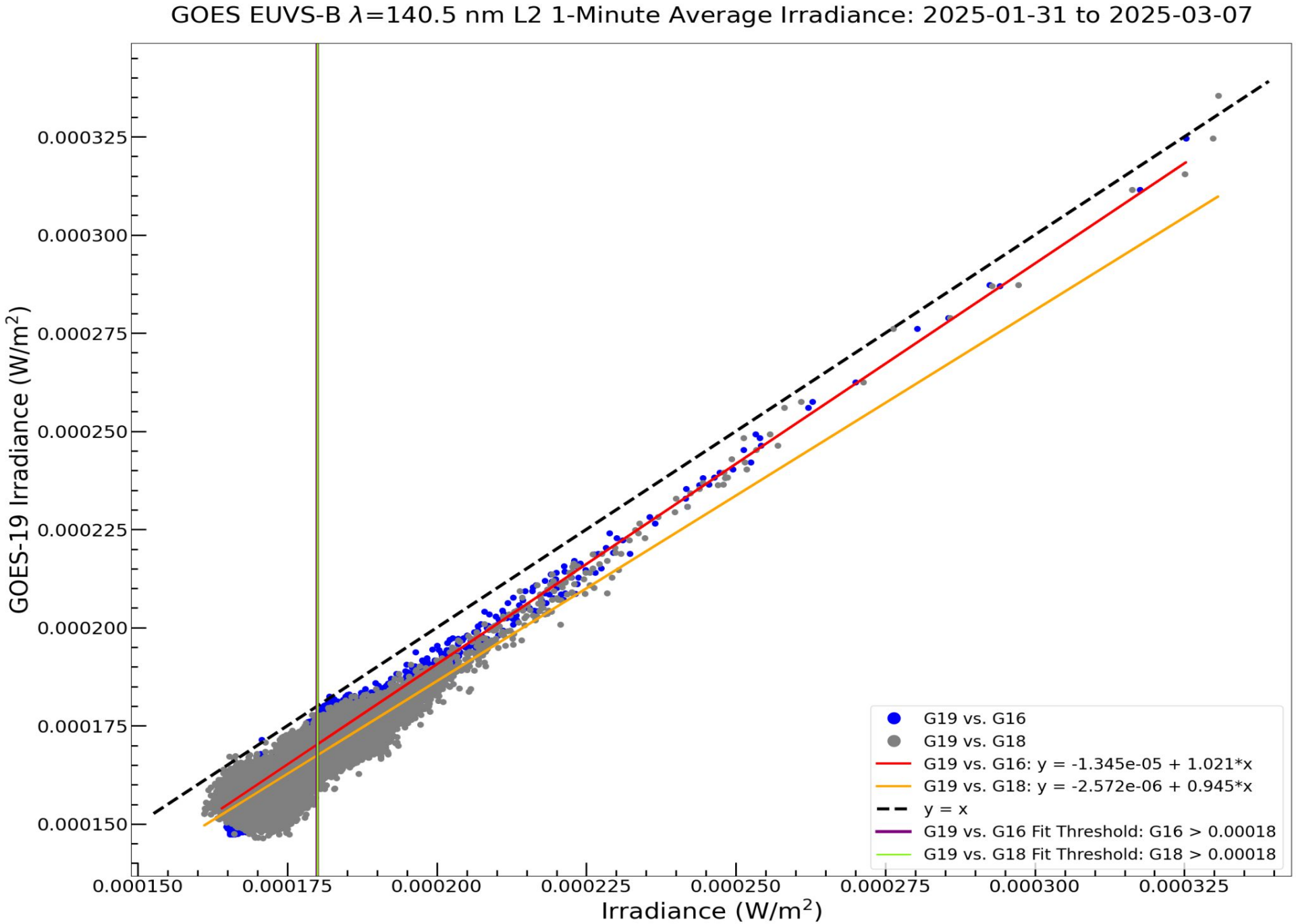

140.5 nm

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EUVS-A & B Summary

- The incorrect scaling in GOES-18 EUVS-A is apparent
- If the satellites matched exactly, the x-coefficient for the irradiance vs. irradiance fits would be 1
- Most wavelengths show offsets <5% of uniformity (within the stability required by MRD 577 and 2032)
    - Routine updates to temperature, dark drift and degradation corrections will ensure irradiance agrees with the other satellites. This analysis is heavily affected by the limited (1.5 months) availability of GOES-19 data.

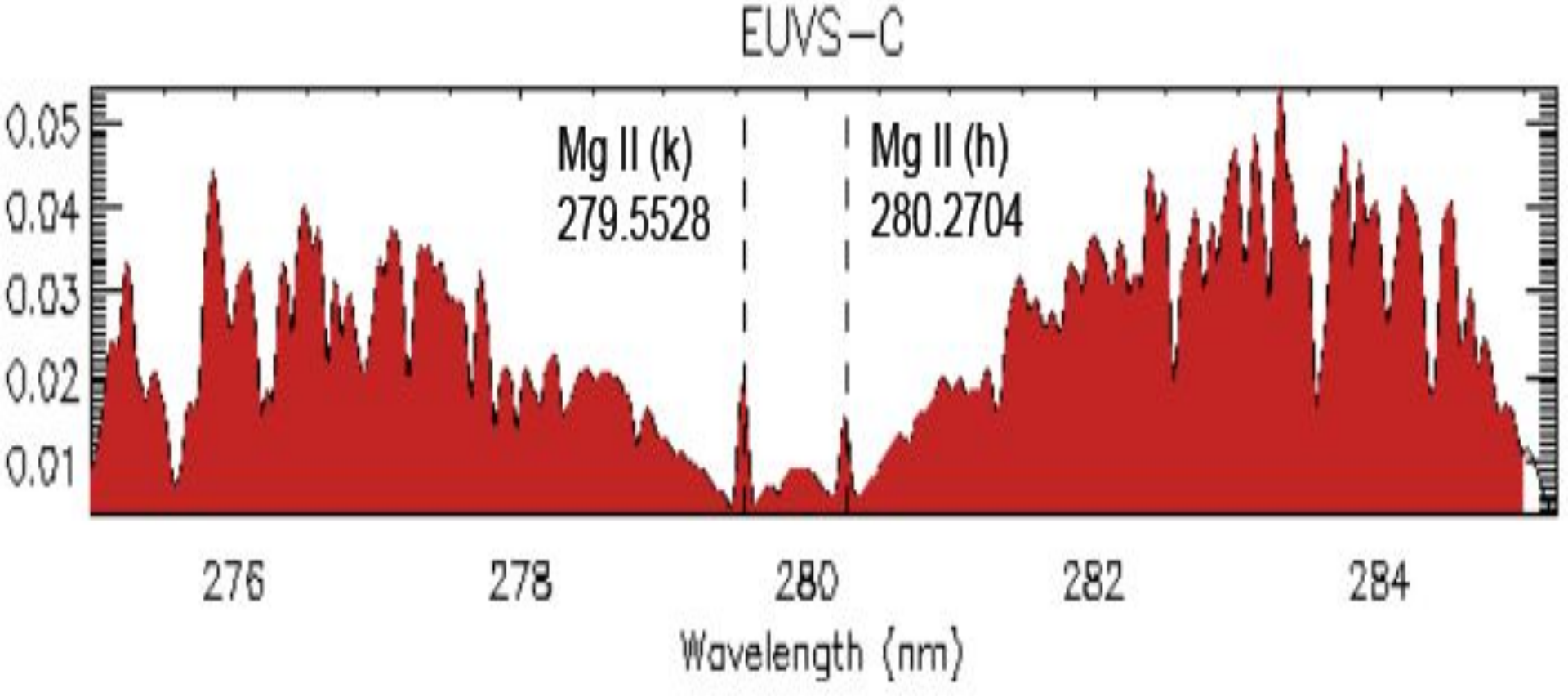
X-Coefficient of G19 Linear Fit	25.6 nm	28.4 nm	30.4 nm	117.5 nm	121.6 nm	133.5 nm	140.5 nm
GOES-16	1.018	1.029	1.016	1.039	1.099	1.095	1.021
GOES-18	1.237	1.187	1.331	0.981	1.051	1.095	0.945

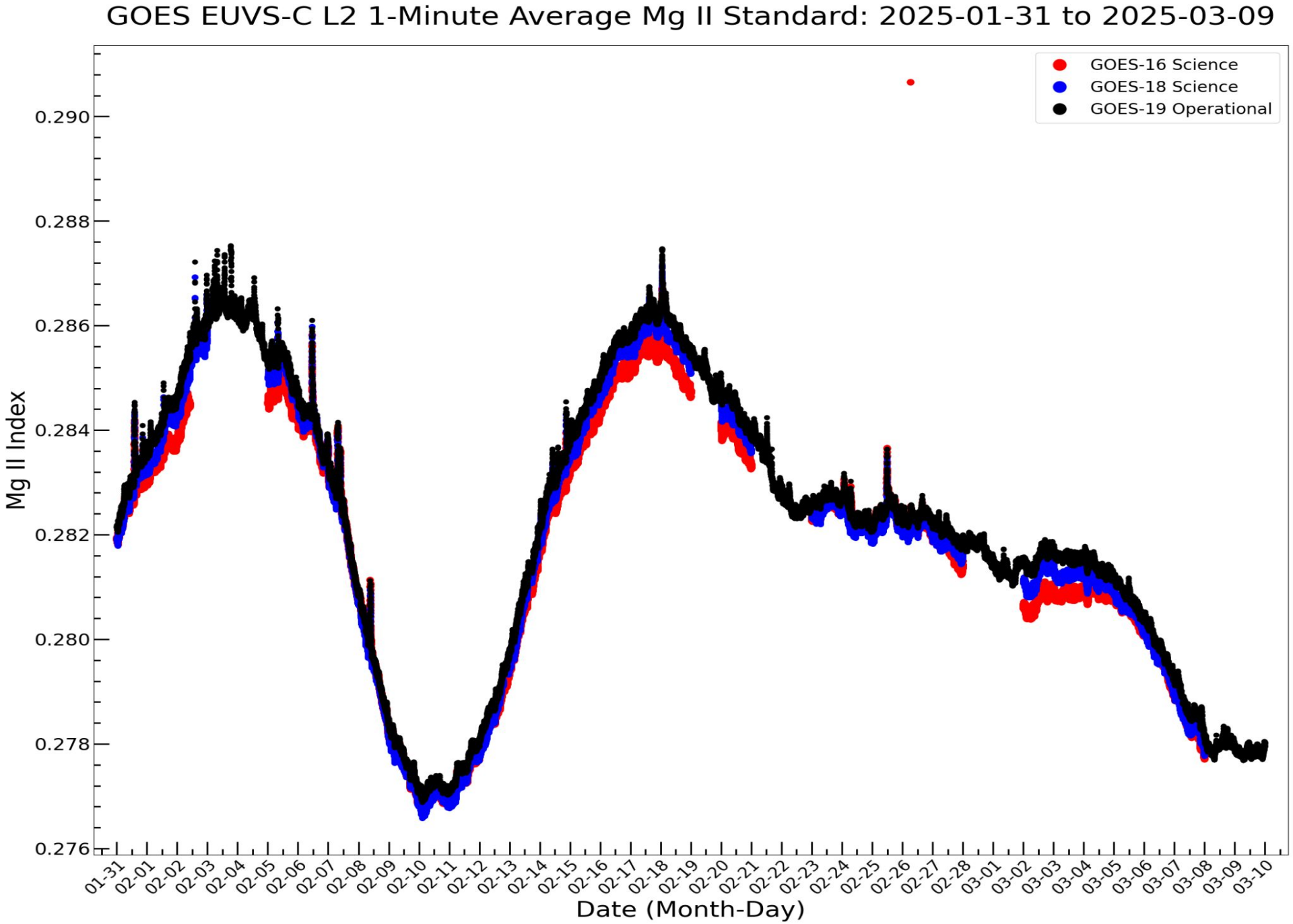
PLPT #14: EUVS-C Mg II Inter-Satellite Comparisons

- Plots show the following:
  - G19 L2 1-minute average operational data
  - G16 & G18 L2 1-minute average science data. L2 data is made from 30-second L1b operational data.
  - G16, G18, and G19 L1b daily average operational data
- Slides 52-53 show the same plots as slides 13-14. These plots show both the Mg II scaling and the Mg II inter-satellite comparisons.
- Slides 54-55 show the red wing, blue wing, H-line and K-line components of the Mg II index.
- Slides 56-57 show the red wing, blue wing, H-line and K-line ratios

EUVS-C Overview

- EUVS-C measures the spectrum near 280 nm
- The Mg II index is a unitless value of EUV solar energy
- Mg II index = $(I_h + I_k) / (I_{red\_wing} + I_{blue\_wing})$
  - Red wing is > 280 nm, blue wing is < 280 nm





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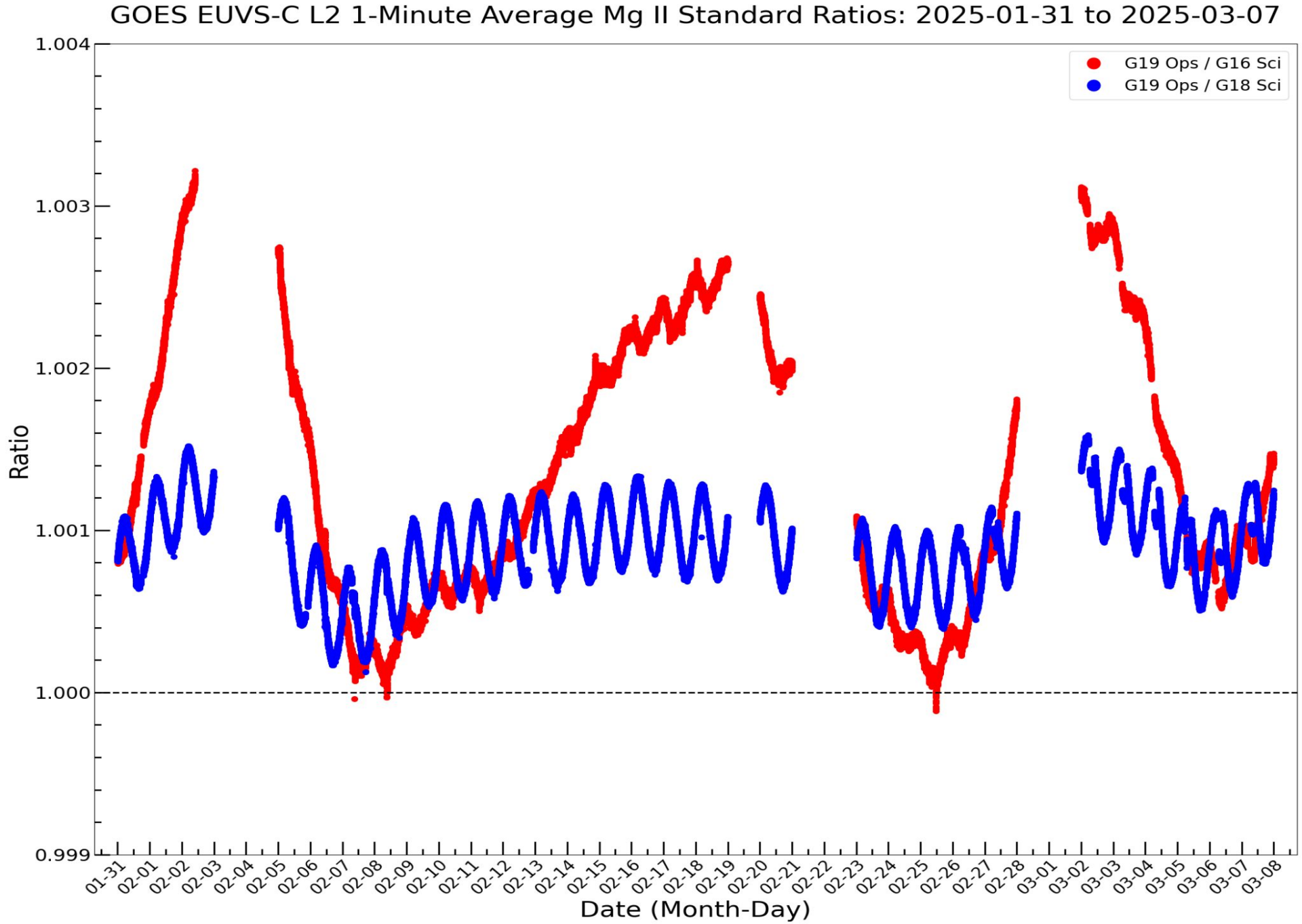

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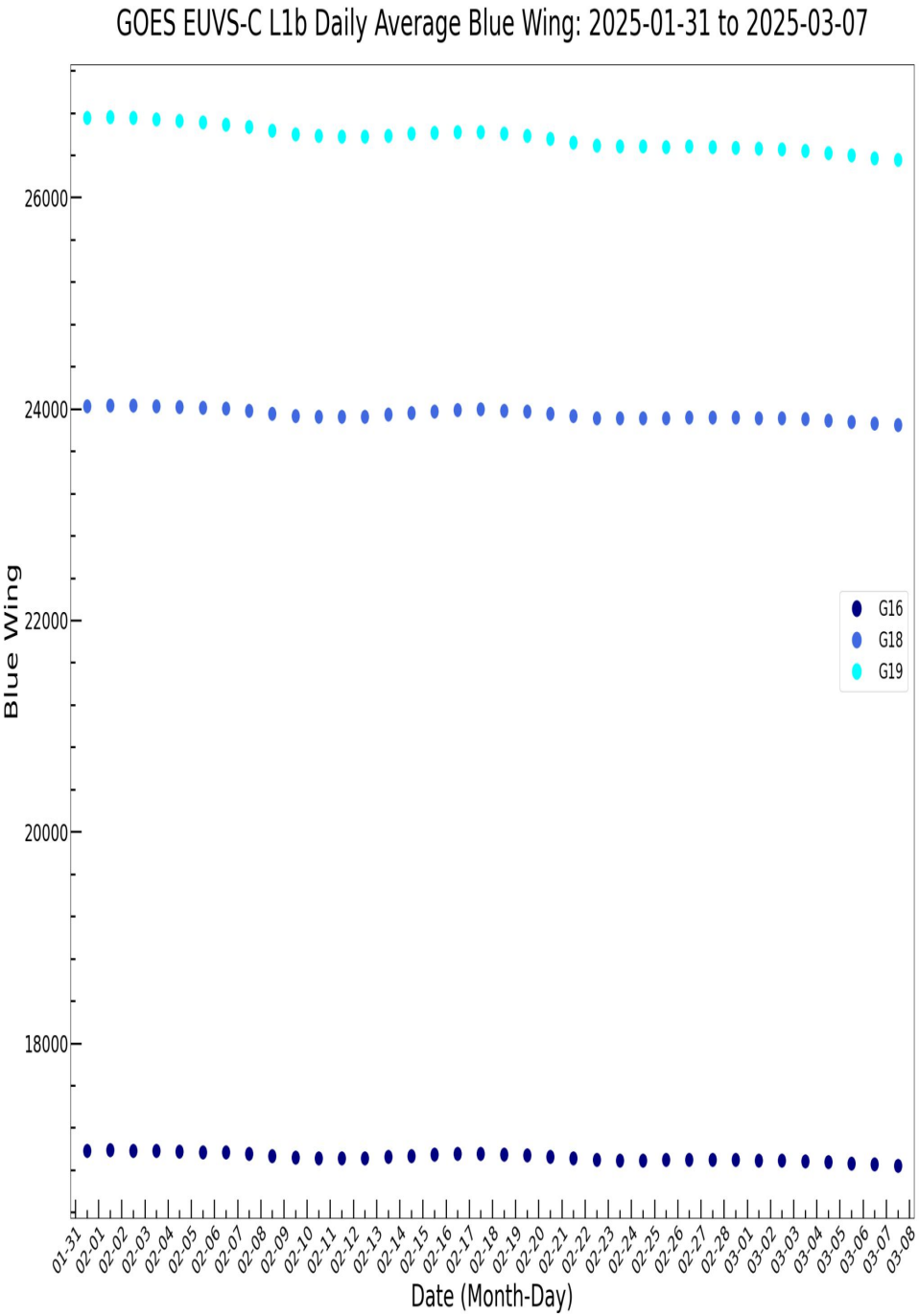

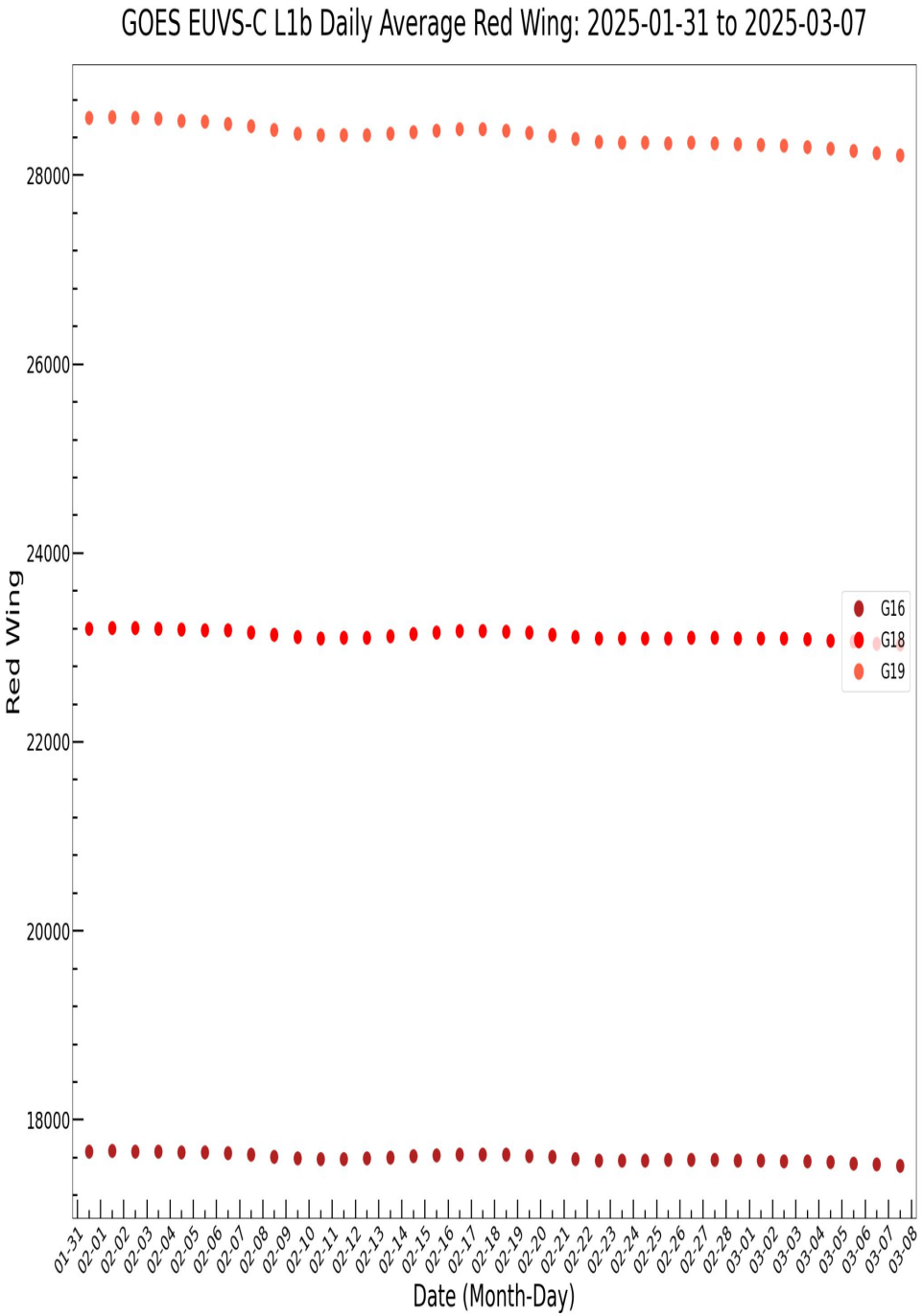

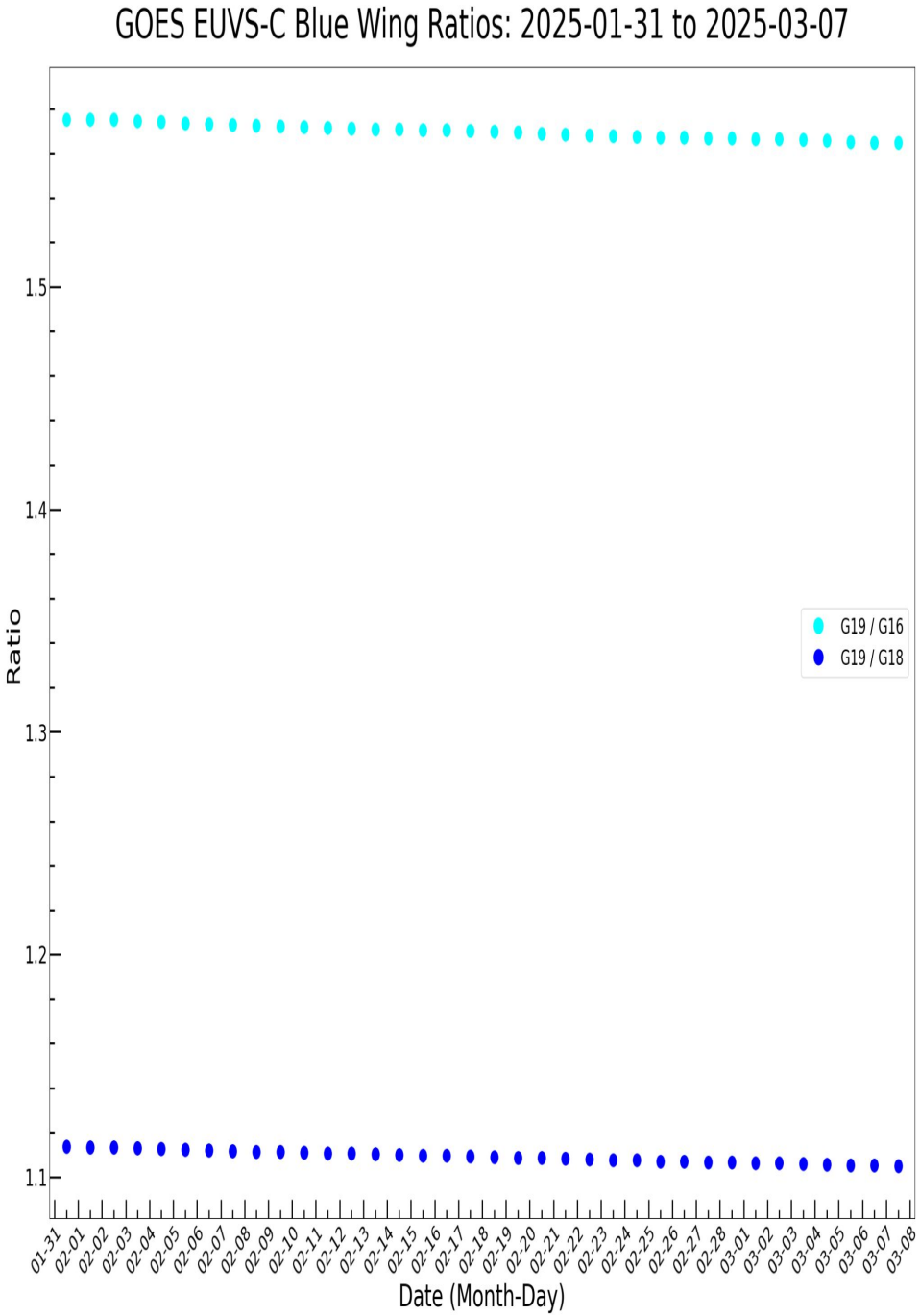

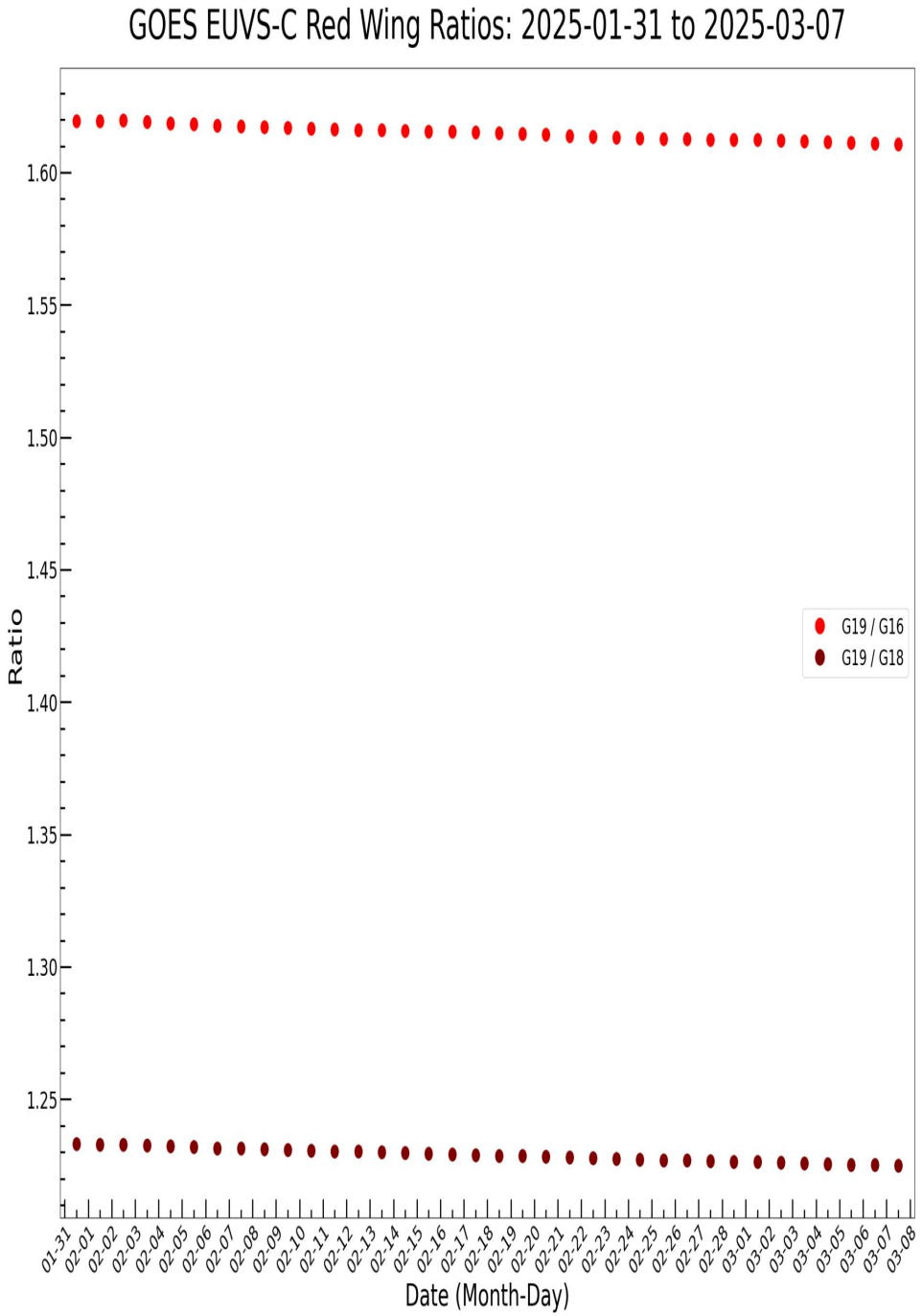

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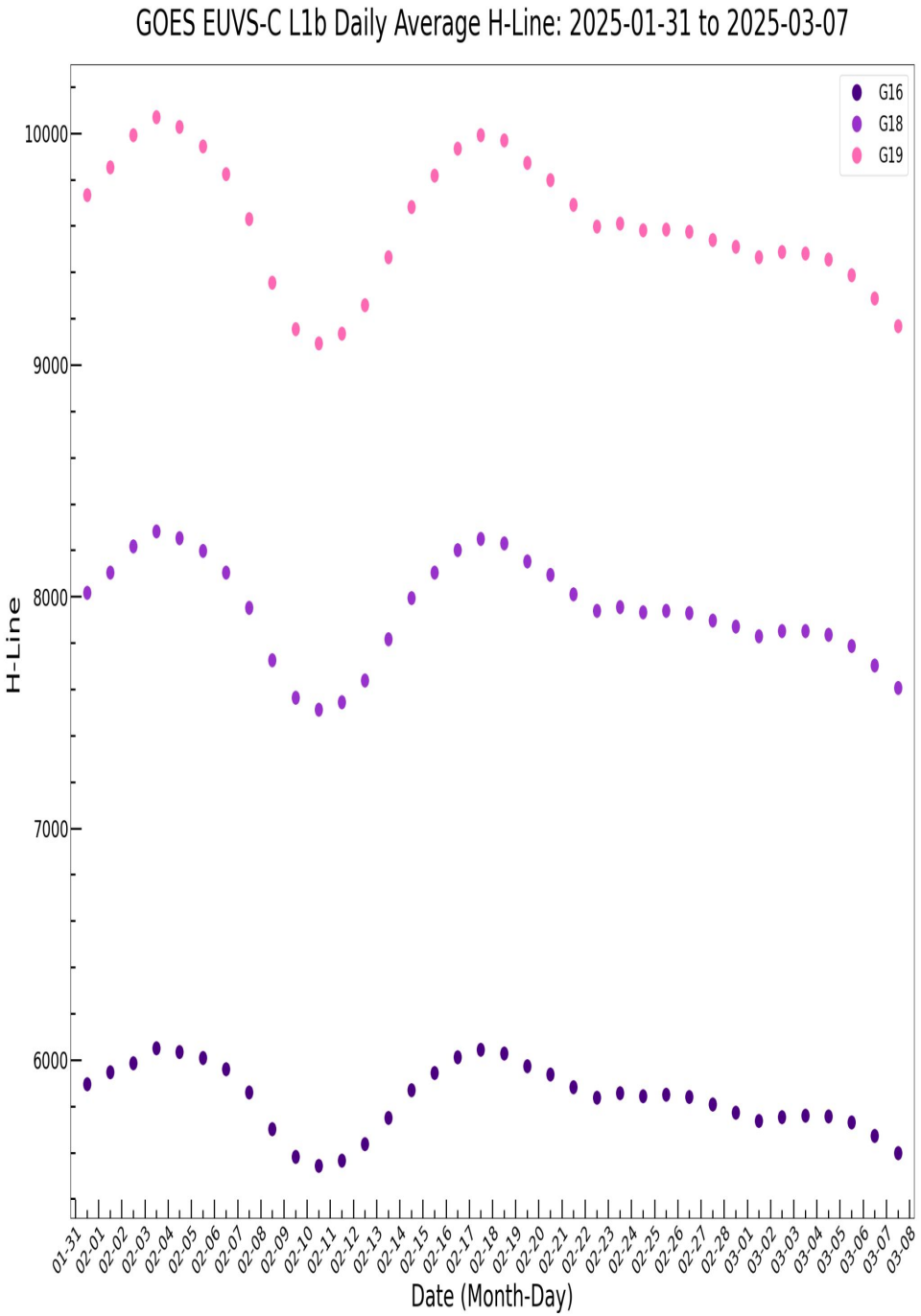
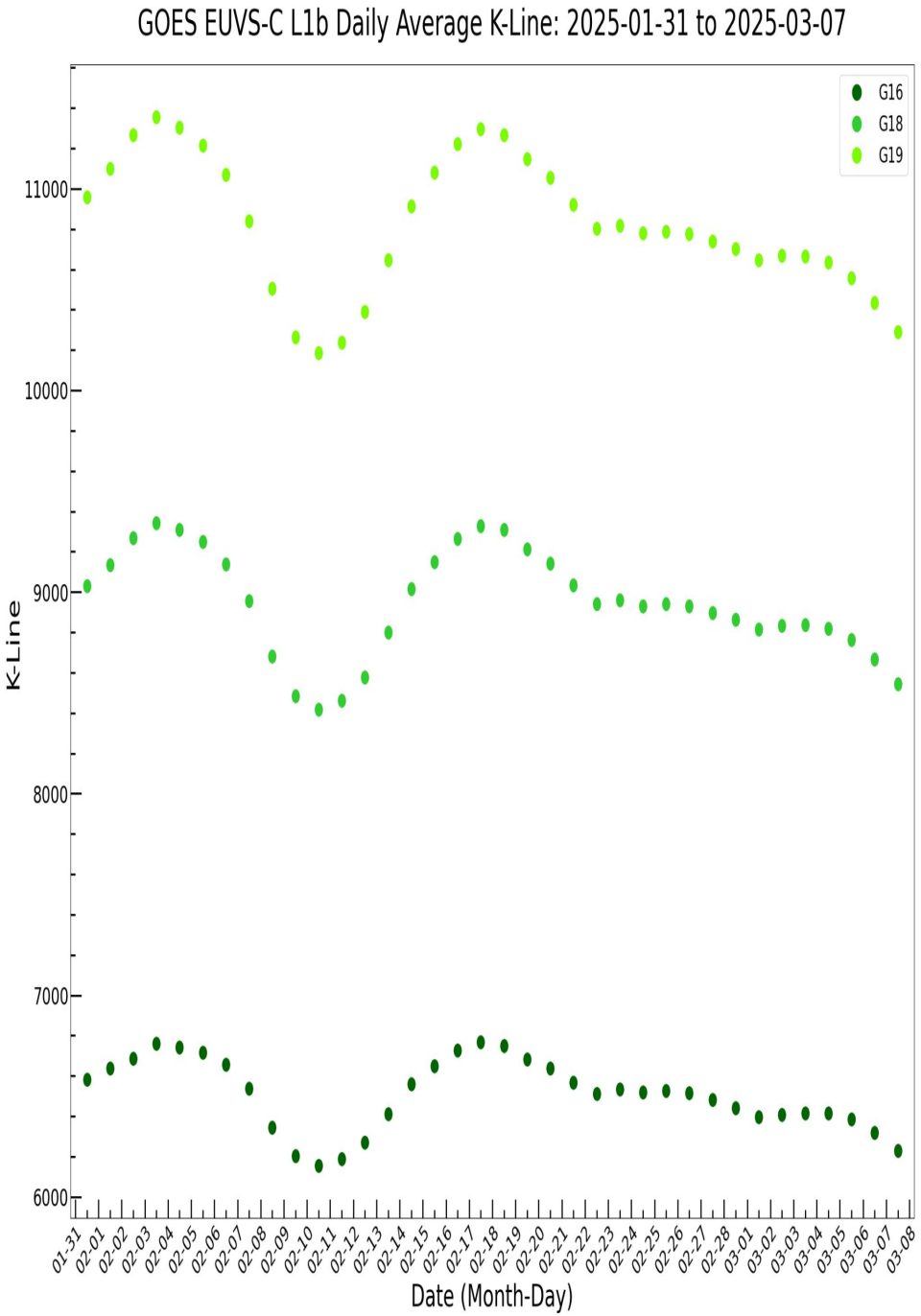
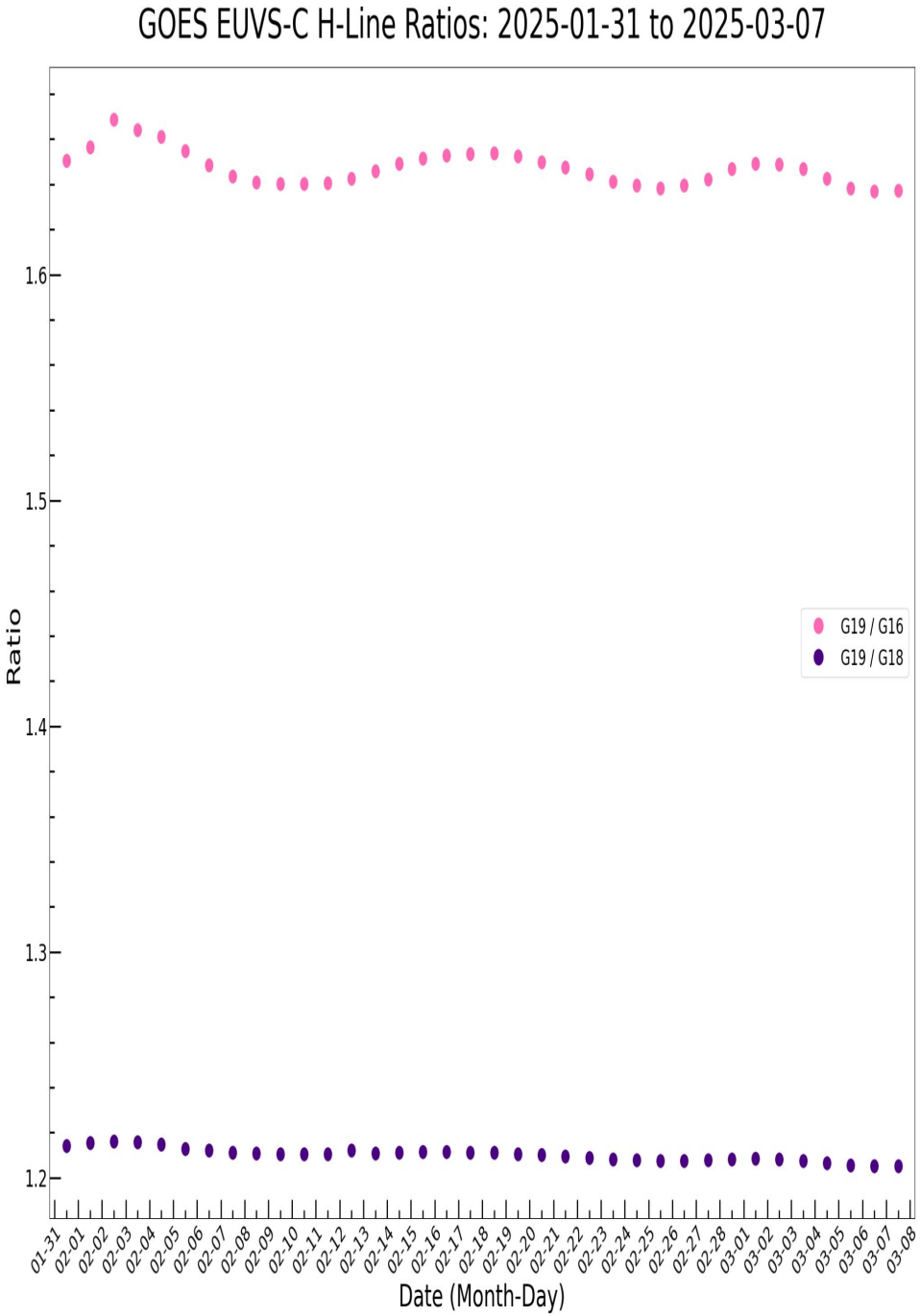
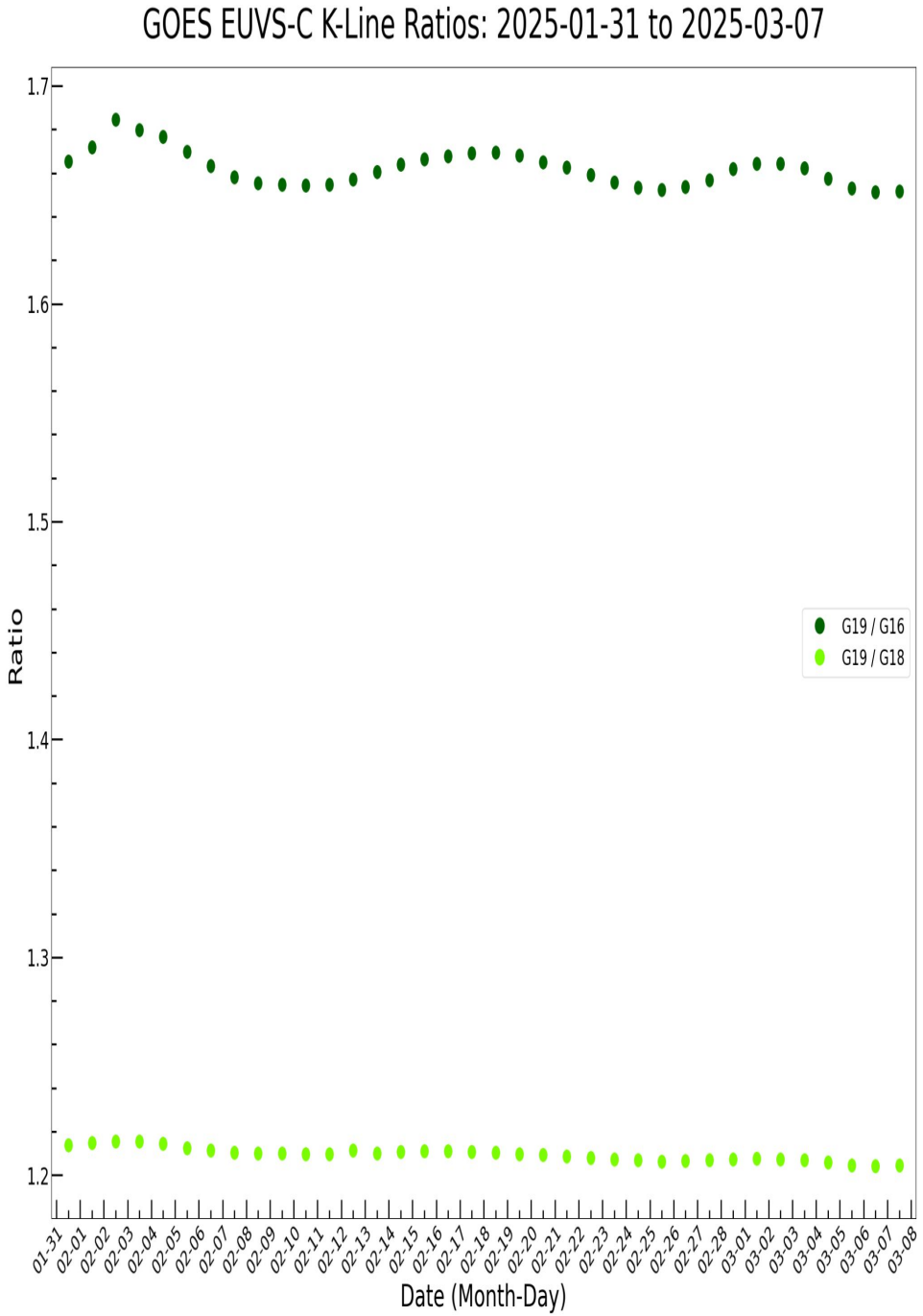








SUMMARY OF REMAINING ISSUES

Remaining EUVS Instrument Issues

#	Title	Description	Comments to Users
1	EUVS-C Spike Removal	Spikes can add noise to the data	L1b code additions will be determined; this issue is also tracked in ADR 1144
2	EUVS-C Degradation	EUVS-C degradation has trends which are non-linear with respect to wavelength and causes an error in the Mg II index.	A time- and wavelength degradation correction is being developed by NCEI and LASP. Small impact at start of missions.
3	Spectral Model Jumps	Jumps in spectral model bins that use 121.6 nm irradiance	New LUT with different coefficients for Case 1 will be generated
4	Oscillation Artifact	Annual cycle oscillation in EUVS-B line irradiances: 117 nm and 140 nm	Under investigation

Remaining EUVS Instrument Issues

#	Title	Description	Comments to Users
5	Post-Eclipse Dips	Unexplained multi-hour dip in the irradiance after each eclipse umbra	This effect is thought to be temperature-related. Analysis is in progress.
6	ECI Correction	All EUVS measurements are bad during Extended Coronal Imaging (ECI)	Pointing thresholds will be redefined so that Sun-pointed measurements can be used.
7	Rescale EUVS-A	In March 2025, GOES-18 EUVS-A will be rescaled to GOES-16 measurements. Later, both satellites should be rescaled to the July 2025 SDO EVE rocket underflight.	GOES-19 EUVS-A is currently scaled to GOES-16; GOES-18 is scaled to the faulty rocket measurements.
8	Diurnal cycle in GOES-18	A possible diurnal cycle is observed in GOES-18 that is an artifact, not due to Doppler shifts.	This will be investigated.

GPA Issues for Provisional Validation

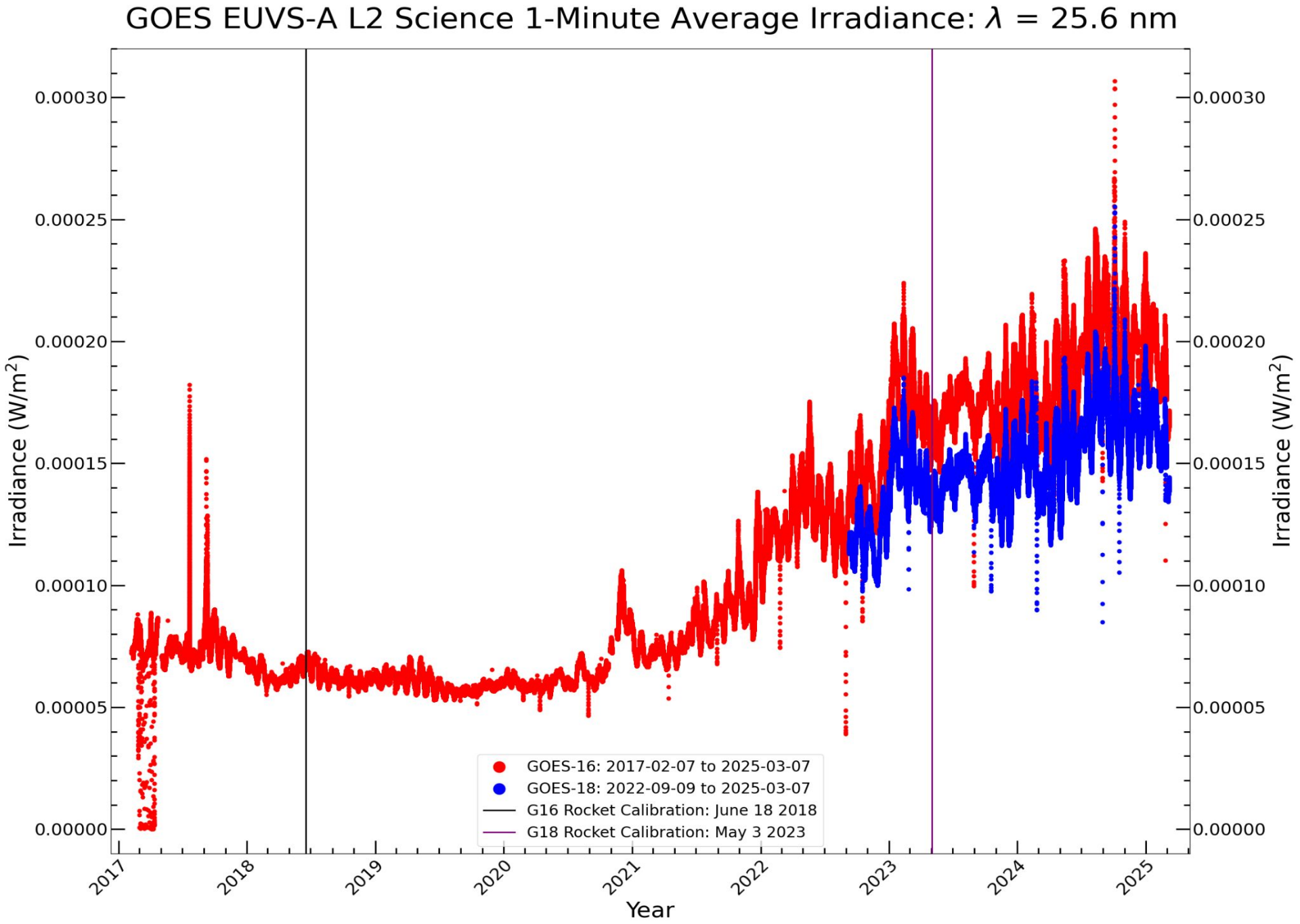
- Installation of new LUTs in operational processing frequently takes 2-3 months. This means the operational data is running 2-3 months behind the most current calibrations. This is especially significant early in the mission, when trending is changing significantly in each LUT update.
  - Validation of LUT testing takes < 1 week; issues with satellite operations and NSOF scheduling cause the vast majority of the delays
- LASP support will decrease to almost none after March 2025; this will affect LUT deliveries
  - LASP maintains access to the GOES-R Portal; LUTs are placed on the Portal for formal delivery
- The regular AART meetings to track/discuss ADRs will be discontinued. New points of contact and procedures will be necessary for delivering LUTs, providing test data, tracking ADRs and installing LUTs in operational processing.

Remaining EUVS GPA Issues

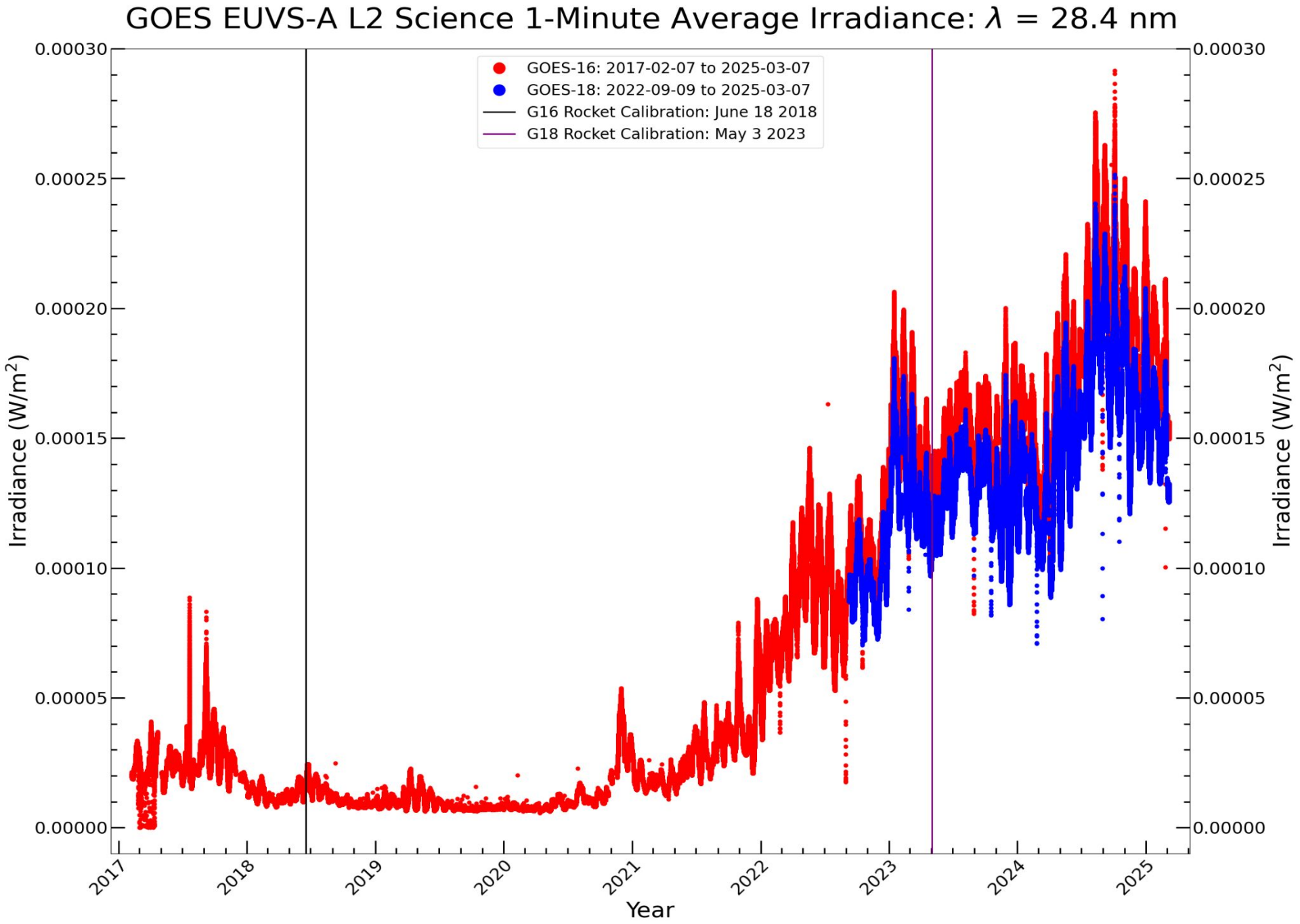
ADR	Issue	Data Impact	Description / Impacts	OE Delivery Date
1144	EUVS During Lunar Transit	Moderate	Remove EUVS-C spikes when eclipse and lunar transit flags are set	DO.13.00; still in analysis
1161	Penumbra-only Flag	Moderate	Add flag to indicate penumbra event without eclipse to SC_eclipse_flag (detailed in GOES-17 EUVS Full Validation PS-PVR)	In analysis under Flight WR 8837 with PRO support. Likely an MM procedural update.
1437	L0 LZSSc Dropouts	Moderate	LZSSc processing for science data is impacted by missing L0 granule files. Initial L3Harris solution has reduced, but not eliminated, the prevalence of these data gaps.	First solution installed January 9 2025
1552	Incorrect Bit Value for exis-l1b-sfeu degraded_due_to_all_invalid_XRS-A_l1b_report_qf Quality Flag	Moderate	The degraded_due_to_all_invalid_XRS-A_l1b_report_qf quality flag bit value is set to 429496729 but should be 4294967296. The value is in the flag_values and flag_masks arrays of the qualityFlags variable.	TBD; should be a quick fix

GOES-18 EUVS-A Scaling

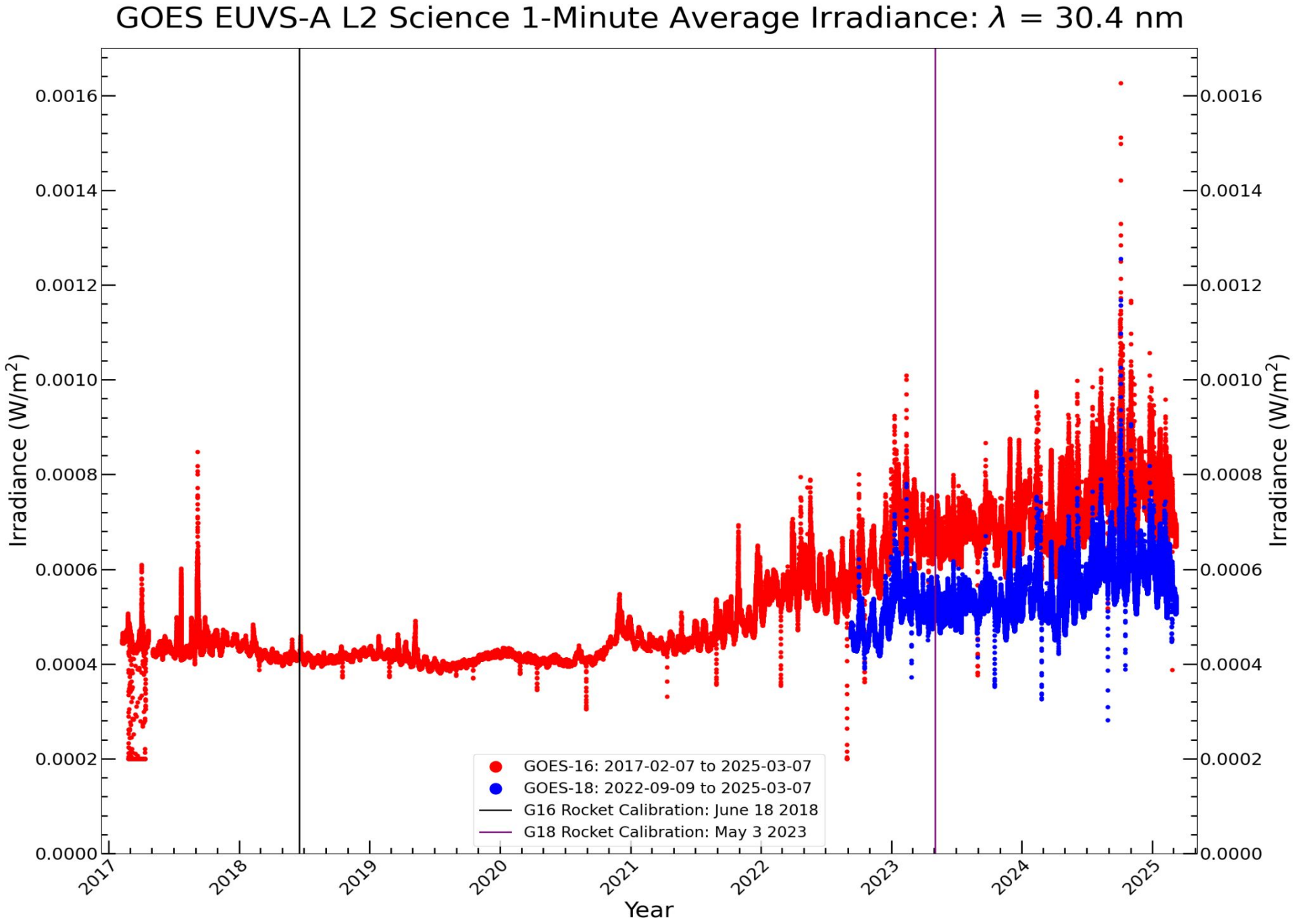
- The EUVS-A irradiance contains an absolute scaling to a reference spectrum
- The reference spectrum is measured by an SDO EVE instrument that flies on a sounding rocket launched from White Sands. This instrument observes the same wavelengths as GOES EXIS EUVS-A.
- The degradation-corrected EUVS-A irradiance is scaled to the rocket irradiance; this is the absolute calibration
- GOES-16 and GOES-17 EUVS-A are scaled to a rocket spectrum measured on June 18 2018; GOES-18 EUVS-A is scaled to a rocket spectrum measured on May 3 2023
- The May 3 2023 rocket irradiance is thought to be too low; as a result, the absolute scaling for GOES-18 does not agree with GOES-16 or GOES-17
- The near-term solution is to scale GOES-18 to GOES-16
- The long-term solution is to re-calibrate the rocket instrument and measure a new spectrum to provide an accurate absolute calibration for GOES-18 and GOES-19
- Additional UV spectra datasets could be used as an absolute calibration; one such example is the FURST mission run by Dr. Charles Kankelborg at Montana State University


GOES EUVS-A L2 Science 1-Minute Average Irradiance: λ = 25.6 nm
Irradiance (W/m²)
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year
GOES-16: 2017-02-07 to 2025-03-07
GOES-18: 2022-09-09 to 2025-03-07
G16 Rocket Calibration: June 18 2018
G18 Rocket Calibration: May 3 2023

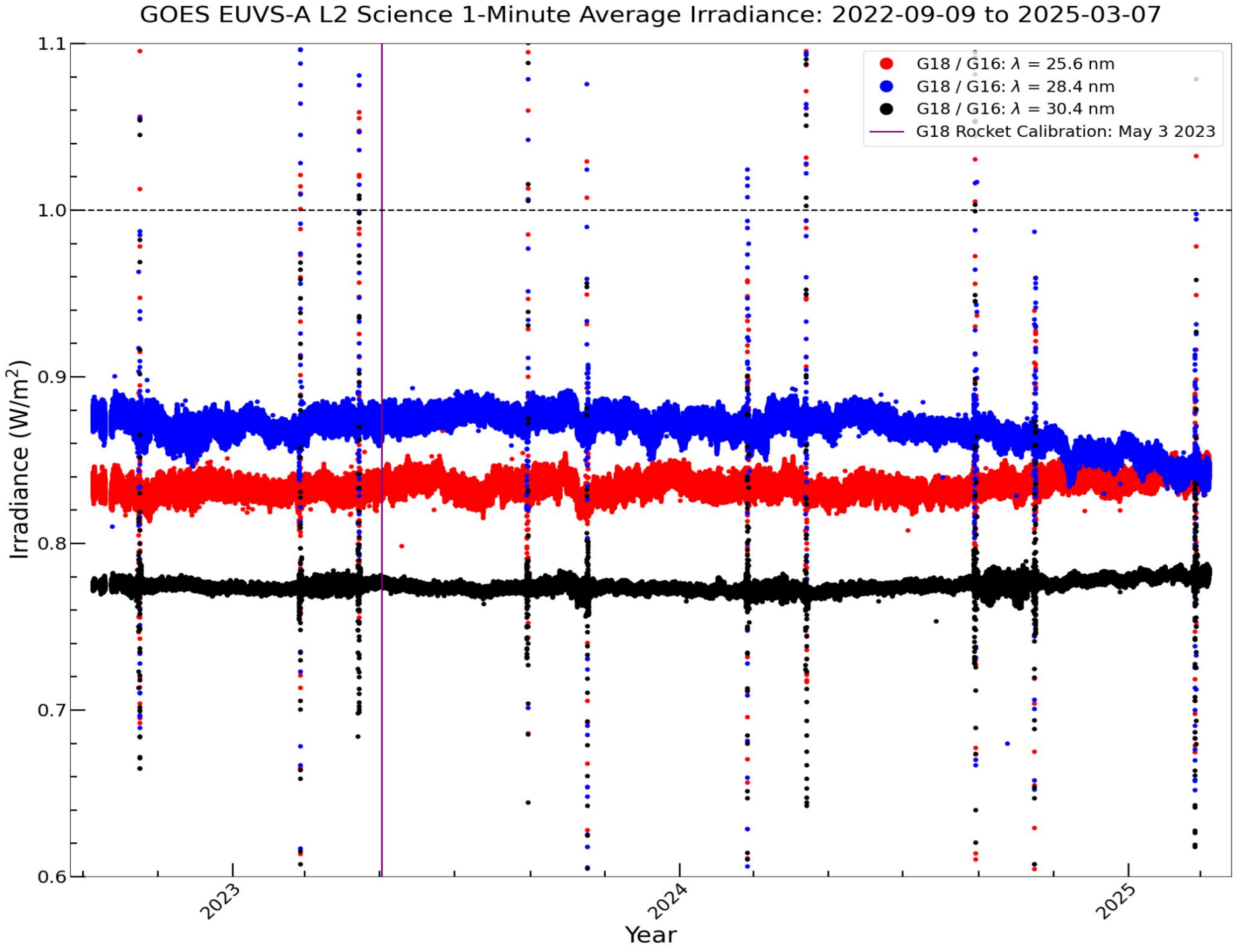
25.6 nm


GOES EUVS-A L2 Science 1-Minute Average Irradiance: λ = 28.4 nm
GOES-16: 2017-02-07 to 2025-03-07
GOES-18: 2022-09-09 to 2025-03-07
G16 Rocket Calibration: June 18 2018
G18 Rocket Calibration: May 3 2023
Irradiance (W/m²)
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

28.4 nm

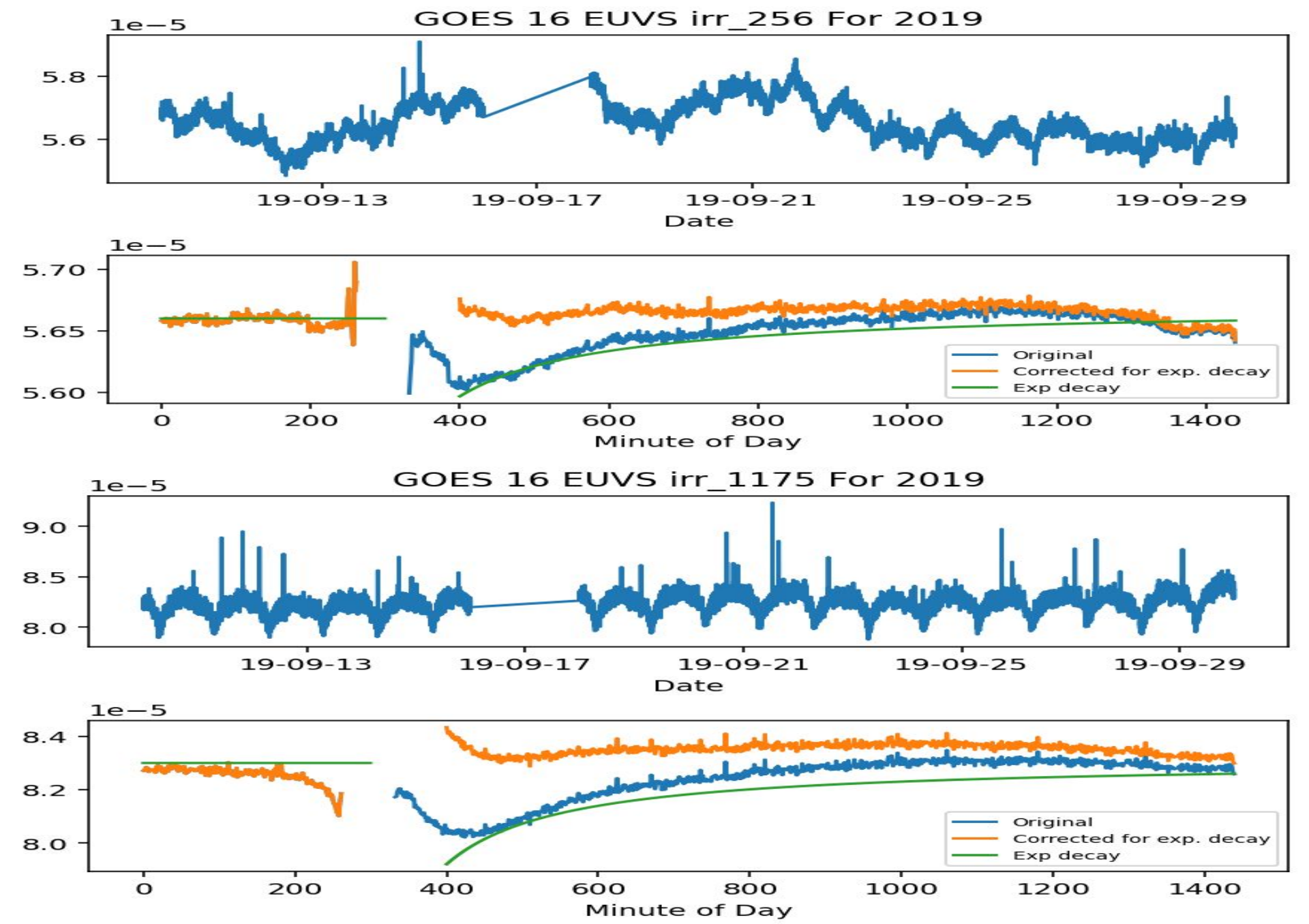

GOES EUVS-A L2 Science 1-Minute Average Irradiance: λ = 30.4 nm
Irradiance (W/m²)
Year
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012
0.0014
0.0016
2017
2018
2019
2020
2021
2022
2023
2024
2025
GOES-16: 2017-02-07 to 2025-03-07
GOES-18: 2022-09-09 to 2025-03-07
G16 Rocket Calibration: June 18 2018
G18 Rocket Calibration: May 3 2023

30.4 nm


GOES EUVS-A L2 Science 1-Minute Average Irradiance: 2022-09-09 to 2025-03-07
G18 / G16: λ = 25.6 nm
G18 / G16: λ = 28.4 nm
G18 / G16: λ = 30.4 nm
G18 Rocket Calibration: May 3 2023
Irradiance (W/m²)
1.1
1.0
0.9
0.8
0.7
0.6
2023
2024
2025
Year

EUVS Temperature Correction

- In the EUVS-A, EUVS-B and EUVS-C channels, there is a dip in the irradiance after the eclipse umbra during the eclipse seasons (late February-early April and late August-early October) that is not being corrected
- The irradiance shows a sharp dip immediately after the umbra, followed by a multi-hour “recovery” of the irradiance to the expected level after the eclipse
- This dip and recovery can be manually removed from the irradiance by applying a correction in the form of a decaying exponential curve
- It is believed this effect is caused by temperature variations in the EUVS instrument
- A possible solution is to add an additional temperature correction, applied after the eclipse umbra, to remove the irradiance dip
- The LASP EXIS team is analyzing this issue to determine a correction


GOES 16 EUVS irr_256 For 2019
1e−5
5.8
5.6
19-09-13
19-09-17
19-09-21
19-09-25
19-09-29
Date
1e−5
5.70
5.65
5.60
0
200
400
600
800
1000
1200
1400
Minute of Day
Original
Corrected for exp. decay
Exp decay
GOES 16 EUVS irr_1175 For 2019
1e−5
9.0
8.5
8.0
19-09-13
19-09-17
19-09-21
19-09-25
19-09-29
Date
1e−5
8.4
8.2
8.0
0
200
400
600
800
1000
1200
1400
Minute of Day
Original
Corrected for exp. decay
Exp decay

Future GPA Updates

- GOES-19 EXIS will become operational when GOES-19 replaces GOES-16 as the GOES-East satellite on April 4 2025
- LASP delivered final GOES-19 EXIS LUTs in January 2025
- NCEI will produce and deliver all subsequent GOES-19 EXIS LUT updates

- 142 EUVS-related ADRs have been closed since 2016
- Significant EUVS ADRs since GOES-18 Full Validation PS-PVR (November 2023):
  - 3 distinct GOES-16 EUVS LUT updates
  - 4 distinct GOES-18 EUVS LUT updates
  - 2 distinct GOES-19 EUVS LUT updates
- 4 EUVS ADRs are currently open

Additional Issues

- LASP support will decrease to almost none after March 2025. This will affect ongoing science investigations, routine calibrations and long-term knowledge of the EXIS instruments.
- There are several calibrations that are not currently maintained by NCEI. These include:
  - Additional XRS FOV correction method that removes flare signals from FOV data using the irradiance from a different GOES satellite
  - Plotting of cruciform scan data
  - Calculation of XRS dark count values; these are used to calculate the new time-dependent XRS dark correction
- The code and procedure for these calibrations are scheduled to be transferred to NCEI in March 2025

PROVISIONAL MATURITY ASSESSMENT

Performance Baseline

MRD ID	Quantity	MRD Requirement	GOES-16 (Full)	GOES-17 (Full)	GOES-18 (Full)	GOES-19 (Provisional)	Related PLPT	Status
577	EUVS Long-term Stability Life of Mission)	< ±5% or ability to track	Track Changes				15, 16, 17	PASS
2027	EUVS Product Measurement Range	EUVS-A: 0.5x Solar Min to 10x Solar Max ($1.4x10^{-5}$ to $5.3x10^{-2}$ W/m^2) EUVS-B: 0.5x Solar Min to 10x Solar Max ($1.4x10^{-5}$ to $5.3x10^{-2}$ W/m^2)	EUVS-A: $4.7x10^{-7}$ to 0.93 W/m^2 EUVS-B: $1.8x10^{-6}$ to 1.64 W/m^2	EUVS-A: $6.3x10^{-7}$ to 1.03 W/m^2 EUVS-B: $1.4x10^{-6}$ to 1.19 W/m^2	EUVS-A: $2.4x10^{-6}$ to 3.05 W/m^2 EUVS-B: $4.9x10^{-6}$ to 12.24 W/m^2	EUVS-A: $2.4x10^{-6}$ to 2.3222 EUVS-B: 4.2 $x10^{-6}$ to 7.2 W/m^2	3	PASS
2028	EUVS Product Measurement Accuracy	< 20%	EUVS-A: ≤ 2.7% EUVS-B: ≤ 7.7%	EUVS-A: ≤ 4.0% EUVS-B: ≤ 5.9%	EUVS-A: ≤8.9% EUVS-B: ≤12.9%	EUVS-A: ≤ 4.4% EUVS-B: ≤ 8.7%	3	PASS
2031	EUVS Product Measurement Precision	< 20% at min flux	EUVS-A: ≤ 2.9% EUVS-B: ≤ 9.4%	EUVS-A: ≤3.3% EUVS-B: ≤5.9%	EUVS-A: ≤ 4.5% EUVS-B: ≤ 4.8%	EUVS-A: ≤ 3.9% EUVS-B: ≤ 4.5%	3	PASS
2032	EUVS Long-term Stability	< ±5% or ability to track	Track Changes				15, 16, 17	PASS

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.

Provisional Maturity Definition	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. Eventual 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.	No severe algorithm anomalies at this time.
Incremental product improvements may still be occurring.	Product improvements will result from the resolution to issues given on the slides in the “Summary of Remaining Issues” section.

Provisional Maturity Definition	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.	EUVS flux measurements have been compared with measurements from GOES-16 and GOES-18 EUVS instruments. GOES-19 instrument was calibrated at SURF.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Product performance will be communicated to users via the Readme *when* data is released.
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.	Remaining GPA issues are documented in ADR summaries. This presentation and Readme summarize remaining issues and planned remediation.
Testing has been fully documented	Documentation includes this presentation, PLT reports, and PLPT reports.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	This data is ready for operational use.

Provisional Validation

- All sensors are performing within expectations. With limited data available for provisional validation analysis, GOES-19 EUVS is producing acceptable results.
- Analysis capability and product quality will improve between now and full validation (2026)
- Calibration LUTs have been updated. Further updates will occur.
- Plans to describe, fix and validate data issues have been identified
- Publicly available EUVS data from NCEI:
  - G16: operational and science-quality
  - G17: operational and science-quality
  - G18: operational and science-quality
  - G19: expected in March or early April 2025

NCEI-CO recommends that GOES-19 EUVS L1b data be transitioned to Provisional Status

ADDITIONAL INFORMATION

EXIS Calibrations

- Nominal Weekly: 90 second 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
- Long-Term Comparisons
  - XRS Compare flare locations from XRS and SUVI
  - XRS, EUVS Compare measurements with other satellites

EXIS Calibrations

Name	Priority	Schedule	Instrument	Affects LUT?	NCEI Handover?
Deliver HDF5 Files	N/A	As Needed	All	Yes	Yes
EUVS-A Filter Degradation	High	6 Months	EUVS-A	Yes	Yes
EUVS-A/B Dark Drift	High	6 Months	EUVS-A/B	Yes	Yes
FOV	Low	Quarterly after each maneuver	All	No	Yes
EUVS-B Degradation	High	6 Months	EUVS-B	Yes	Yes
EUVS-C Dark	High	6 Months	EUVS-C	Yes	Yes
Thermal Dark Correction	High	6 months (after eclipse seasons)	EUVS-A/B	Yes	Yes
EUVS-C Degradation	Low	6 Months	EUVS-C	No	No
EUVS-C Readout Noise	Low	Quarterly	EUVS-C	No	Yes
EUVS-A Flatfield	Low	Annually	EUVS-A	Yes	Yes
EUVS-B Flatfield	Low	Annually	EUVS-B	Yes	Yes
EUVS-A Gain	Low	6 months (Weekly Calibrations)	EUVS-A	Yes	Yes
EUVS-B Gain	Low	6 months (Weekly cals)	EUVS-B	Yes	Yes
XRS Gain	Low	Annually (Quarterly Calibrations)	XRS	Yes	Yes
SPS Gain	Low	Annually (Quarterly Calibrations)	SPS	Yes	Yes
SPS Darks	Low	Annually (Eclipses)	SPS	Yes	Yes
XRS Darks	Medium	Quarterly (Off-Point)	XRS	Yes	Yes
XRS Inter-Satellite Flare Peak Comparisons	Low	6 Months	XRS	No	No
Cruciform	Low	Quarterly	All	No	No

Current EUVS Operational LUTs

Satellite	EUVS-A	EUVS-B	EUVS-C	EUVSPEC	1 AU
GOES-16	Rev V	Rev V	Rev M	Rev J	2025
GOES-17	Rev Q	Rev O	Rev K	Rev H	2025
GOES-18	Rev J	Rev J	Rev D	Rev C	2025
GOES-19	Rev C	Rev C	Rev C	Rev B	2025

EUV Variability Used in Drag Model

- Space Environment Technologies (SET) uses EUV to form solar indices
  - Uses GOES-R EUVS lines* and Mg II

- High Accuracy Satellite Drag Model (HASDM)
  - Uses these indices as inputs
  - Run by the USAF
  - The output used to revise NORAD catalogue of satellite 2 line elements every 8 hours

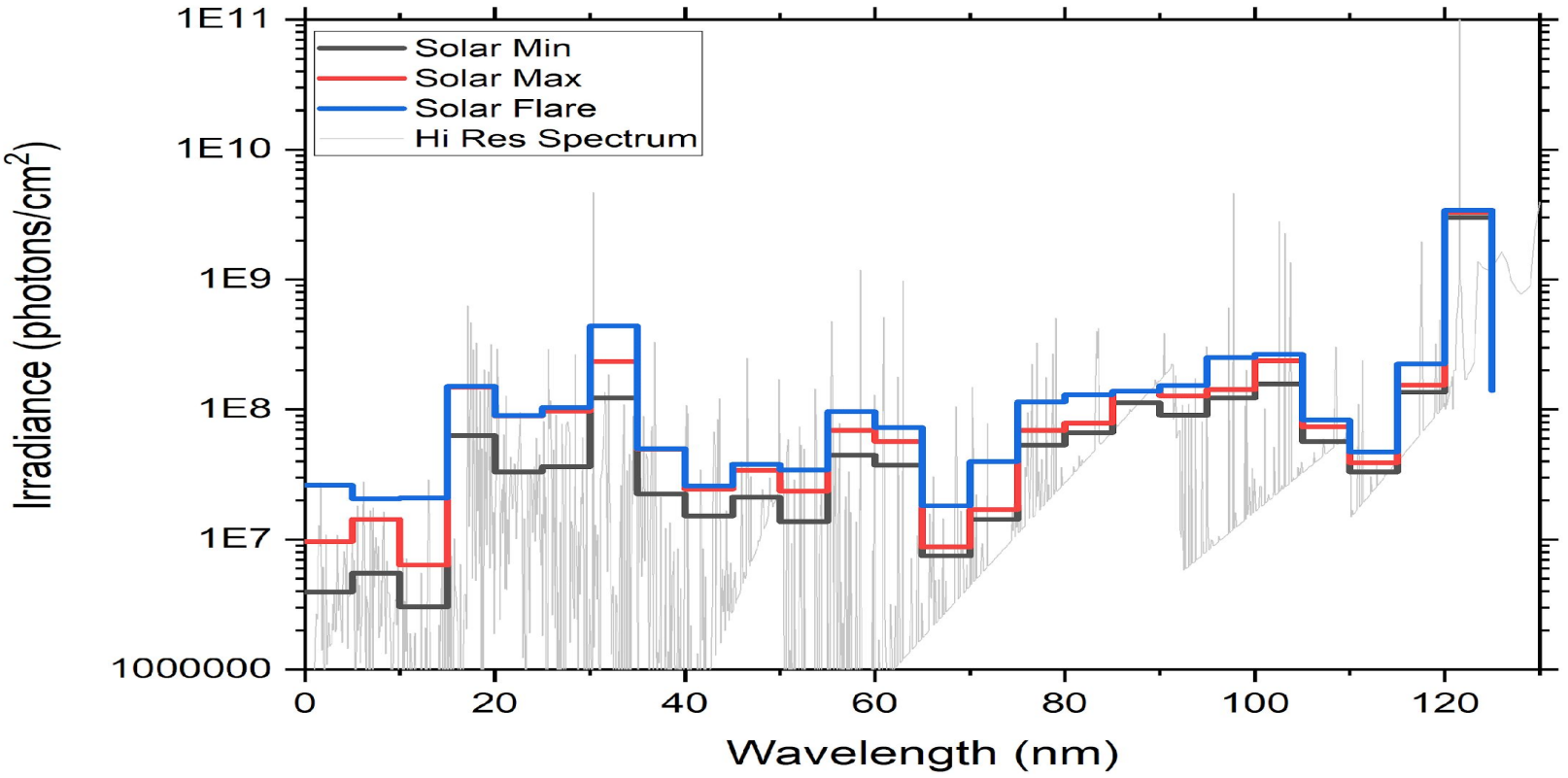
* 28.4, 30.4 and 121.6 nm

EUVS Sensor

- Primary Measurements Used in Spectral Model:
  - Chromospheric:
    - MgII C/W **(EUVS-C)**
    - CIII 117.5 nm **(EUVS-B)**
    - CII 133.5 nm **(EUVS-B)**
  - Transition Region:
    - Ly-alpha 121.6 nm **(EUVS-B)**
    - SiIV/OIV 140.5 nm **(EUVS-B)**
    - HeII 30.4 nm **(EUVS-A)**
    - HeII 25.6 nm **(EUVS-A)**
  - Corona:
    - FeXV 28.4 nm **(EUVS-A)**
  - Hot Coronal:
    - 0.1-0.8 nm **(XRS)**
    - 0.05-0.4 nm **(XRS)**

EUVS Science

- EUV (10-120 nm) and soft X-ray irradiance create the ionosphere and heat the thermosphere
- Solar EUV irradiances change by factors of 2 to 50 on times scales of minutes to years
- The thermosphere (neutral density) and ionosphere (electron density) change by similar amounts across all time scales
- EUV / X-ray irradiances have the highest variability
- < 0.01% of total solar irradiance (TSI)
- Total solar irradiance (TSI) varies by 0.1% while EUV varies by <2, X-rays by $<10^5$



EUVS L1b Uncertainty Equations

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

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

Error Propagation: $\sigma_C{}^2 = \left(\frac{\partial C}{\partial g}\varepsilon_g\right)^2 + \left(\frac{\partial C}{\partial S}\sigma_S\right)^2 + \left(\frac{\partial C}{\partial S_0}\sigma_{S_0}\right)^2 + \left(\frac{\partial C}{\partial \Delta t}\sigma_{\Delta t}\right)^2$

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

Irradiance: $E = \frac{C}{R}$

C = Diode Current (Amps)
R = Diode Responsivity (Amps m^2 W^{-1})

Relative Uncertainty: $\frac{\sigma_E}{E} = \left[\left(\frac{\sigma_C}{C}\right)^2 + \left(\frac{\sigma_R}{R}\right)^2\right]^{1/2}$

Credit: Tom Eden