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

GOES-18 EXIS EUVS

L1b Provisional Maturity

November 17 2022

Presenter

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Contributors

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Summary

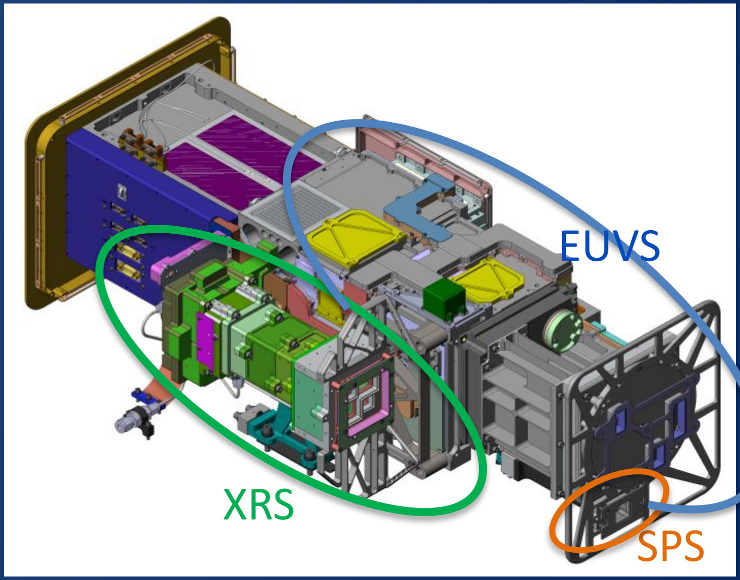
- Initial testing using L0 data processed by LASP has provided most cal values
- GOES-18 behavior is similar to GOES-16 & GOES-17 using LASP-processed-L0 data and Ground System OE L1b
  - No surprises
  - Studies done with L1b, L2, and LASP-L0-processed data
- GPA: Many ADRs submitted, many resolved, a few remain
- Instrument: RevC LUTs installed October 12 2022. This is the start of operational-quality L1b/L2 data.
- All PLPTs: PASSED
- Provisional Validation Product Maturity Assessment: PASSED

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

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)



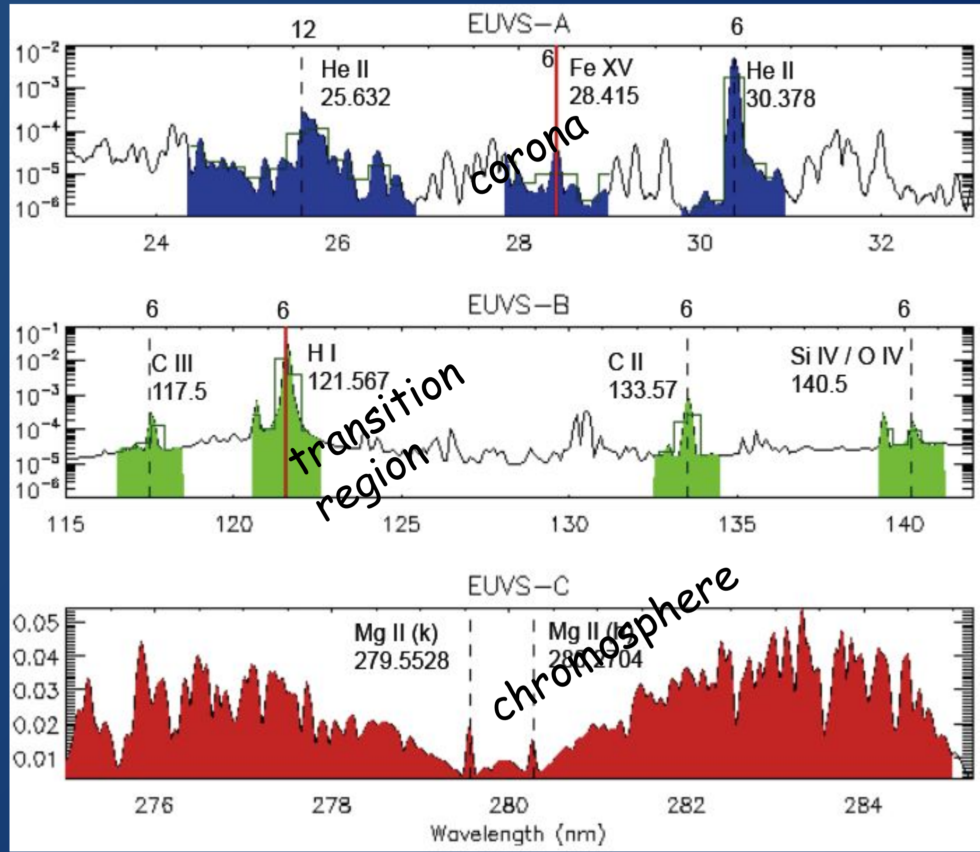
EXIS was designed, built and tested by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado

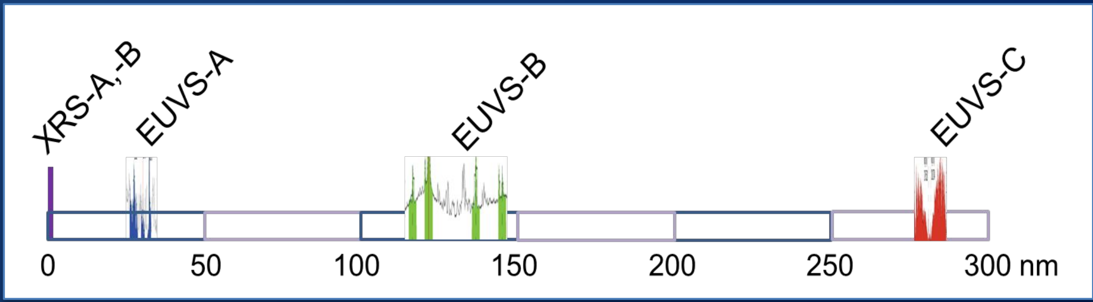
Extreme Ultraviolet Sensor (EUVS)

- 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?

Variations in solar EUV by up to a factor of 10 increase have major impacts for satellites in LEO.

- More EUV irradiance causes more heating in the thermosphere
  - A warmer atmosphere expands
    - Satellite drag can increase by a factor of 10
      - Satellite operators must correct orbit calculations

- More EUV irradiance modifies the ionosphere
  - Impacts radio communications and GPS navigation

Image Credit: ESA

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)

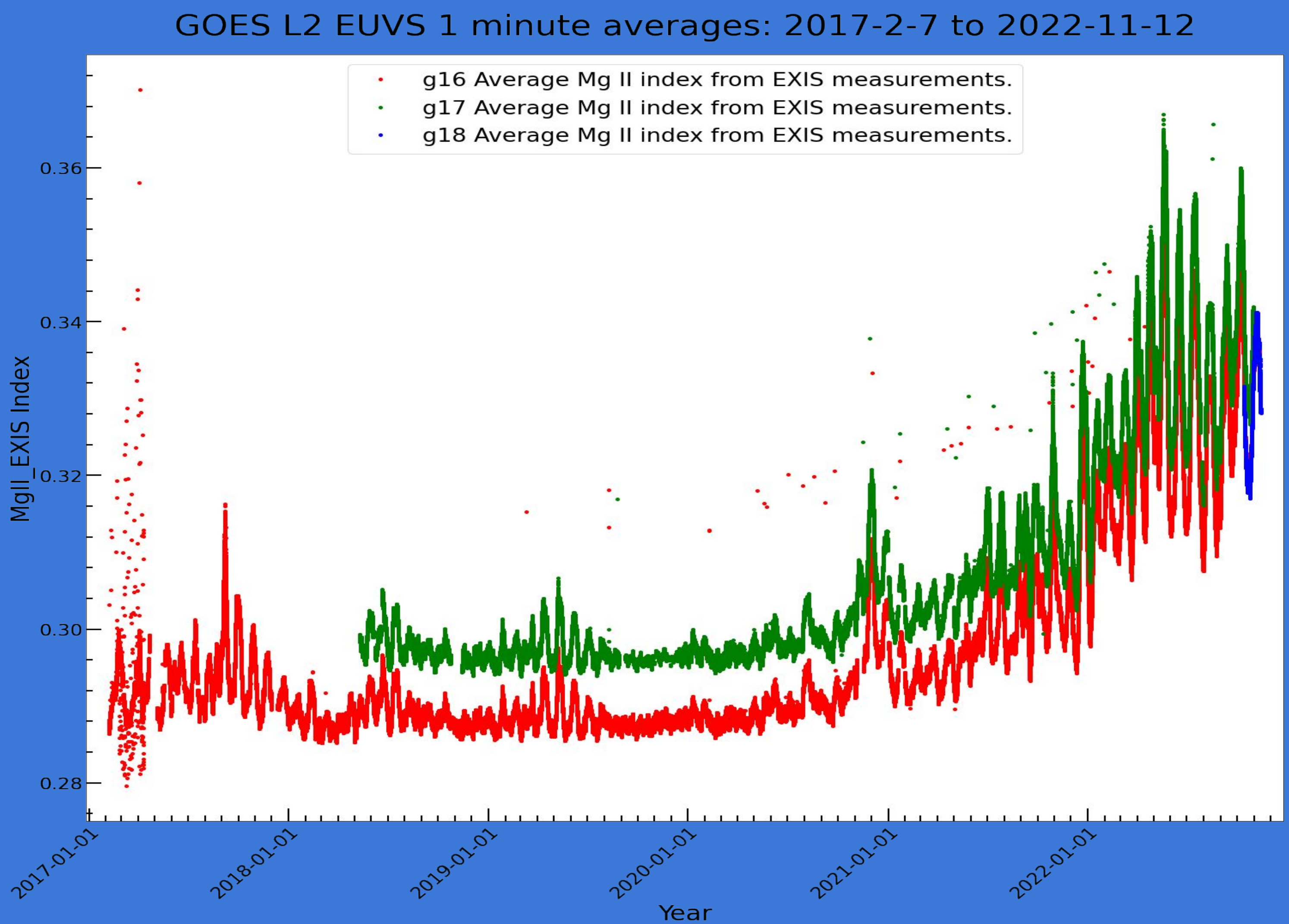
PLPT #1: EUVS-C Mg II Scaling

- **Objective**: 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 = 0.1905 b = 0.2354
  - GOES-17: a = 0.2074 b = 0.1750
  - GOES-18: a = 0.1846 b = 0.2723
- 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

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.

PLPT #1: EUVS-C Mg II Scaling

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



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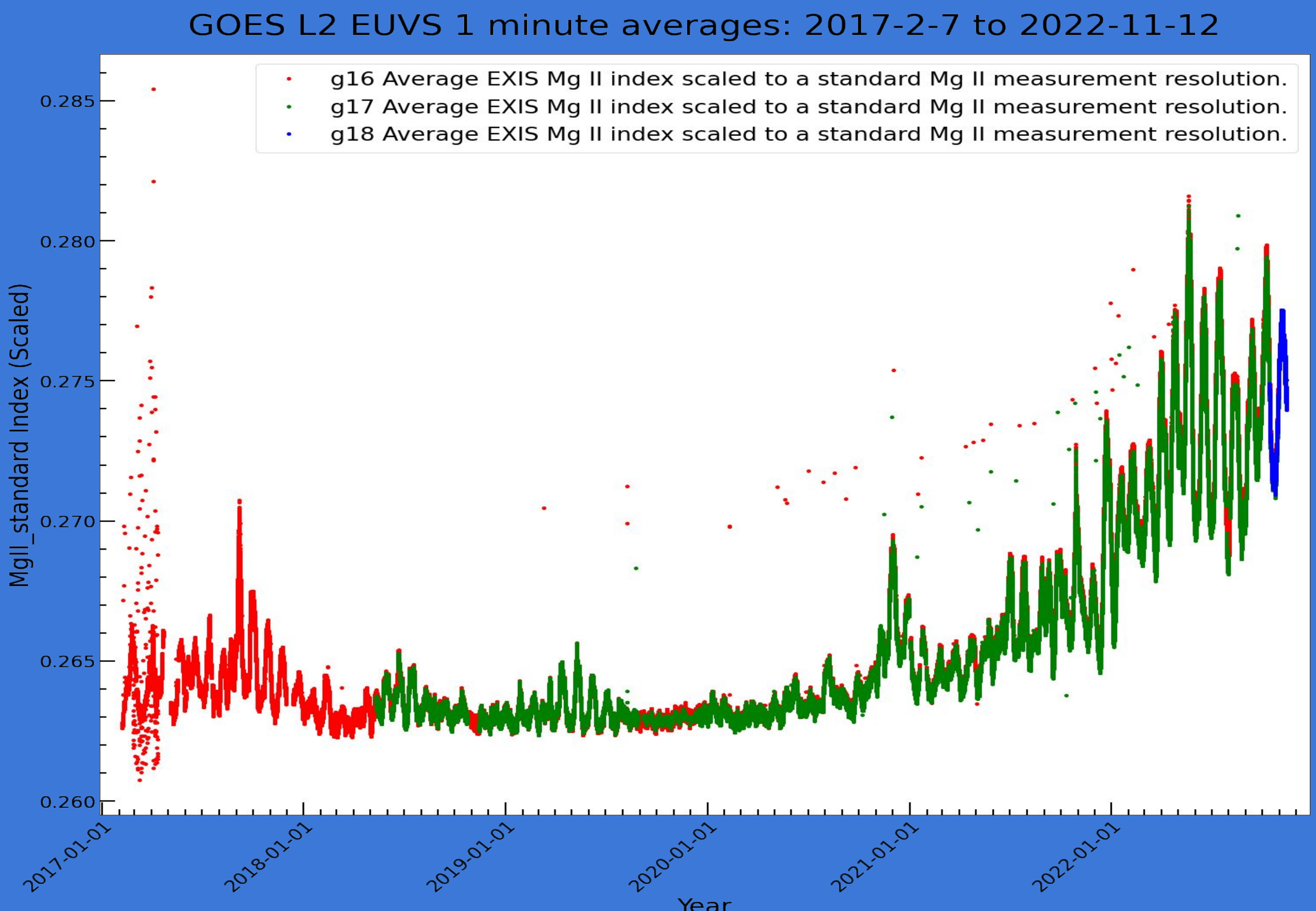
PLPT #1: EUVS-C Mg II Scaling

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



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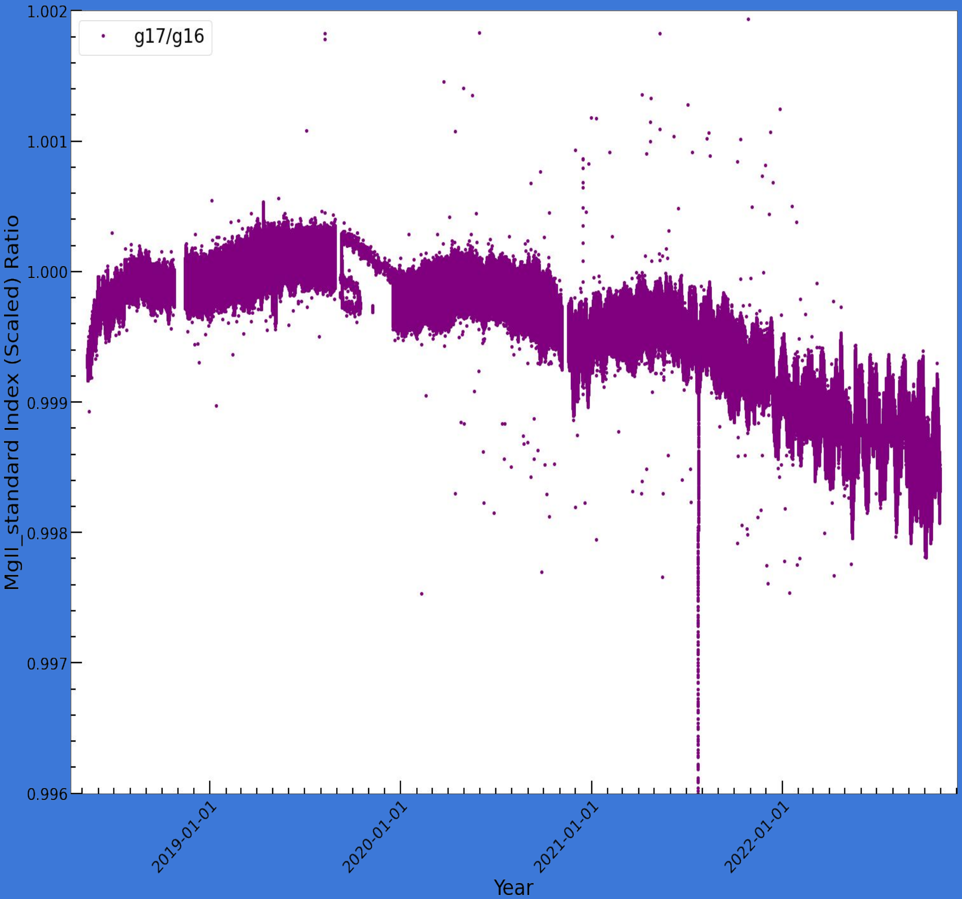
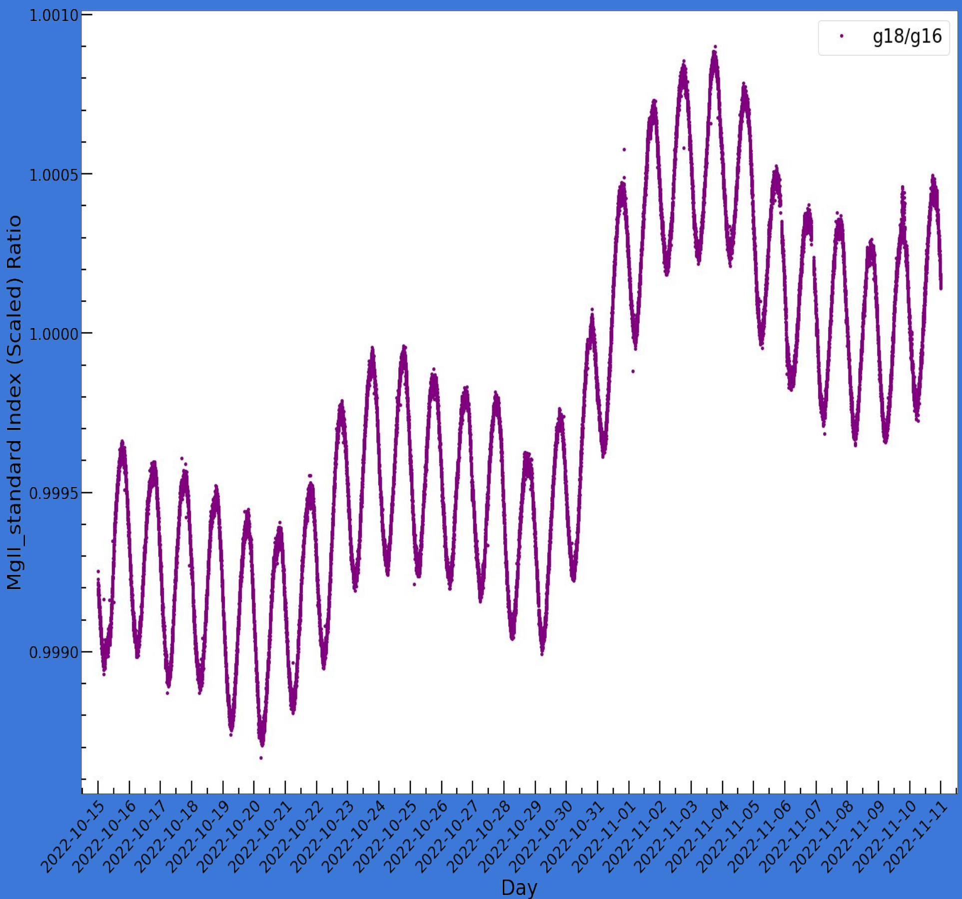
PLPT #1: EUVS-C Mg II Scaling

- All satellites show similar variability in the scaled Mg II indices
- GOES-18: 0.07% daily variability and 0.2% overall variability from GOES-16
- GOES-17: 0.1% daily variability and 0.25% overall variability from GOES-16

GOES L2 EUVS 1 minute averages: 2018-5-11 to 2022-10-29



GOES L2 EUVS 1 minute averages: 2022-10-15 to 2022-11-12



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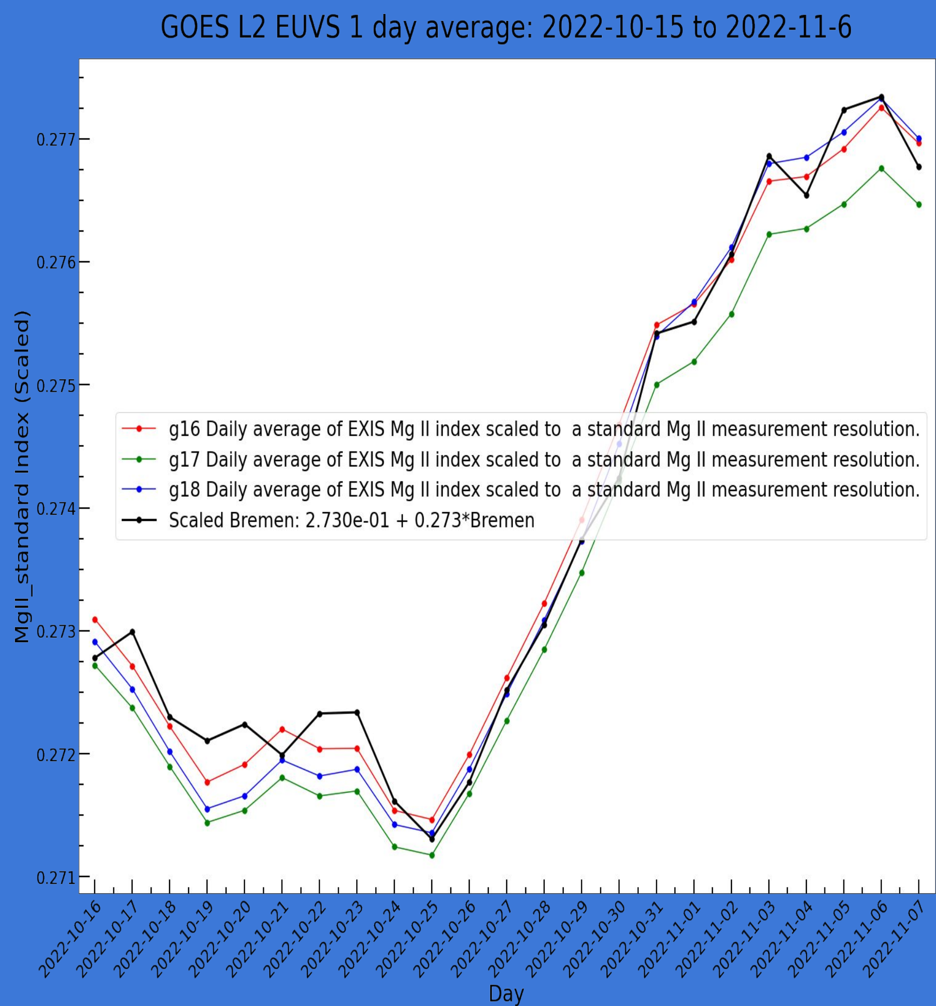
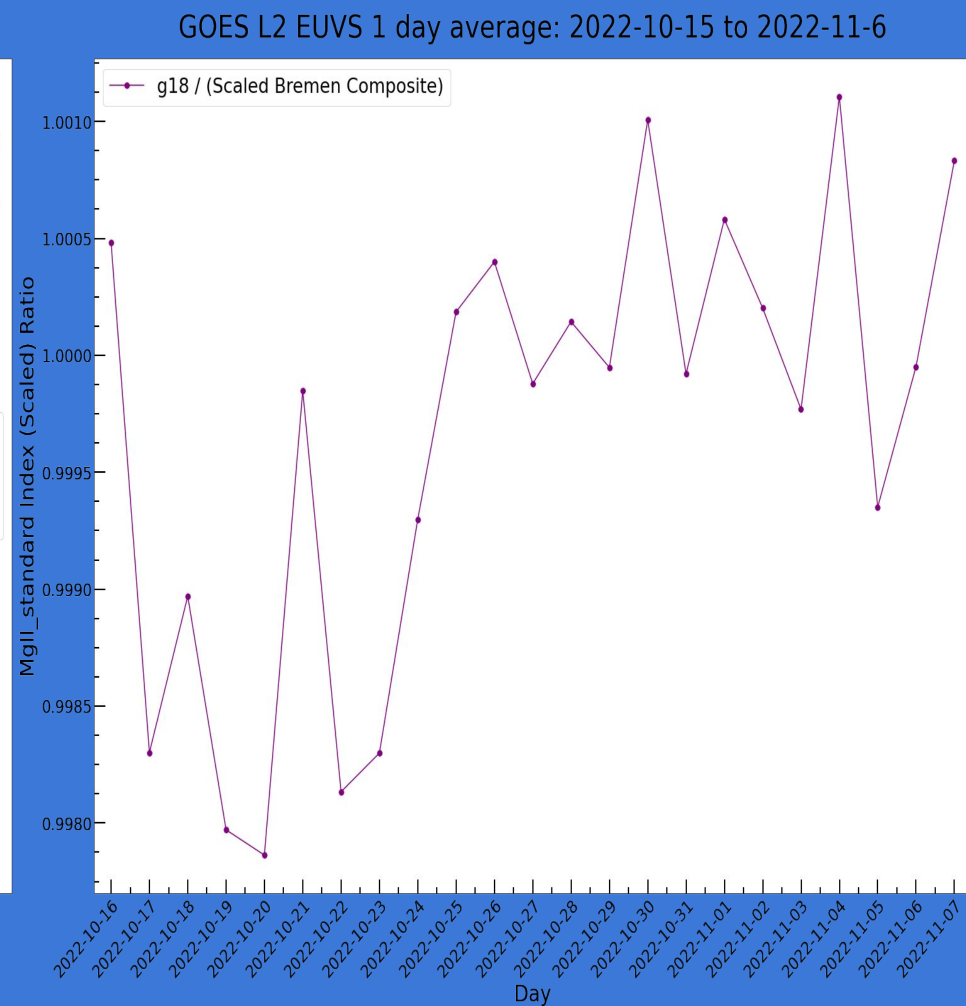
PLPT #1: EUVS-C Mg II Scaling

- EUVSC MgII_standard index for G16, G17 and G18 and the Bremen composite data
- Bremen composite data is from GOME-2B. This is a standard long-term Mg II index.
- G18 agrees with Bremen composite to +/- .15%





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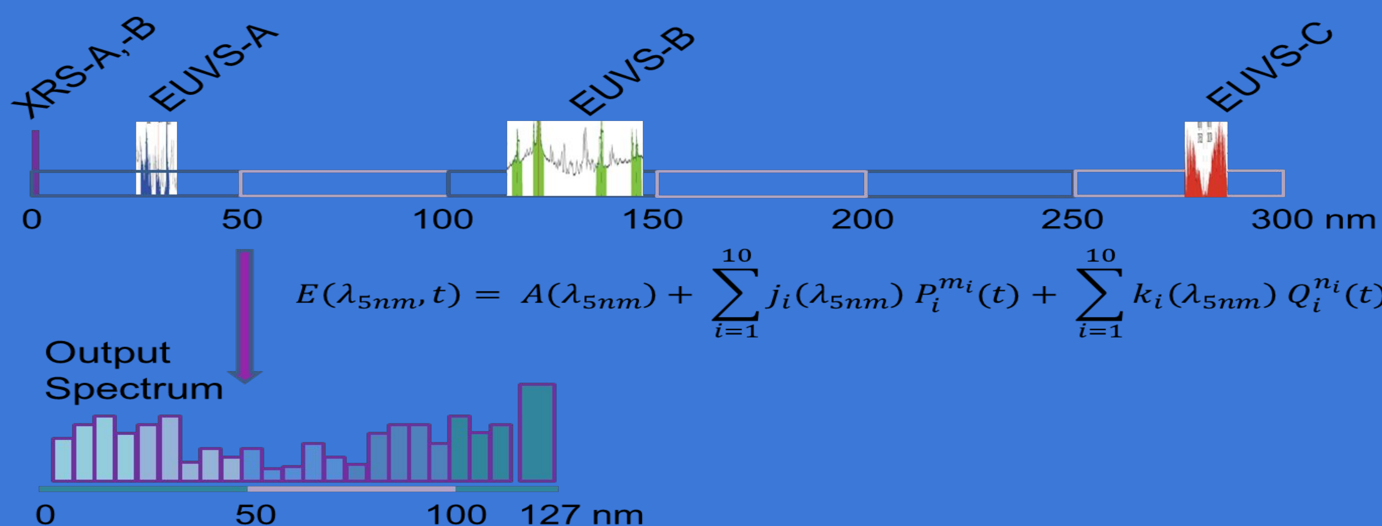
PLPT #2: EUVS L1b Model Baseline

- **Objective**: Determine if coefficient parameter updates are needed for the EUVS proxy model.
- The same model spectrum coefficients are in use for all 3 satellites (GOES-16, GOES-17, GOES-18)
- Plots show G16 and G18 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.



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

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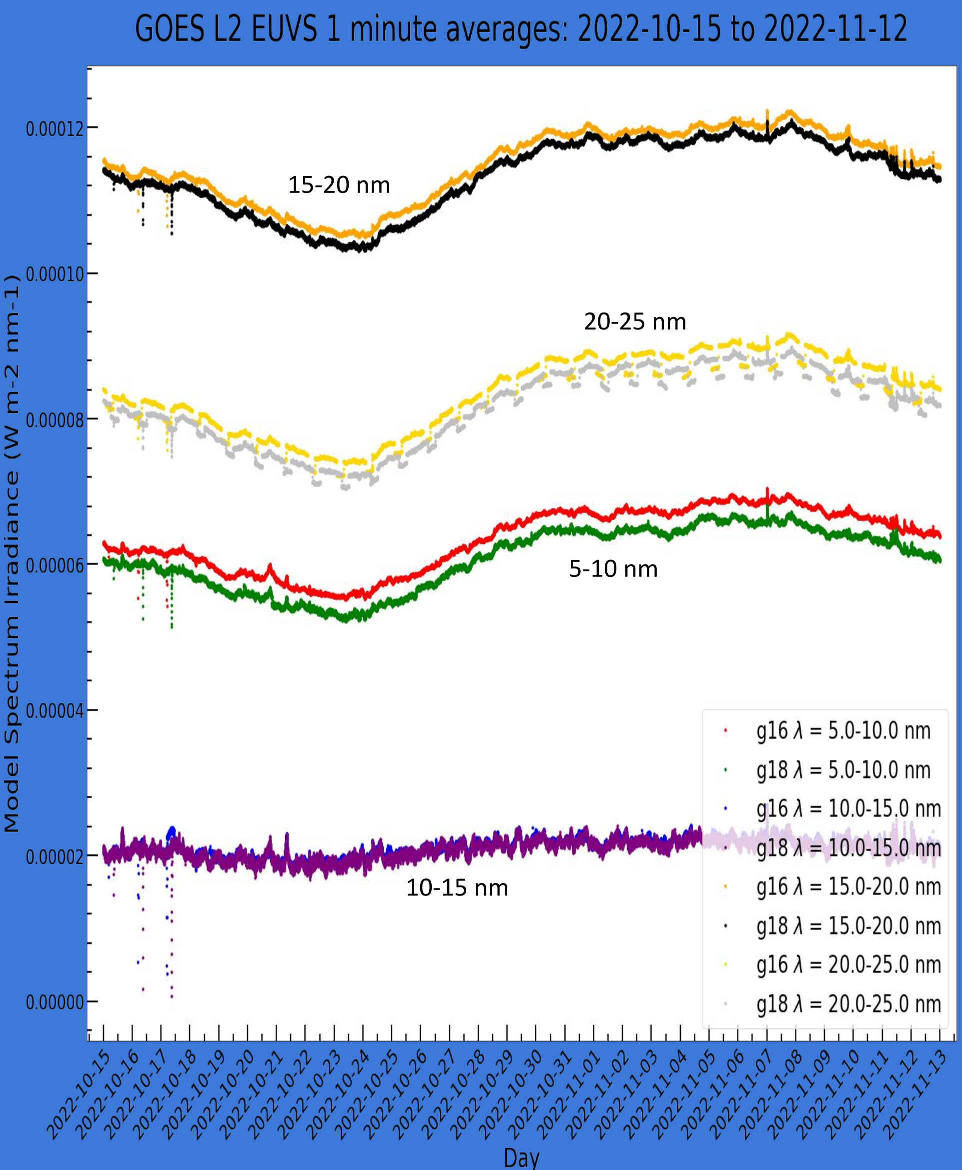

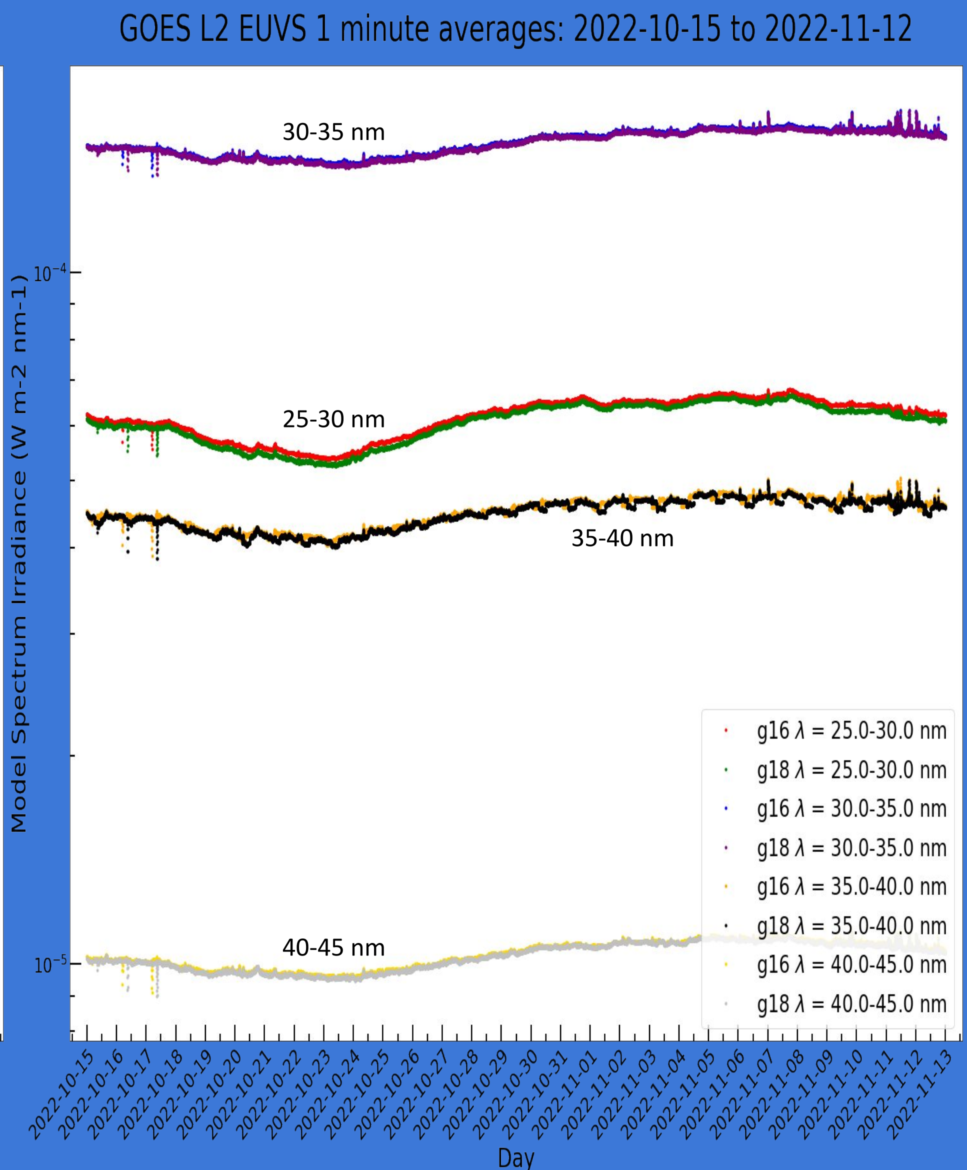

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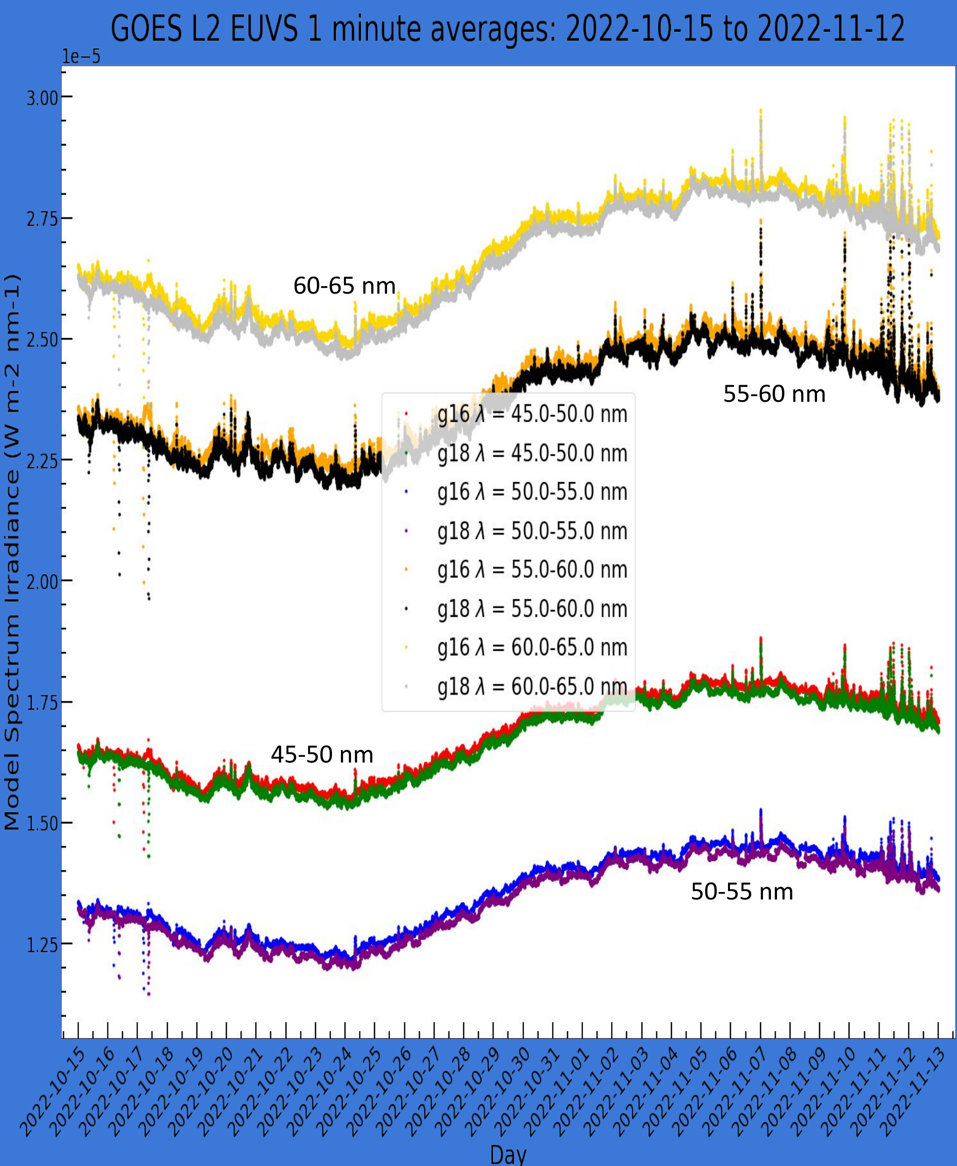

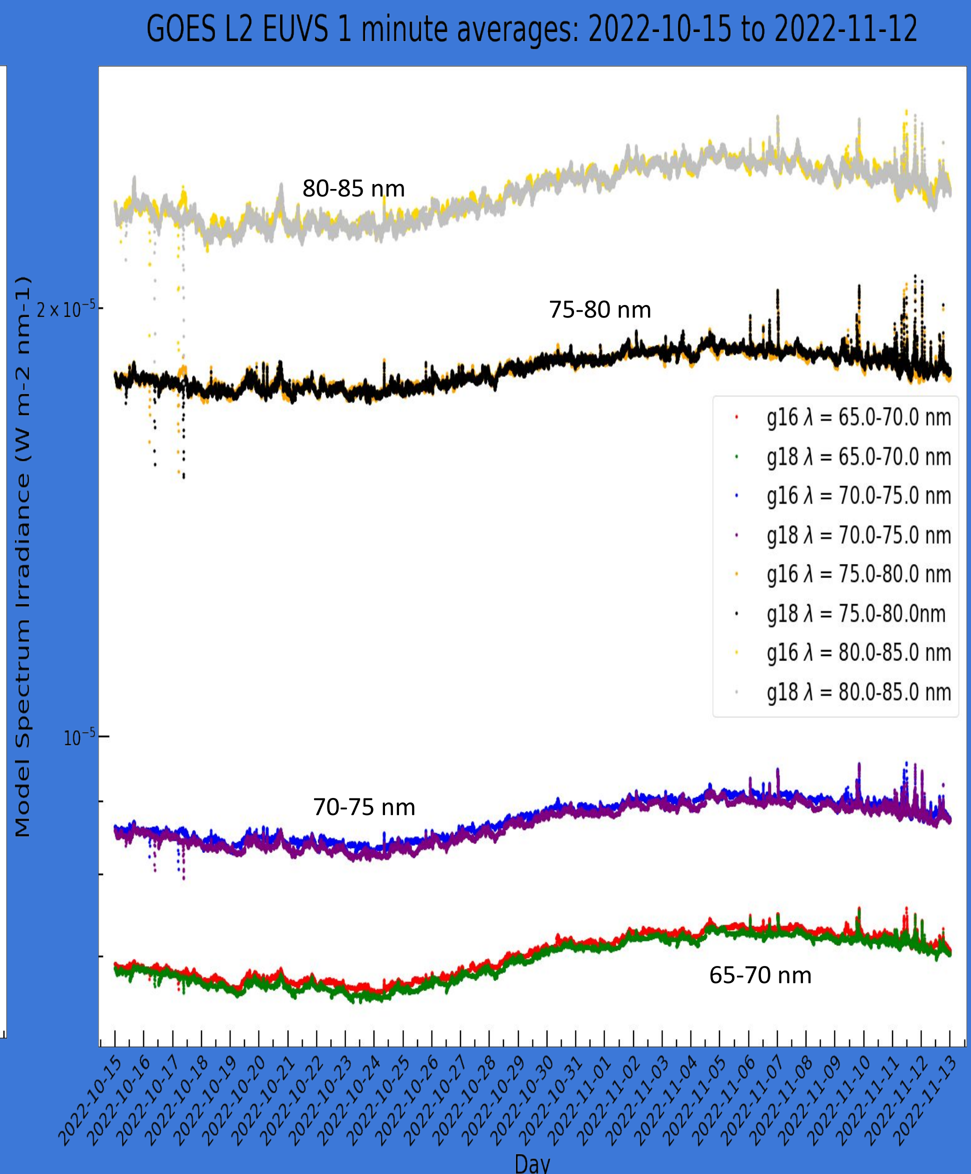

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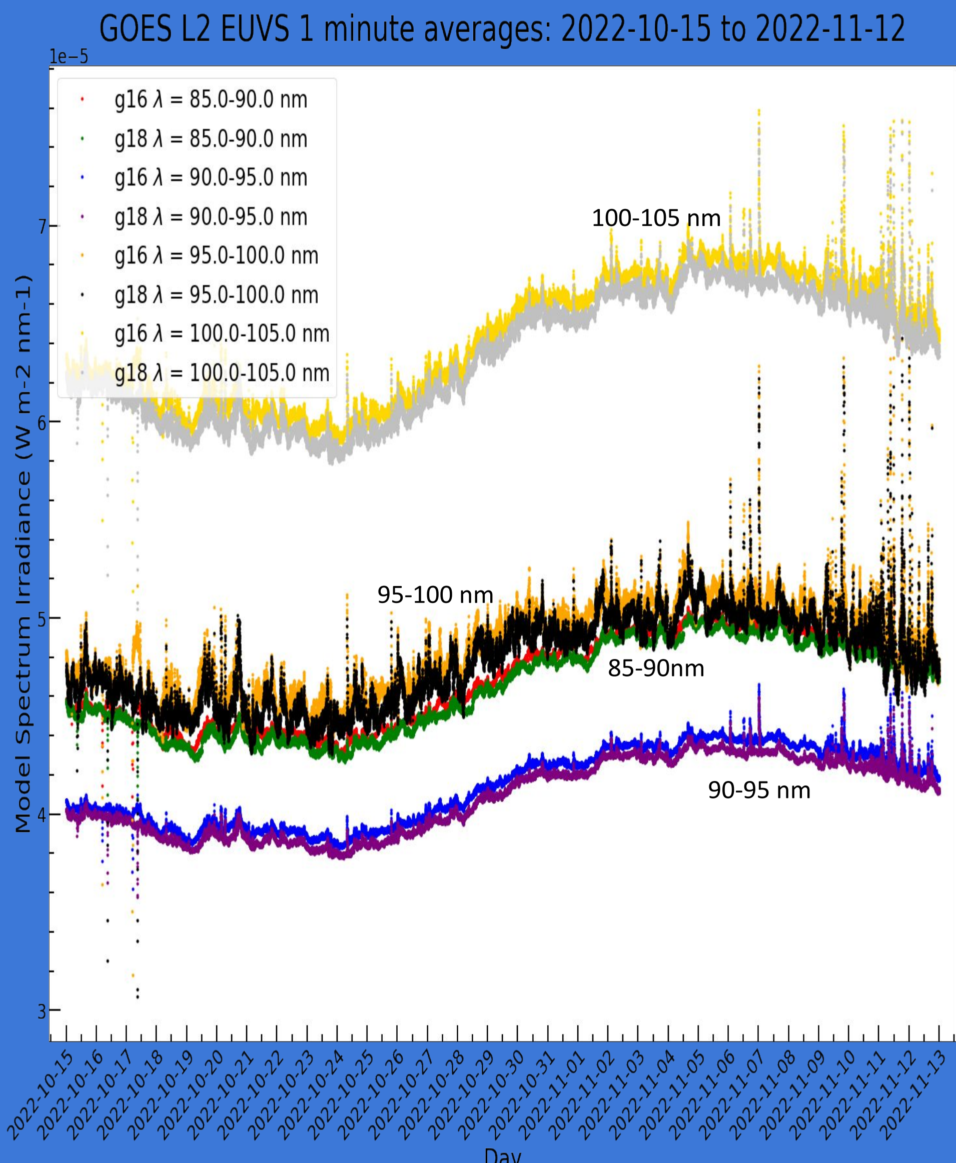

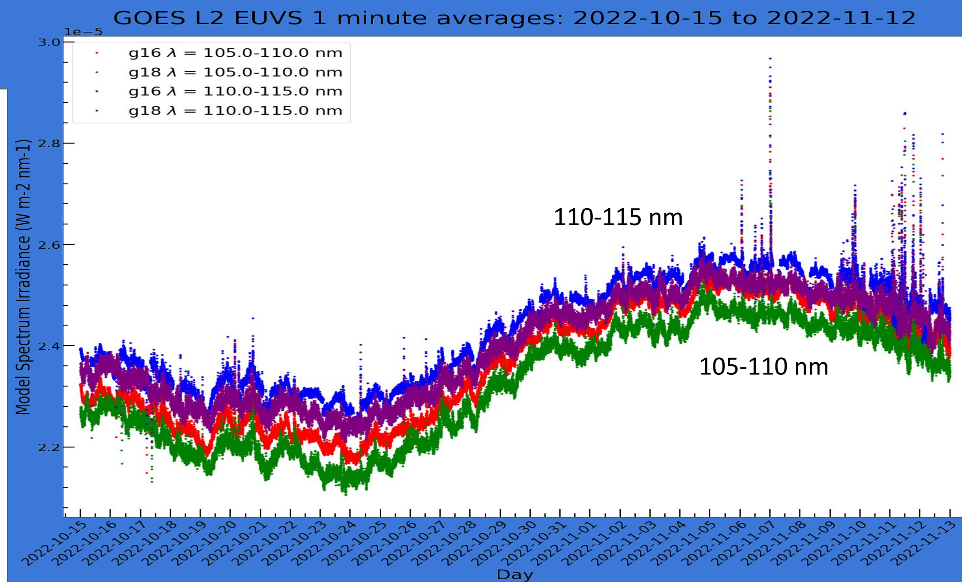

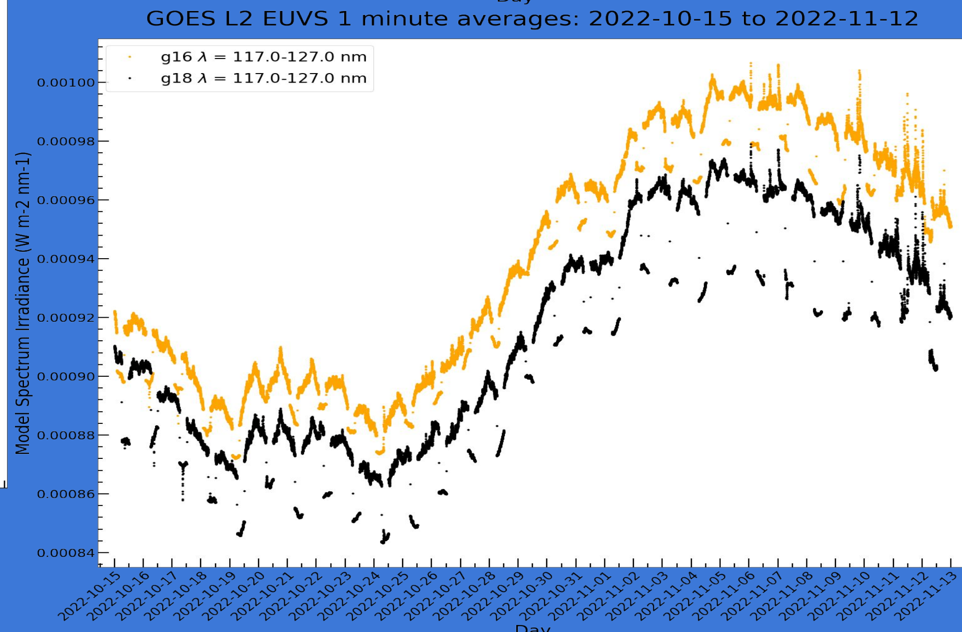

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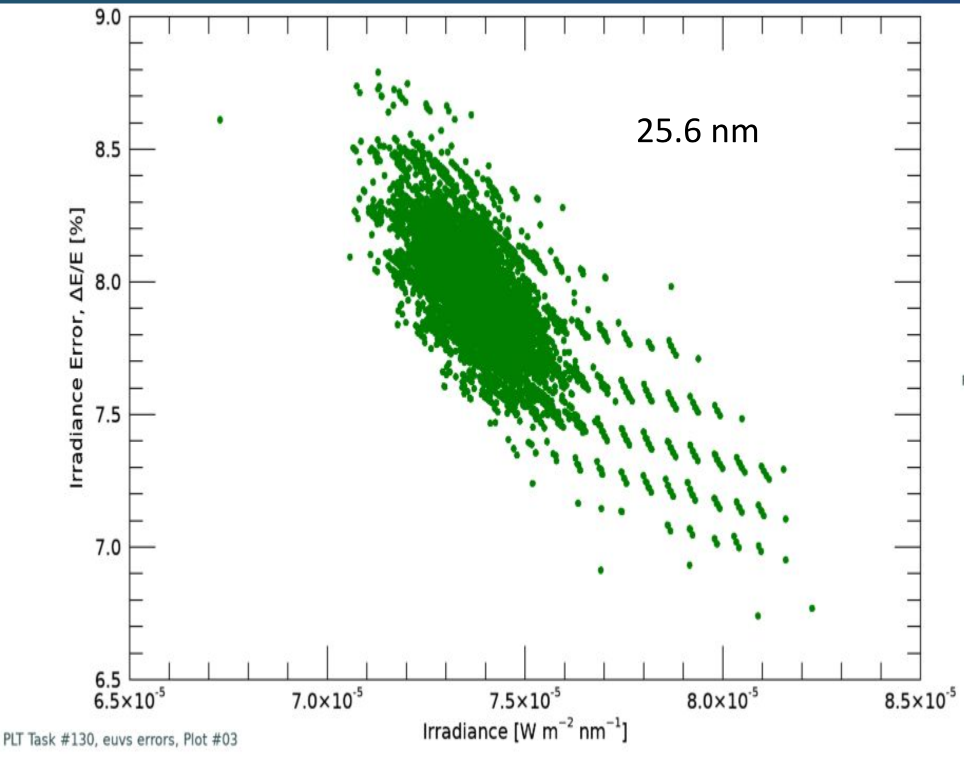
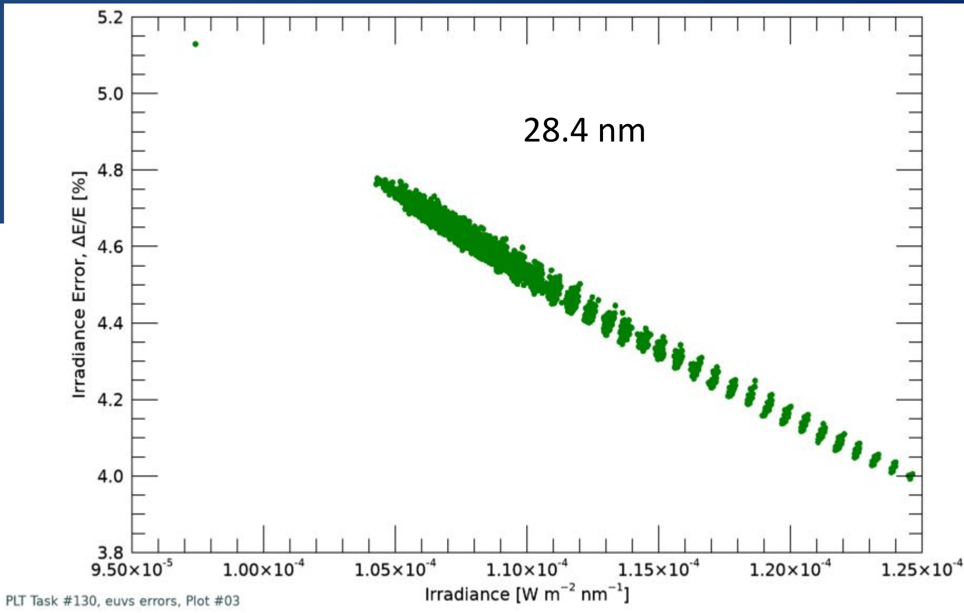
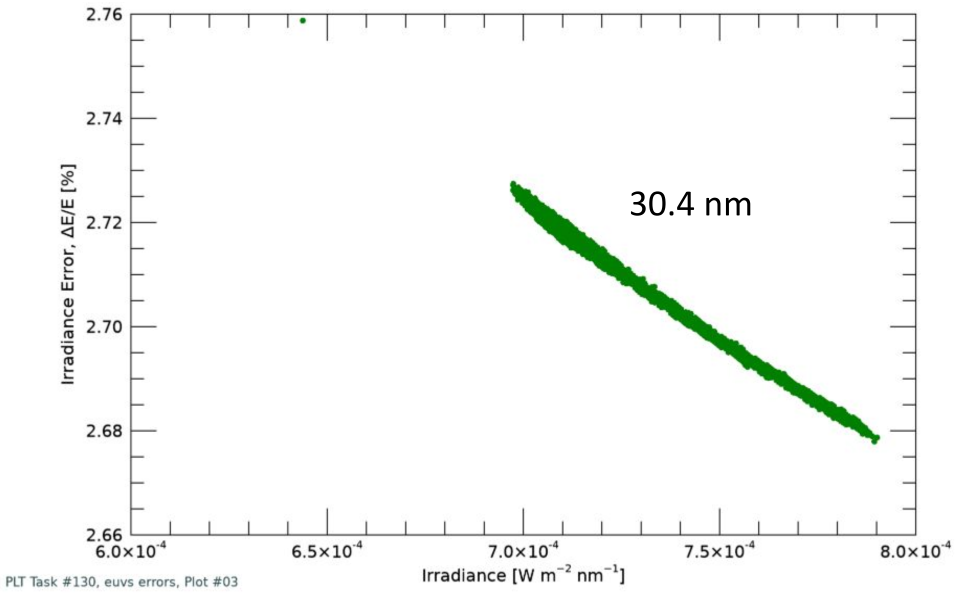
PLPT #3: EUVS L1b Uncertainties

- EUVS-A uncertainties calculated on 2022189; EUVS-B uncertainties calculated on 2022275
- These days had enough solar activity to energize flares in the EUVS wavelength bands
- 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; they are not shown here

EUVS-A Uncertainty







Credit: Tom Eden

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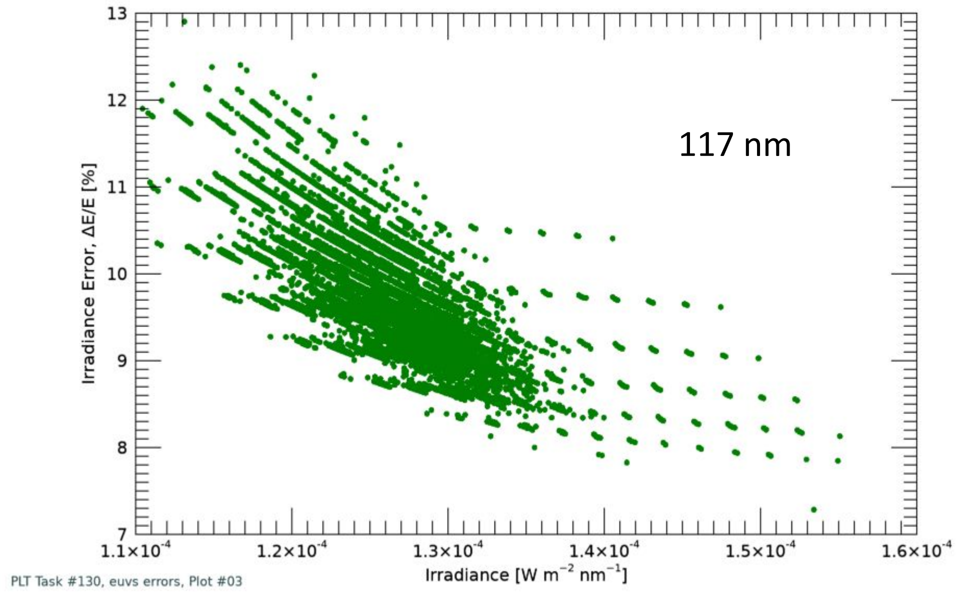
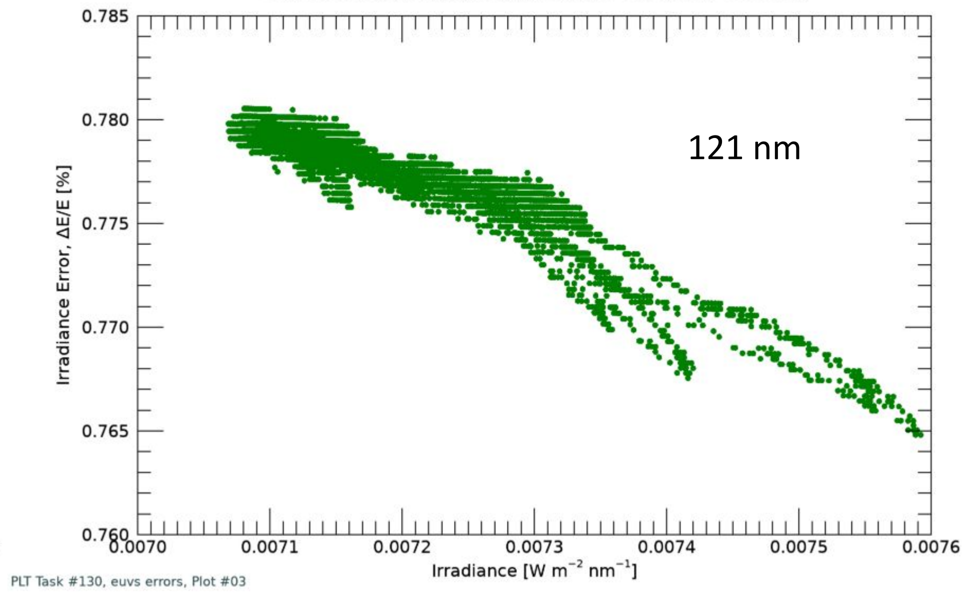
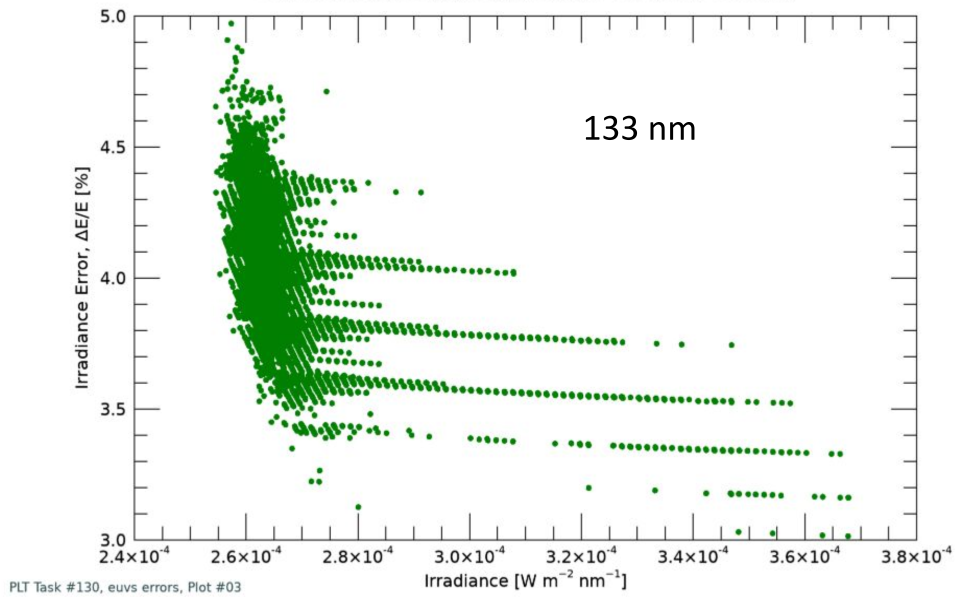
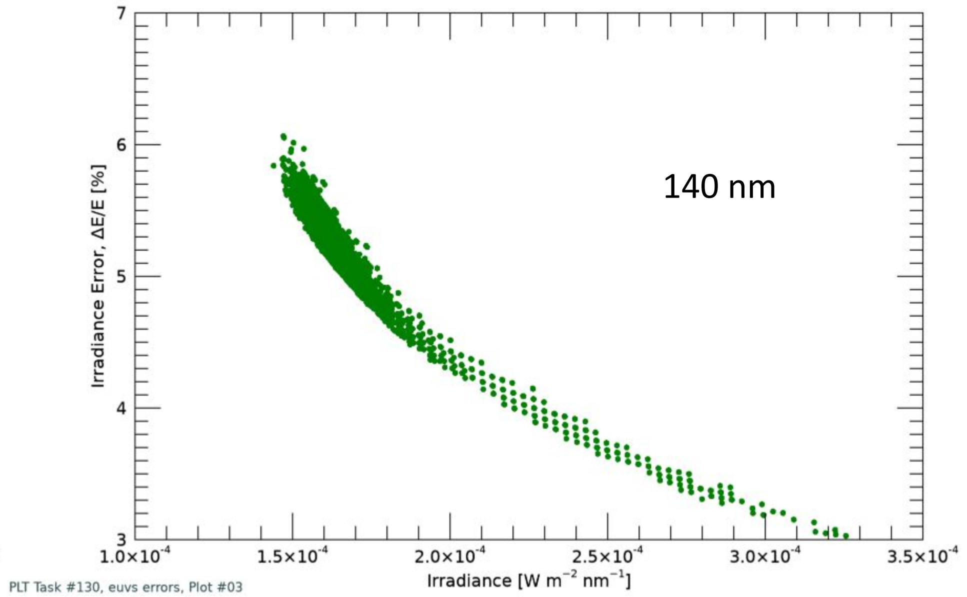
EUVS-B Uncertainty









Credit: Tom Eden

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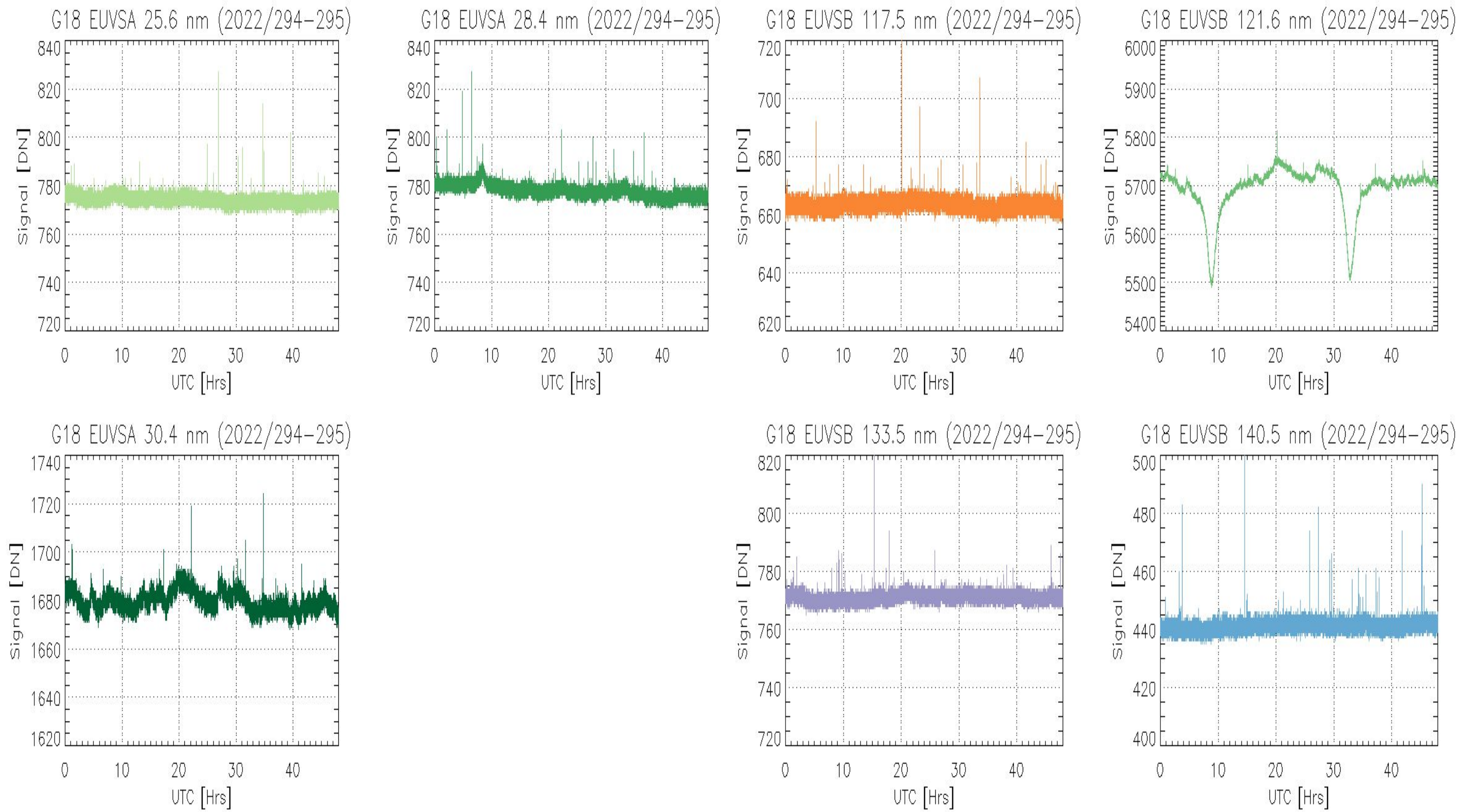
Uncertainty Statistical Analysis

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



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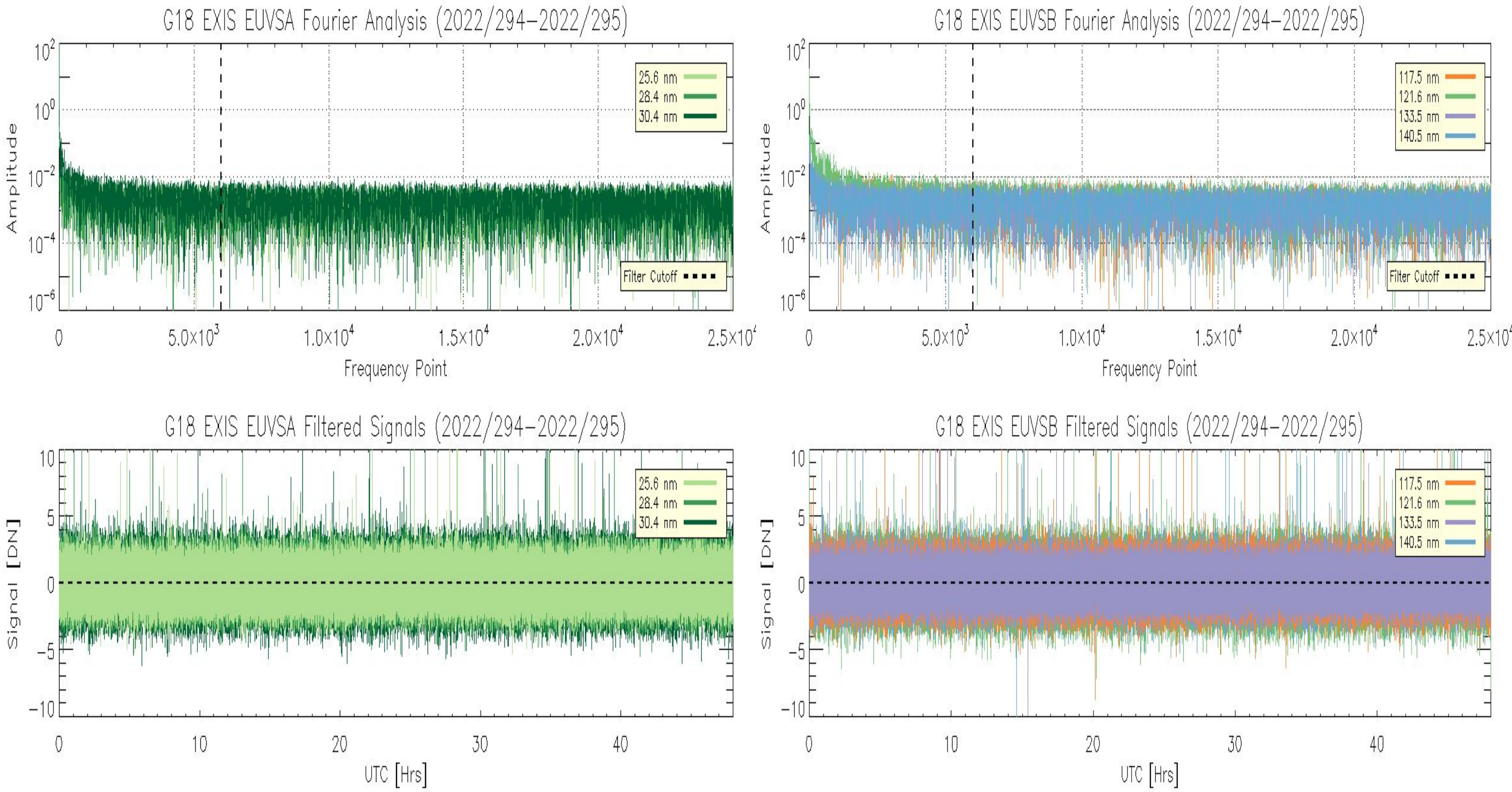
Uncertainty Statistical Analysis

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



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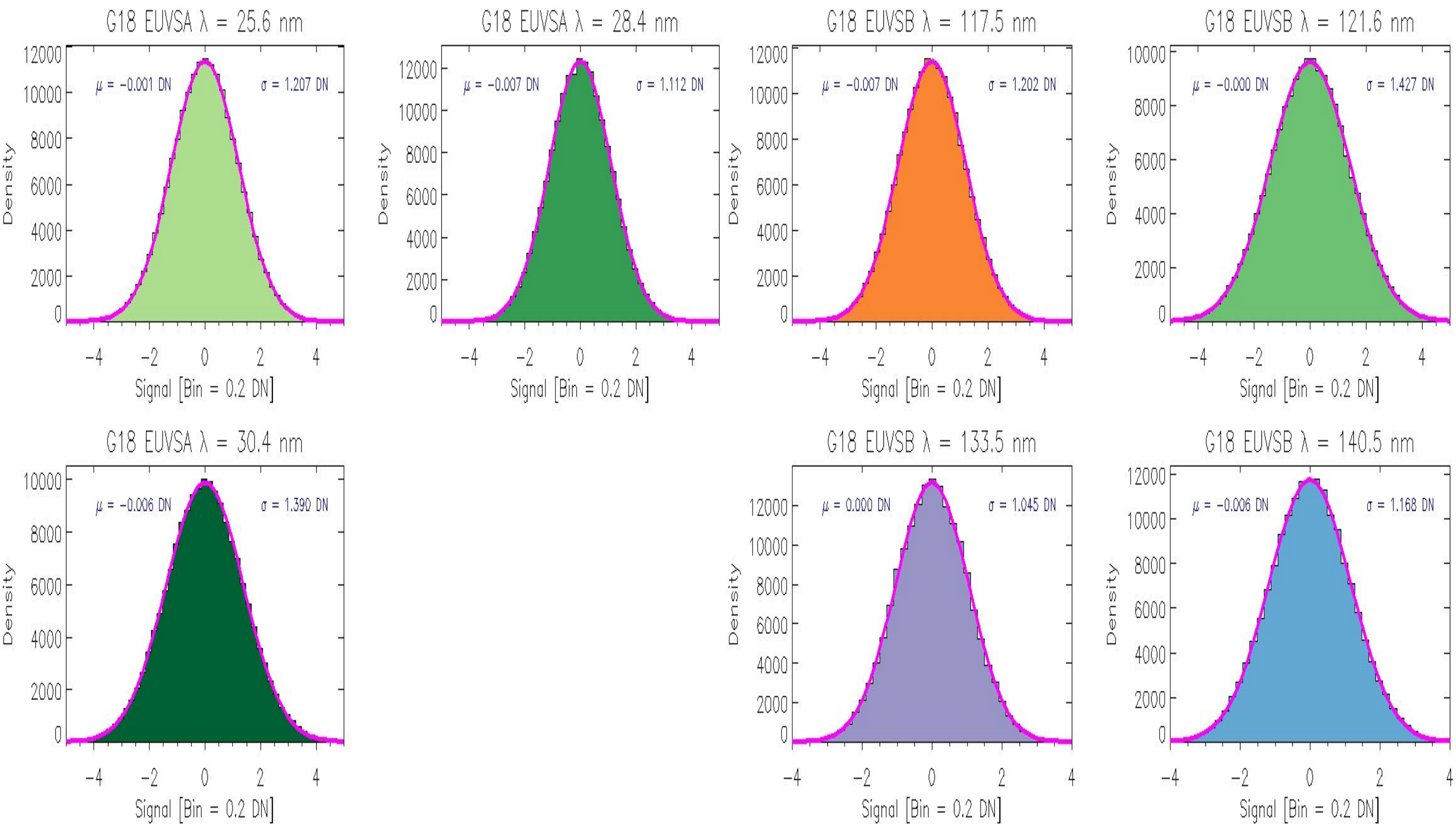
Uncertainty Statistical Analysis

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



Credit: Tom Eden

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Uncertainty Statistical Analysis

- 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

Uncertainty Statistical Analysis

Wavelength	1-DN Irradiance (W/m^2)*	Uncertainty (DN)	Uncertainty (W/m^2)	Minimum Irradiance (W/m^2)	Maximum Irradiance (W/m^2)	% Precision
25.6 nm	3.0857e-6	1.207	3.7244e-6	3.7244e-6	3.0517	**4.1425**
28.4 nm	2.1604e-6	1.112	2.4024e-6	2.4024e-6	2.1366	**4.4963**
30.4 nm	2.7266e-6	1.390	3.7899e-6	3.7899e-6	2.6966	**3.5972**
117.5 nm	1.2373e-5	1.202	1.4872e-5	1.4872e-5	12.2369	**4.1598**
121.6 nm	6.5602e-6	1.427	9.3614e-6	9.3614e-6	6.4880	**3.5039**
133.5 nm	5.0075e-6	1.045	5.2328e-6	5.2328e-6	4.9524	**4.7847**
140.5 nm	4.2159e-6	1.168	4.9242e-6	4.9242e-6	4.1695	**4.2808**

*Mean ASIC Temperatures: EUVS-A = 15.38 C, EUVS-B = 16.99 C. 1 DN equivalent irradiances from 2022215.

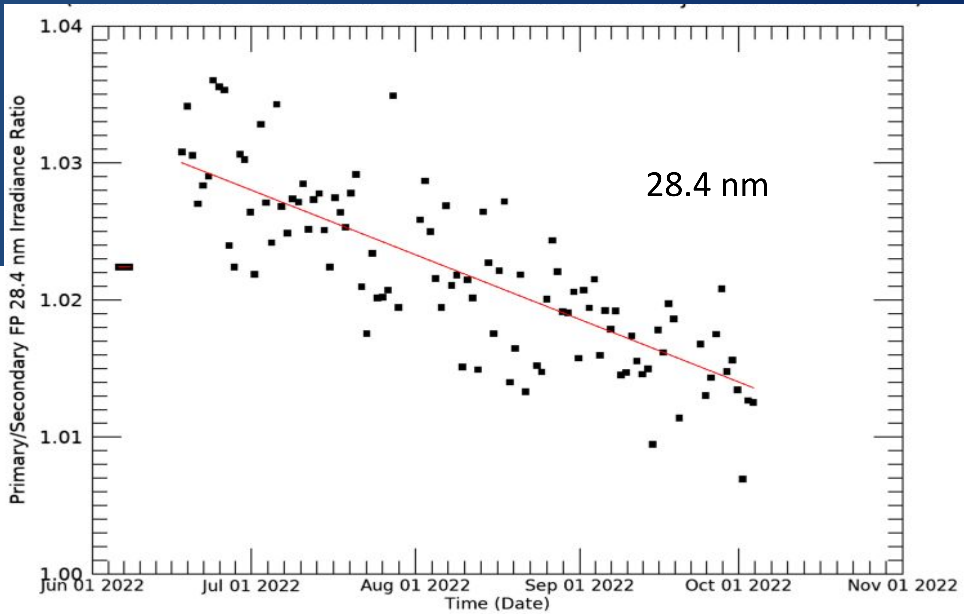
- Precision for all wavelengths is well within 20% requirement of MRD 2031

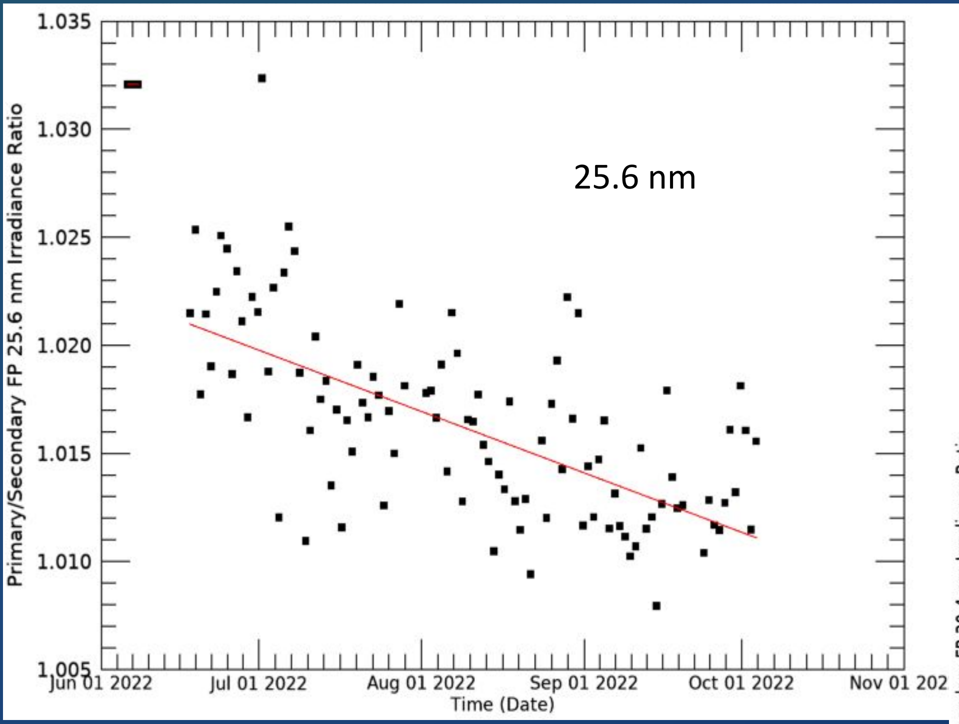
PLPT #15: EUVS-A Degradation Trending

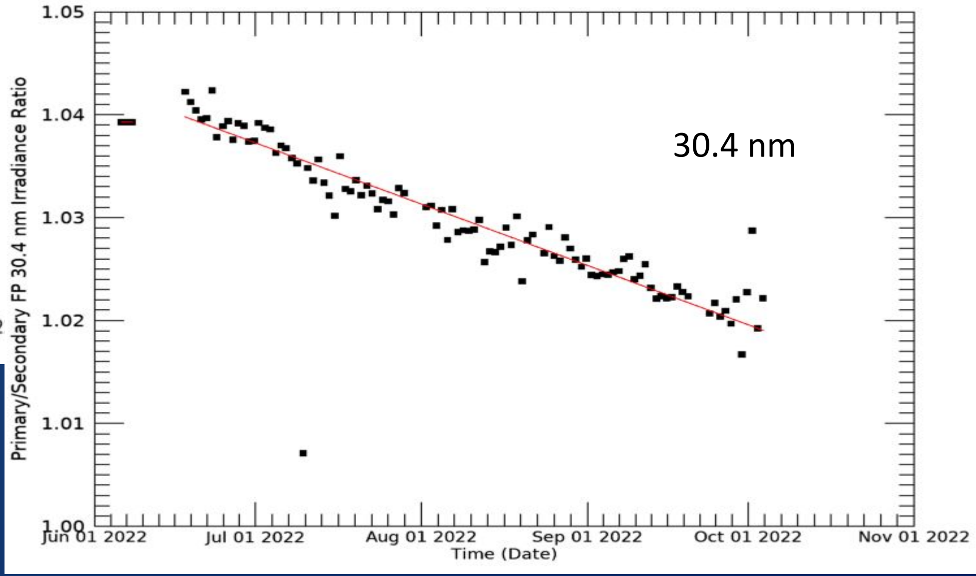
- EUVS-A wavelengths are 25.6 nm, 28.4 nm and 30.4 nm
- Filters were calibrated at SURF (Synchrotron Ultraviolet Radiation Facility; NIST calibration laboratory)
- On-orbit degradation is tracked with daily primary/secondary filter comparisons
- Degradation trending is preliminary due to minimally available data
- EUV degradation rates tend to start high and decrease in time

PLPT #15: EUVS-A Degradation Trending

- Red lines are fits to degradation
- Fit uncertainties are ~±0.5-3% and depend on signal strength







Credit: Don Woodraska

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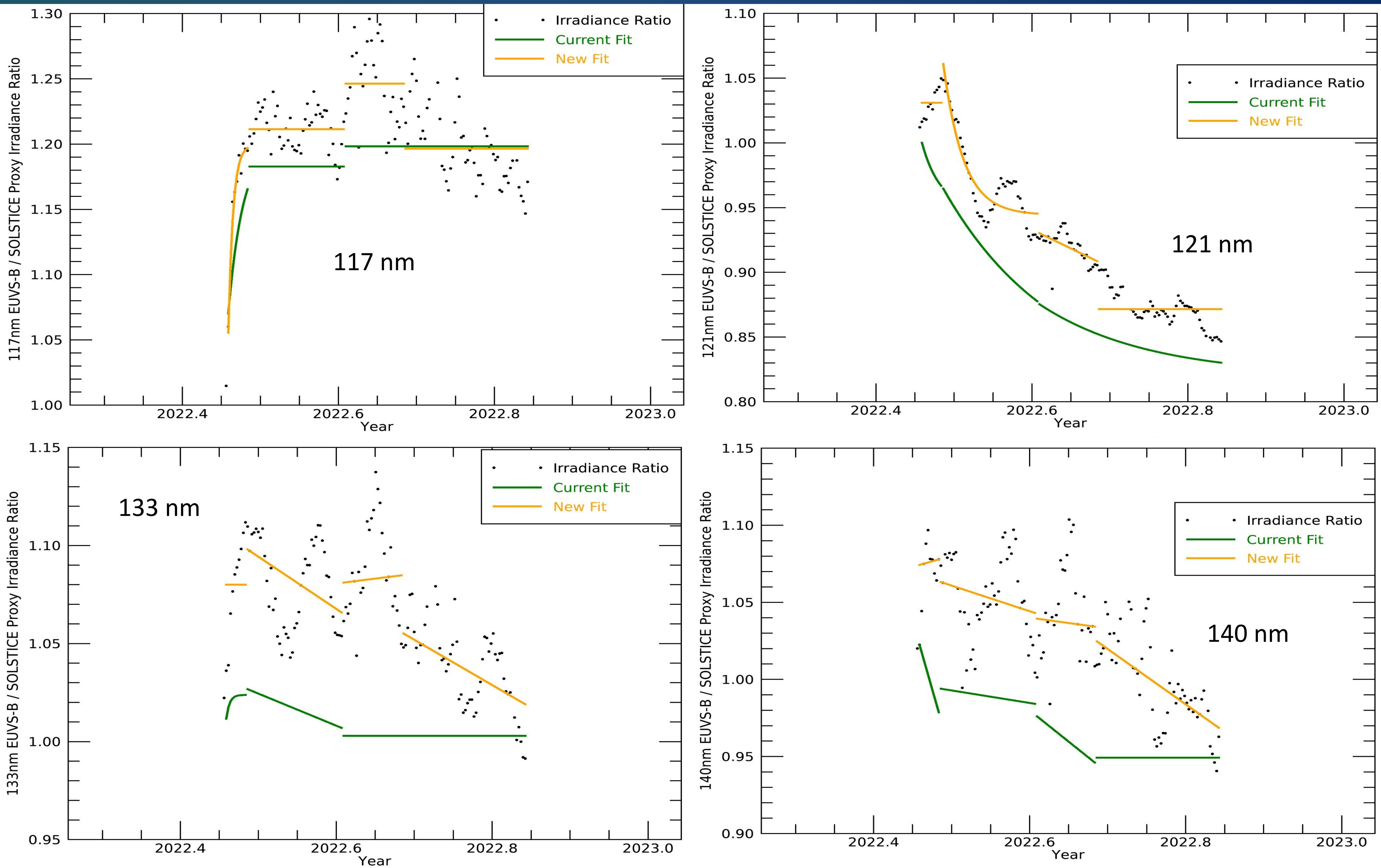
PLPT #16: EUVS-B Degradation Trending

- 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
- Contributions to irregular behavior:
  - Possible degradation rate changes with solar variability and ops changes
  - Limited GOES-18 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

PLPT #16: EUVS-B Degradation Trending



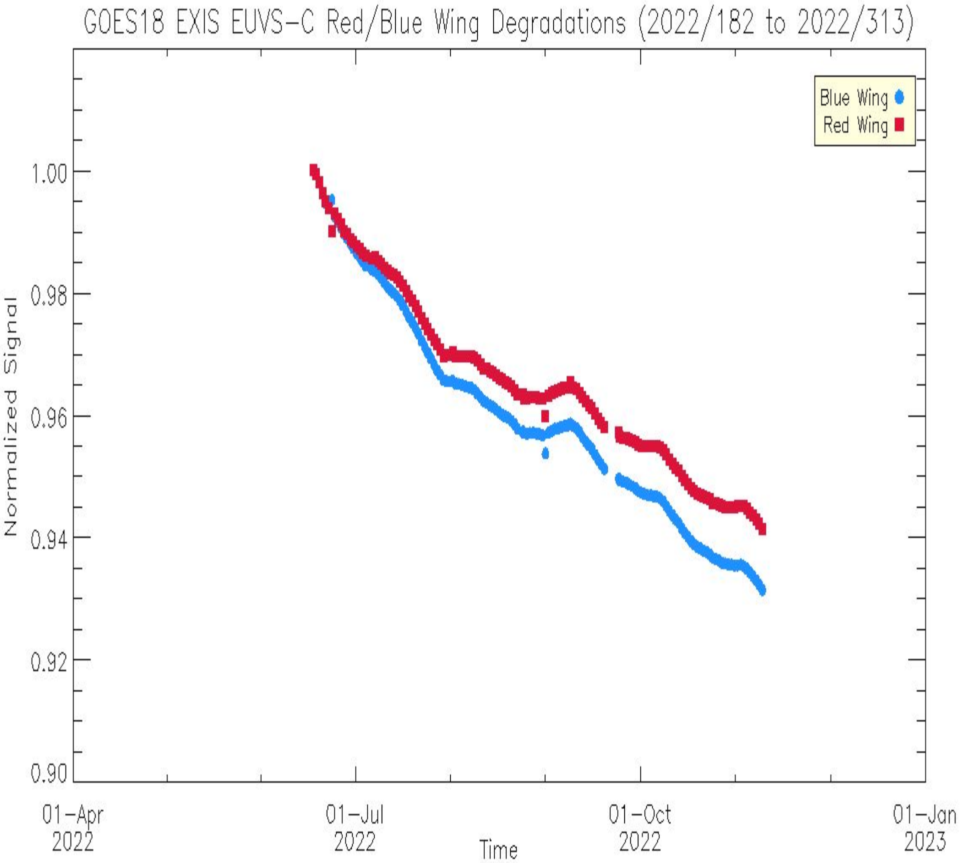
PLPT #16: EUVS-B Degradation Trending

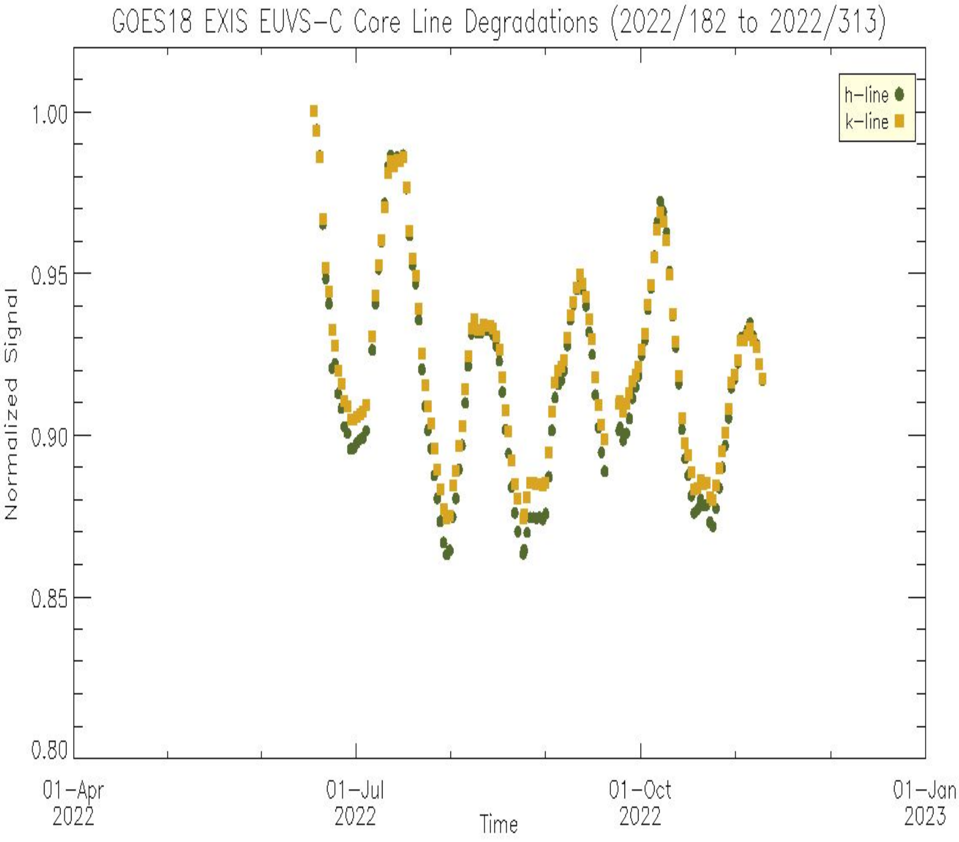
- EUVS-B degradation is routinely updated after each eclipse season (2x per year) with new temperature and dark count corrections. Line segments are re-fit to provide a more accurate model of the degradation.
- These results are preliminary and will change in subsequent LUT updates

Degradation %	Years Post-Launch (Launch Date = 2022060)	
Wavelength (nm)	**1**	**5**
117	**1.212**	**< 1.212**
121	**0.872**	**< 0.872**
133	**0.918**	**< 0.918**
140	**1.001**	**0.723**

PLPT #17: EUVS-C Degradation Trending

- Data is normalized to the first data point. Degraded data is then measured from this initial normalization.
- If the wings degrade more than the core, the Mg II index increases, which affects EUVS-B degradation. This is under investigation.
- The core line degradation shows more variation, correlated with solar activity



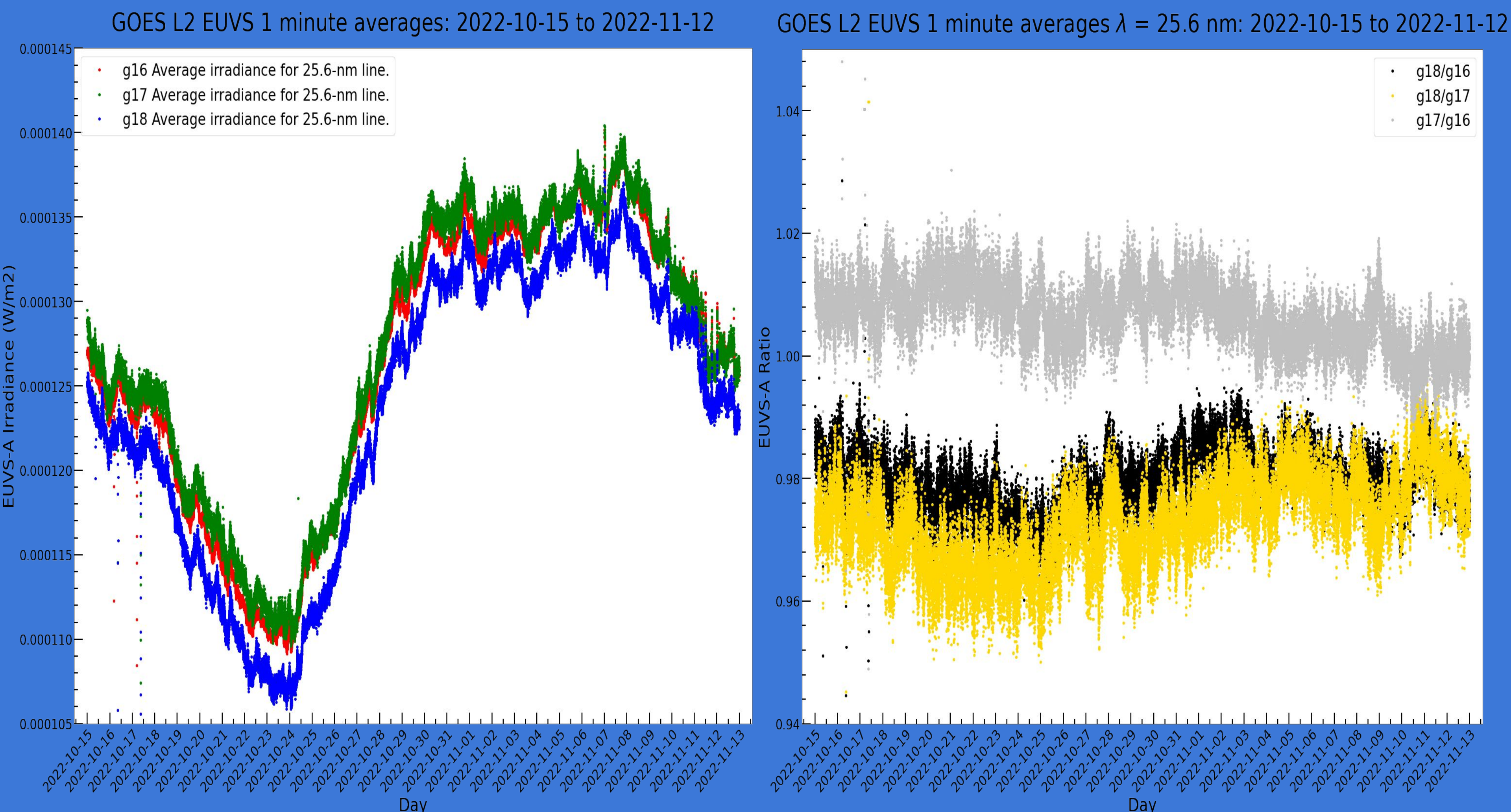


PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A and EUVS-B: Comparisons of G16, G17 and G18
- G17 and G16 have different bandpasses and so do not agree for dim lines
- Plots show L2 (1-minute average) operational data. L2 data is made from 30-second L1b operational data.
- Plots show the following:
  - Line irradiances and their ratios (G18/G16, G18/G17, G17/G16)
  - G18 and G17 vs. G16 (line irradiances) and linear fits

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

- EUVS-A: 25.6 nm. All satellites show 2% variability from the others.



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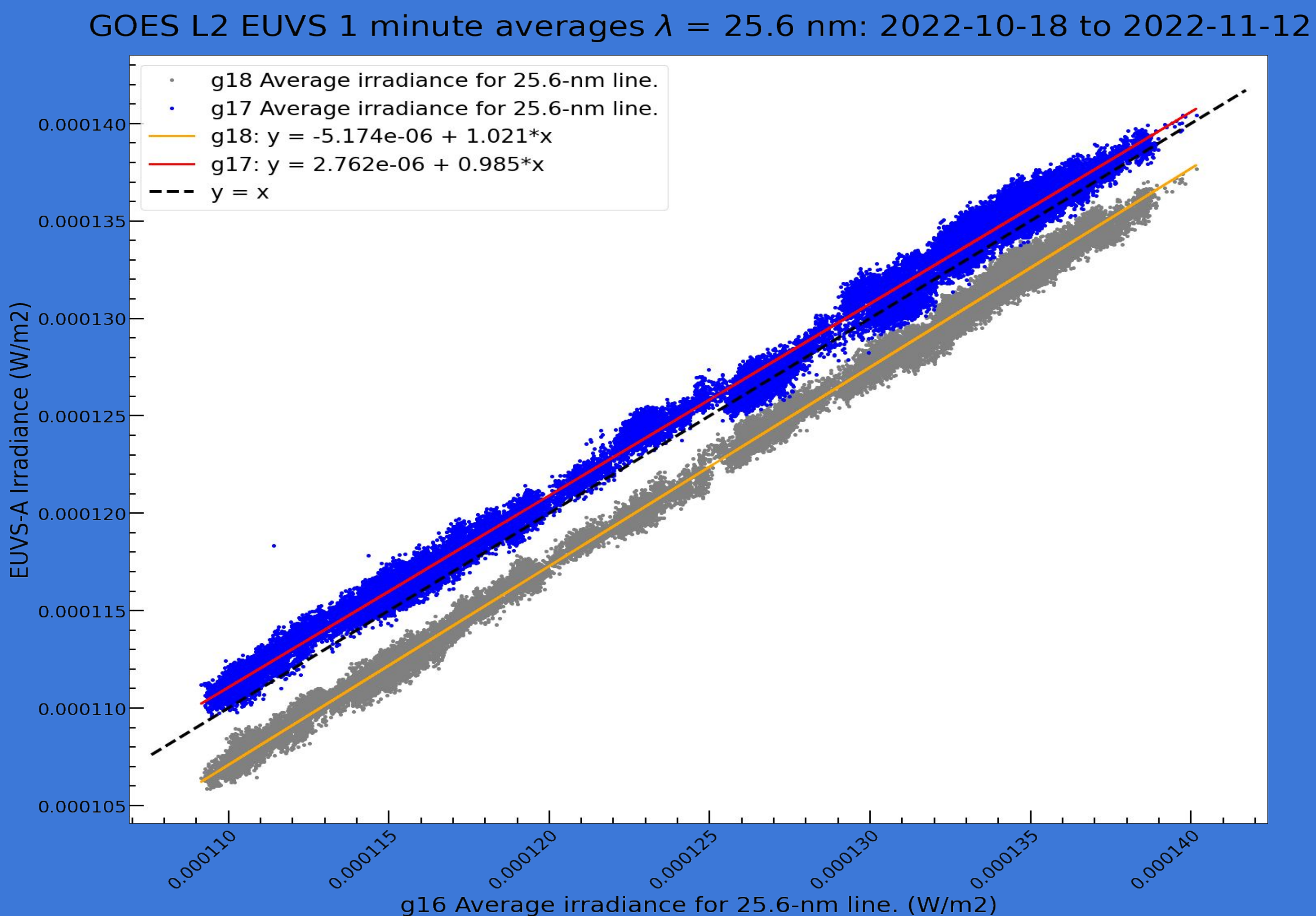
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 25.6 nm. GOES-18 shows 2.1% and GOES-17 shows 1.5% variability from GOES-16.



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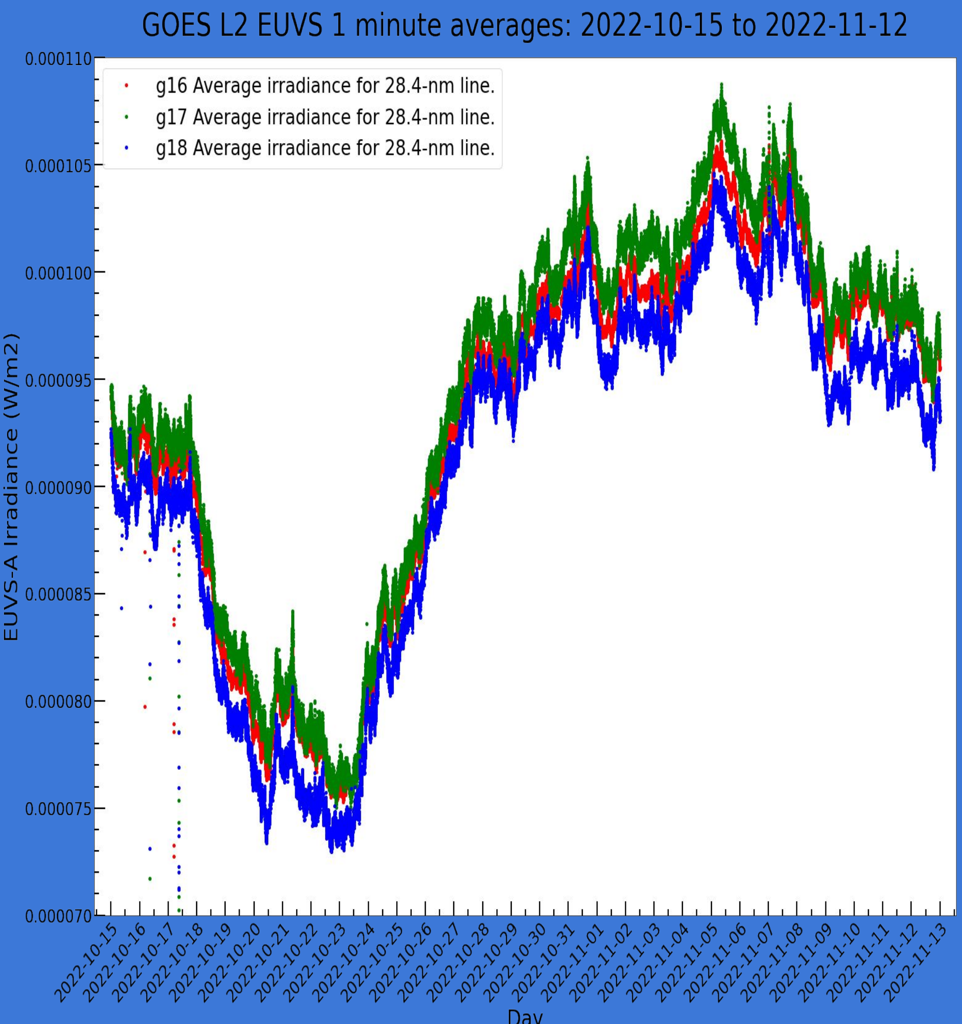
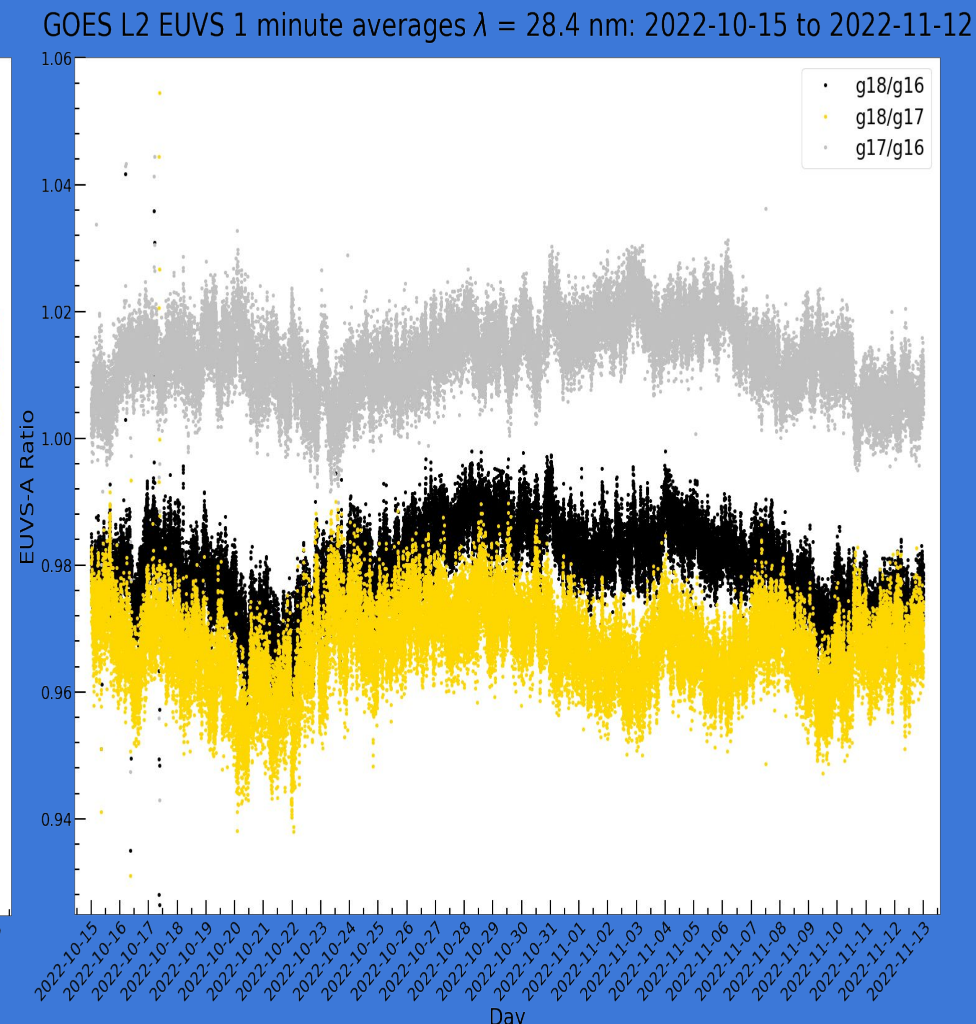
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 28.4 nm. All satellites show 2% variability from the others.





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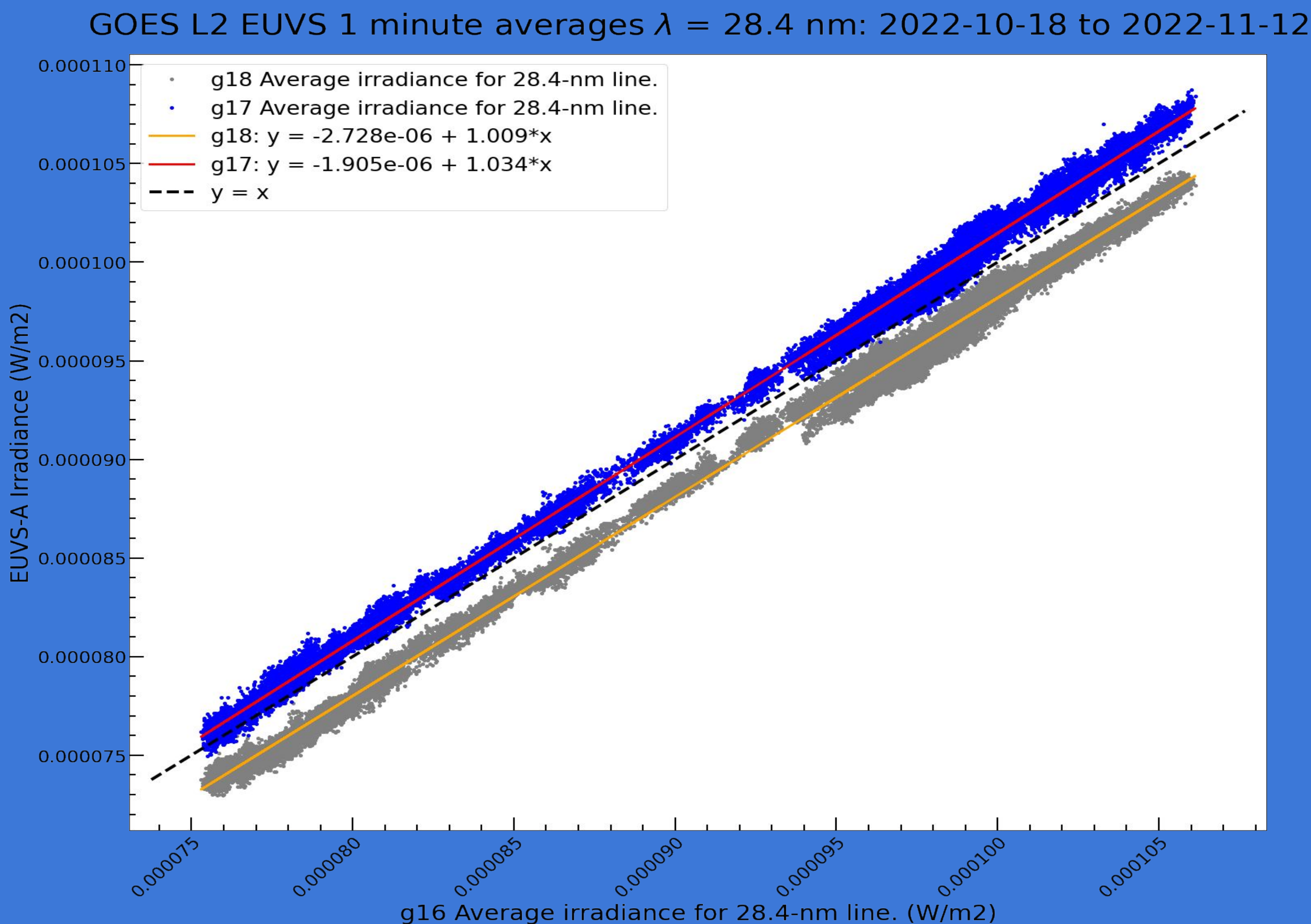
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 28.4 nm. GOES-18 shows 0.9% and GOES-17 shows 3.4% variability from GOES-16.



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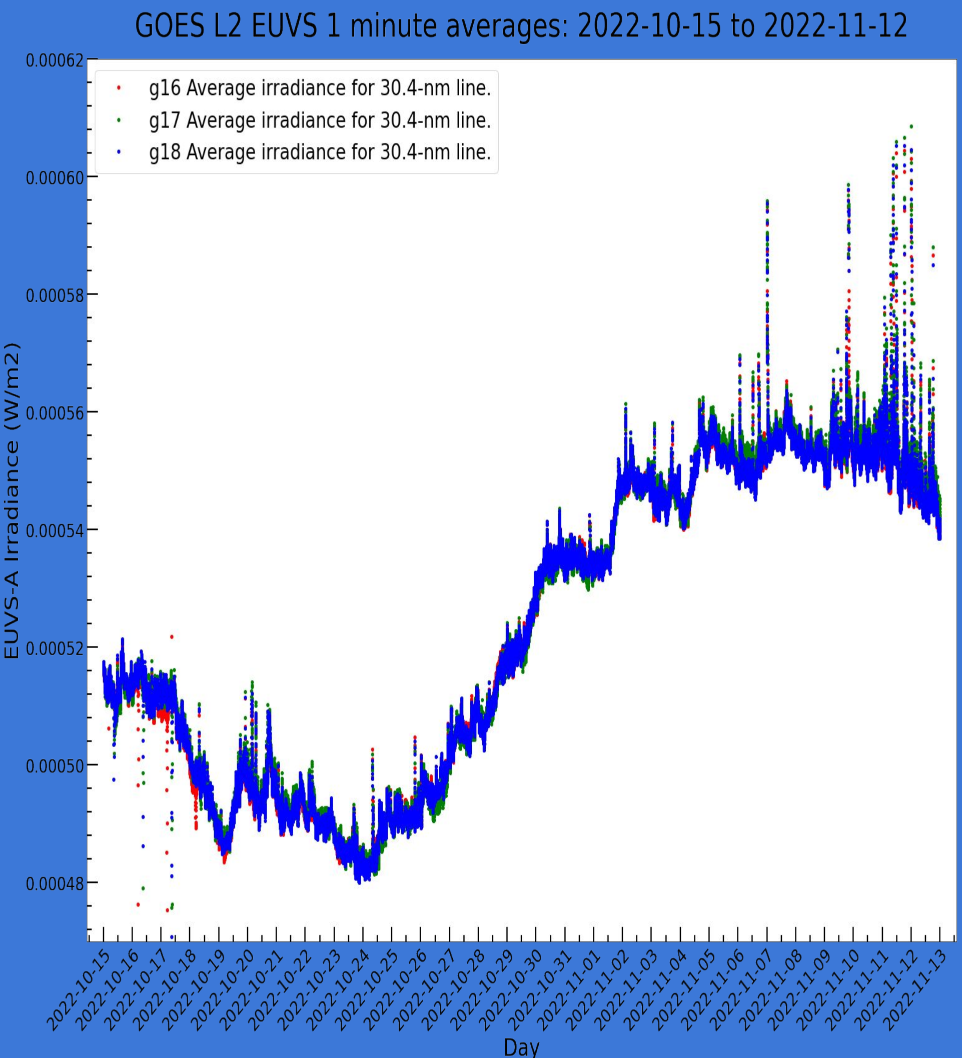
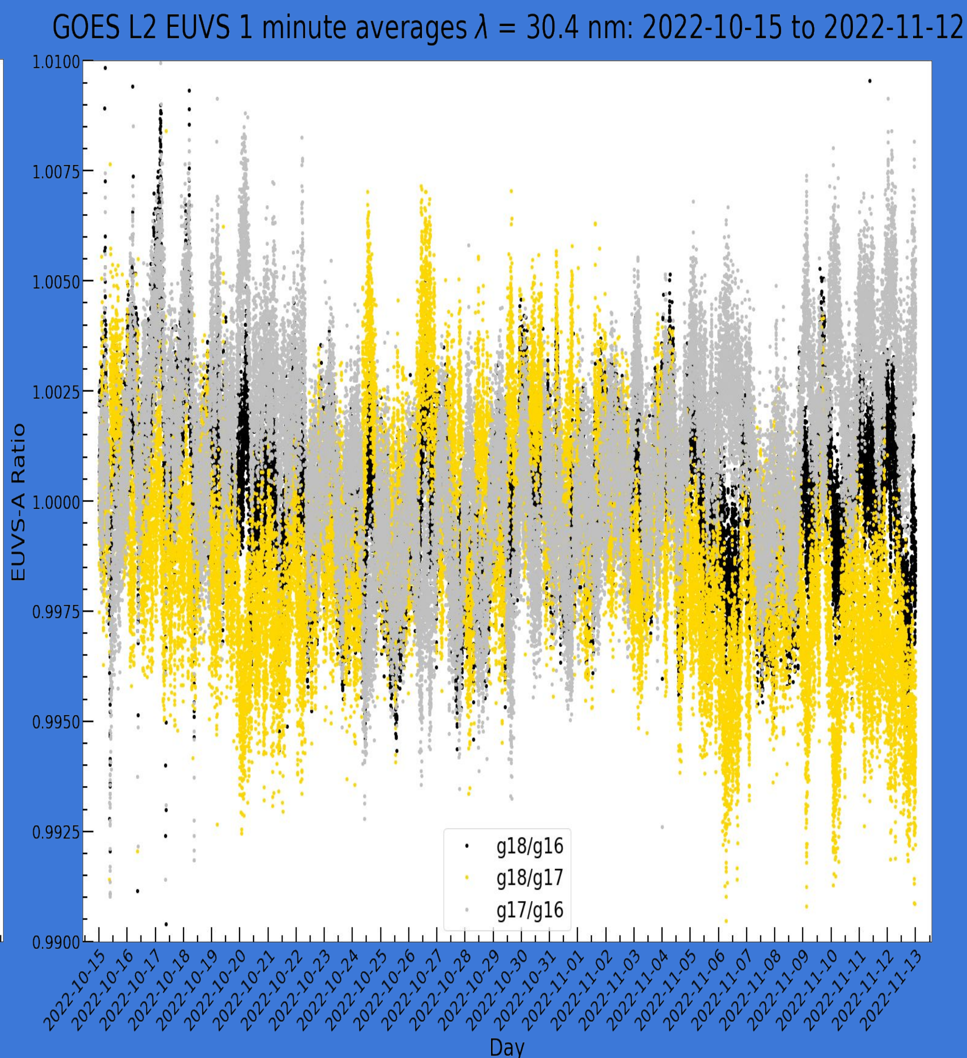
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 30.4 nm. All satellites show 0.5-1% variability from the others.





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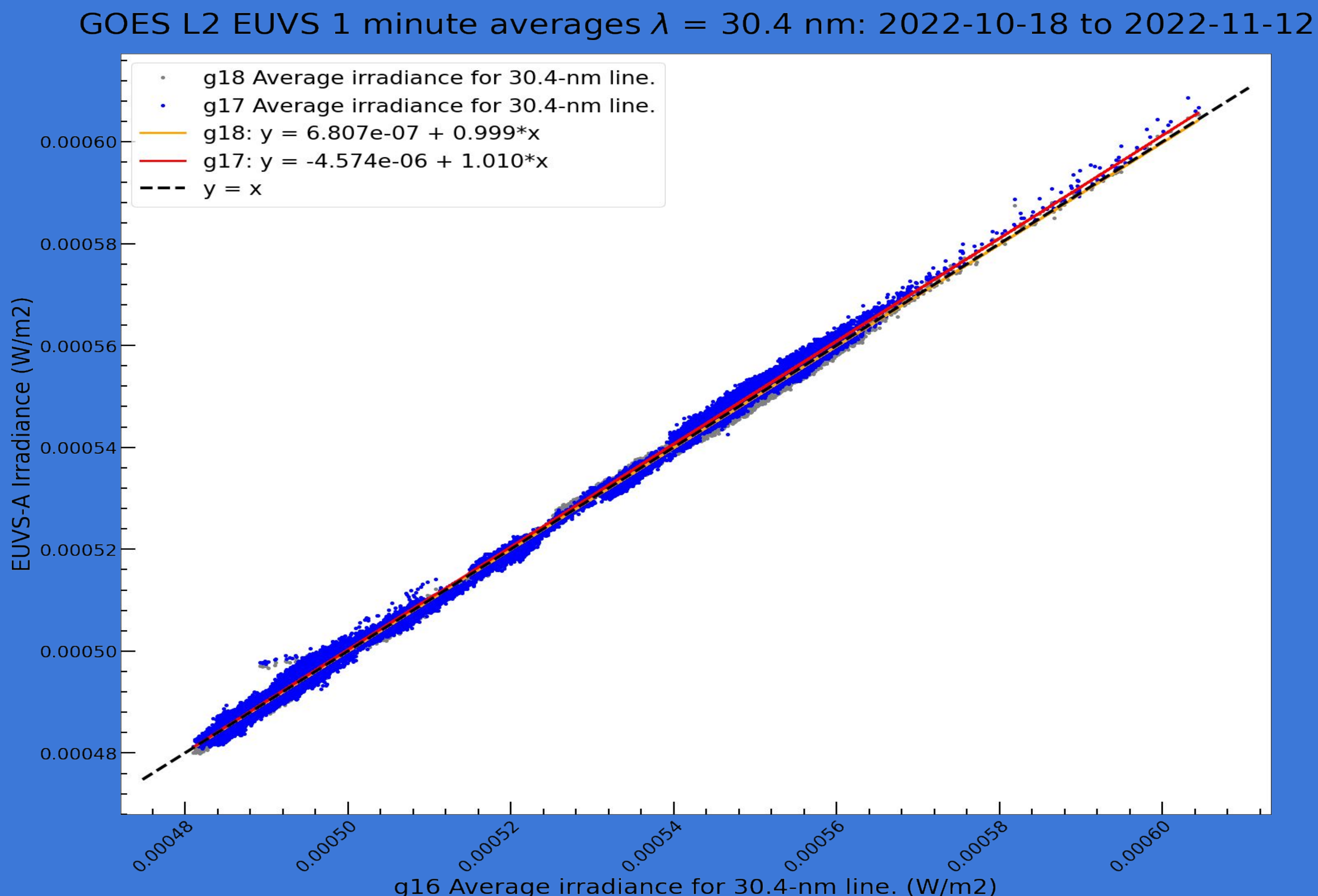
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 30.4 nm. GOES-18 shows 0.01% and GOES-17 shows 1% variability from GOES-16.



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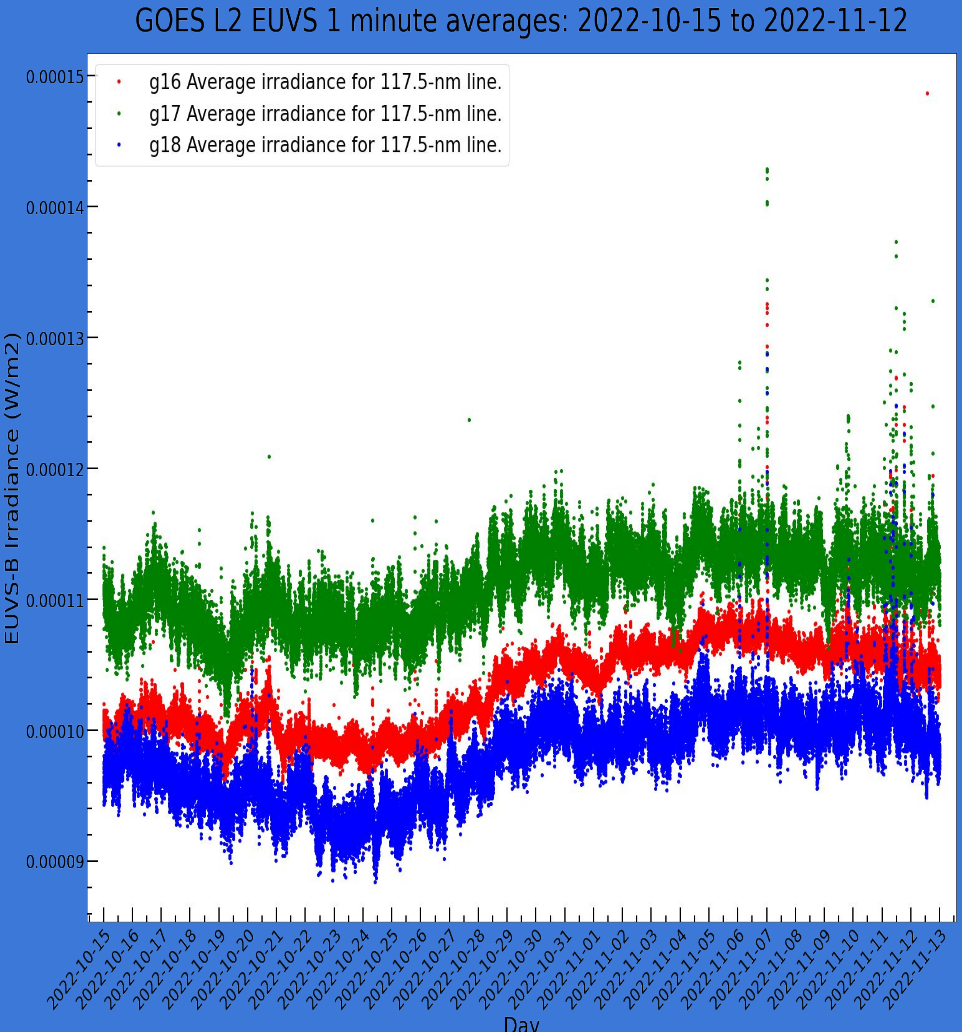
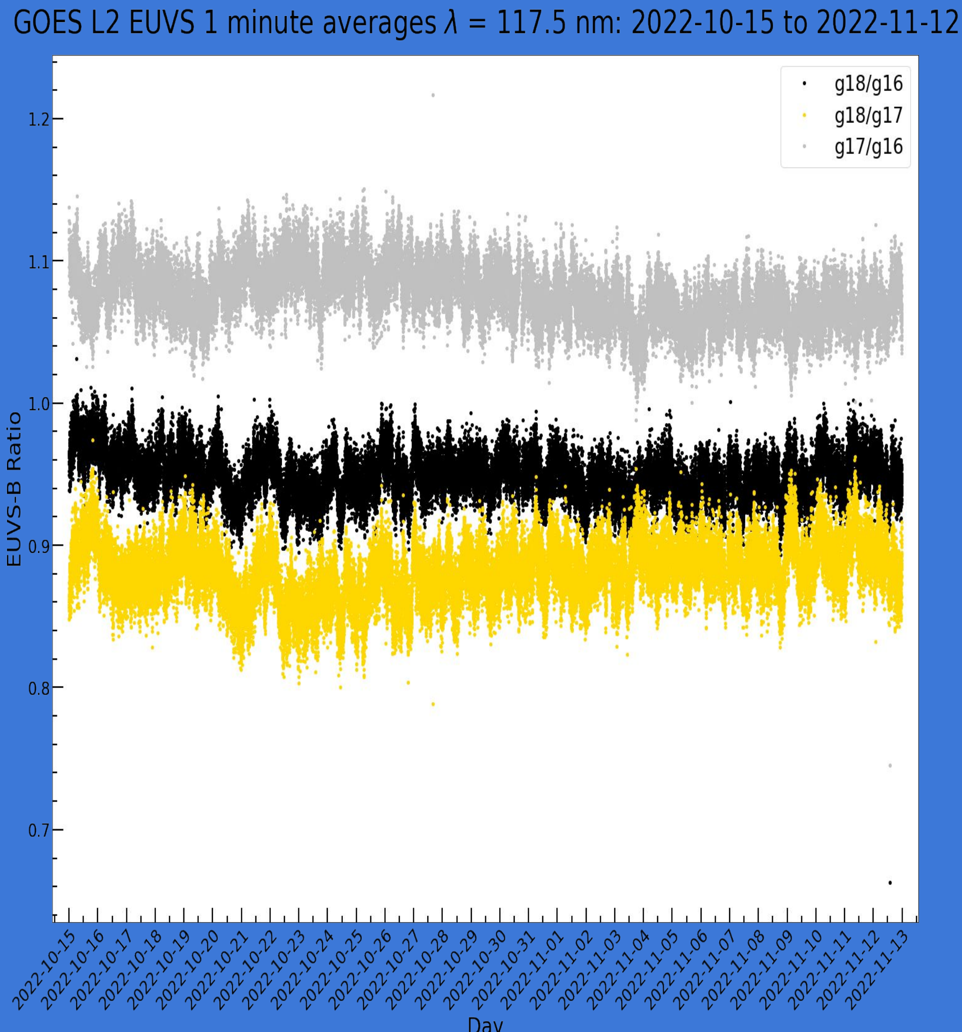
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 117.5 nm. All satellites show 8% variability from the others.





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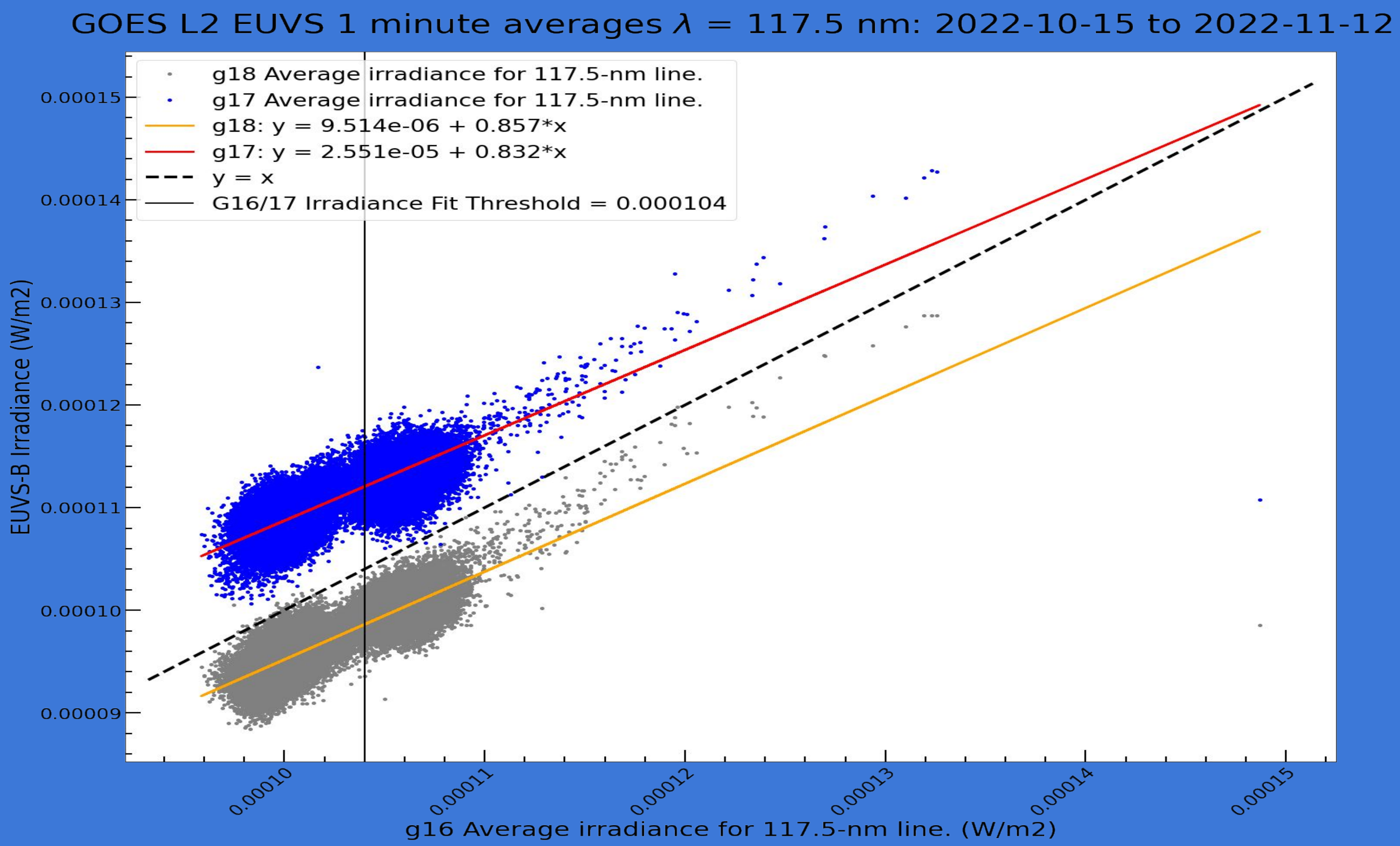
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 117.5 nm. GOES-18 shows 14.3% and GOES-17 shows 16.8% variability compared to GOES-16.
- Clustered and outlying data affect the quality of the fit



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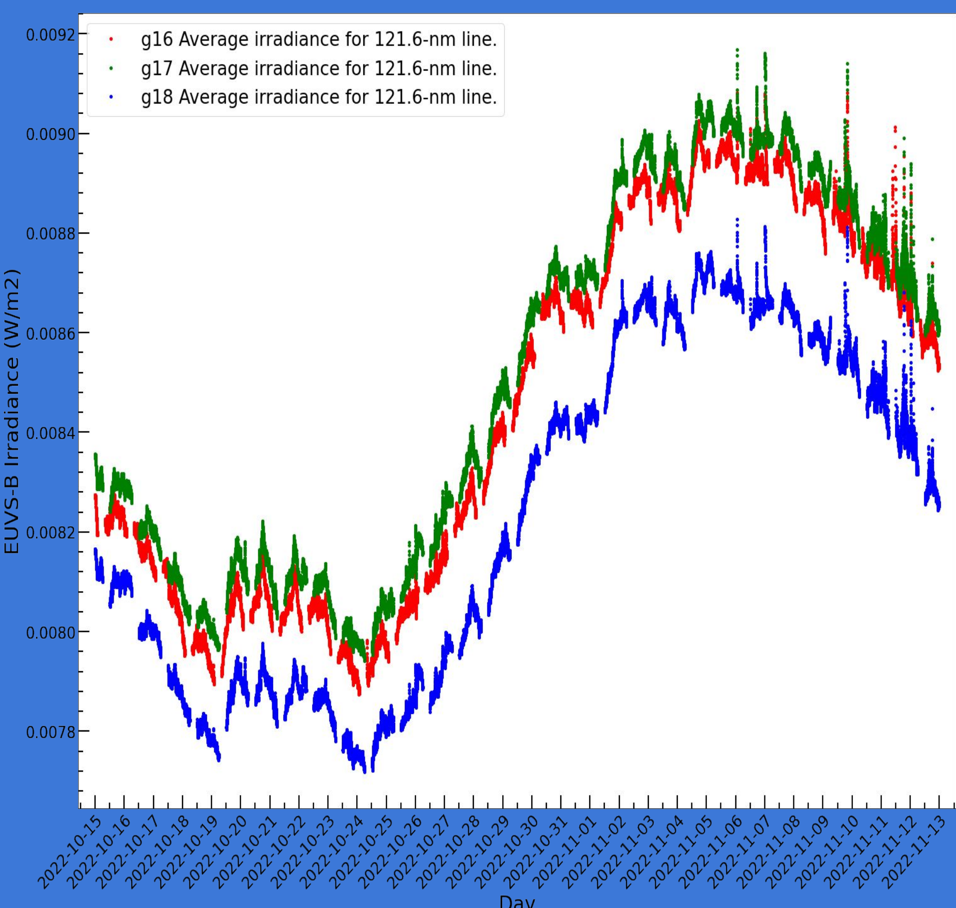
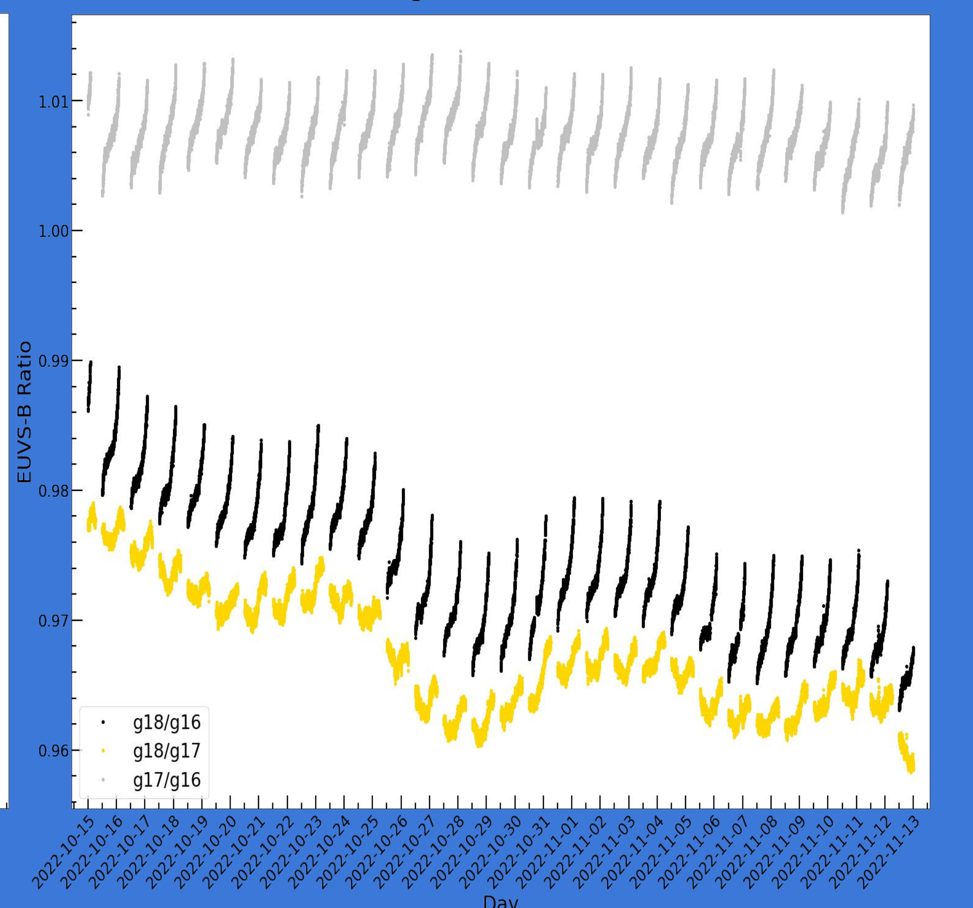
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 121.6 nm. GOES-18 shows 1% variability from GOES-16 and 0.4% variability from G17. GOES-17 shows ~1% variability from GOES-16.
- Data taken in the geocorona is excluded from these plots. The systematic effect in the ratio plot is due to the difference in satellite orbit locations. G17 and G18 are in the west orbital position, and G16 is in the east orbital position. The geocorona gaps are offset in time.

GOES L2 EUVS 1 minute averages: 2022-10-15 to 2022-11-12



GOES L2 EUVS 1 minute averages λ = 121.6 nm: 2022-10-15 to 2022-11-12



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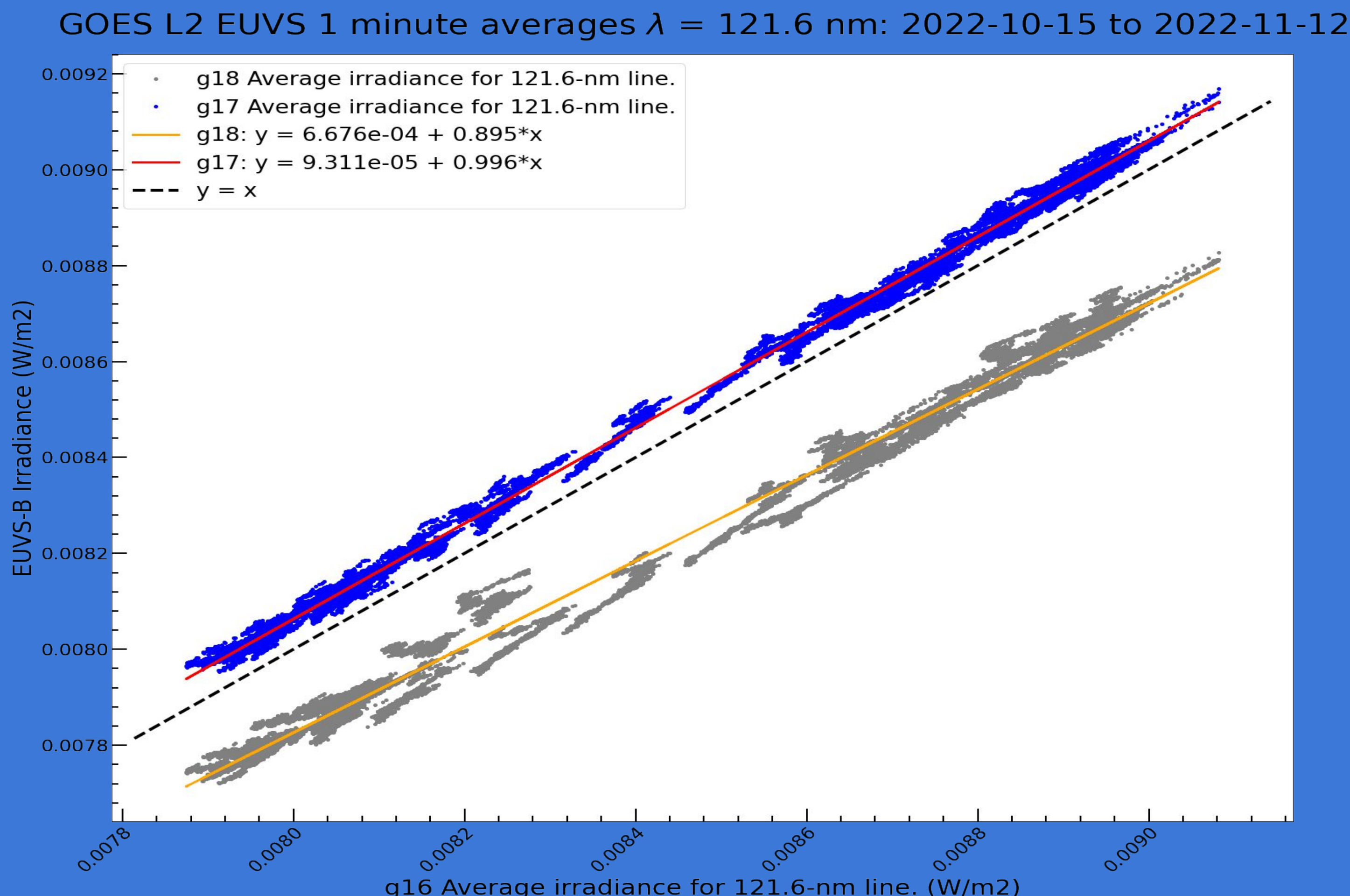
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 121.6 nm. GOES-18 shows 11.5% and GOES-17 shows 0.4% variability from GOES-16.
- Data taken in the geocorona is excluded from these plots. The systematic effect is due to the difference in satellite orbit locations. G17 and G18 are in the west orbital position, and G16 is in the east orbital position. The geocorona gaps are offset in time.



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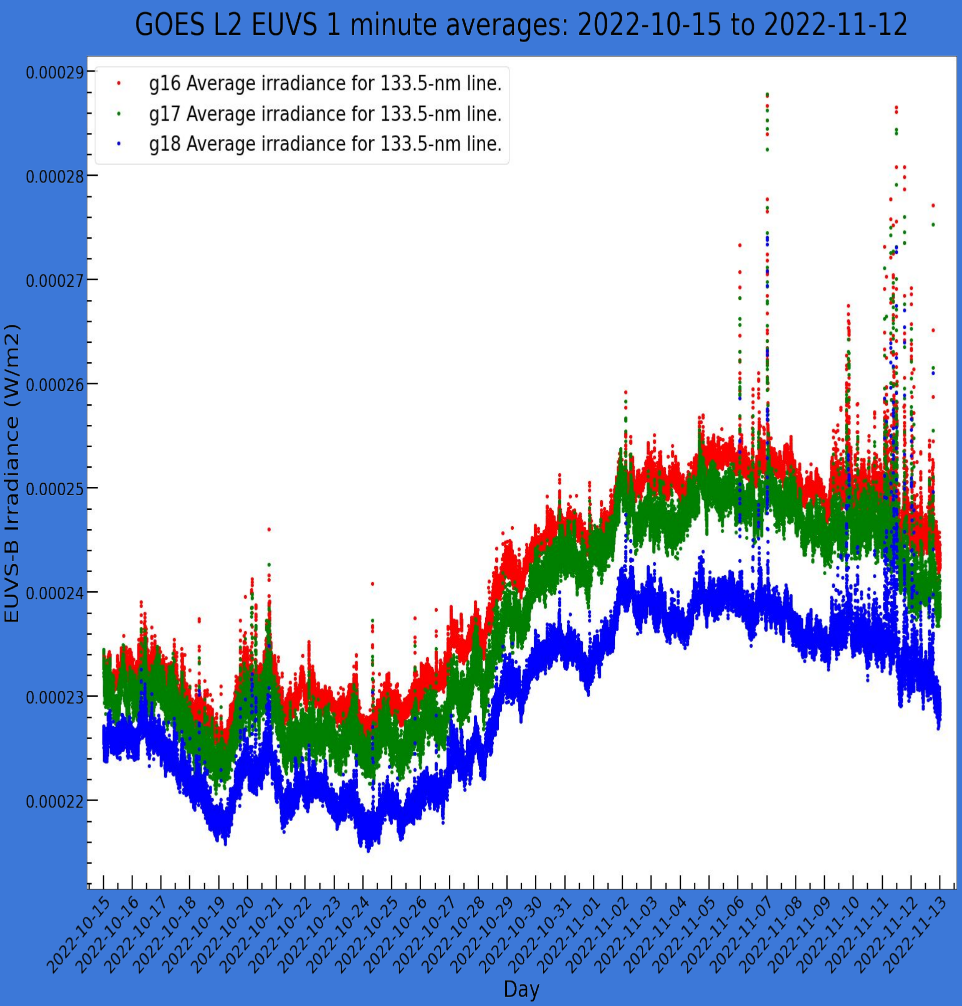
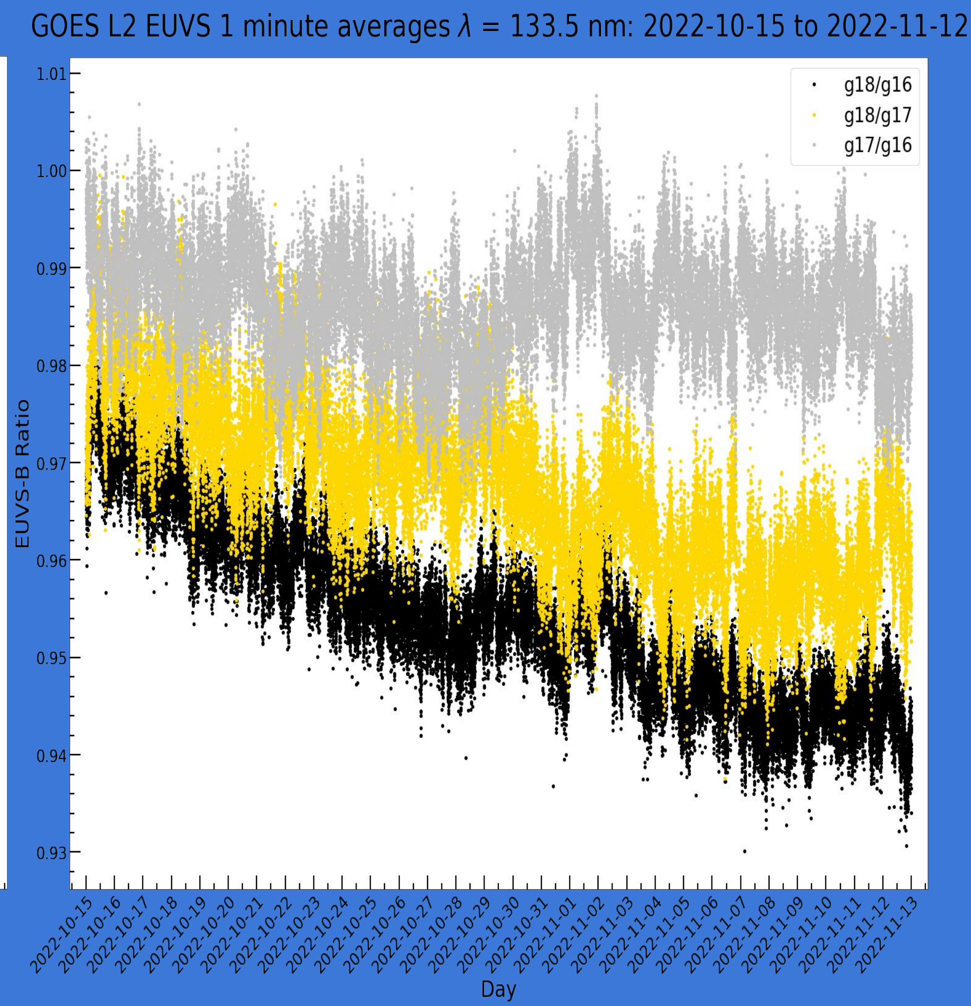
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 133.5 nm. All satellites show 2% variability from the others.





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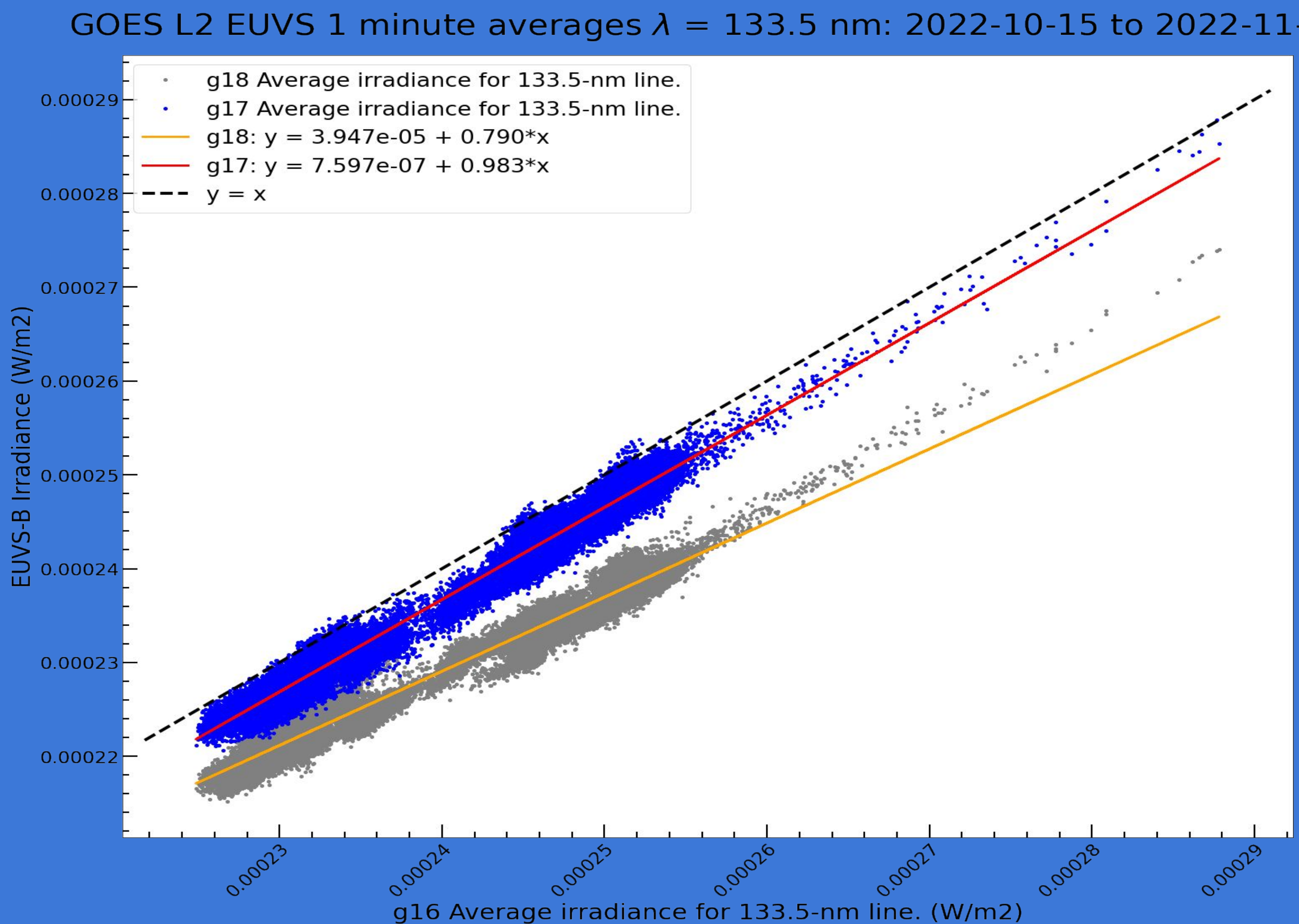
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 133.5 nm. GOES-18 shows 21% and GOES-17 shows 1.7% variability from GOES-16.
- Clustered and outlying data affect the quality of the fit



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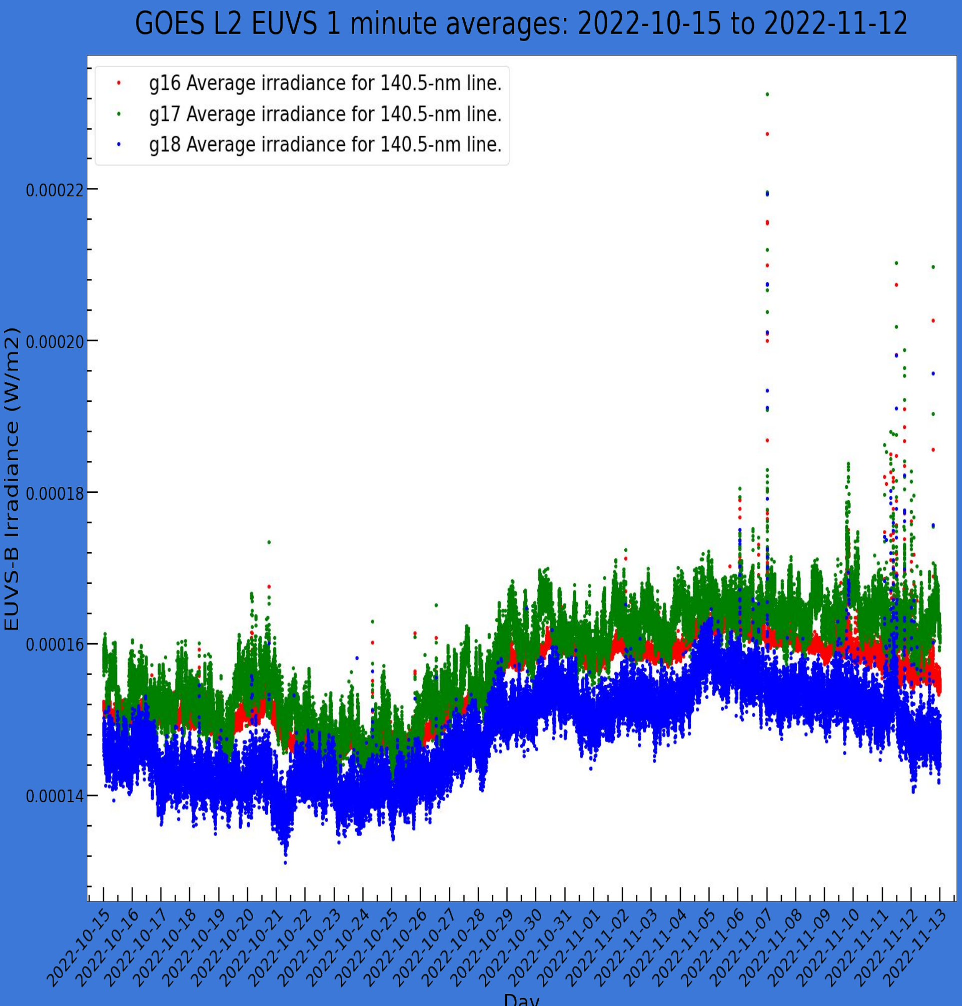
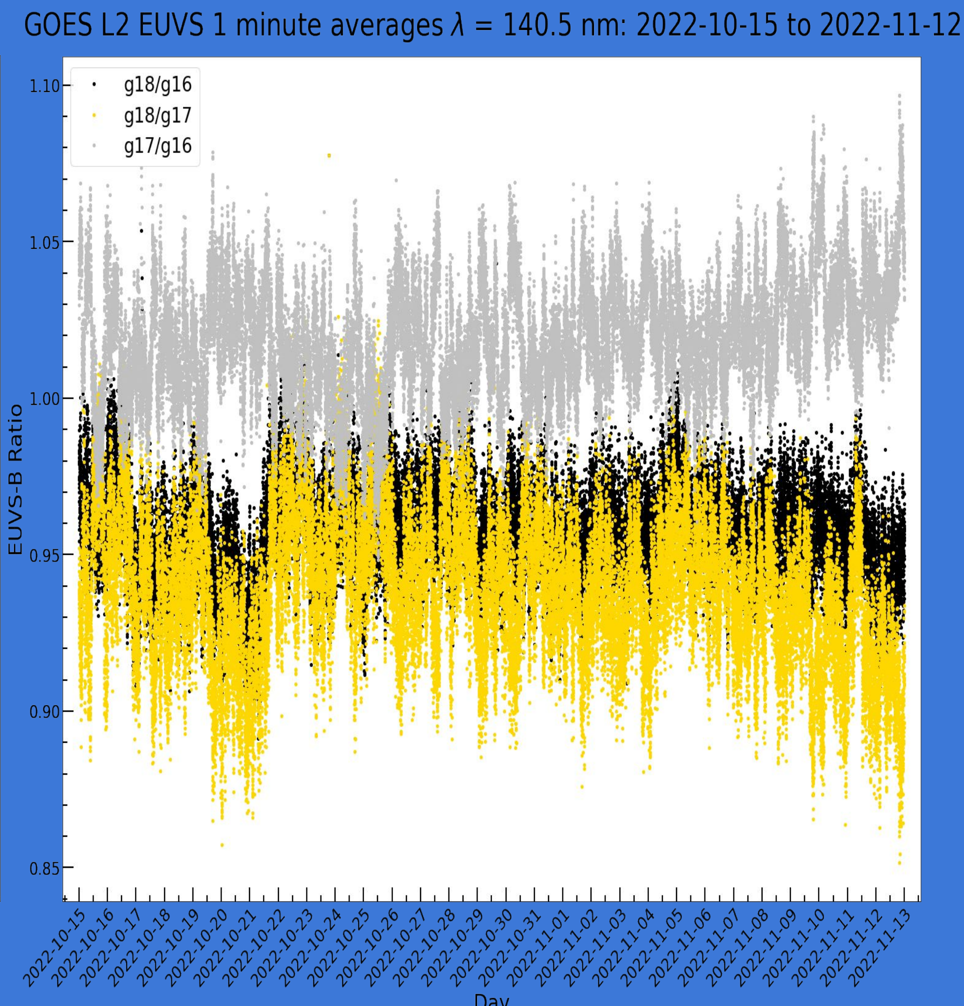
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 140.5 nm. GOES-18 and GOES-17 show 10% variability from GOES-16
- Significantly less noise in GOES-16 data





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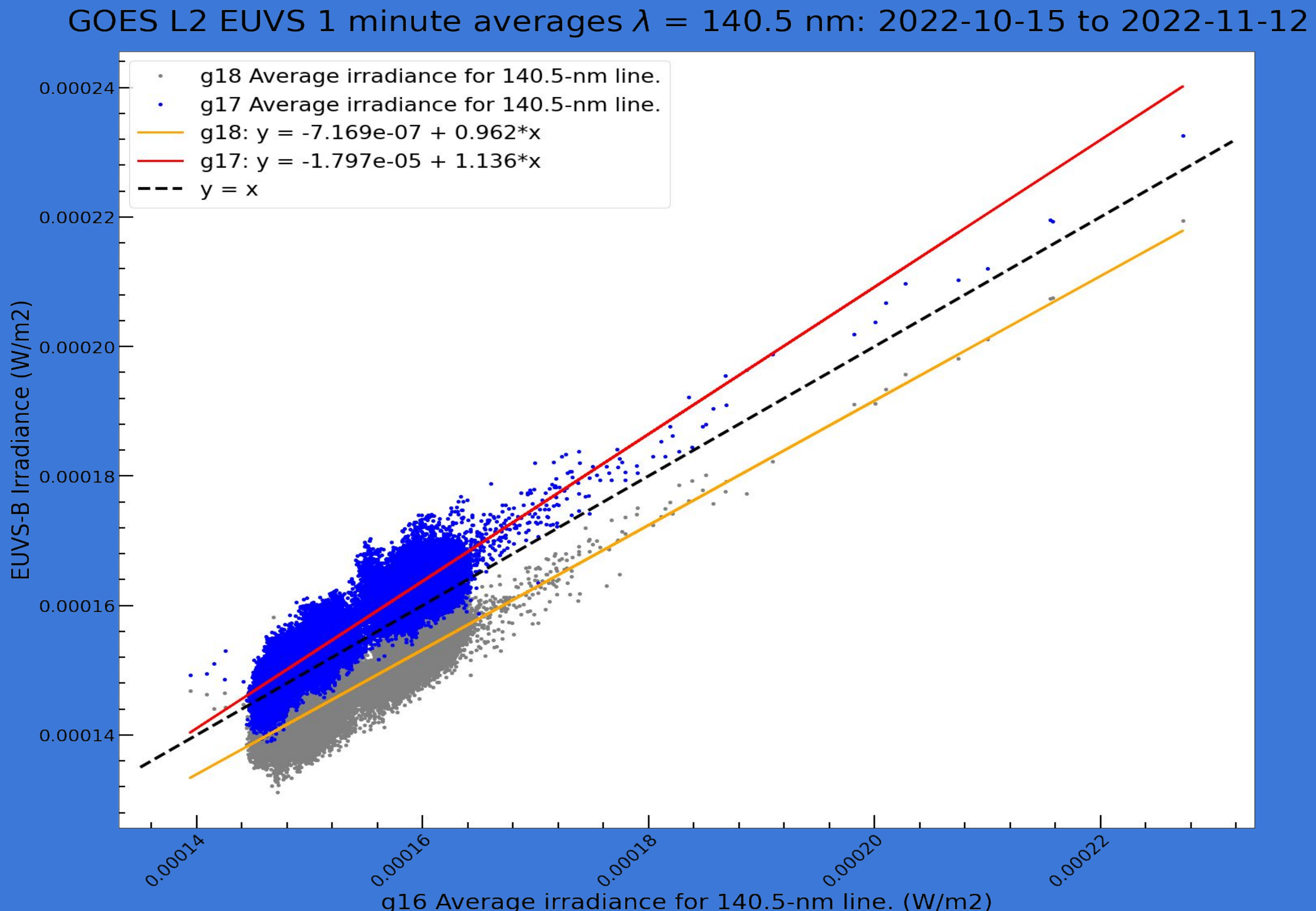
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-B: 140.5 nm. GOES-18 shows 3.8% and GOES-17 shows 13.6% variability from GOES-16.
- Clustered and outlying data affect the quality of the fit



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

- If the satellites matched exactly, the x-coefficient for the irradiance vs. irradiance fits would be 1
- Most wavelengths show offsets <5% (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 month) availability of GOES-18 data.

X-coefficient of G16 linear fit	25.6 nm	28.4 nm	30.4 nm	117.5 nm	121.6 nm	133.5 nm	140.5 nm
GOES-17	0.985	1.009	0.999	0.832	0.996	0.983	1.136
GOES-18	1.021	1.034	1.01	0.857	0.895	0.79	0.962

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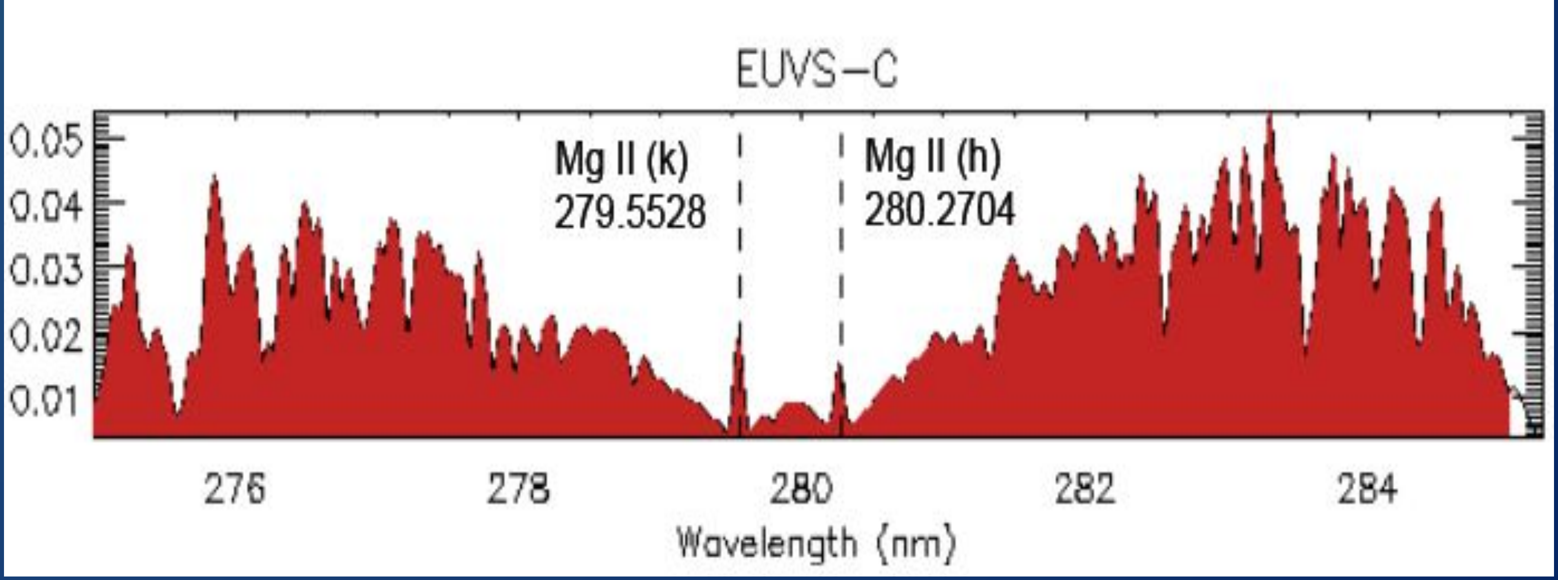
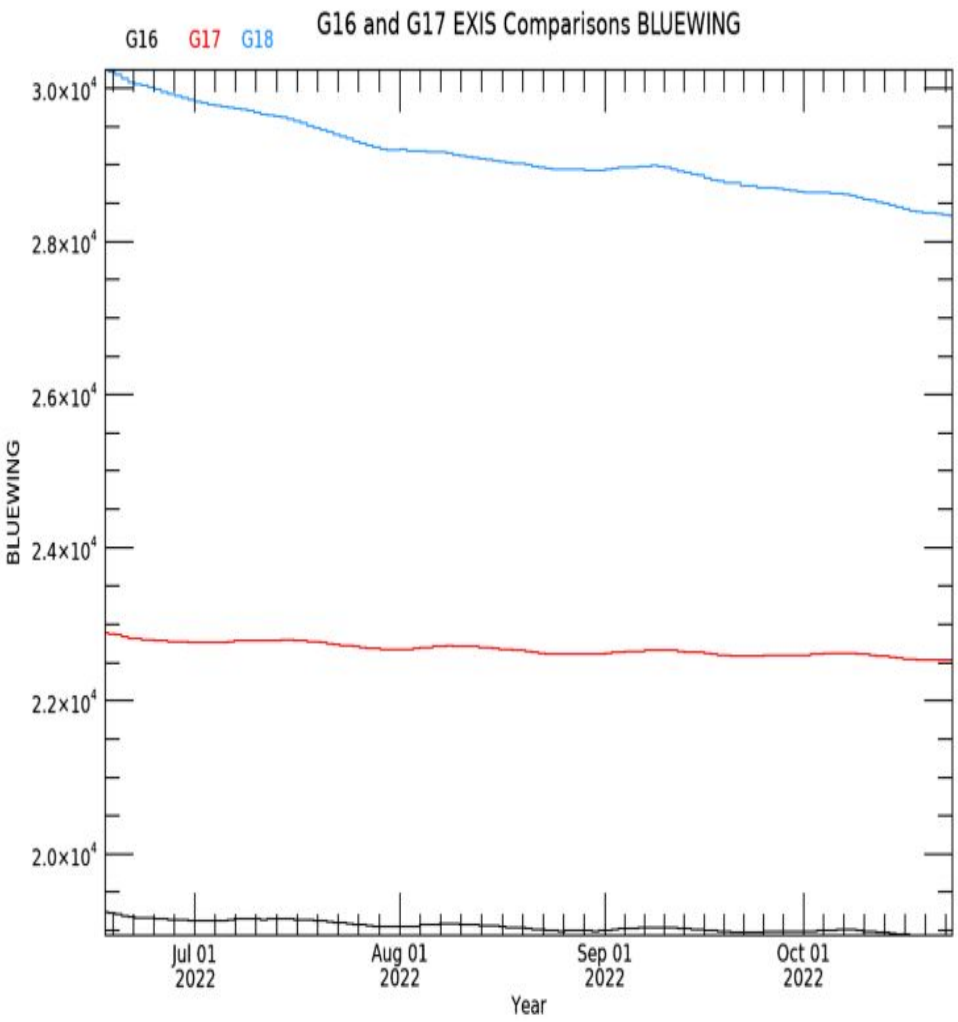
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

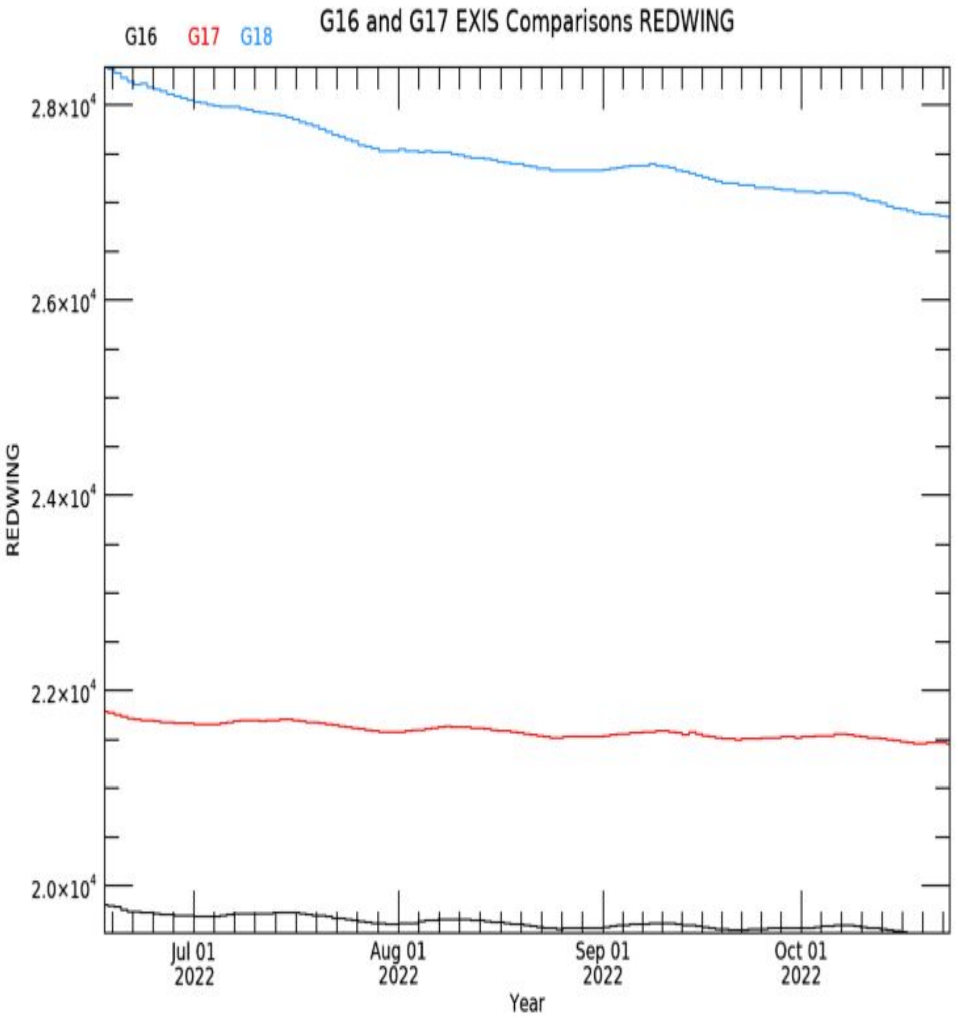
- EUVS-C: Comparisons of G16, G17 and G18
- EUVS-C measures the spectrum near 280 nm
- The Mg II index is a unitless value of EUV solar energy
- Mg II index = $(I_h + I_k) / (I_{red\_wing} + I_{blue\_wing})$
    - Red wing is > 280 nm, blue wing is < 280 nm



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

- G18 shows clear degradation, while G17 and G16 are much flatter
- EUV degradation rates tend to start high and decrease in time





Credit: Don Woodraska

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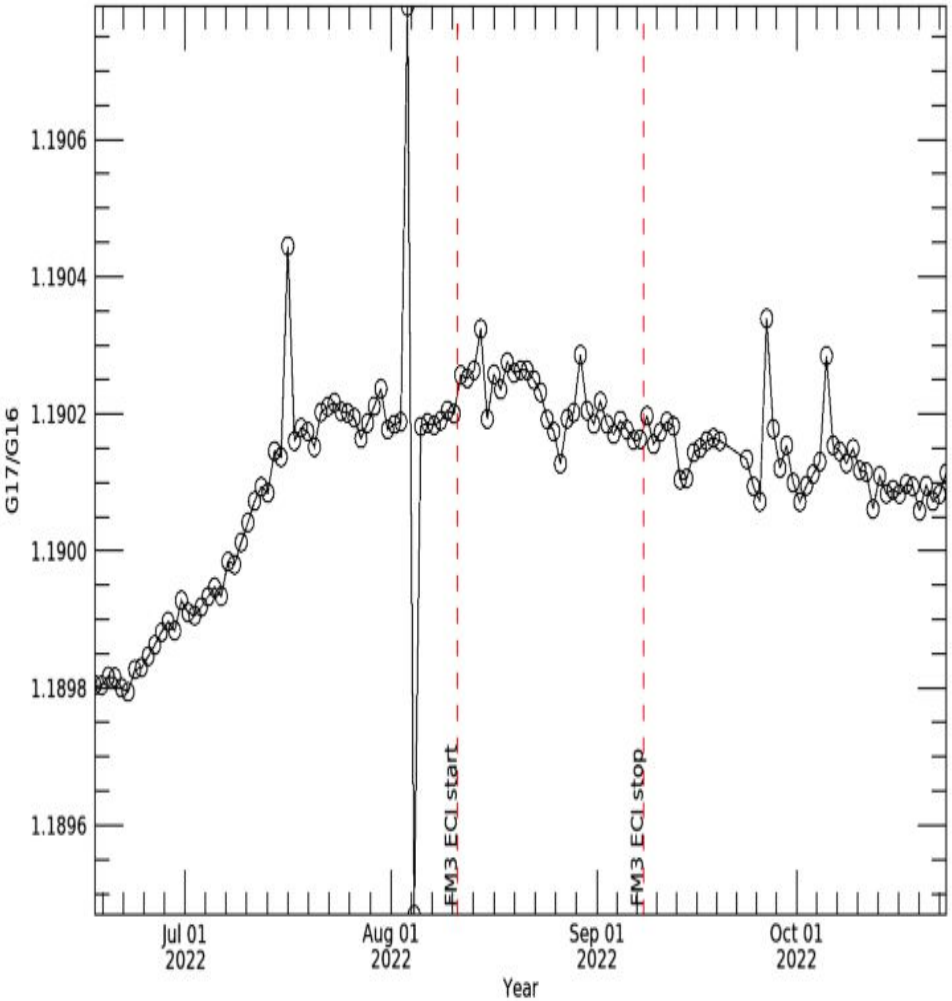
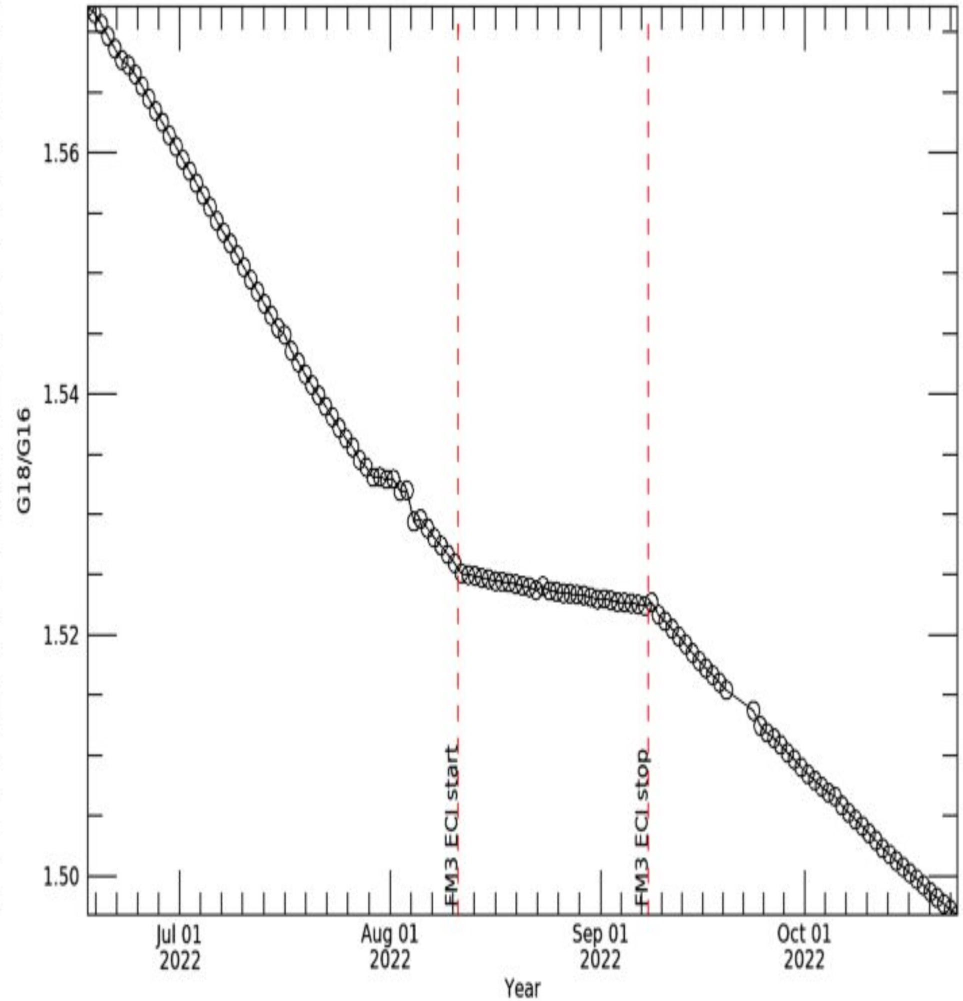
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-C Blue Wing ratios (G17/G16 on left plot, G18/G16 on the right plot)
- G18 shows clear degradation relative to G16. In ~4 months, the ratio already shows degradation of 7%.





Credit: Don Woodraska

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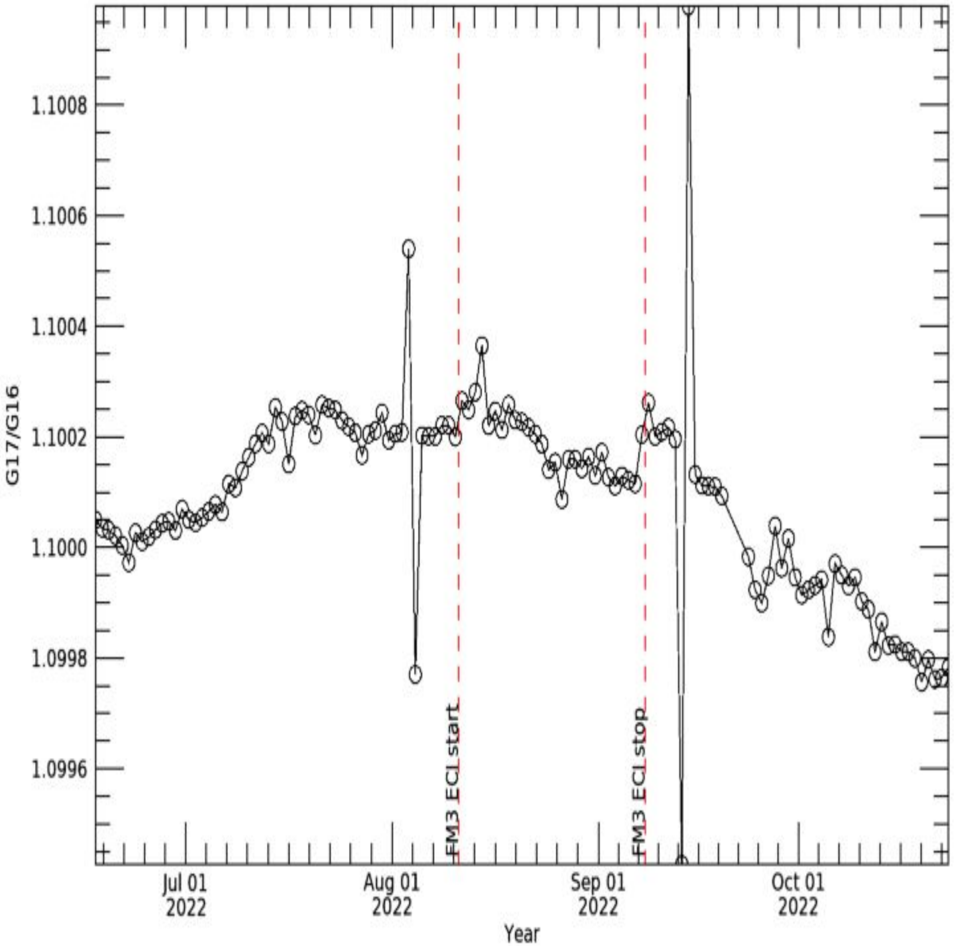
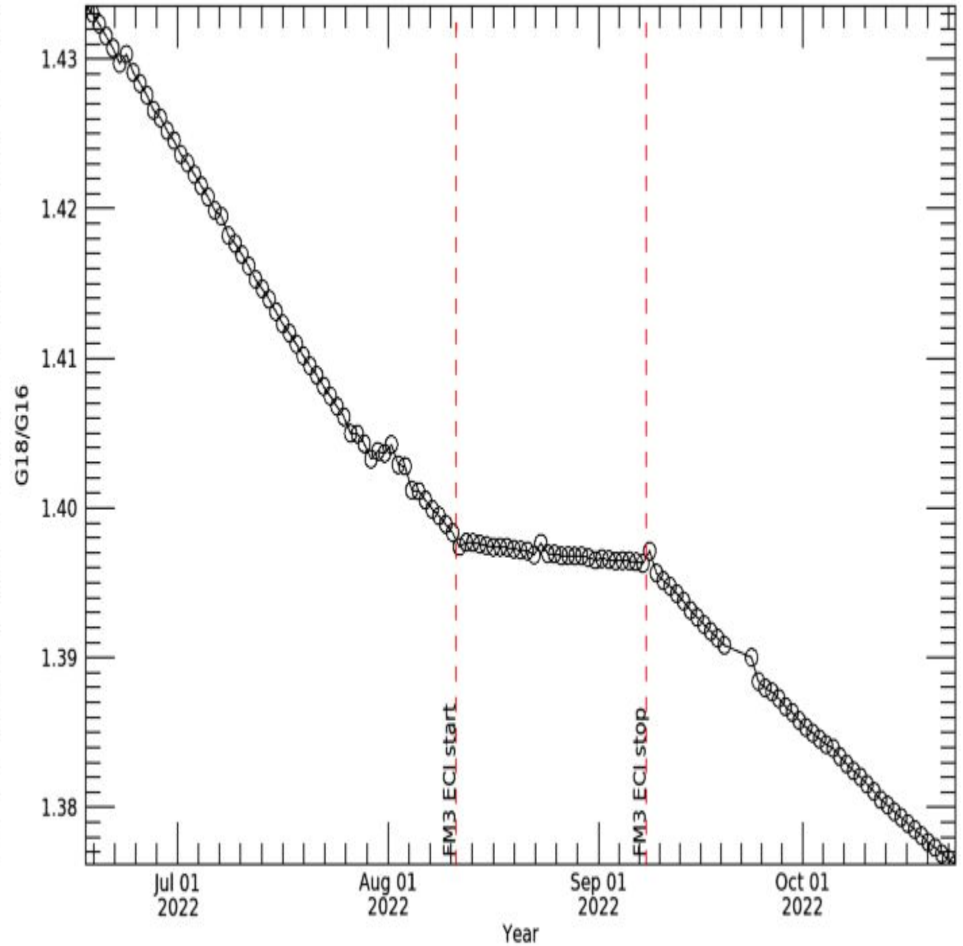
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-C Red Wing ratios (G17/G16 on left plot, G18/G16 on the right plot)
- G18 shows clear degradation relative to G16. In ~4 months, the ratio already shows degradation of 5%.

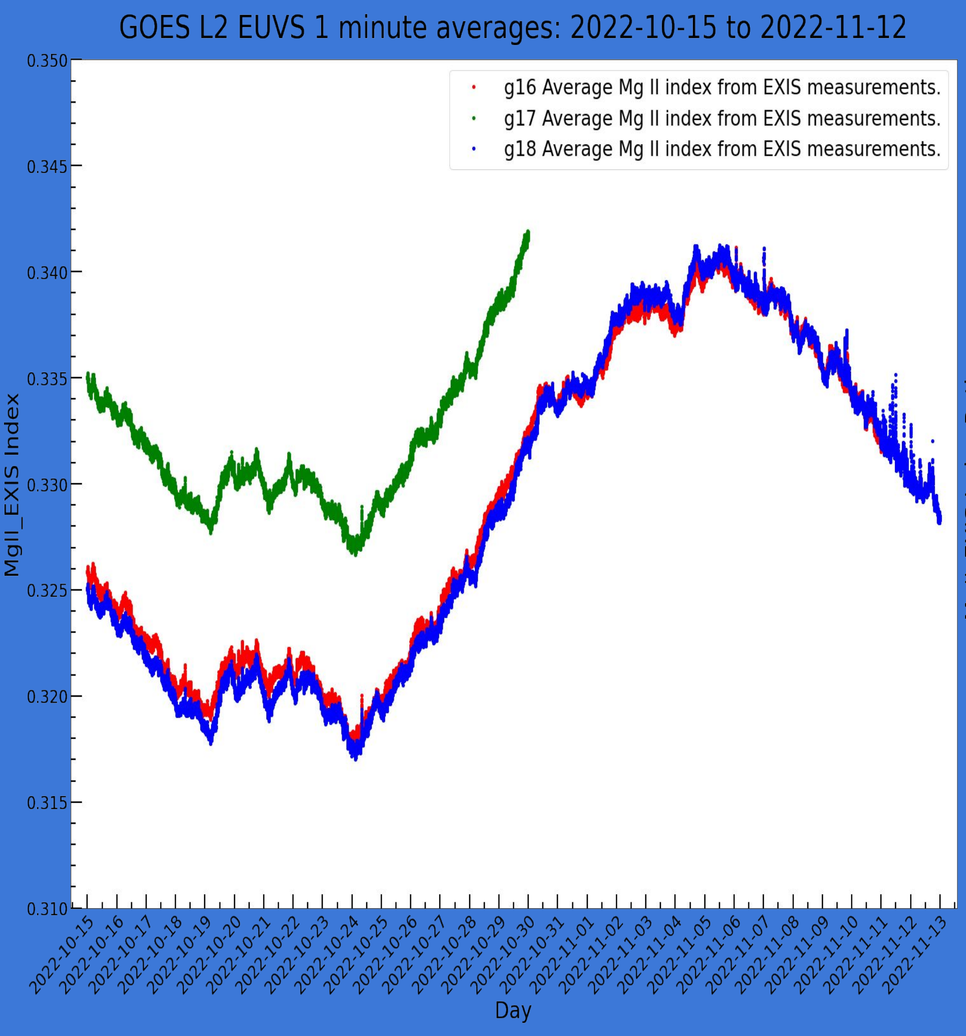


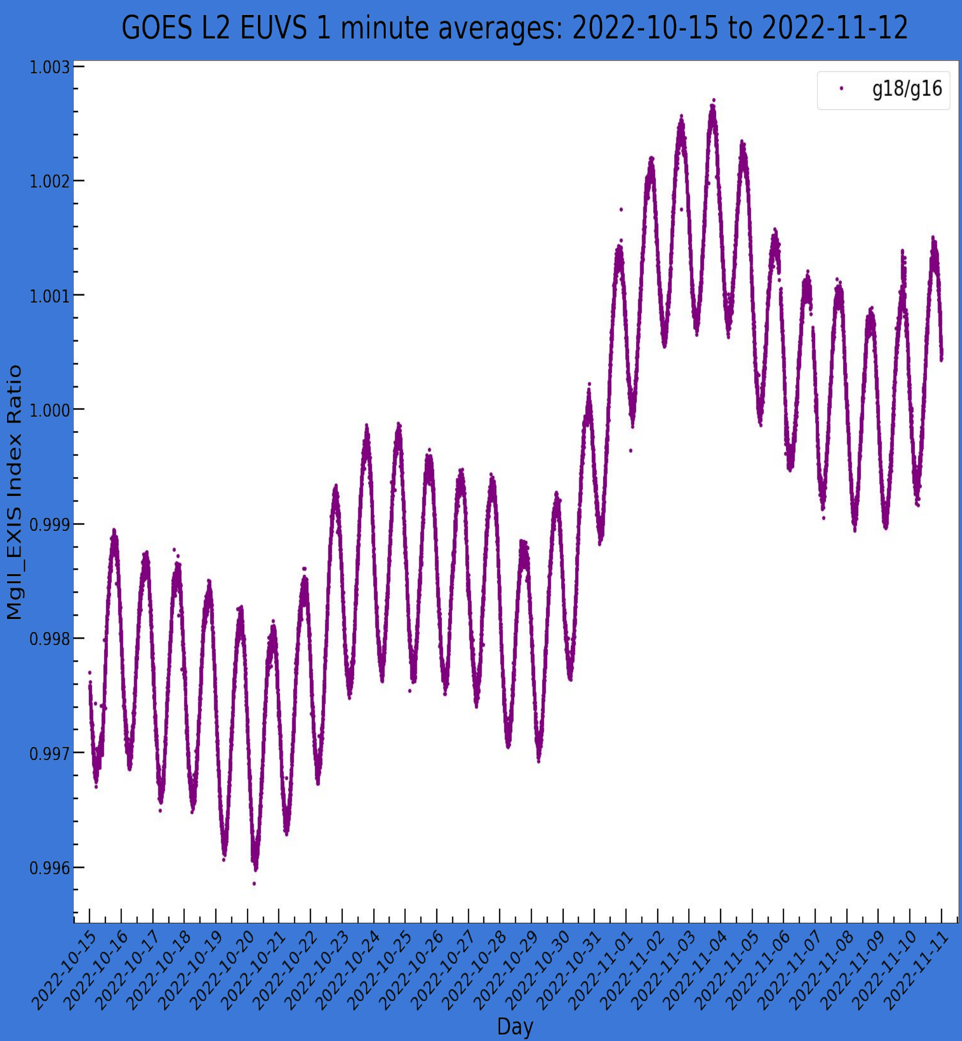


Credit: Don Woodraska

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

- EUVS-C MgII_EXIS index. The measurements from each satellite are NOT yet scaled.
- GOES-18 shows 0.2% daily variability and 0.7% overall variability from GOES-16





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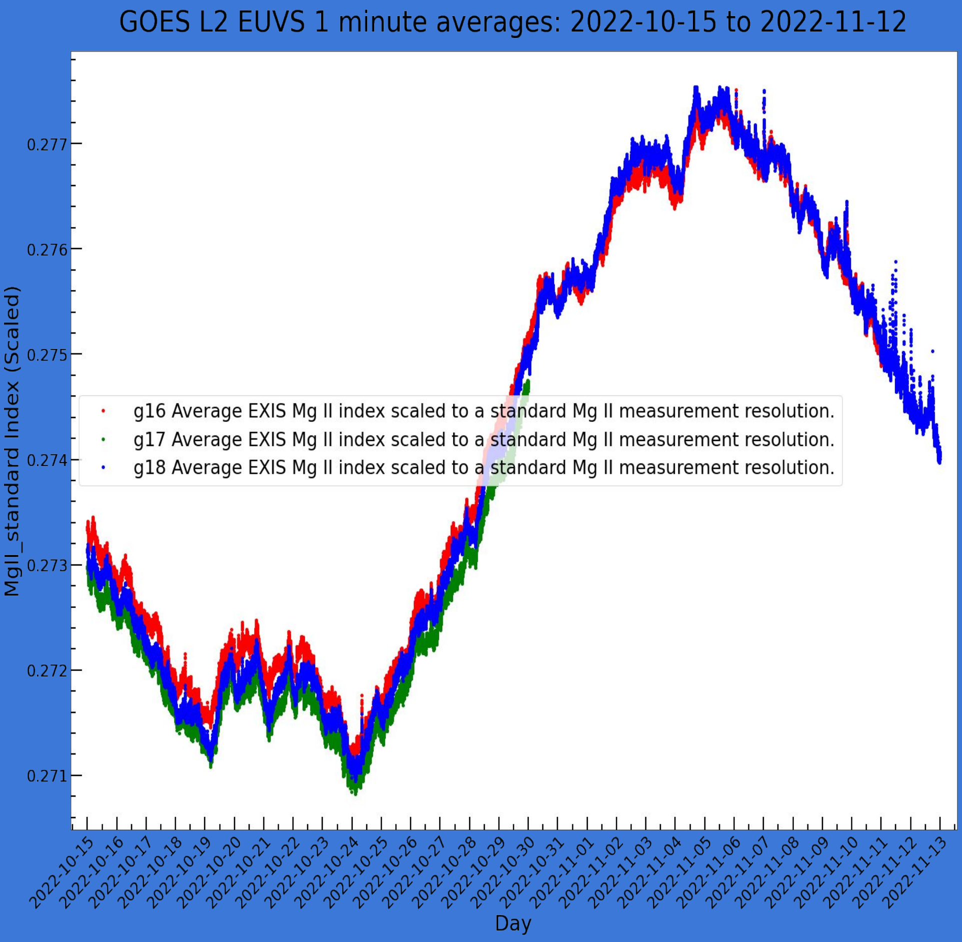
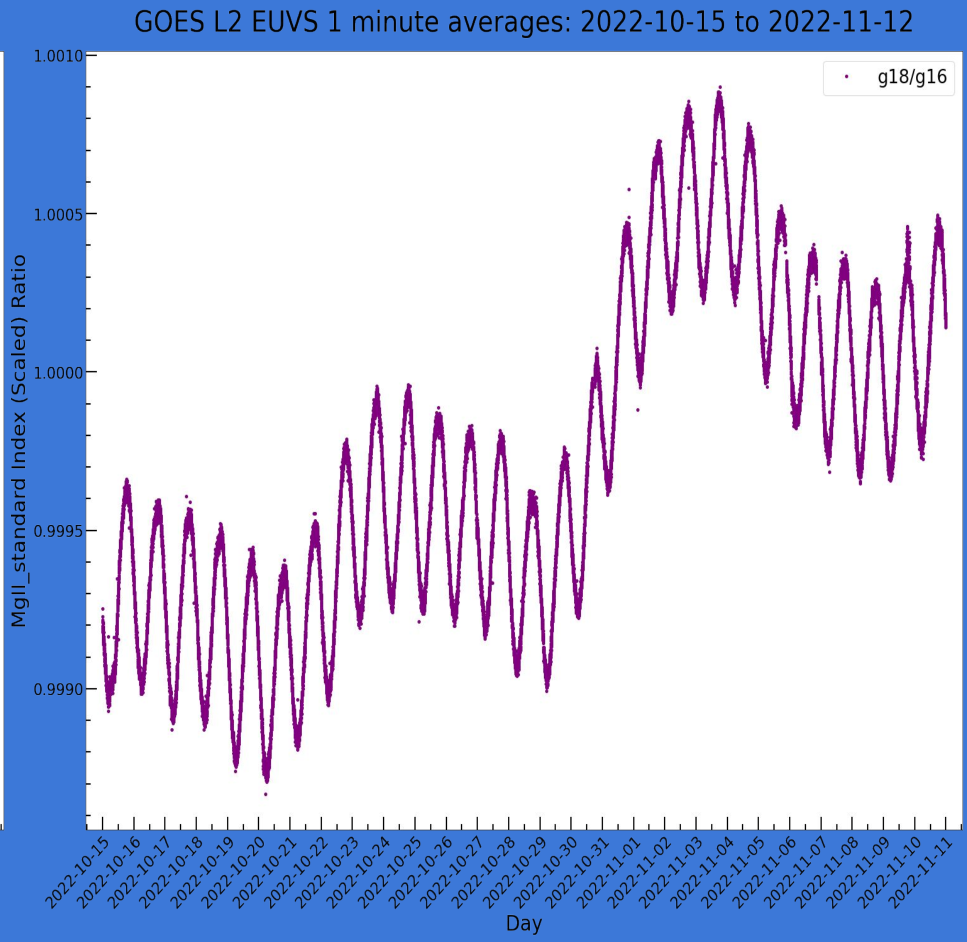
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-C MgII_standard index. The measurements from each satellite are scaled and show much closer agreement.
- GOES-18 shows 0.07% daily variability and 0.2% overall variability from GOES-16 This is significantly better agreement than the MgII_EXIS ratio shown on the previous slide.





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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
2	EUVS-C Systematic Behavior	Effects of Doppler and seasonal variation and degradation trends	Wing and line behavior will be investigated
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

GPA Issues for Provisional Validation

- 120 EUVS-related ADRs have been closed since 2016
- Significant EUVS ADRs fixed since GOES-17 Full Validation PS-PVR (May 2021):
  - ADR 840: EUVS Case Numbers Set Incorrectly
  - ADR 857: EUVS Negative Currents
  - ADR 898: EUVS Dark Current Temperature Correction
  - ADR 958: Update EXIS LUT Variables to Double Precision
- 6 EUVS ADRs are currently open. None of these have significant impacts to data processing or quality.

Remaining EUVS GPA Issues

ADR	Issue	Data Impact	Description / Impacts	OE Delivery Date
872	Solar array currents incorrect in GOES-17	Minor	Solar array currents variables are incorrect. Telemetry issue.	Not scheduled
1144	EUVS during lunar transit	Moderate	Spectral lines and Mg II set to fill values during eclipse and lunar transit (detailed in GOES-17 EUVS Full Validation PS-PVR)	Not scheduled
1157	EUVS metadata	Minor	Minor changes to metadata	Not scheduled
1158	EUVS calibration flag change	Minor	Modify quality flags to clearly label calibrations	Not scheduled
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)	Not scheduled
1171	Increase ECEF_Z range	Minor		DO 12.00

Future GPA Updates

- GOES-18 EXIS will become operational when GOES-18 replaces GOES-17 as the GOES-West satellite on January 4, 2023
- LASP will deliver next EUVS LUTs in early December 2022
  - EUVS-A and EUVS-B LUTs will have updated dark drift corrections
  - EUVS-B LUT will have updated degradation correction
  - EUVS-C LUT will have slight adjustments to the Mg II scaling factors
- NCEI will produce and deliver all subsequent GOES-18 EUVS LUT updates

PROVISIONAL MATURITY ASSESSMENT

Performance Baseline

MRD ID	Quantity	MRD Requirement	GOES-16 (Full)	GOES-17 (Full)	GOES-18 (Provisional)	Related PLPTs	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 (1.4×10^{-5} to 5.3×10^{-2} W/m^2) EUVS-B: 0.5x Solar Min to 10x Solar Max (1.4×10^{-5} to 5.3×10^{-2} W/m^2)	EUVS-A: 4.7×10^{-7} to 0.93 W/m^2 EUVS-B: 1.8×10^{-6} to 1.64 W/m^2	EUVS-A: 6.3×10^{-7} to 1.03 W/m^2 EUVS-B: 1.4×10^{-6} to 1.19 W/m^2	EUVS-A: 2.4×10^{-6} to 3.05 W/m^2 EUVS-B: 4.9×10^{-6} to 12.24 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%	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%	3	PASS
2032	EUVS Long-term Stability	< ±5% or ability to track	Track Changes			15, 16, 17	PASS

Provisional Validation

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 titled "GPA Issues for Provisional Validation", "Remaining EUVS Instrument Issues" and "Remaining EUVS GPA Issues"

Provisional Validation

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-17 EUVS instruments. Instrument was calibrated at NIST.
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	This presentation, PLT reports, 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 very well
- Calibration LUTs have been updated. Further updates will occur.
- Paths toward diagnoses and fixes of issues have been identified
- Publicly available EUVS data from NCEI:
  - G16: operational and science-quality
  - G17: operational and science-quality (will be released by the end of 2022)
  - G18: operational (will be released January/February 2023); science-quality (tentative release date of spring 2023)

NCEI-CO recommends that GOES-18 EUVS L1b data be transitioned to Provisional status at this time.

ADDITIONAL INFORMATION

EUV Variability used in Drag Model

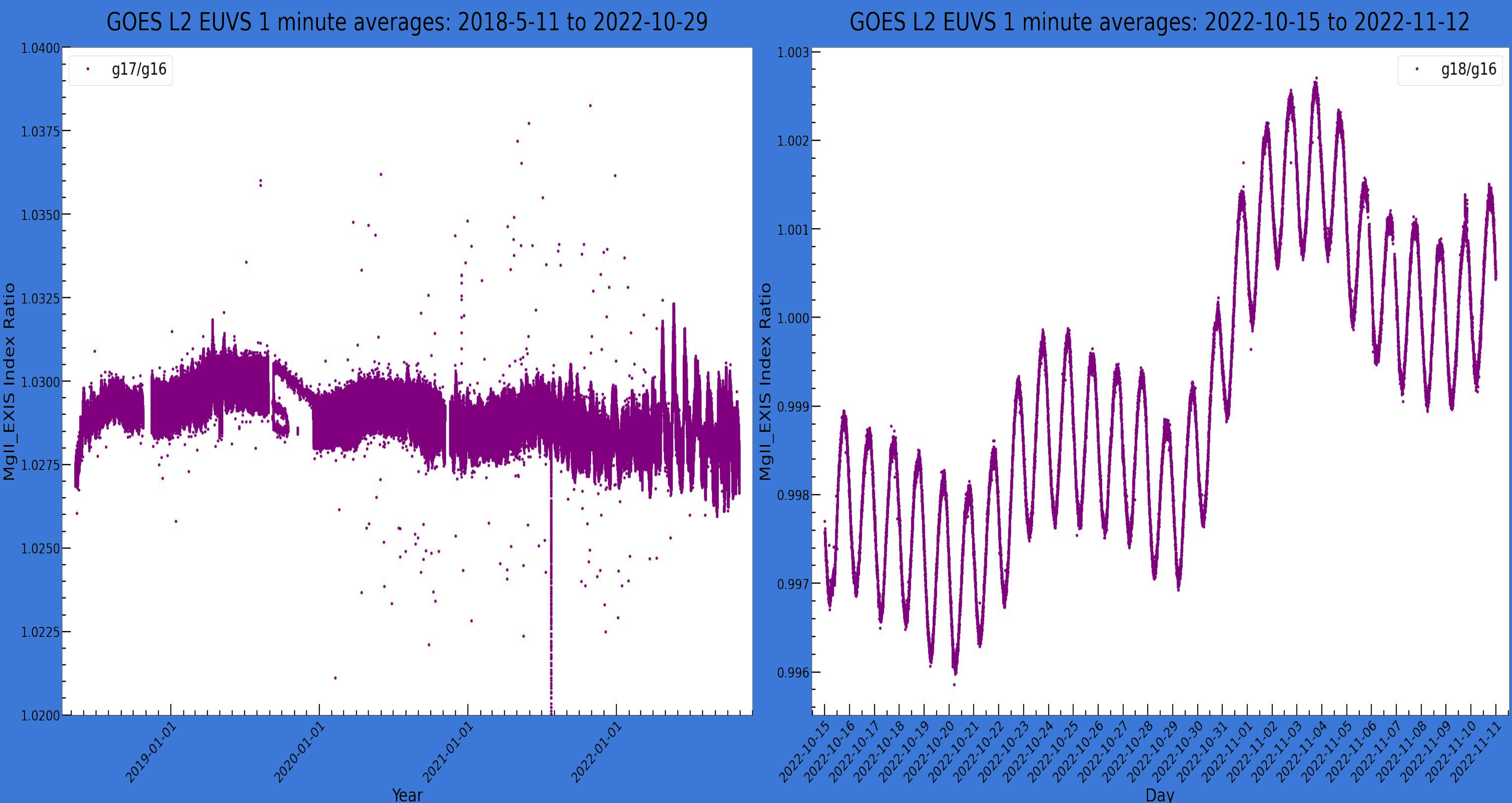
- Space Environment Technologies (SET) uses EUV to form solar indices
  - Uses GOES-R EUVS lines* and Mg II

- 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

PLPT #1: EUVS-C Mg II Scaling

- GOES-18 shows 0.2% daily variability and 0.7% overall variability from GOES-16
- GOES-17 shows 0.25-0.5% daily variability and 1% overall variability from GOES-16



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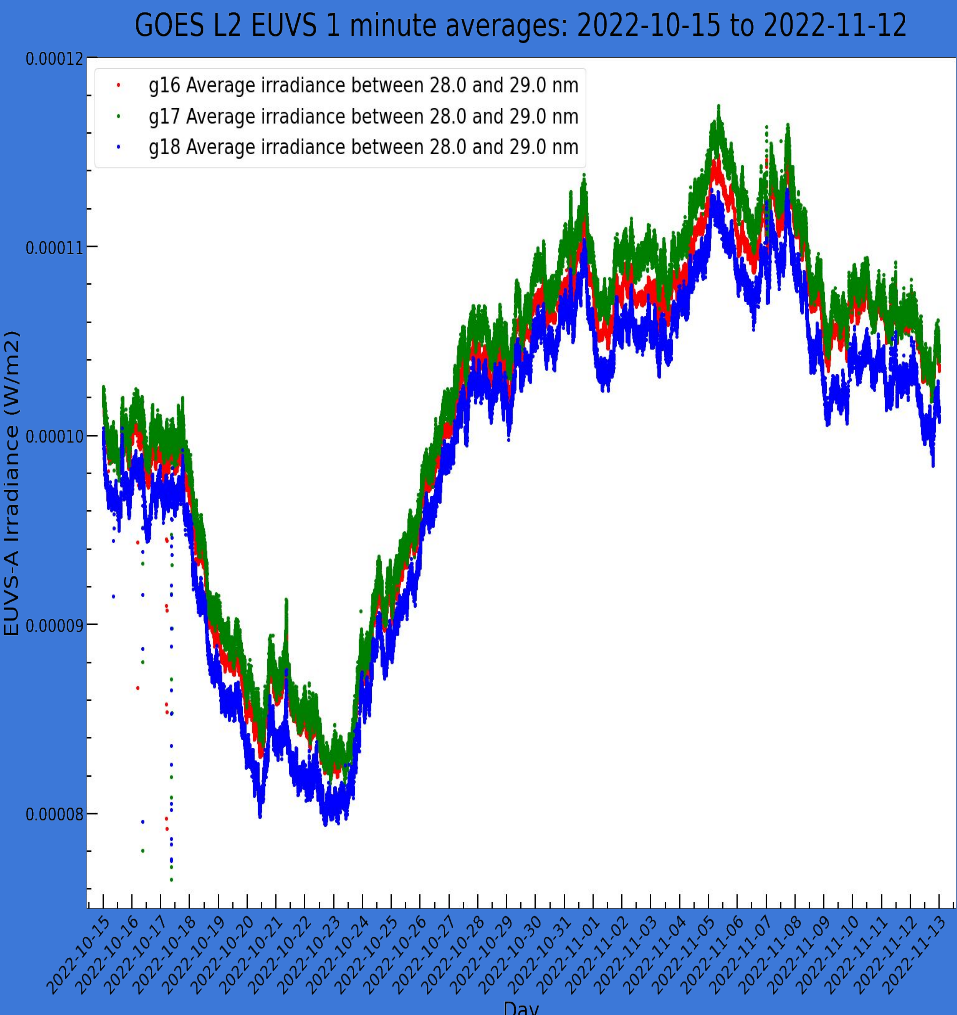
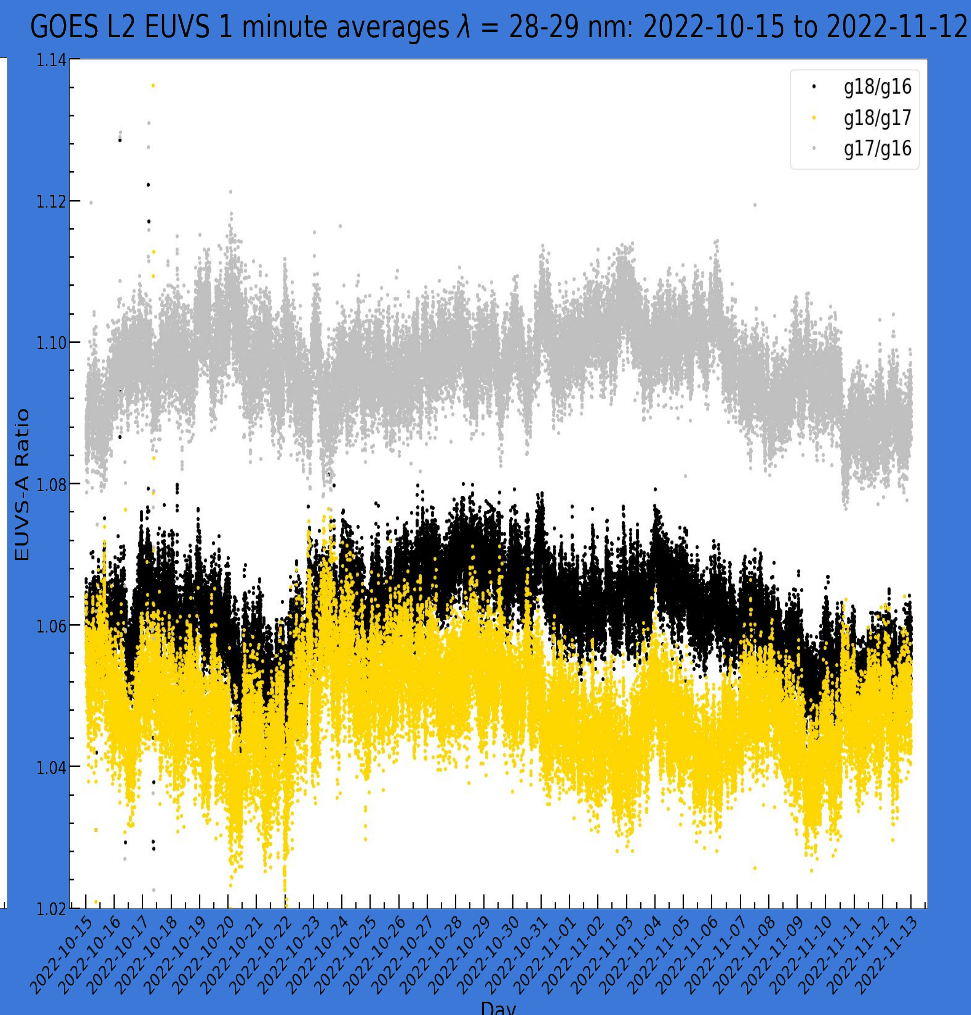
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 28.4 nm, scaled to 1 nm. G18 shows 2% variability from G16 and 4% variability from G17.





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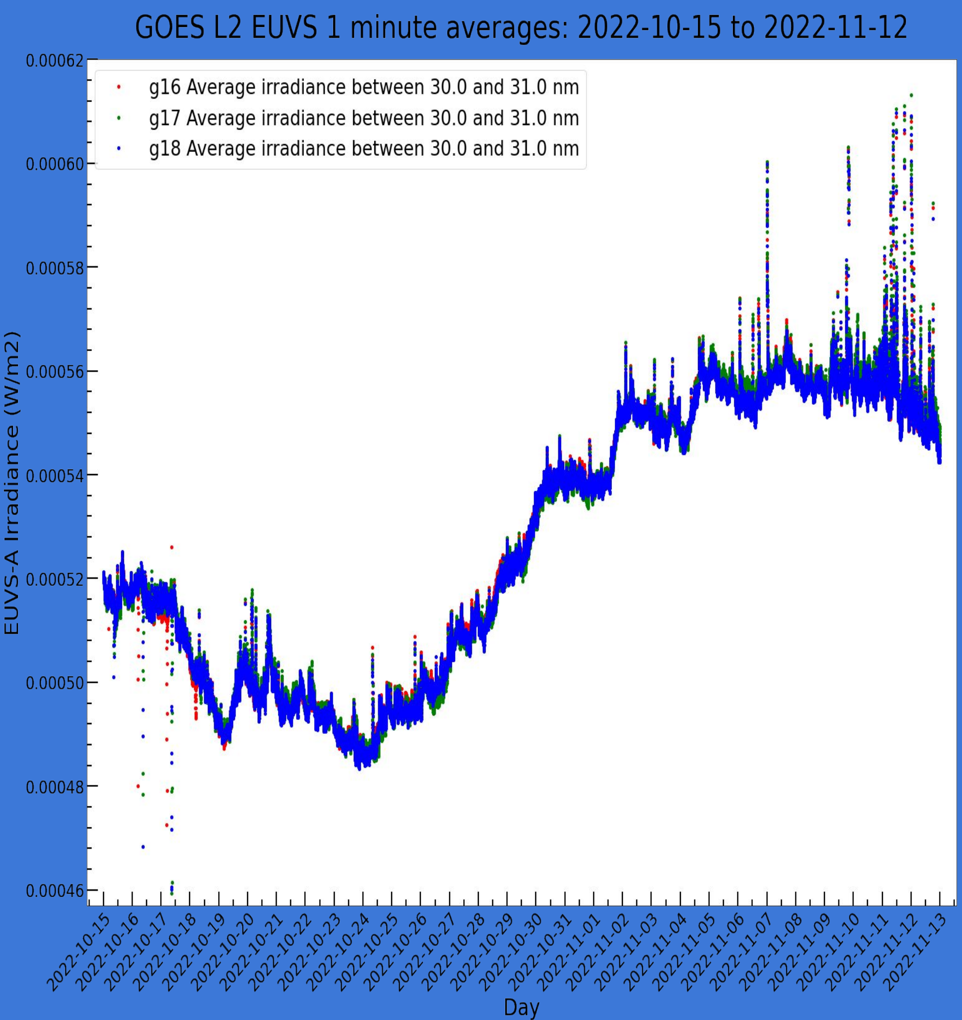
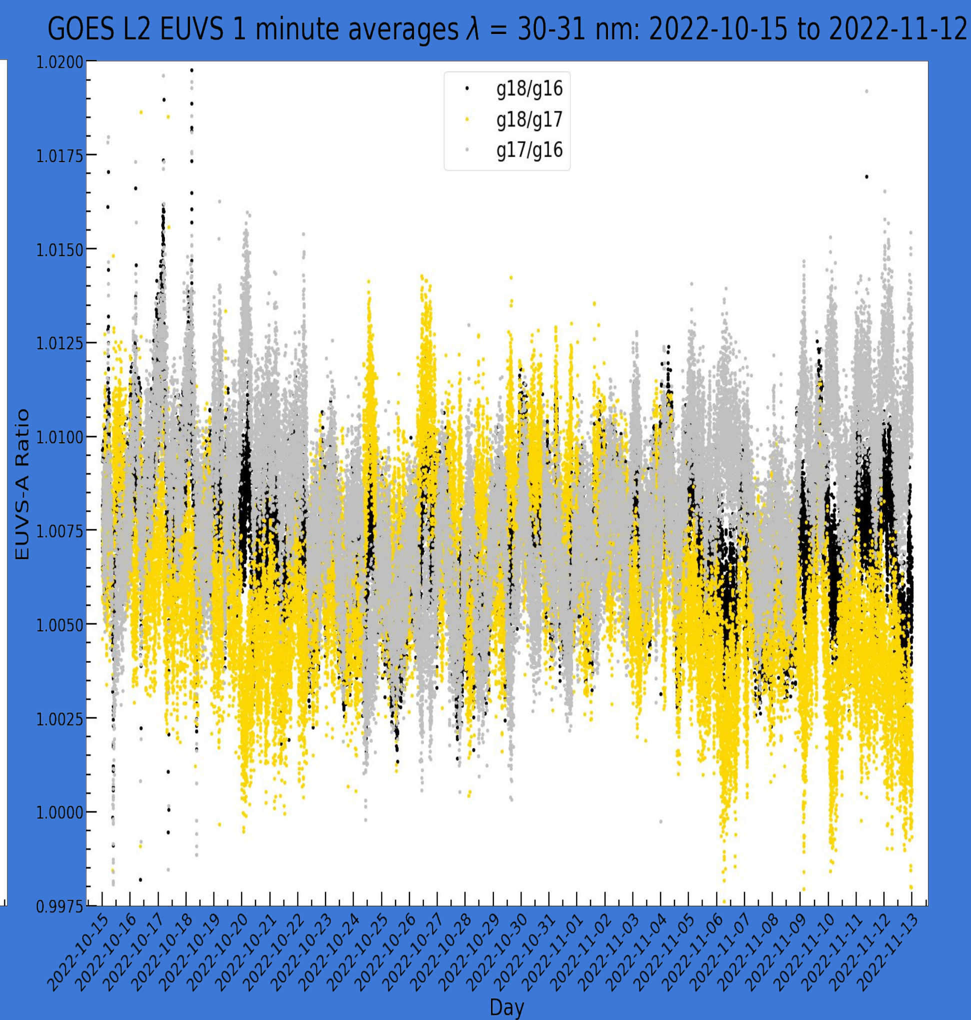
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 30.4 nm, scaled to 1 nm. G18 shows 0.5% variability from G16 and 1.5% variability from G17.





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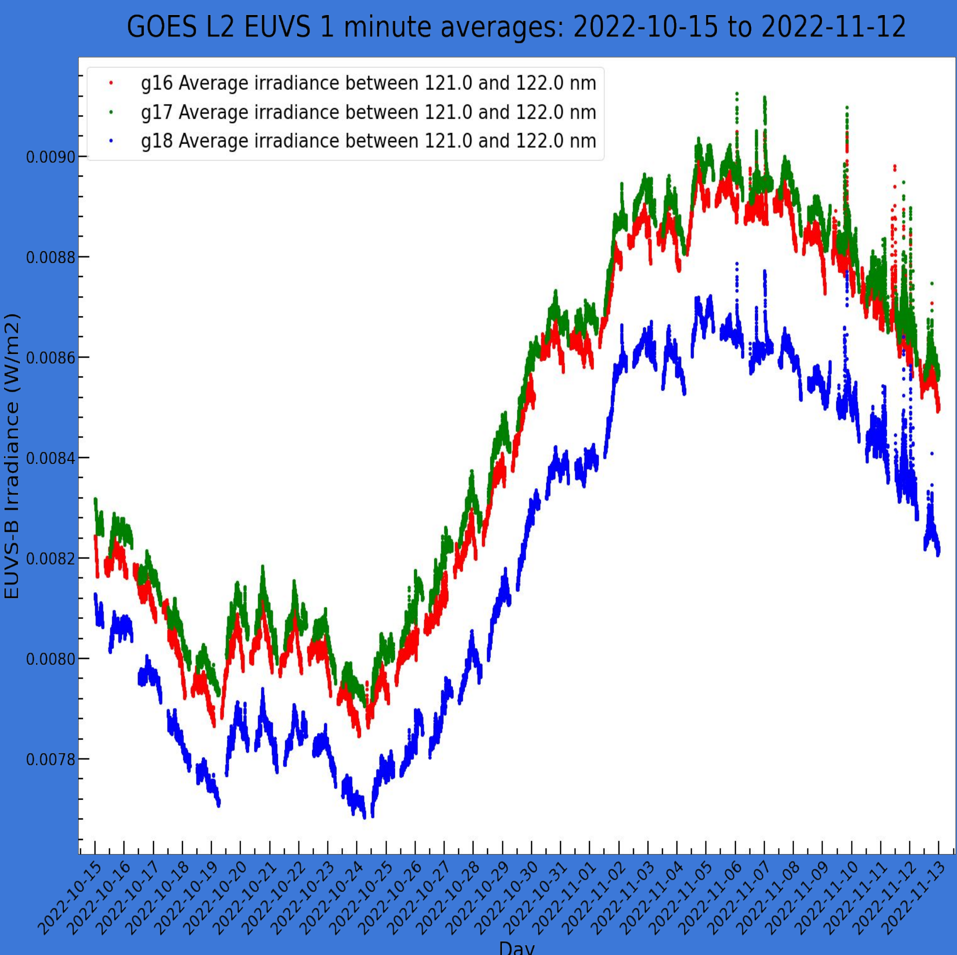
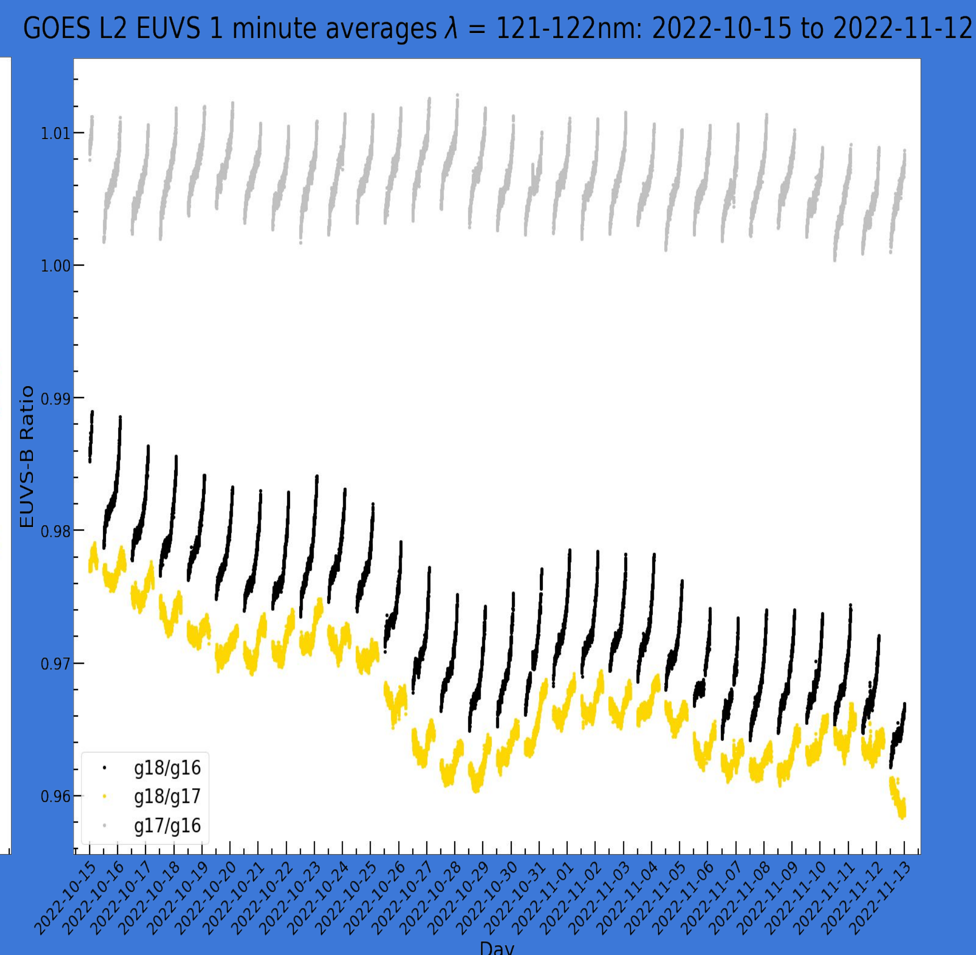
PLPT #14: EUVS/Mg II Inter-Satellite Comparisons

- EUVS-A: 121.6 nm, scaled to 1 nm. G18 shows 1% variability relative to G16 and G17.
- Data taken in the geocorona is excluded from these plots. The systematic effect in the ratio plot is due to the difference in satellite orbit locations. G17 and G18 are in the west orbital position, and G16 is in the east orbital position. The geocorona gaps are offset in time.





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.

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

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

EXIS Calibrations

Name	Priority	Schedule / repeat	Instrument	Affects LUT?	NCEI Handover?
Bundle HDF5 files for delivery	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 (consider checking every 3 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 cals)	EUVS-A	Yes	Yes
EUVS-B gain	Low	6 months (weekly cals)	EUVS-B	Yes	Yes
XRS gain	Low	Annually (quarterly cals)	XRS	Yes	Yes
SPS gain	Low	Annually (quarterly cals)	SPS	Yes	Yes
SPS darks	Low	Annually (eclipses)	SPS	Yes	Yes
Science packet telemetry trending	Low	Weekly	All	No	No
XRS darks	Medium	Quarterly (off-point)/6 months for eclipse season.	XRS	Yes	No
XRS inter-satellite flare peak comparisons	Low	6 months	XRS	No	No
EUVS-C particle filtering	Low	As needed	EUVS-C	No	No
Cruciform	Low	Quarterly	All	No	No

Current EUVS LUTs

GOES-16

EUVSA_Cal_INR(FM1A_CDRL79RevP_PR_09_08_36)
EUVSB_Cal_INR(FM1A_CDRL79RevP_PR_09_08_36)
EUVSC_Cal_INR(FM1A_CDRL79RevM_PR_09_08_01)
EUVSPEC_Cal_INR(FM1A_CDRL79RevJ_DO_10_01_00)
Yearly_1AU_Correction_Table(2022)

GOES-17

EUVSA_Cal_INR(FM2A_CDRL79RevN_PR_09_08_36)
EUVSB_Cal_INR(FM2A_CDRL79RevN_PR_09_08_36)
EUVSC_Cal_INR(FM2A_CDRL79RevK_PR_09_08_01)
EUVSPEC_Cal_INR(FM2A_CDRL79RevH_DO_10_01_00)
Yearly_1AU_Correction_Table(2022)

GOES-18

EUVSA_Cal_INR(FM3A_CDRL79revC_PR_09_08_37)
EUVSB_Cal_INR(FM3A_CDRL79revC_PR_09_08_37)
EUVSC_Cal_INR(FM3A_CDRL79revC_PR_09_08_37)
EUVSPEC_Cal_INR(FM3A_CDRL79revC_PR_09_08_37)
Yearly_1AU_Correction_Table(2022)