Protocol of the solar UV intercomparison at PMOD/WRC, Davos, Switzerland from August 19 to August 27, 2024, with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Gregor Hülsen

Operator: Gregor Hülsen

The purpose of the visit was the comparison of spectral global solar irradiance measurements between the 10 spectrophotometers participating at the 19th Regional Brewer Calibration Center – Europe (RBCC-E) Campaign and the travel reference spectroradiometer QASUME. The measurement site is located at Davos; Latitude 46.82 N, Longitude 9.86 W and altitude 1585 m a.s.l.
The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 6:00 UT and 19:00 UT have been analysed.

QASUMEII was installed in the Garden of PMOD/WRC, in line to the Brewer spectrophotometers with the entrance optic of QASUMEII between 2 and 10 m away from the other instruments. The measurement campaign lasted ten days. UV measurements were acquired from noon of August 21 to the morning of August 29.

QASUMEII was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T16573 and T68523) were used to obtain an absolute spectral irradiance calibration traceable to the primary reference held at PMOD/WRC, which is traceable to PTB. The daily mean responsivity of the instrument based on these calibrations varied by less than 1 % during the intercomparison period.
The wavelength shifts relative to the QASUMEFTS (Gröbner et al., 2017) spectrum as retrieved from the MatSHIC analysis were between ±50 pm in the spectral range 290 to 400 nm.

Table 1: Participating Brewer spectrophotometers; 3 single and 7 double monochromators.

Instrument ID	Institution	Operator	Country
#040-MKII	PMOD/WRC	Franz Zeilinger	Switzerland
#072-MKII	PMOD/WRC	Franz Zeilinger	Switzerland
#093-MKIV	BOKU Wien	Daniel Rauter	Austria
#156-MKIII	PMOD/WRC	Franz Zeilinger	Switzerland
#158-MKIII	Kipp & Zonen	Pavel Babal	The Netherland
#163-MKIII (ISQ)	PMOD/WRC	Julian Gröbner	Switzerland
#185-MKIII (IZ3)	AEMET IZAÑA	Alberto Redondas	Spain
#226-MKIII	DWD Hohenpeissenberg	Voltaire Velazco	Germany
#245-MKIII	Kipp & Zonen	Pavel Babal	The Netherland
#258-MKIII	AEMET IZAÑA	Alberto Redondas	Spain

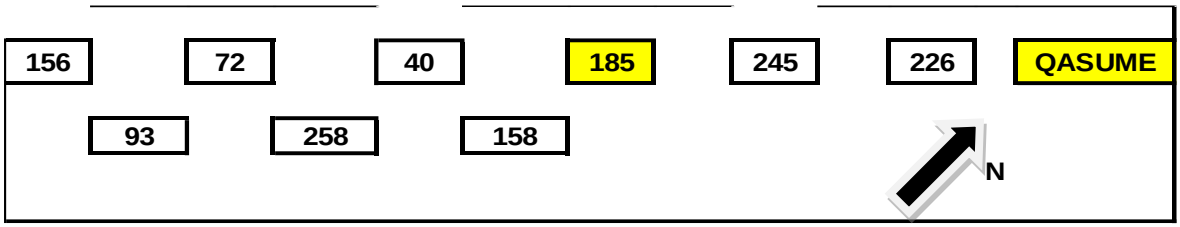


Figure 1: Setup at PMOD/WRC in the garden measurement field.
Brewer 163 is installed on the roof of the PMOD/WRC building.
Brewer 40, 72 and 156 from Meteoswiss are not recording any UV measurements.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 to 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.
The official UV days were scheduled from 23 to 27 August. However, UV scans were performed throughout the campaign.

DOY	Date	DAY	Weather	Comment (time in UT)
234	21-Aug	Wednesday	Mix of sun & clouds	Installed at 07:00
235	22-Aug	Thursday	Mix of sun & clouds	
236	23-Aug	Friday	Mostly clear sky	
237	24-Aug	Saturday	Mostly clear sky	
238	25-Aug	Sunday	Diffuse sky	
239	26-Aug	Monday	Diffuse sky	Calibrated: 11:50 using T16573
				Calibrated: 12:15 using T68523
240	27-Aug	Tuesday	Clear sky (morning)	
			Mix of sun & clouds	
241	28-Aug	Wednesday	Clear sky (morning)	Calibrated: 07:10 using T68523
			Mix of sun & clouds	
242	29-Aug	Thursday	Clear sky (morning)	
			Mix of sun & clouds	End of Campaign 07:30

Results:

Up to 62 synchronised simultaneous spectra from QASUMEII and the Brewer spectrophotometers are available from the measurement period. Measurements between 6:30 and 18:00 UT have been analysed (SZA smaller than 90°) using matSHIC.

Remarks:

The comparison between the Brewers and QASUME was very successful, and consistent with the results obtained in previous visits (see Figure 2-X of the Annex).
No UV data is available for Brewer 226 (DWD).

Data Processing:

- The data from Brewers 163 were processed by the responsible operator.
- The data from Brewers 93, 226 and 245 were processed with Eubrewnet Level 1.5.
- The data from Brewers 158, 185 and 258 were processed with Eubrewnet Level 2 (cosine correction & matshic).

More information can be found here:
https://eubrewnet.aemet.es/dokuwiki/doku.php?id=codes:uvaccess

https://eubrewnet.aemet.es/dokuwiki/doku.php?id=codes:uvaccess#process_uvl1

https://eubrewnet.aemet.es/dokuwiki/doku.php?id=codes:uvaccess#uv_corrections_flag

https://drive.google.com/file/d/1RitZadF38CQhpnoA3vFugaHFSlaDys4p/view?usp=sharing

https://drive.google.com/file/d/1ZaLHi5eGPvdadnCkE84Idp8_5V1I1B4Z/view?usp=sharing

Conclusion:

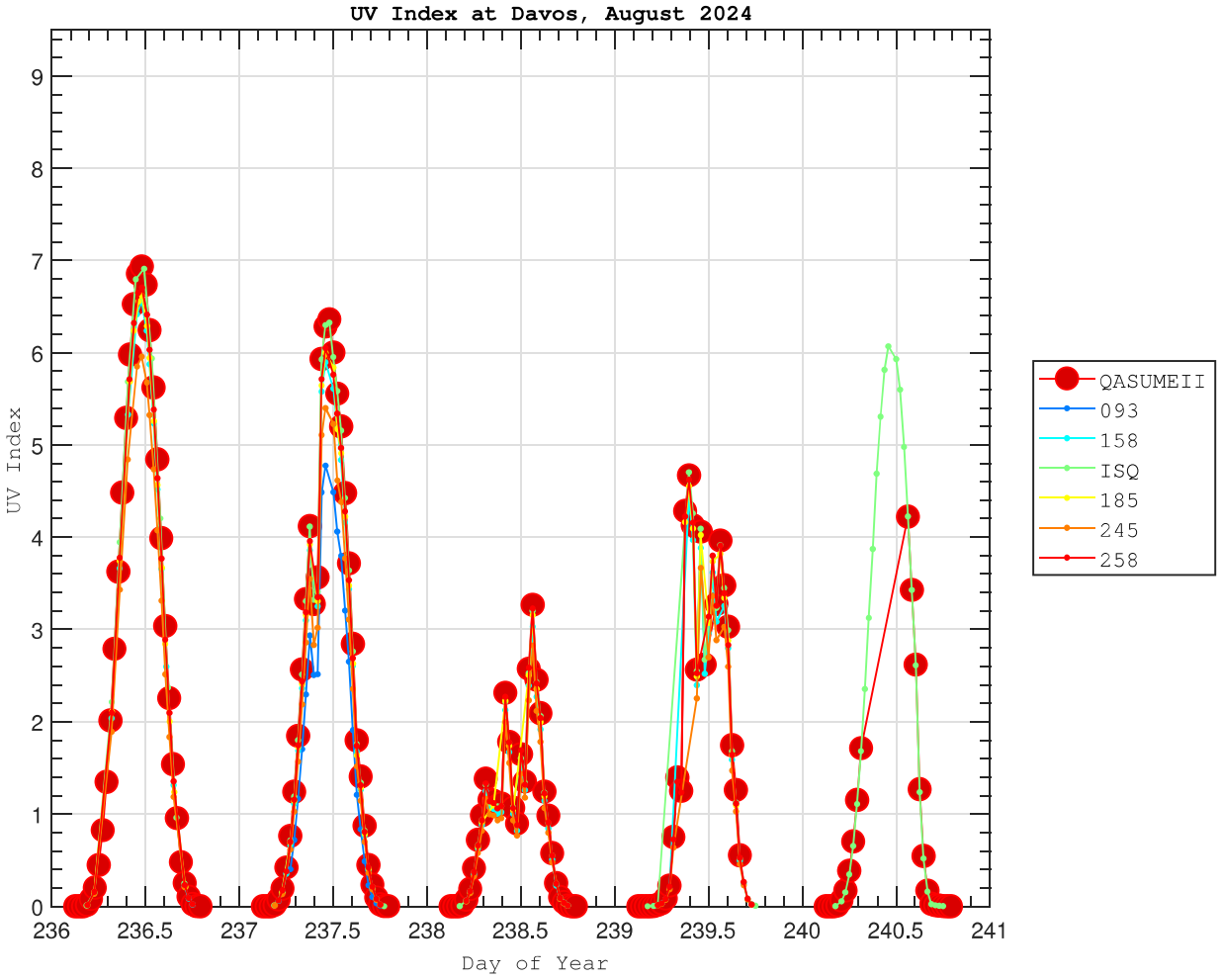
The angular response correction was applied to the solar UV spectra of 3 Brewer and show a considerably improvement to the comparison to QASUME. Remaining uncertainties are the stray-light for single monochromator brewers and the temperature dependence.

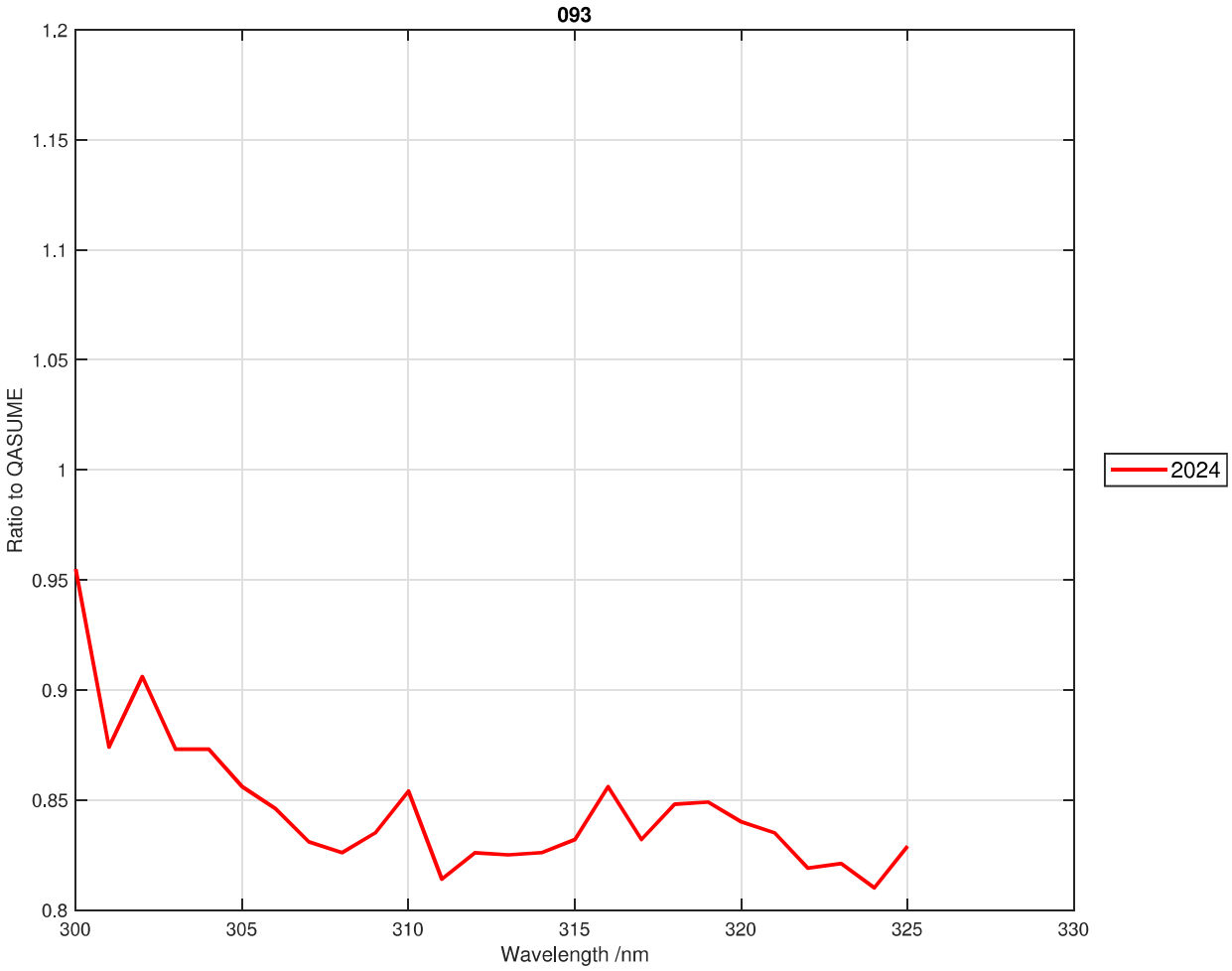
References:

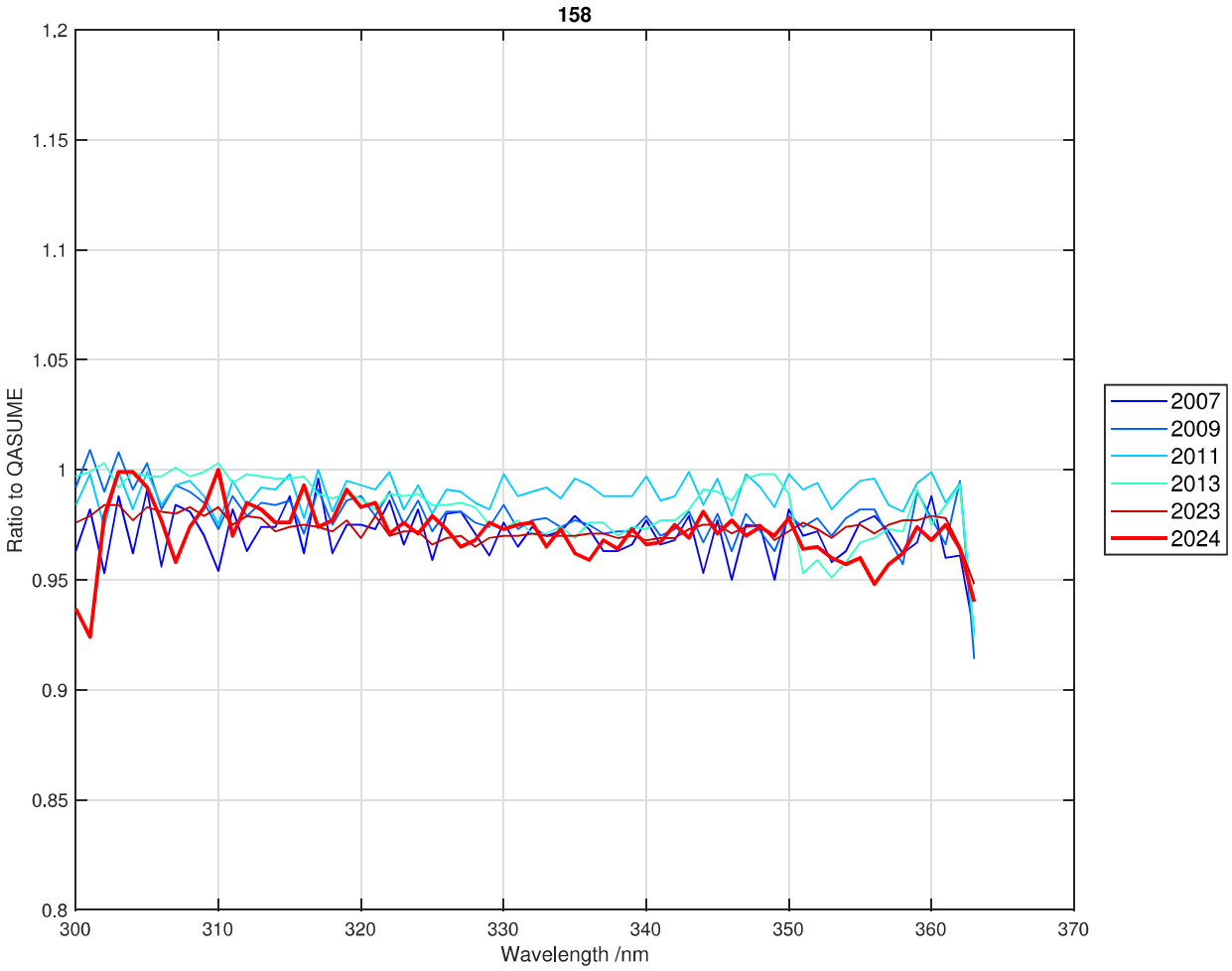
Gröbner, J., Kröger, I., Egli, L., Hülsen, G., Riechelmann, S., and Sperfeld, P.: The high-resolution extraterrestrial solar spectrum (QASUMEFTS) determined from ground-based solar irradiance measurements, Atmos. Meas. Tech., 10, 3375-3383, https://doi.org/10.5194/amt-10-3375-2017, 2017.

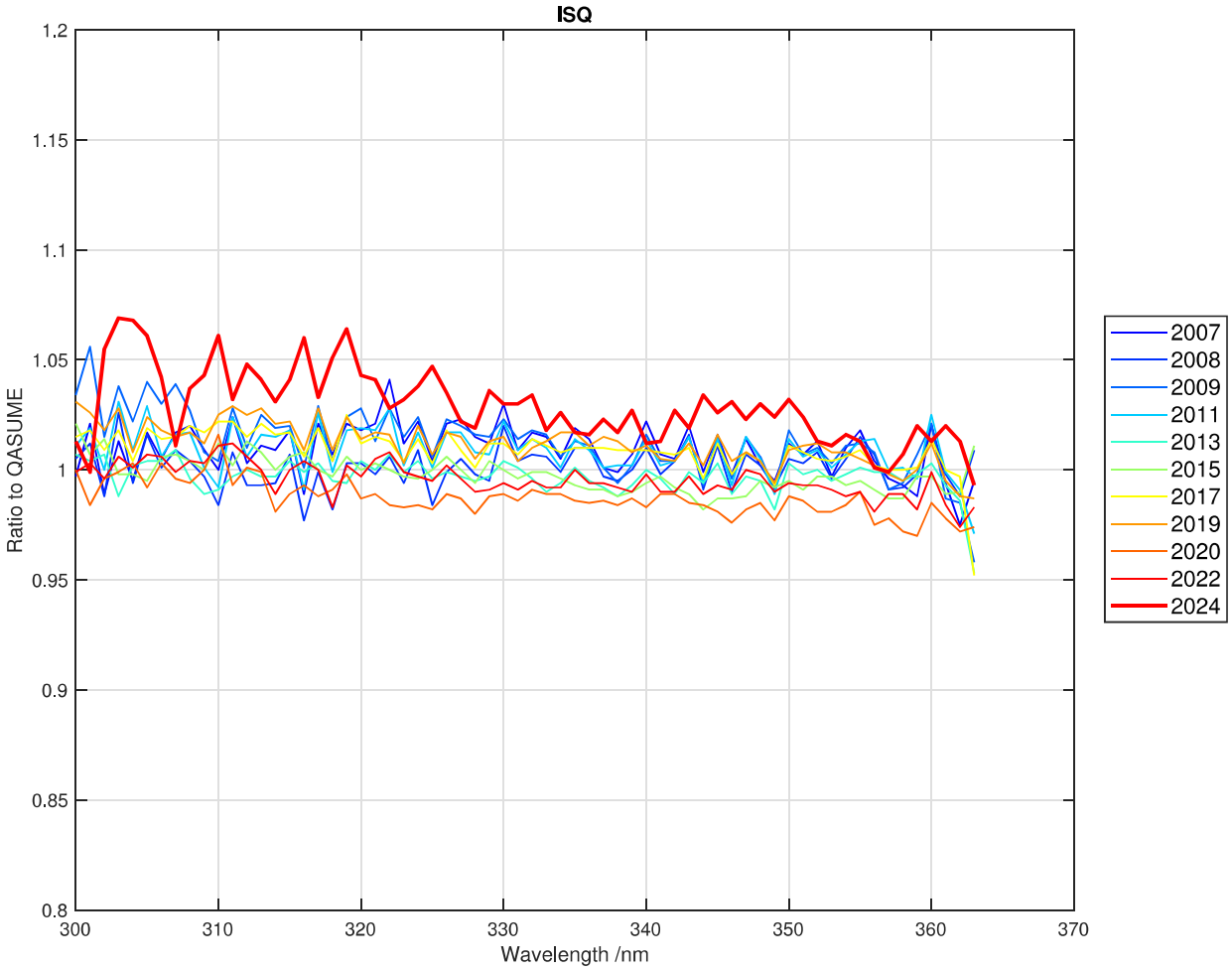
Appendix

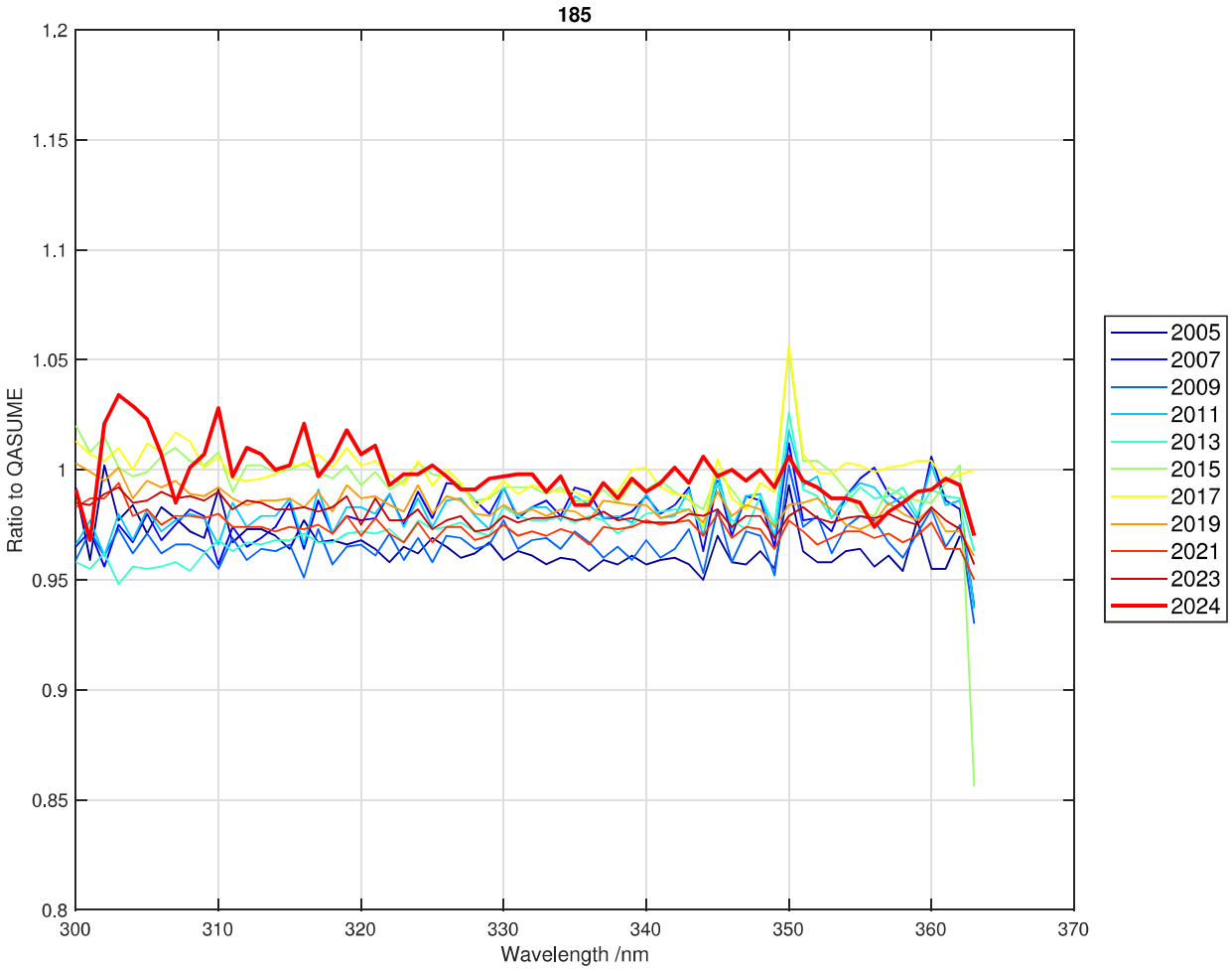
Detailed results for all Brewer spectrophotometers with respect to the reference spectroradiometer QASUME

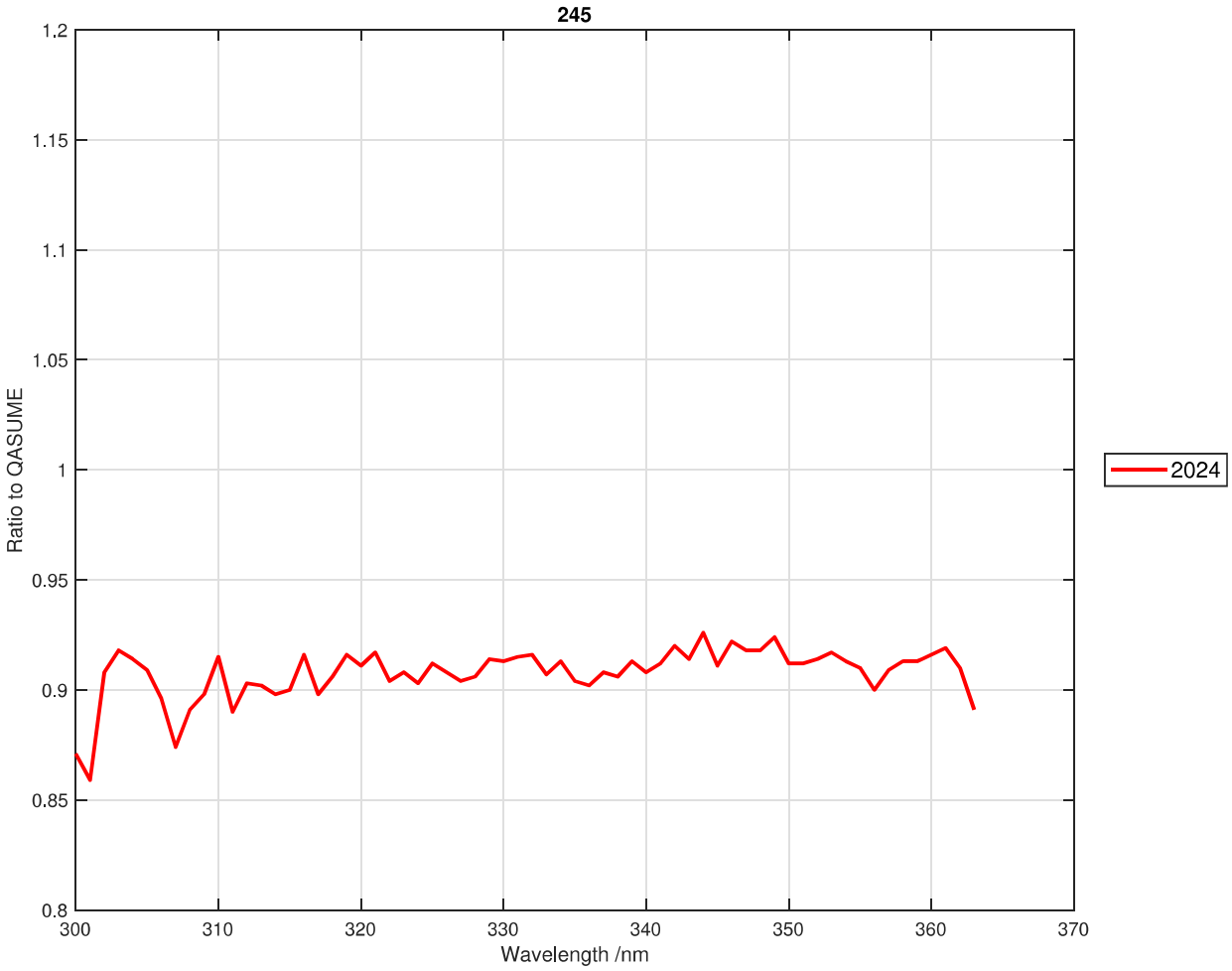

UV Index at Davos, August 2024
UV Index
Day of Year
0
1
2
3
4
5
6
7
8
9
236
236.5
237
237.5
238
238.5
239
239.5
240
240.5
241
QASUMEII
093
158
ISQ
185
245
258

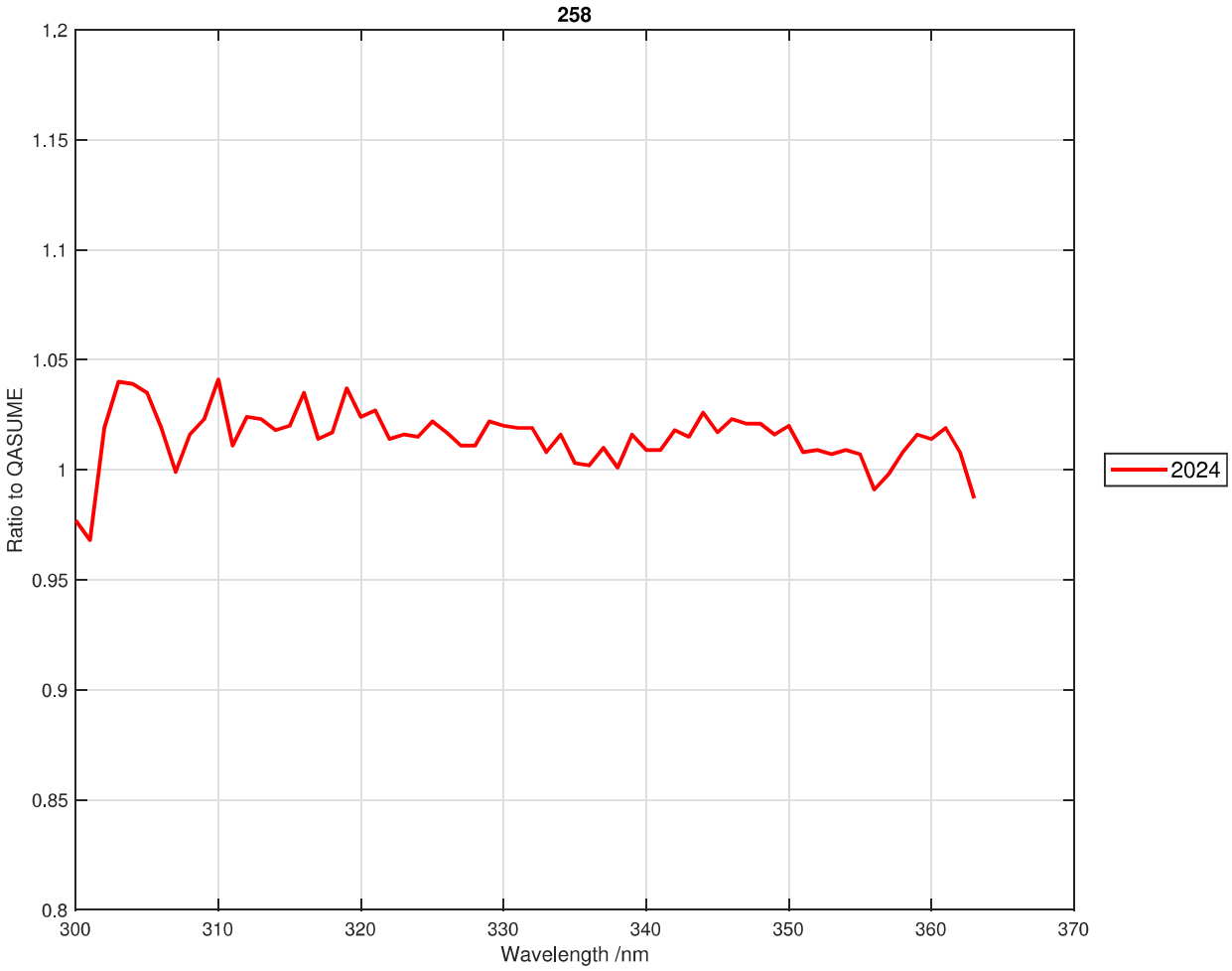

093
Ratio to QASUME
Wavelength /nm
2024

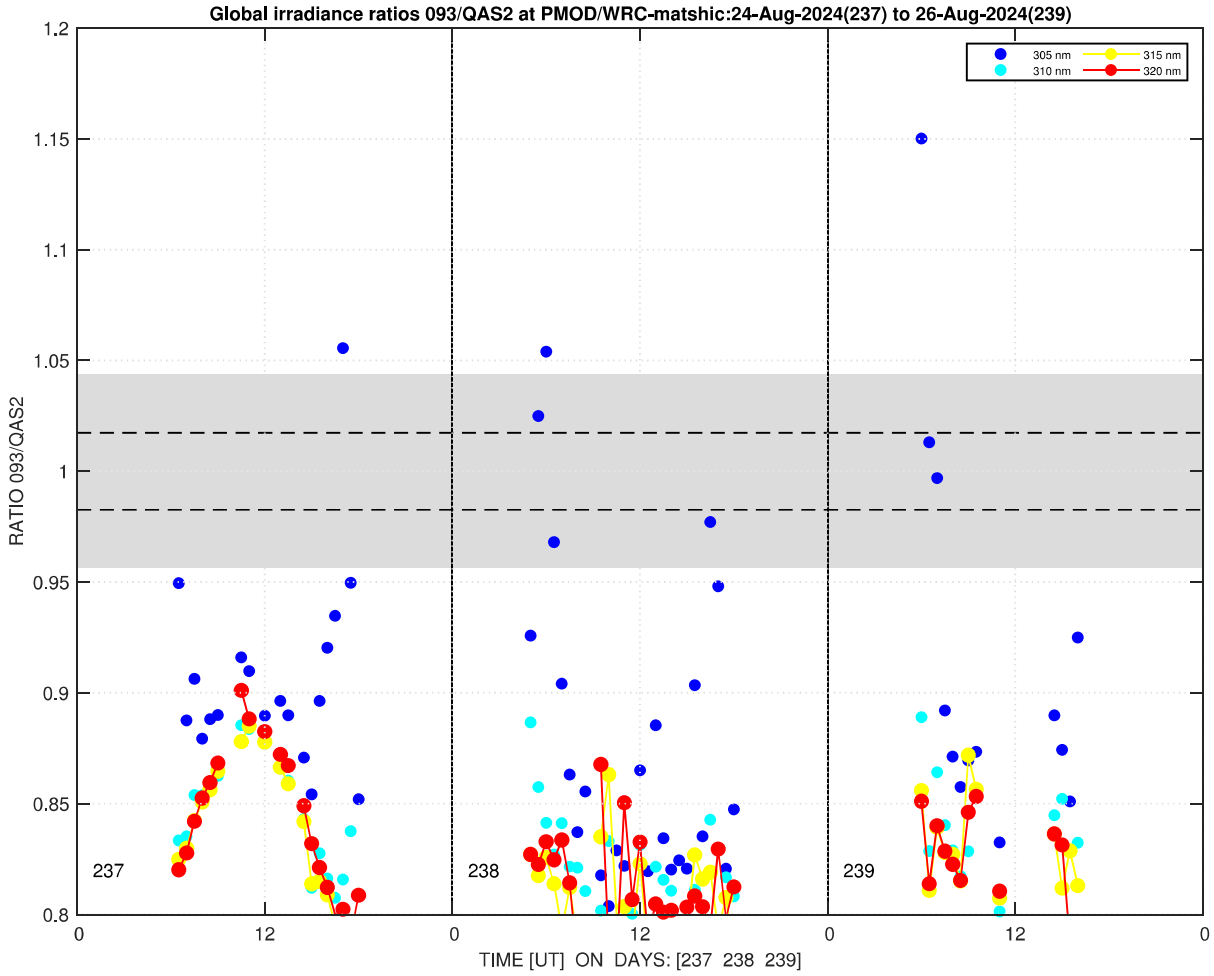

158
Ratio to QASUME
Wavelength /nm
2007
2009
2011
2013
2023
2024

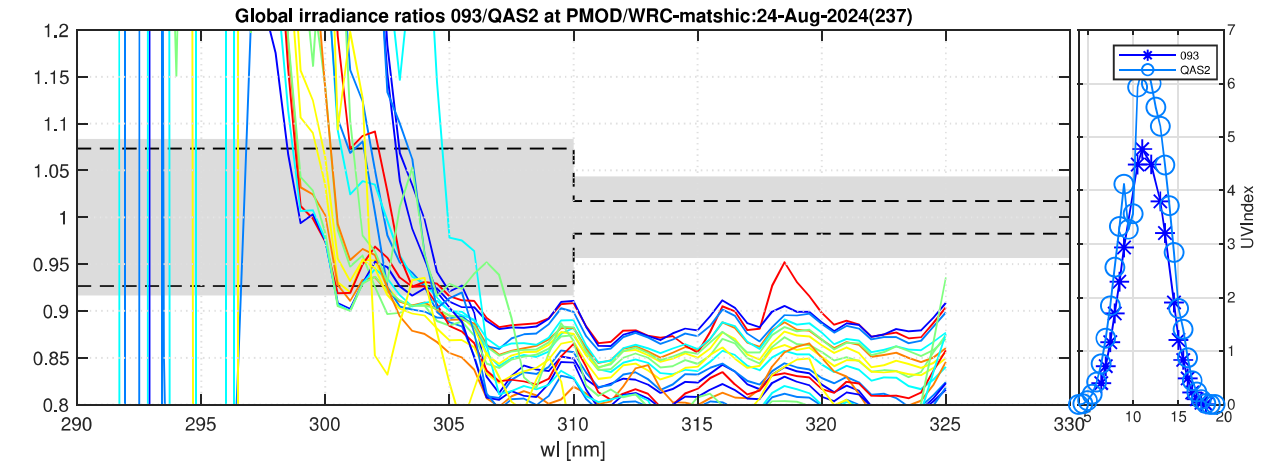

ISQ
Ratio to QASUME
Wavelength /nm
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370
2007
2008
2009
2011
2013
2015
2017
2019
2020
2022
2024

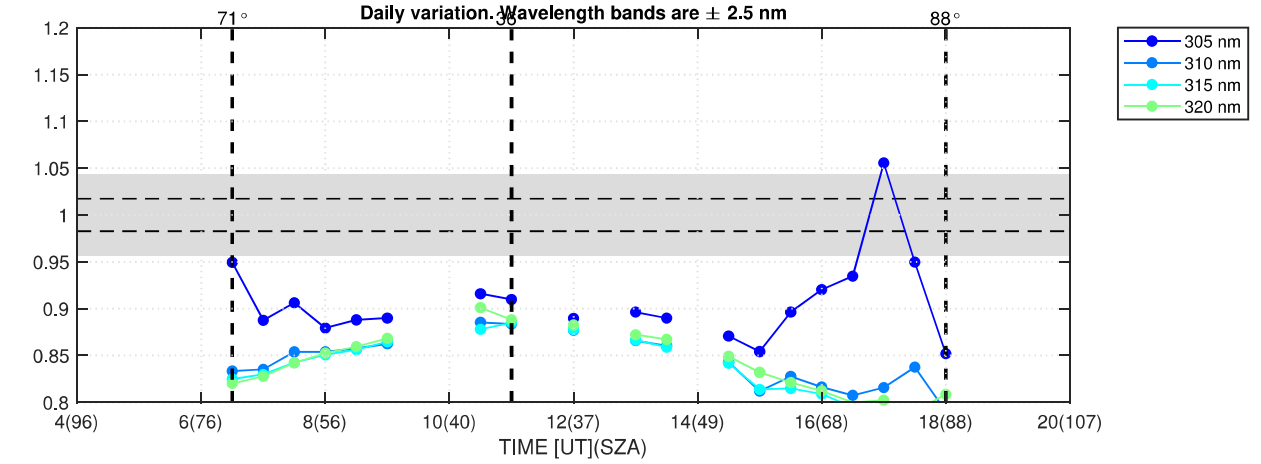

185
Ratio to QASUME
Wavelength /nm
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2024

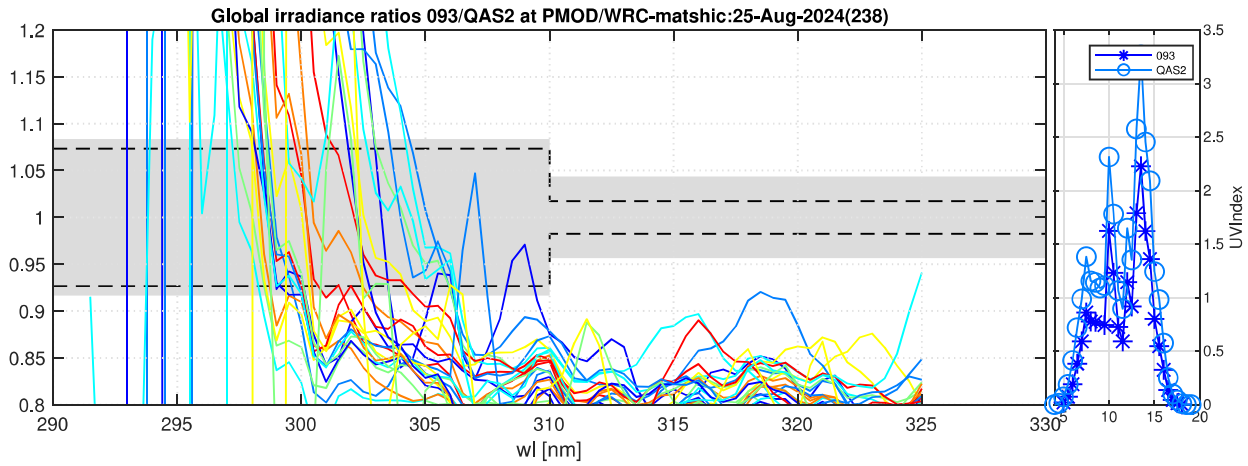

245
Ratio to QASUME
Wavelength /nm
2024
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370

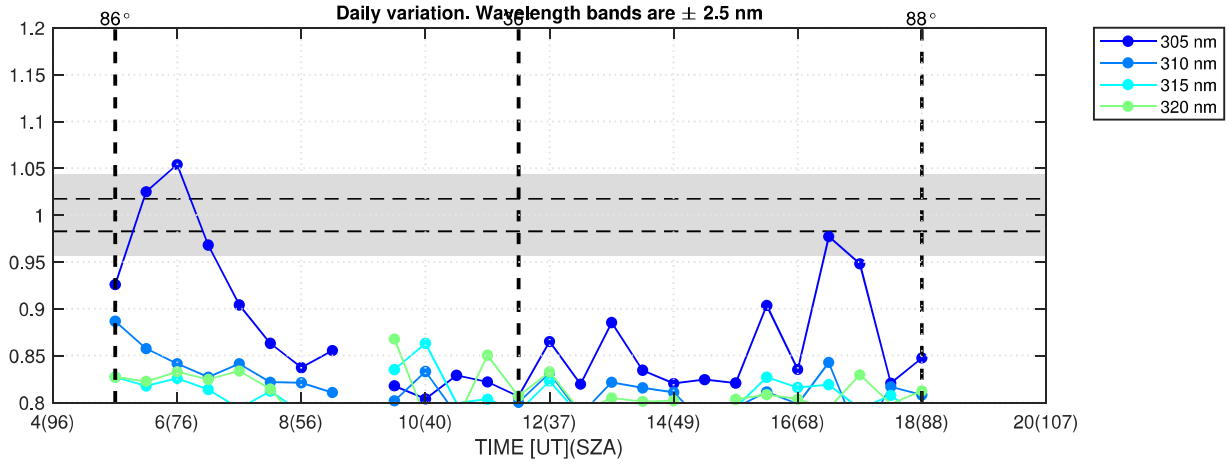

258
Ratio to QASUME
Wavelength /nm
2024
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370

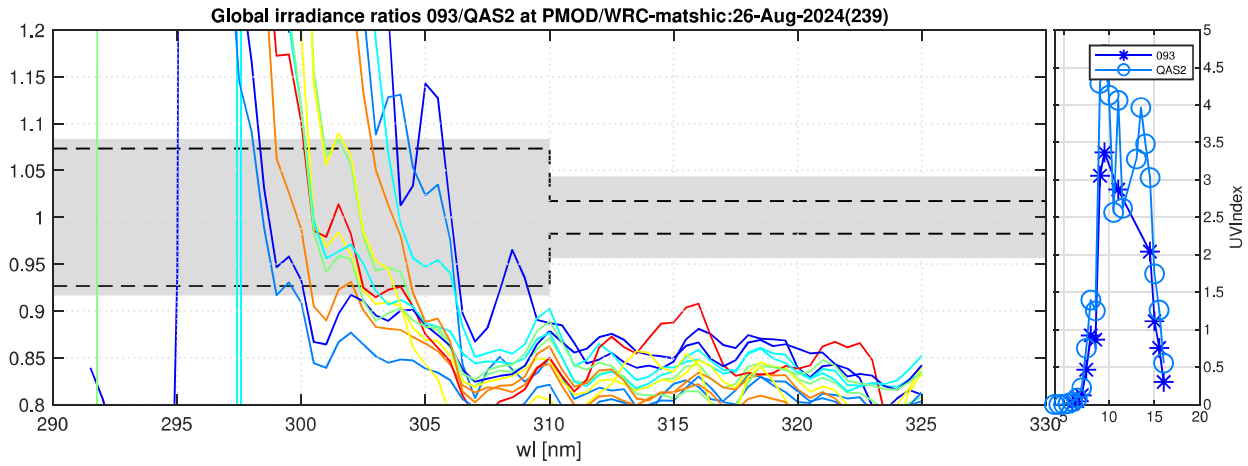

Global irradiance ratios 093/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237) to 26-Aug-2024(239)
305 nm
310 nm
315 nm
320 nm
RATIO 093/QAS2
237
238
239
TIME [UT] ON DAYS: [237 238 239]

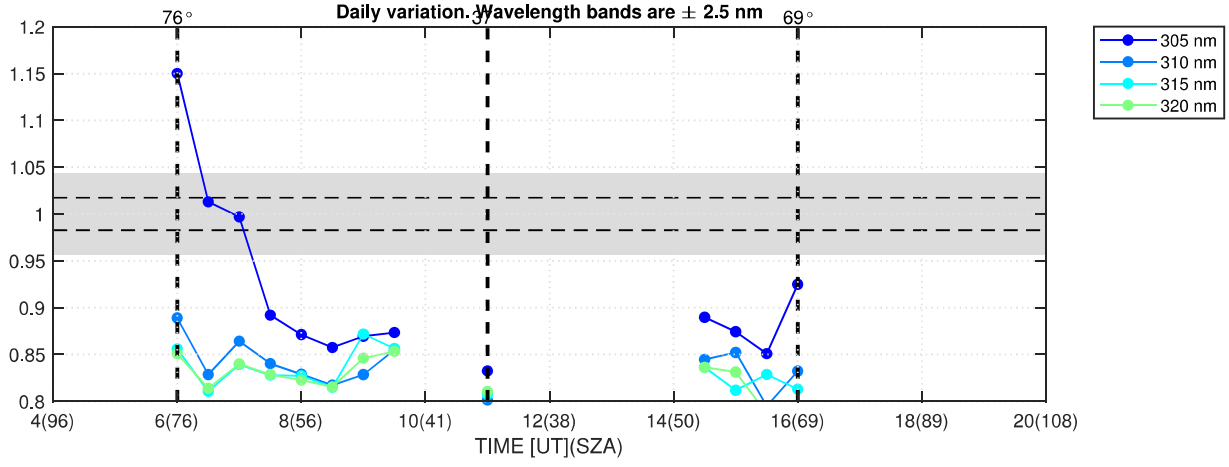

Global irradiance ratios 093/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
093
QAS2
UVIndex
wl [nm]

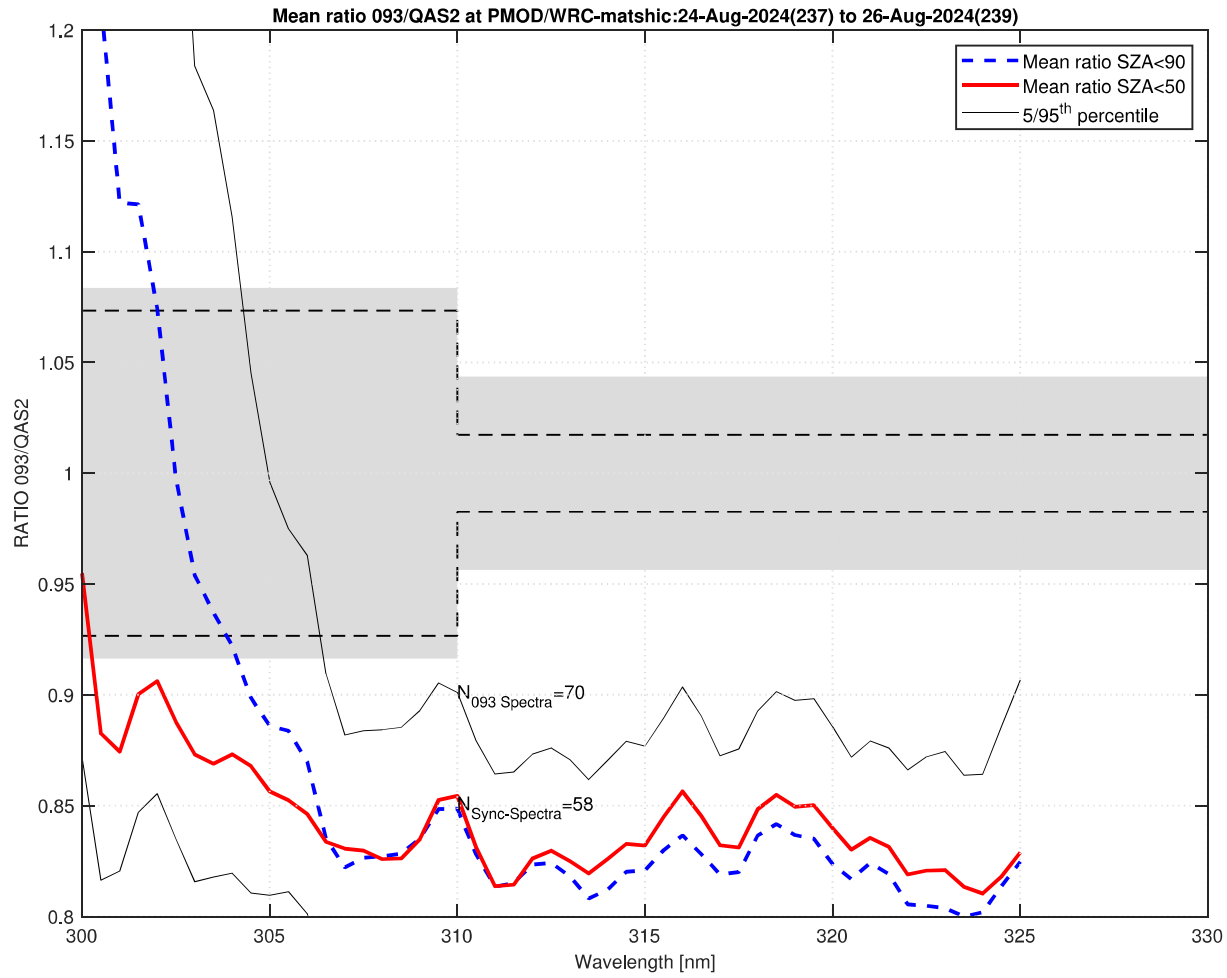

Daily variation. Wavelength bands are ± 2.5 nm
71°
88°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

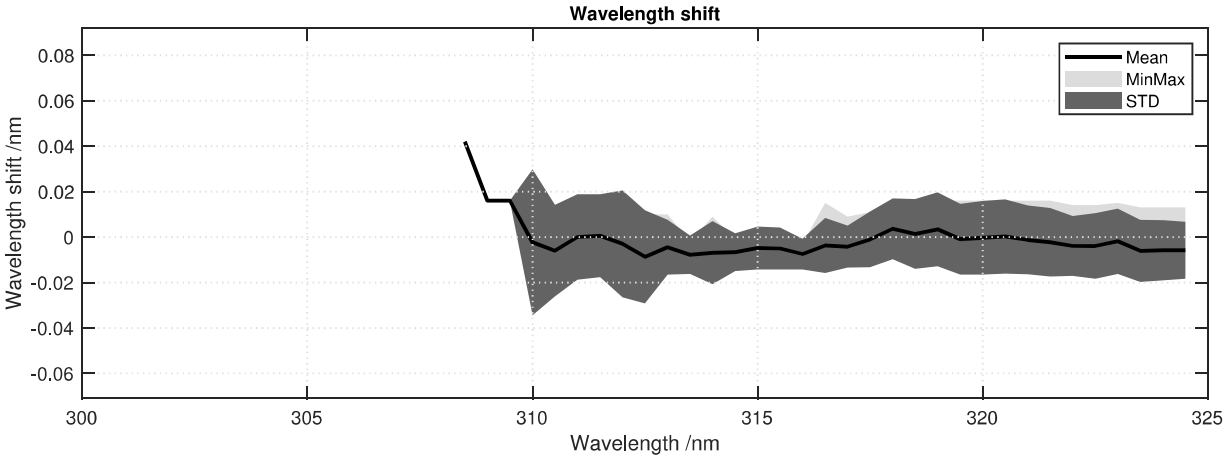

Global irradiance ratios 093/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
093
QAS2

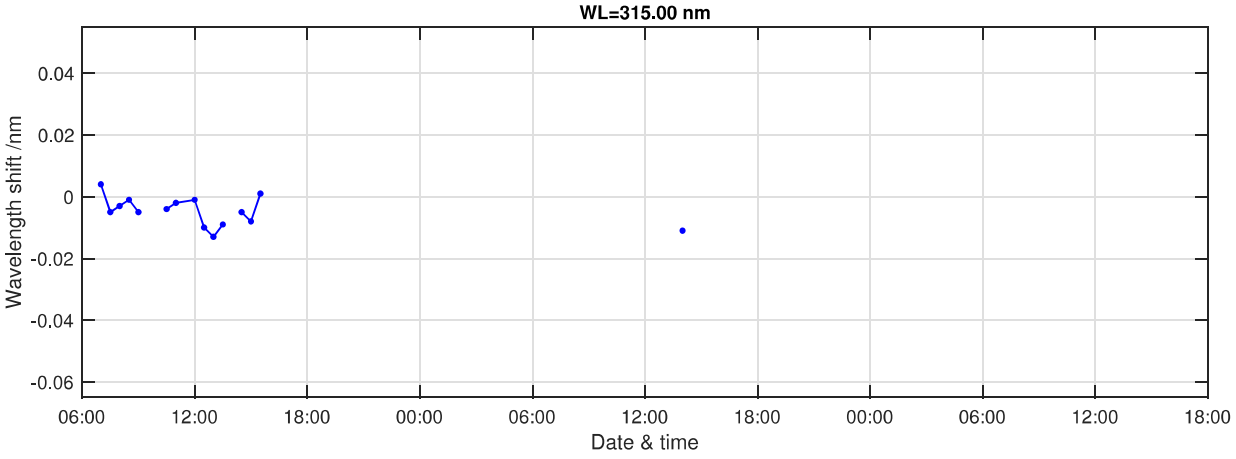

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
4(96)
6(76)
8(56)
10(40)
12(37)
14(49)
16(68)
18(88)
20(107)
305 nm
310 nm
315 nm
320 nm

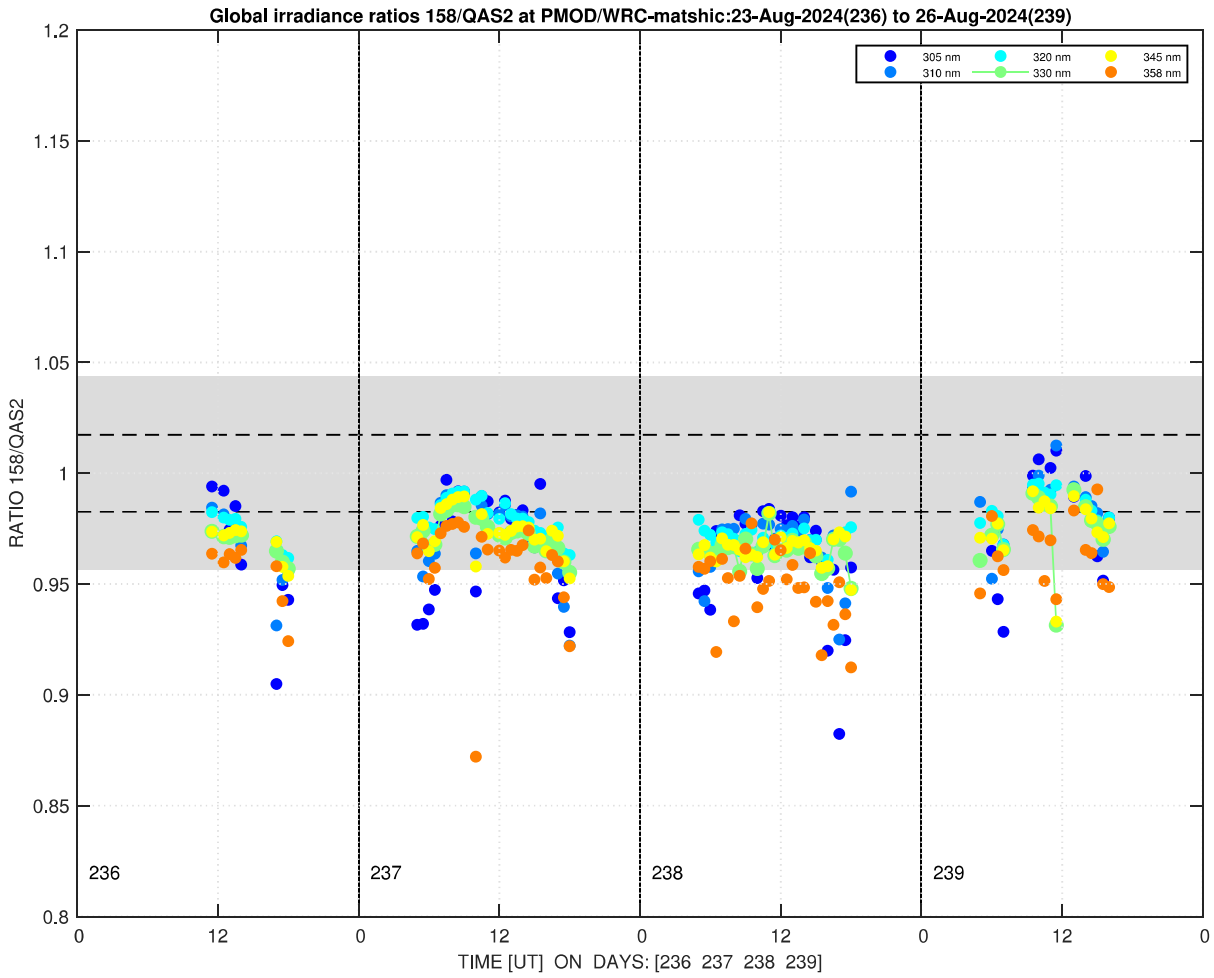

Global irradiance ratios 093/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
093
QAS2

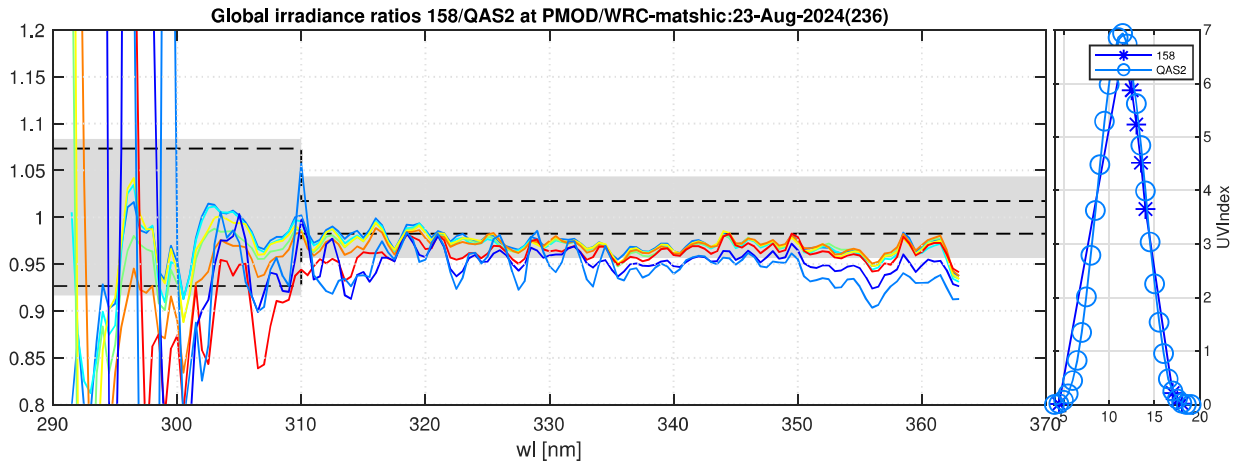

Daily variation. Wavelength bands are ± 2.5 nm
76°
69°
TIME [UT](SZA)
4(96)
6(76)
8(56)
10(41)
12(38)
14(50)
16(69)
18(89)
20(108)
305 nm
310 nm
315 nm
320 nm

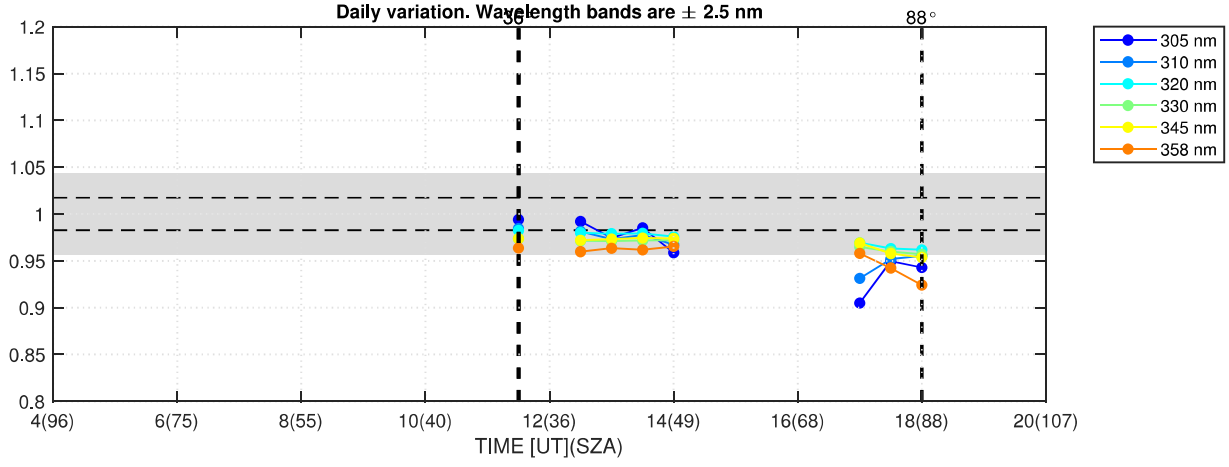

Mean ratio 093/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237) to 26-Aug-2024(239)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
RATIO 093/QAS2
N093 Spectra=70
NSync-Spectra=58
Wavelength [nm]

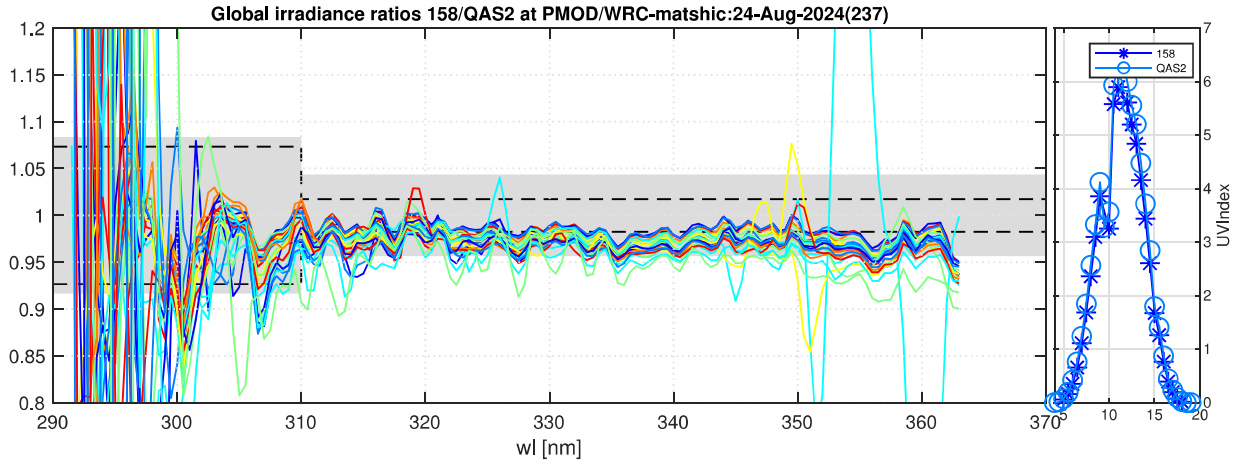

Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
Wavelength /nm

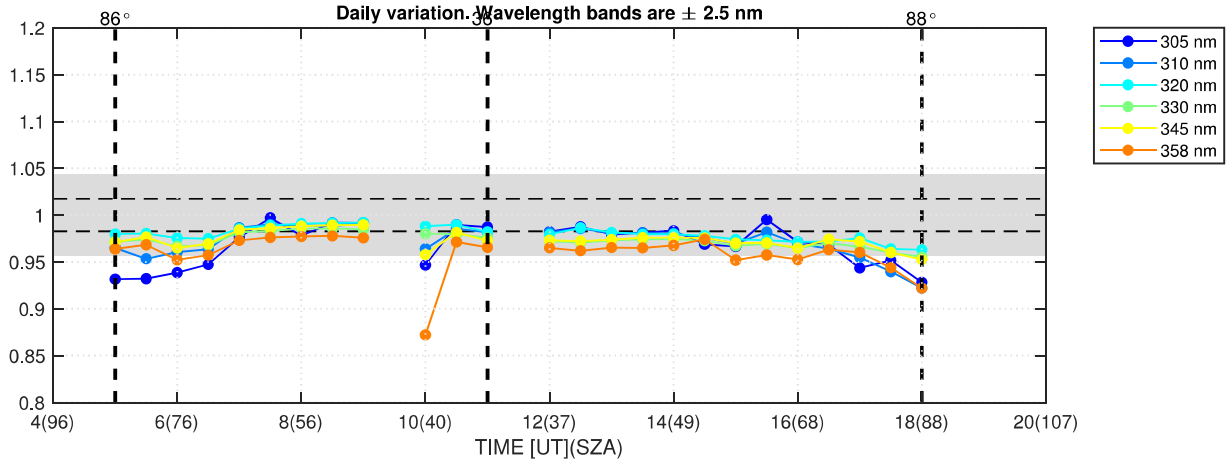

WL=315.00 nm
Wavelength shift /nm
Date & time

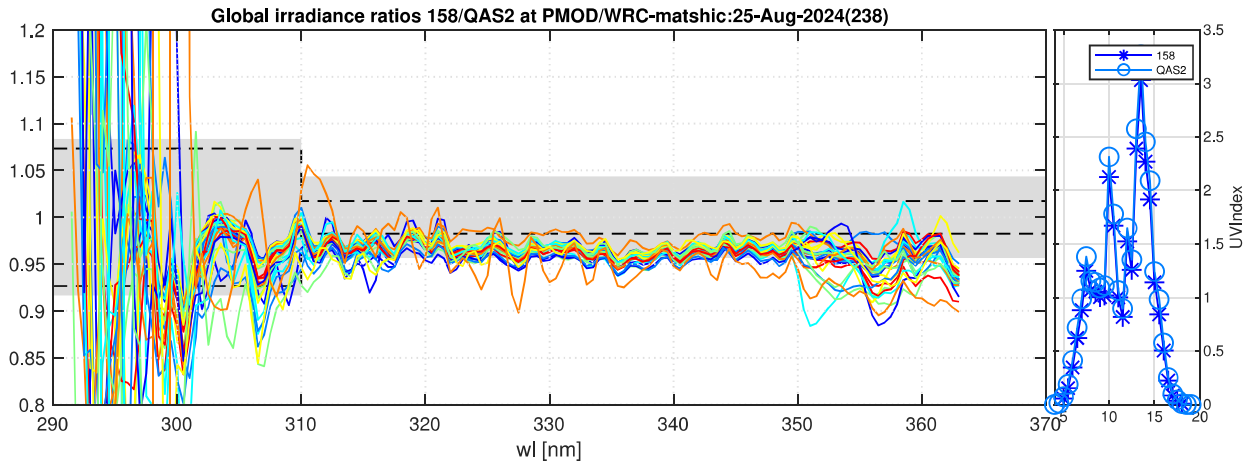

Global irradiance ratios 158/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO 158/QAS2
236
237
238
239
TIME [UT] ON DAYS: [236 237 238 239]

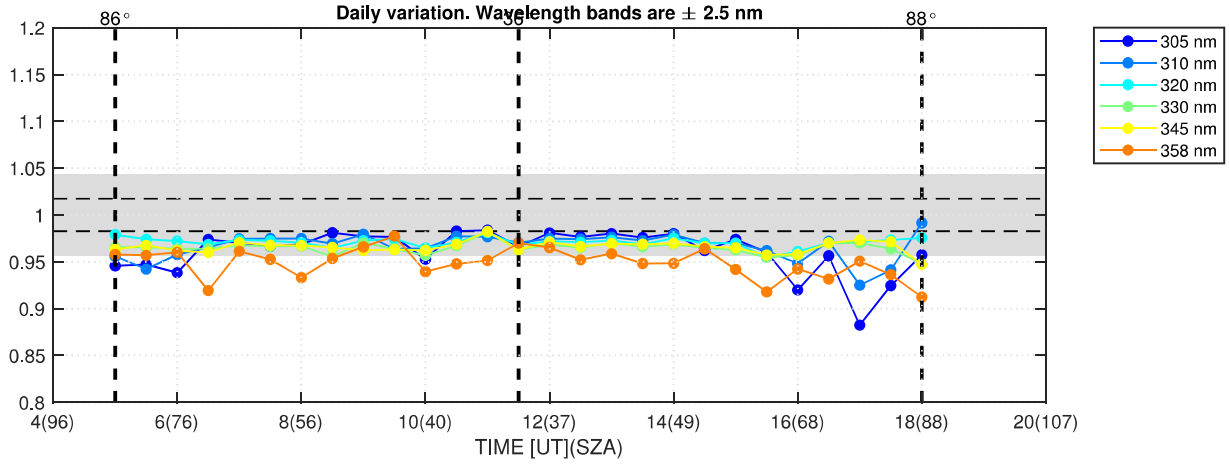

Global irradiance ratios 158/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236)
158
QAS2
UVIndex
wl [nm]

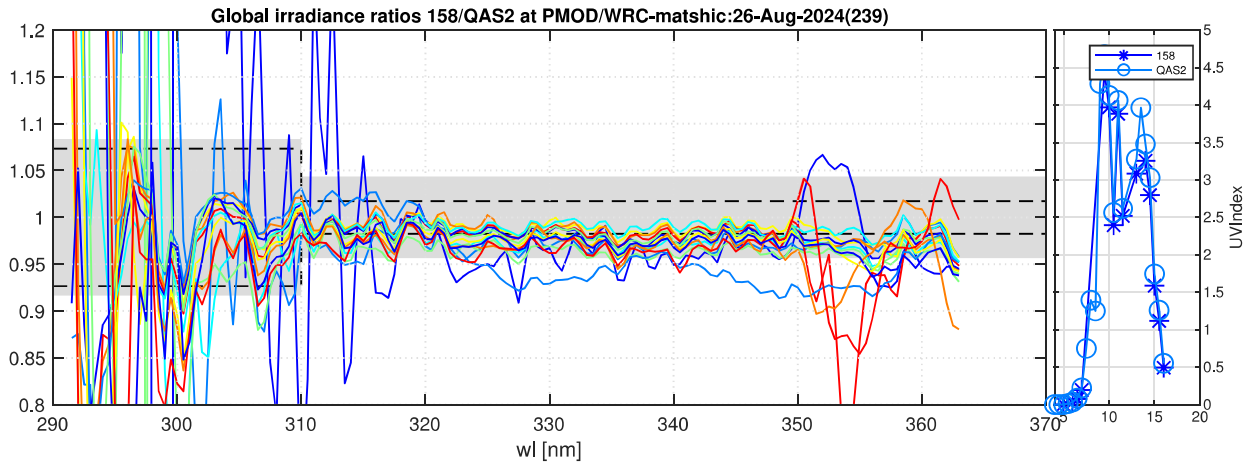

Daily variation. Wavelength bands are ± 2.5 nm
88°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

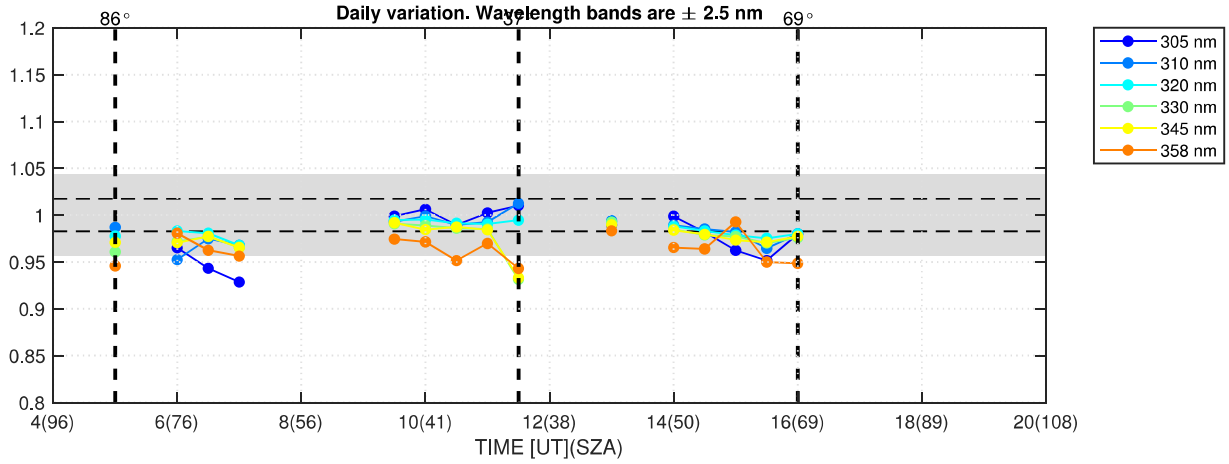

Global irradiance ratios 158/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
wl [nm]
UVIndex
158
QAS2

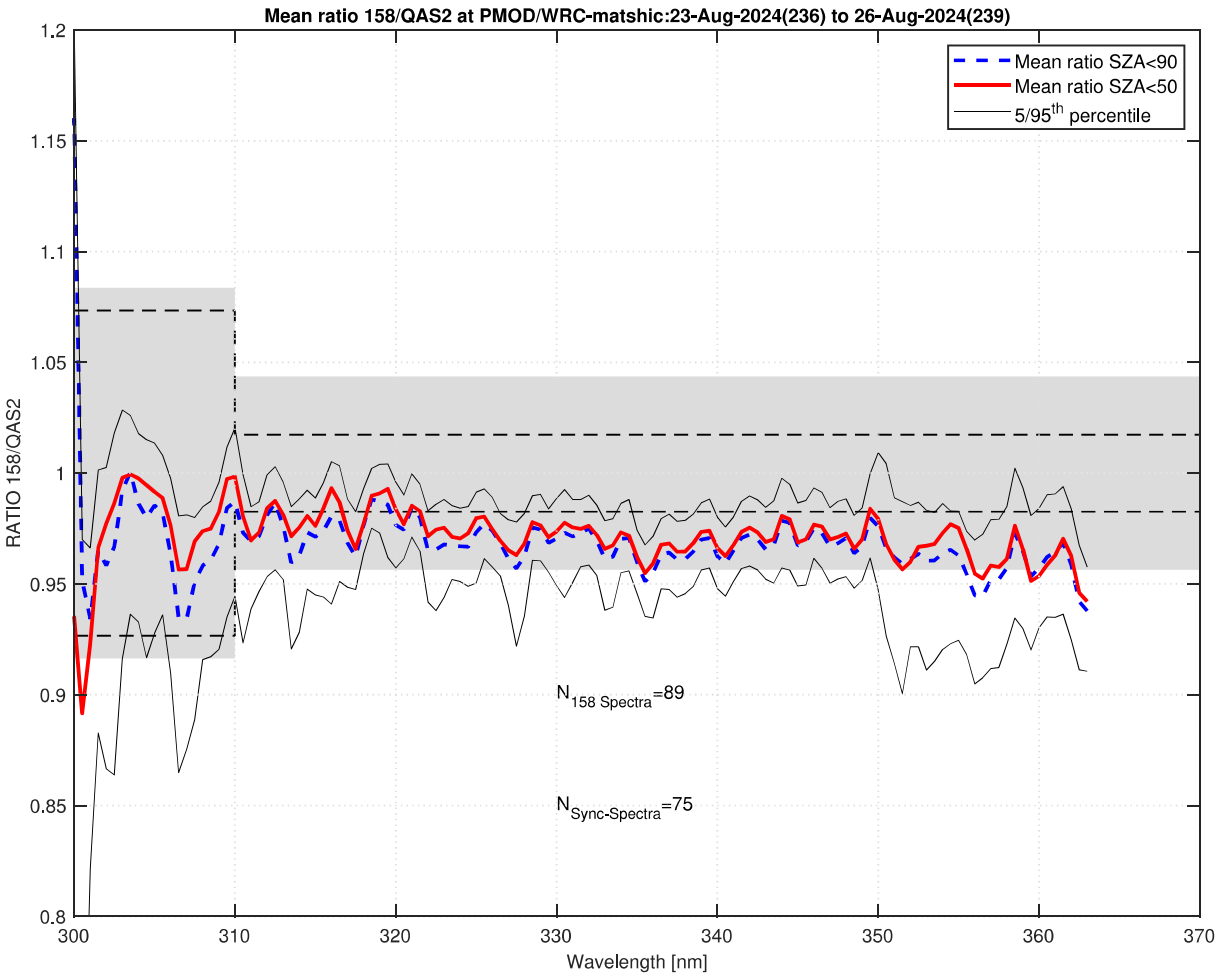

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

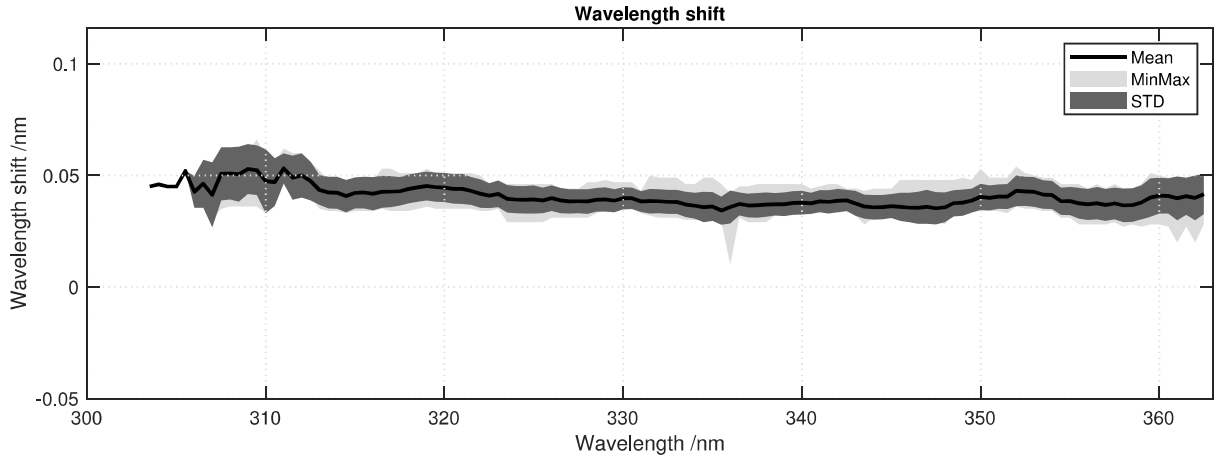

Global irradiance ratios 158/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
158
QAS2

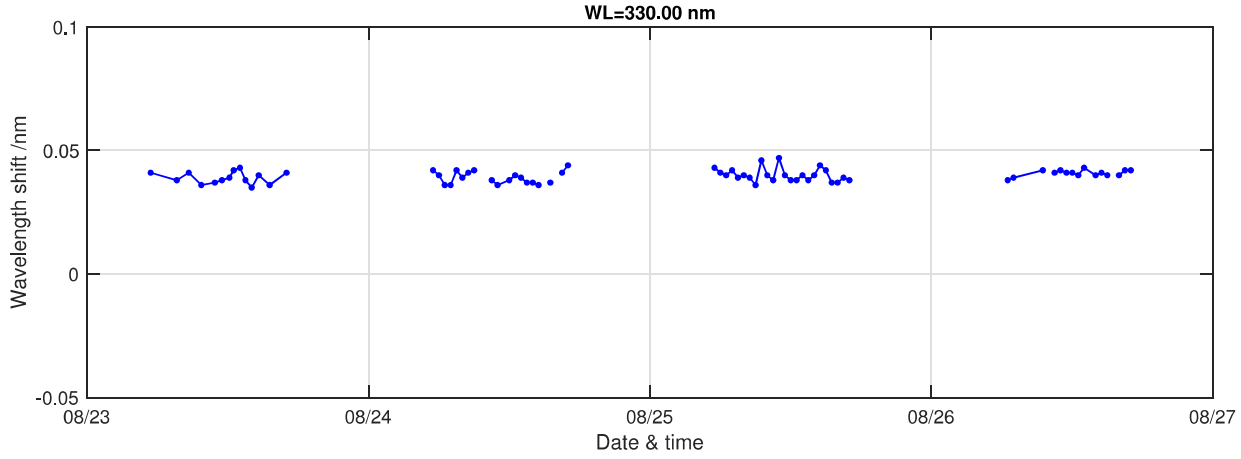

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

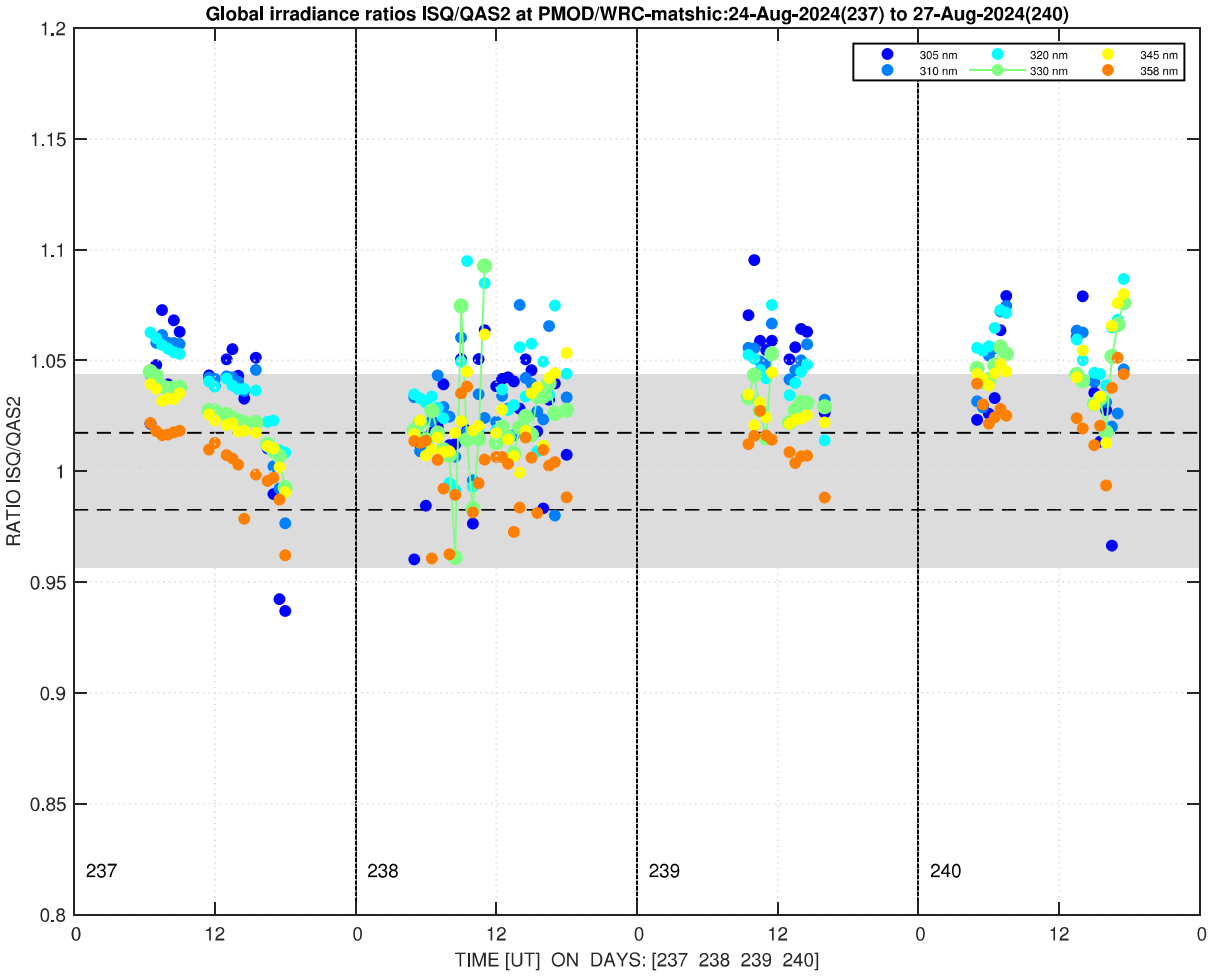

Global irradiance ratios 158/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
158
QAS2

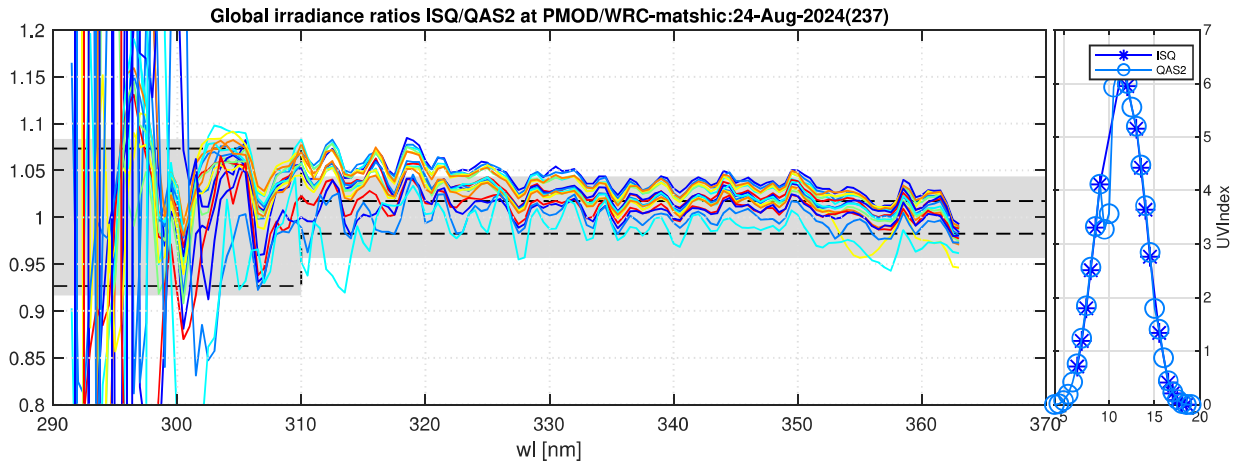

Daily variation. Wavelength bands are ± 2.5 nm
86°
37°
69°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

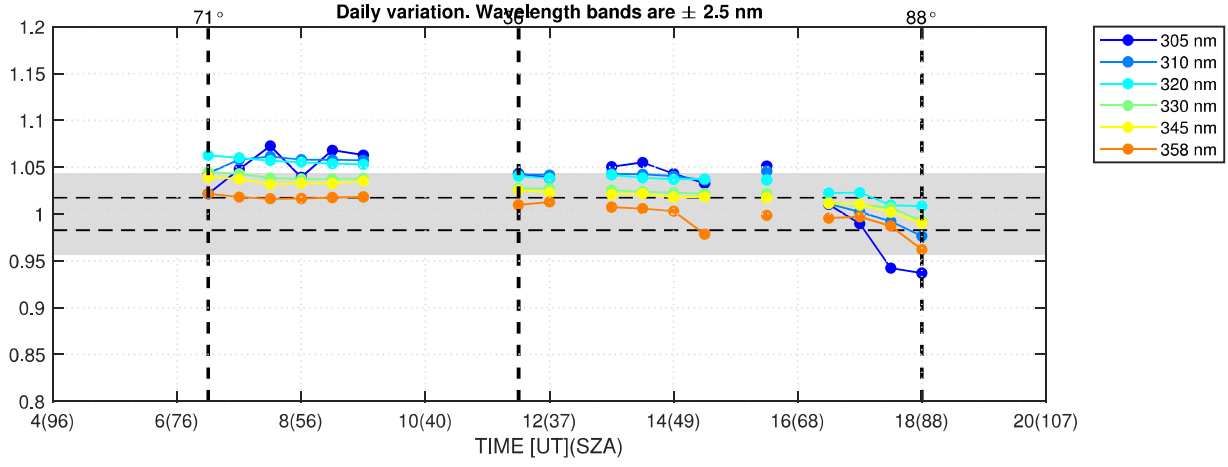

Mean ratio 158/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
RATIO 158/QAS2
Wavelength [nm]
N158 Spectra=89
NSync-Spectra=75

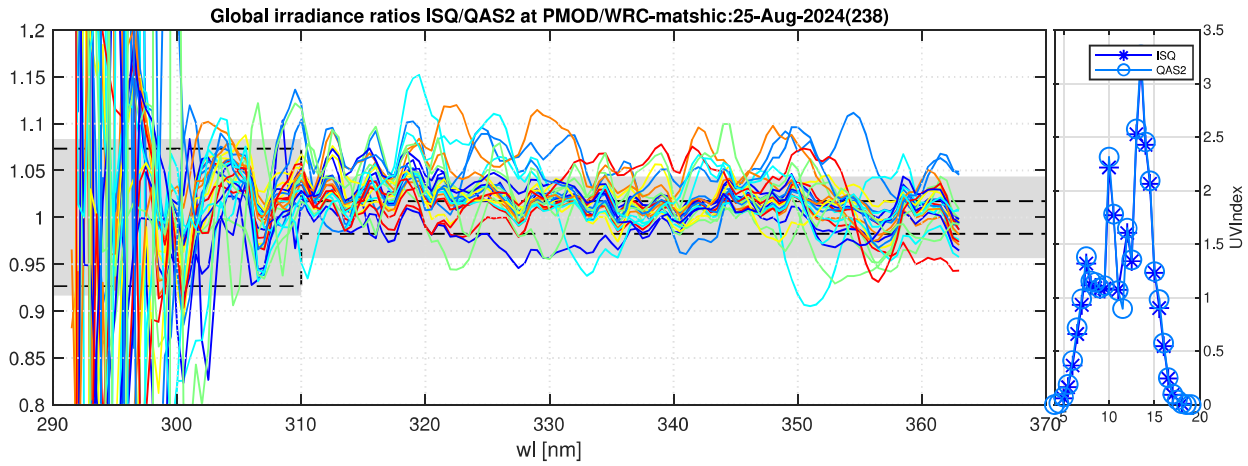

Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
0.1
0.05
0
-0.05
300
310
320
330
340
350
360
Wavelength /nm

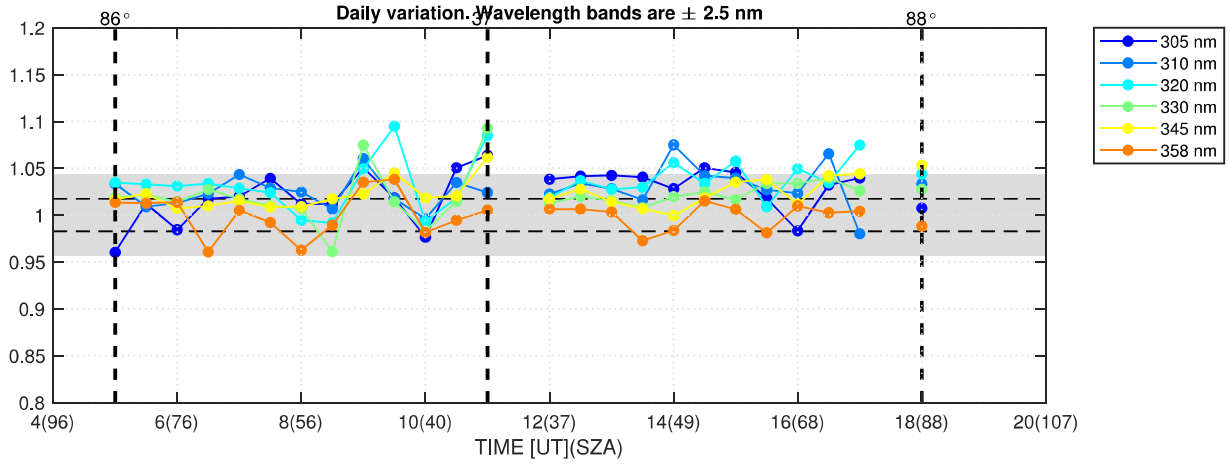

WL=330.00 nm
Wavelength shift /nm
0.1
0.05
0
-0.05
08/23
08/24
08/25
08/26
08/27
Date & time

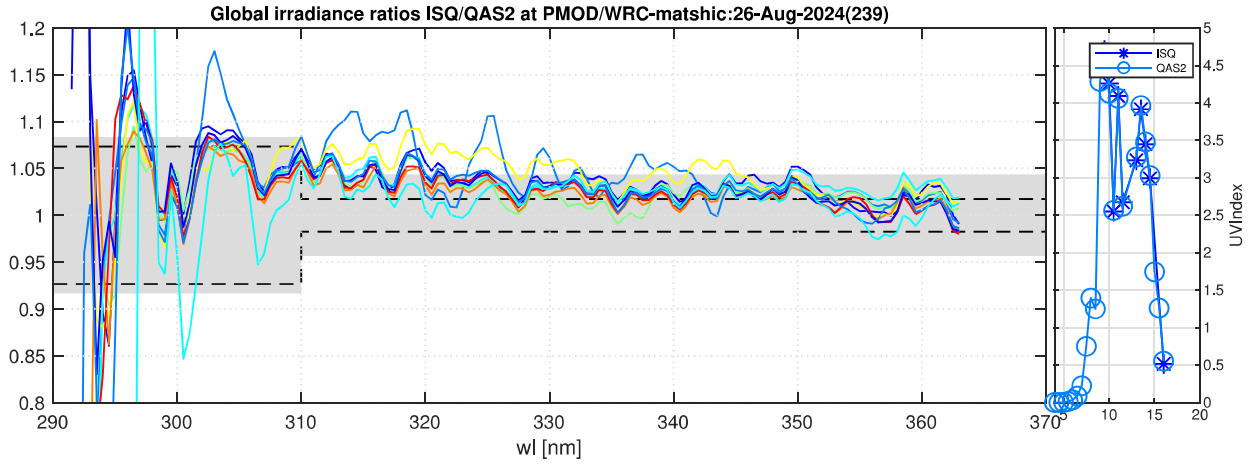

Global irradiance ratios ISQ/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237) to 27-Aug-2024(240)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO ISQ/QAS2
237
238
239
240
TIME [UT] ON DAYS: [237 238 239 240]

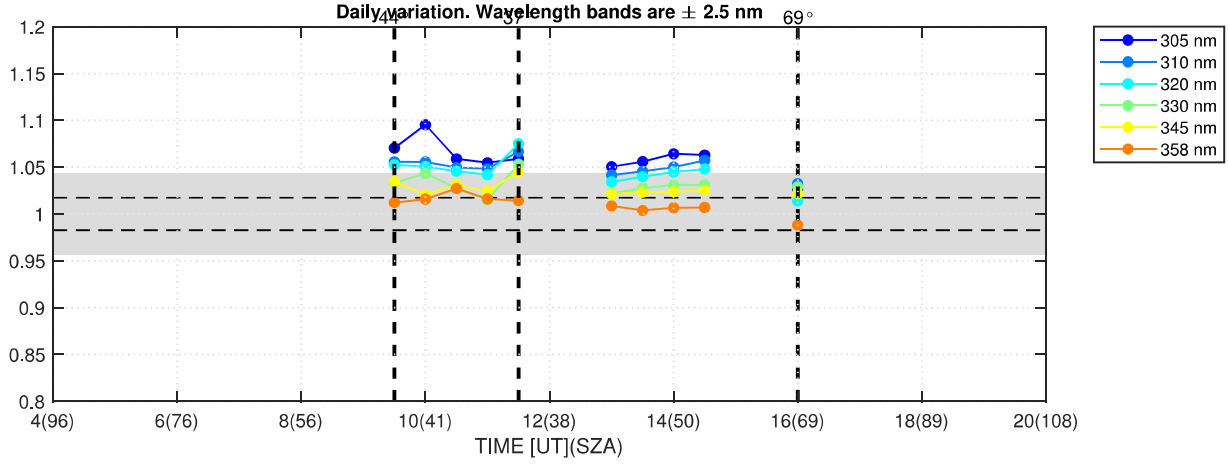

Global irradiance ratios ISQ/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
ISQ
QAS2
UVIndex
wl [nm]

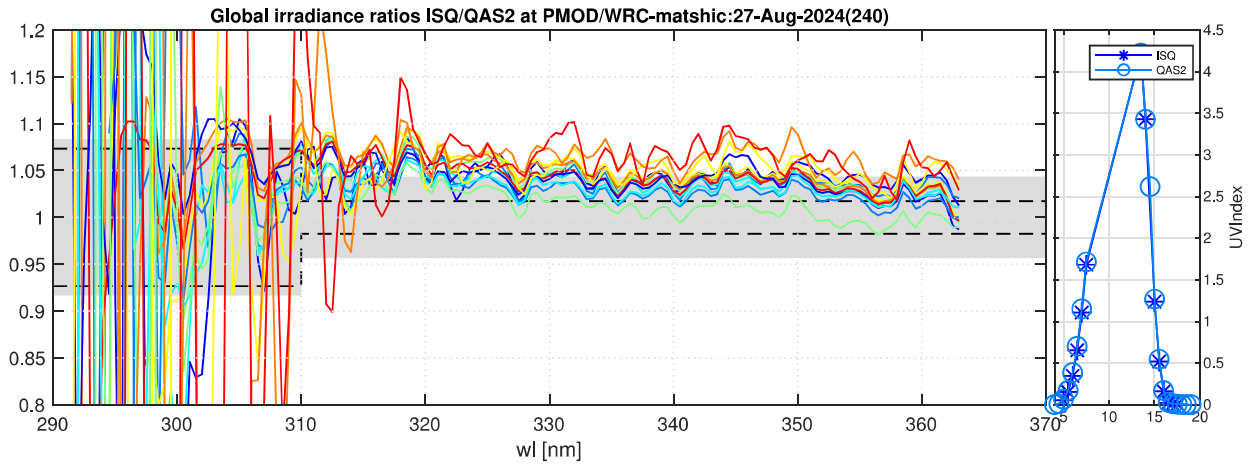

Daily variation. Wavelength bands are ± 2.5 nm
71°
88°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

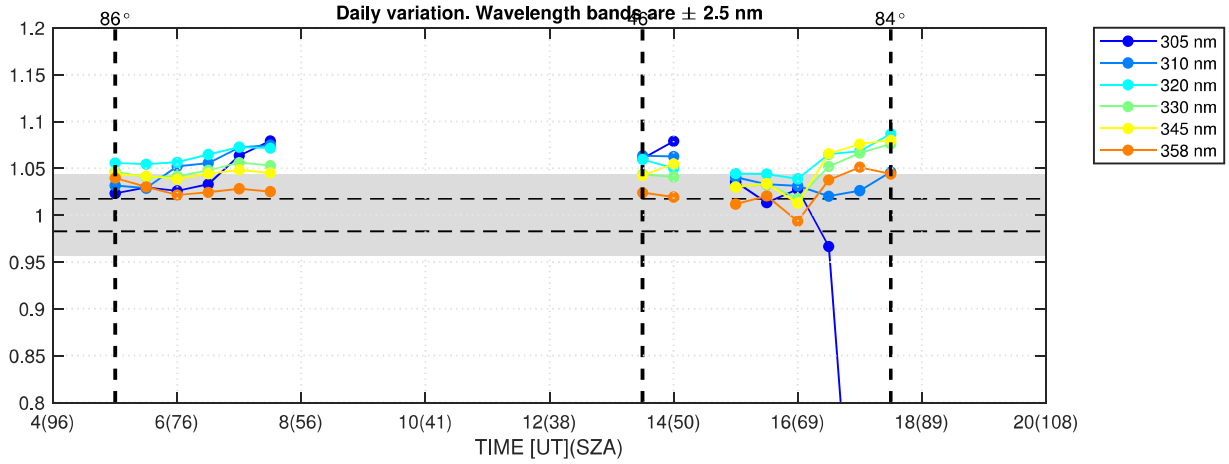

Global irradiance ratios ISQ/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
ISQ
QAS2

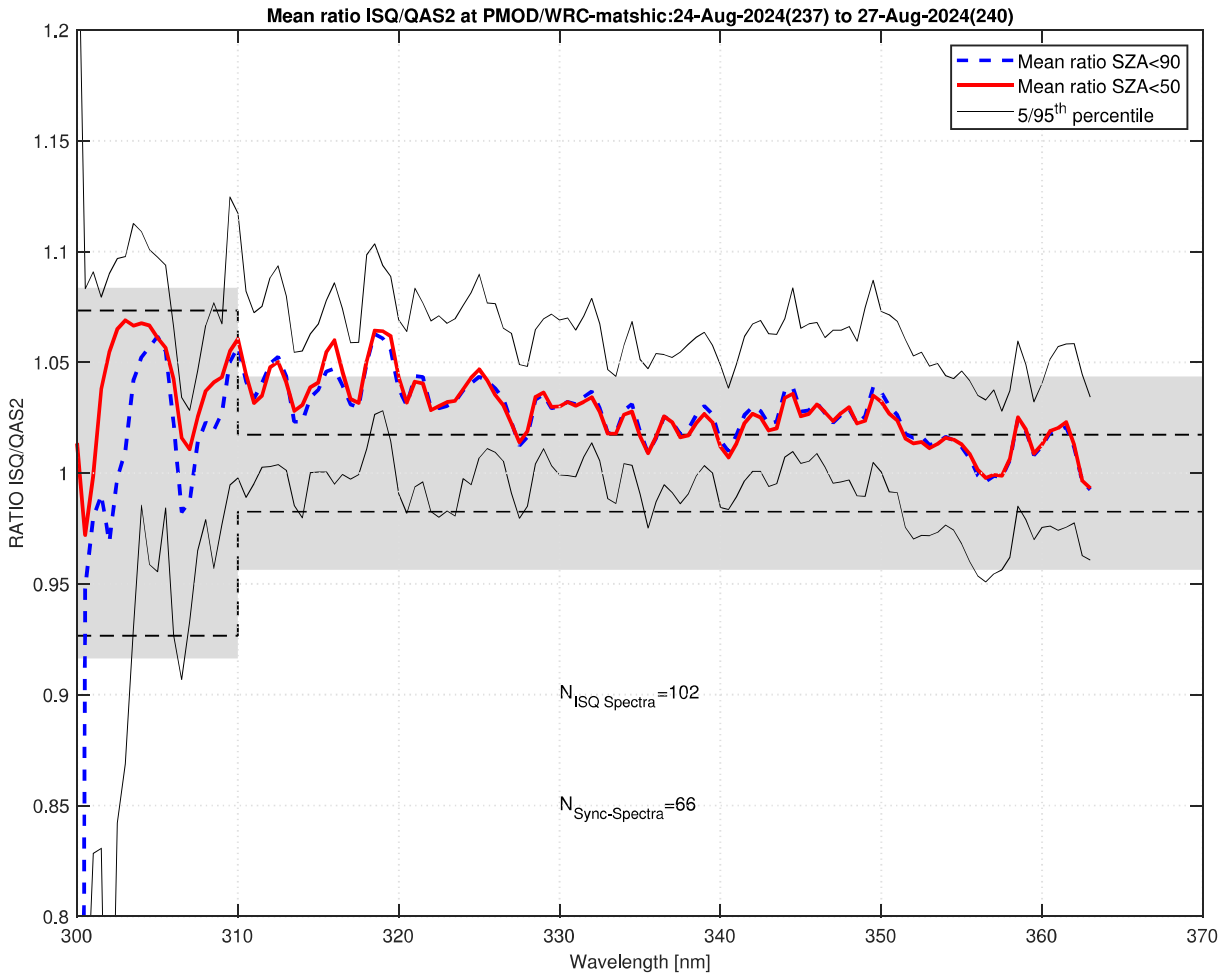

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

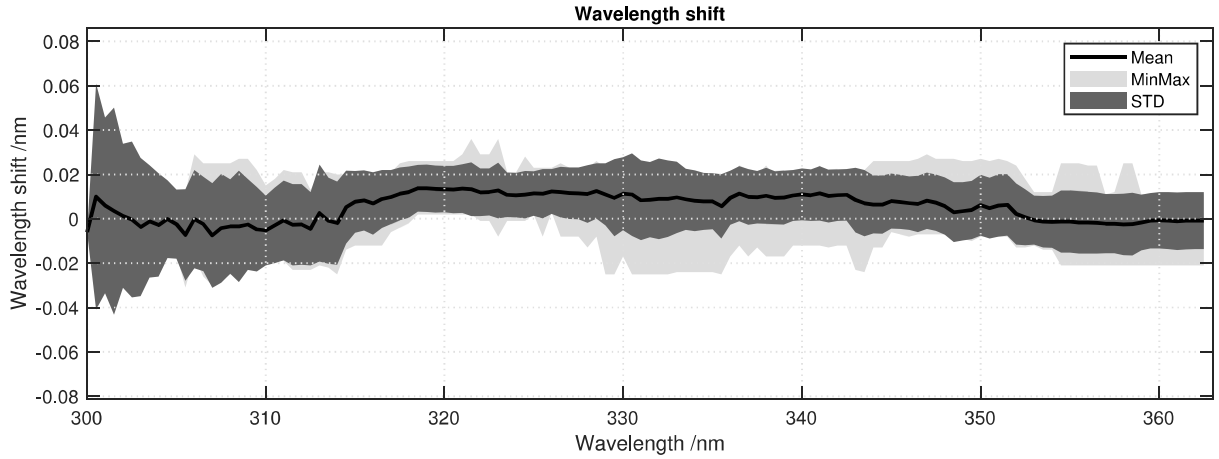

Global irradiance ratios ISQ/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
ISQ
QAS2

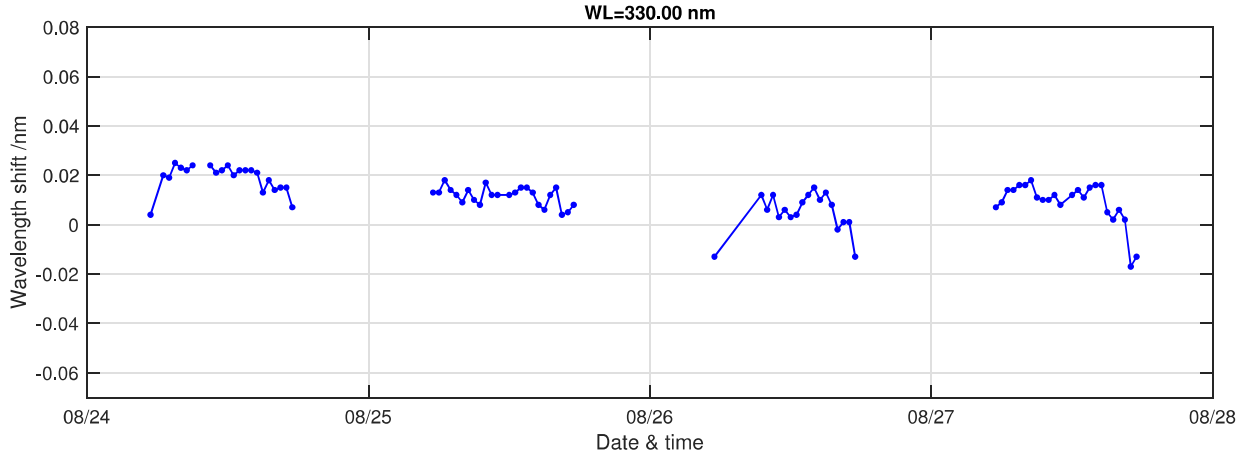

Daily variation. Wavelength bands are ± 2.5 nm
44°
69°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

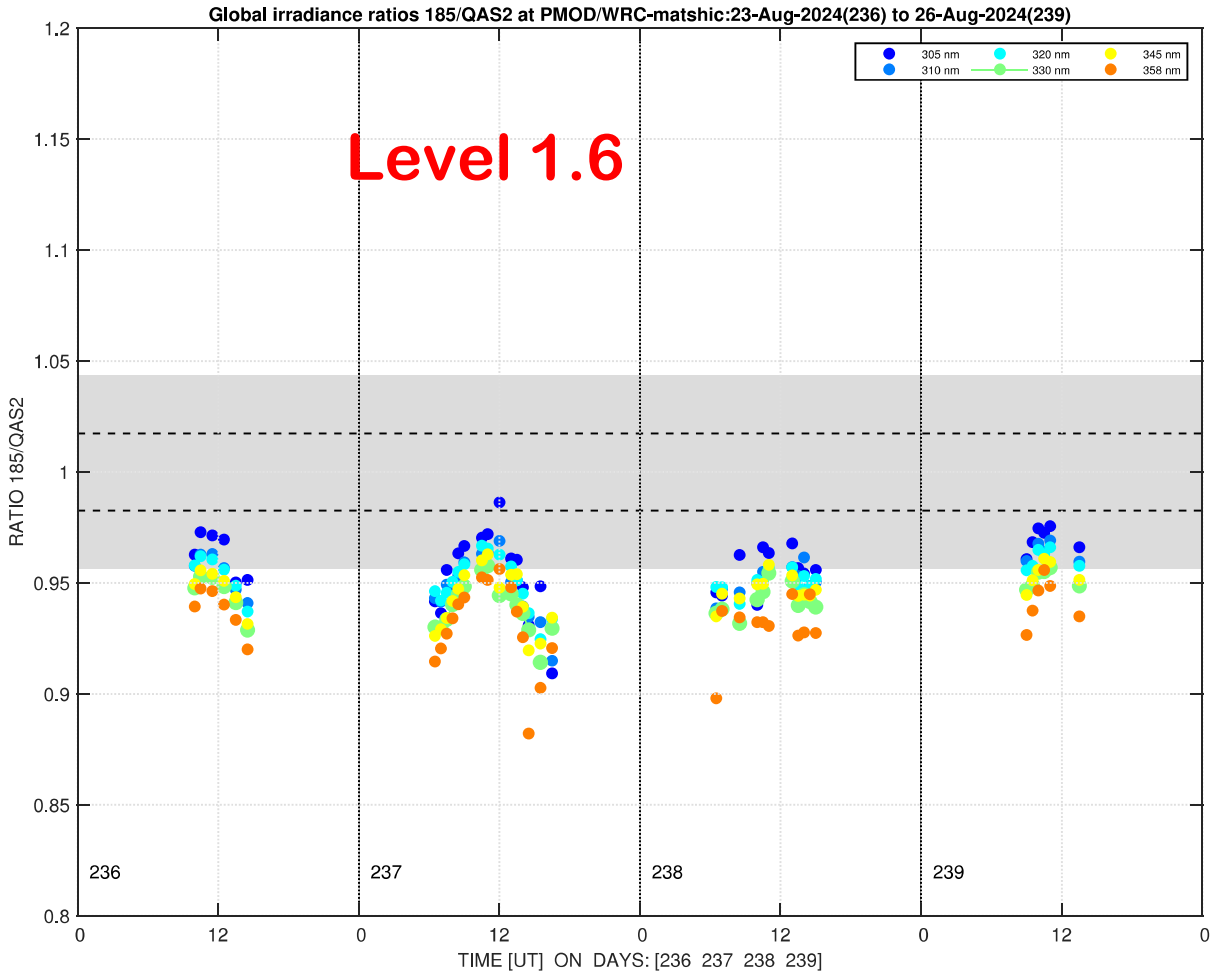

Global irradiance ratios ISQ/QAS2 at PMOD/WRC-matshic:27-Aug-2024(240)
wl [nm]
UVIndex
ISQ
QAS2

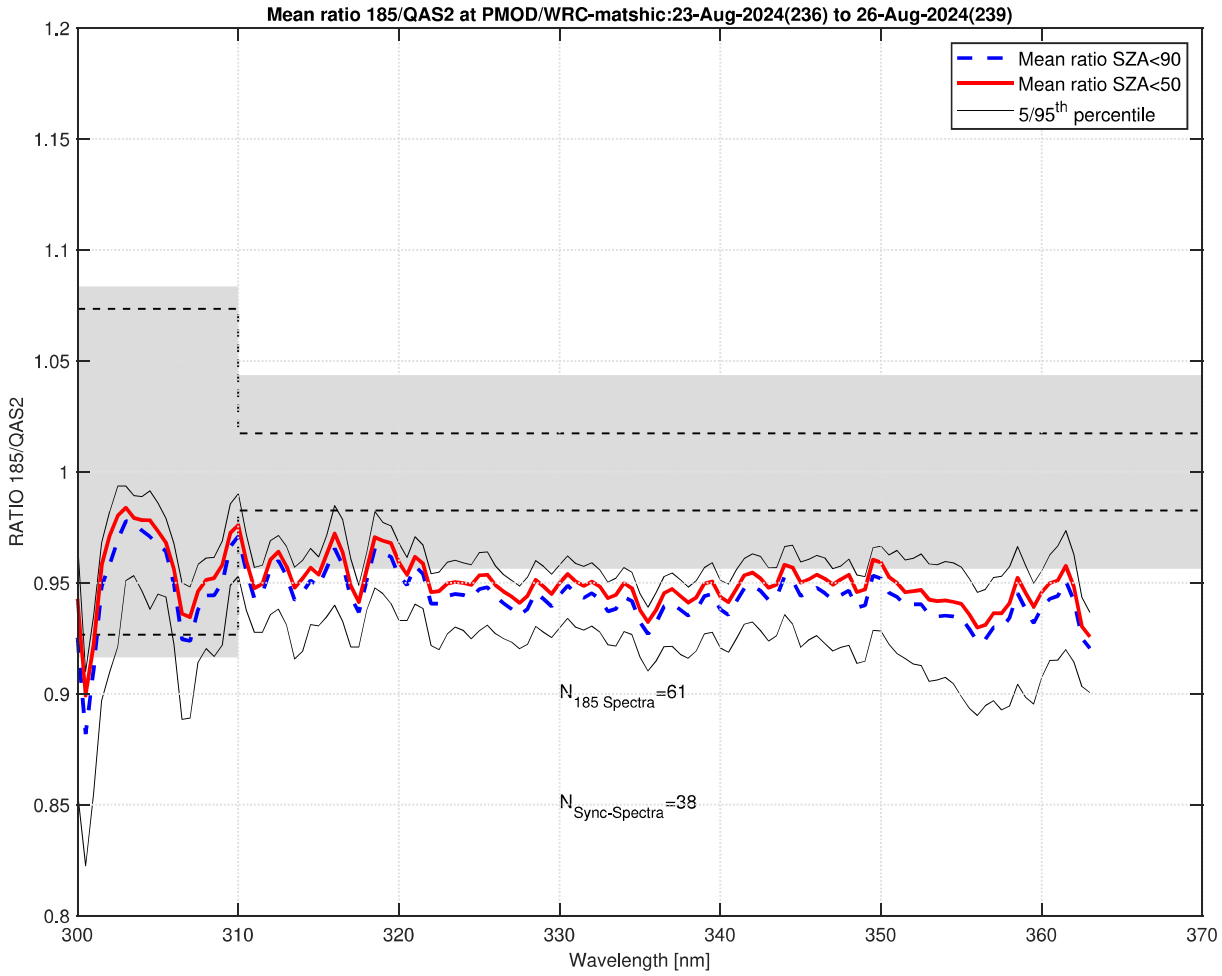

Daily variation. Wavelength bands are ± 2.5 nm
86°
46
84°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

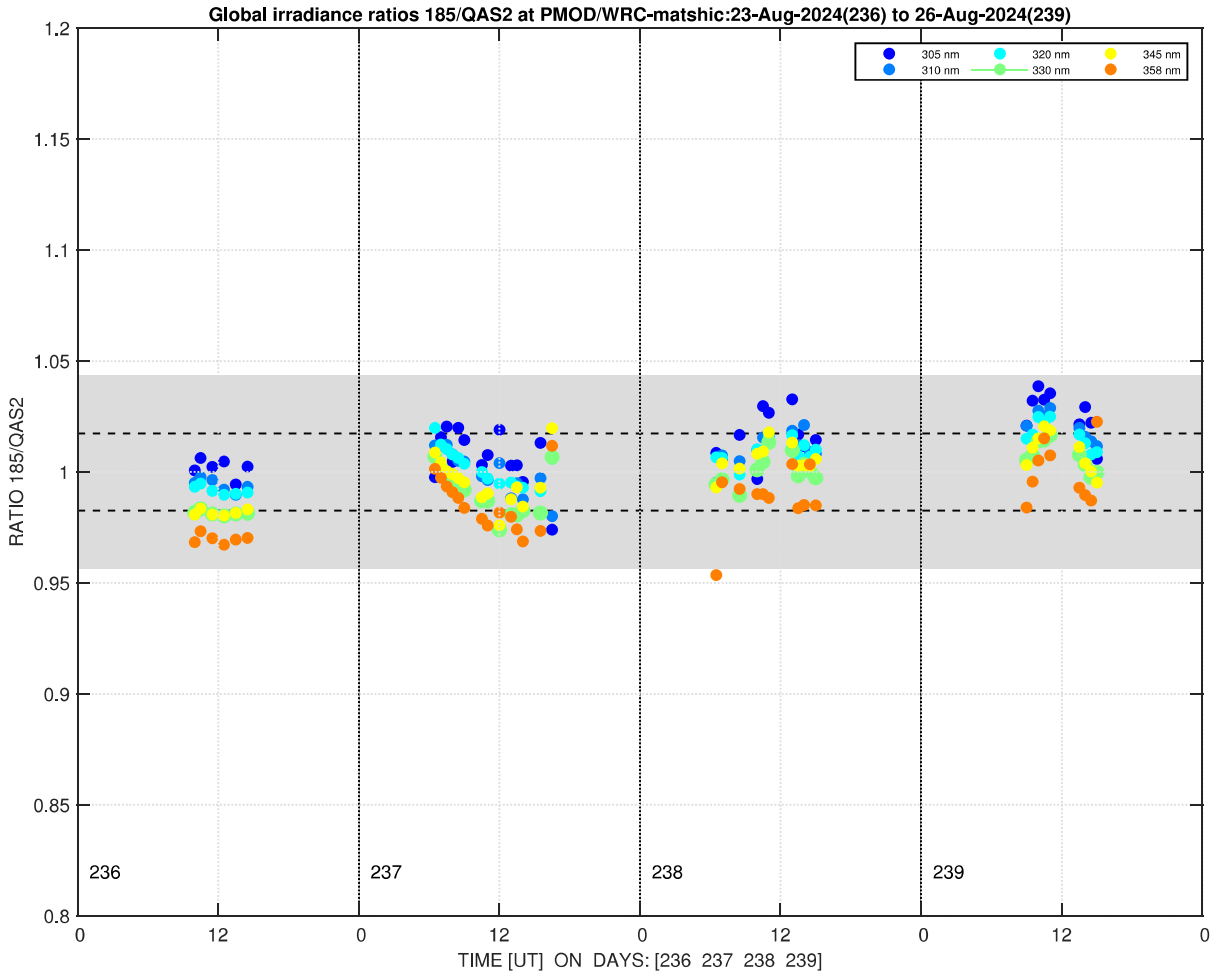

Mean ratio ISQ/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237) to 27-Aug-2024(240)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
RATIO ISQ/QAS2
Wavelength [nm]
N ISQ Spectra=102
N Sync-Spectra=66

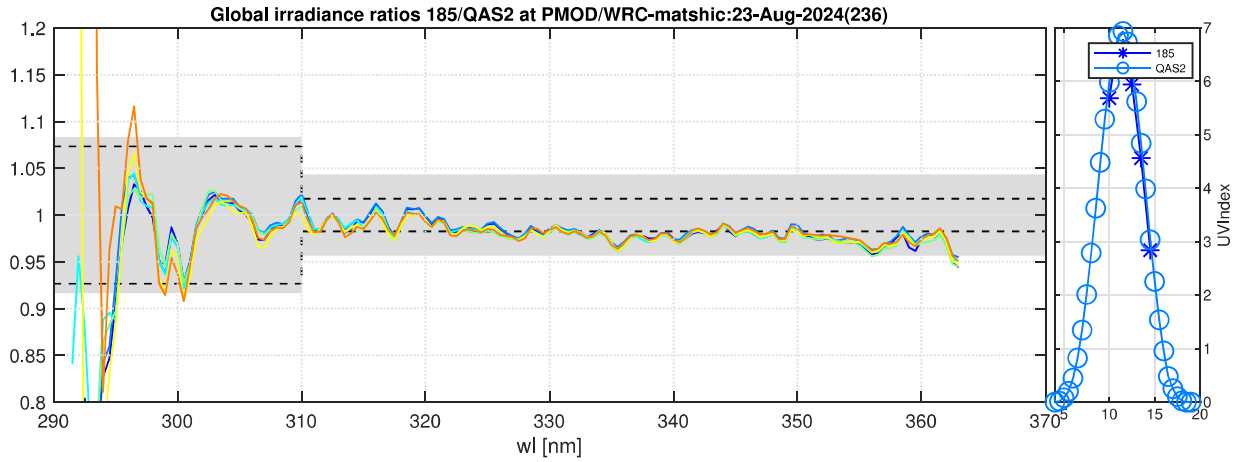

Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
300
310
320
330
340
350
360
Wavelength /nm

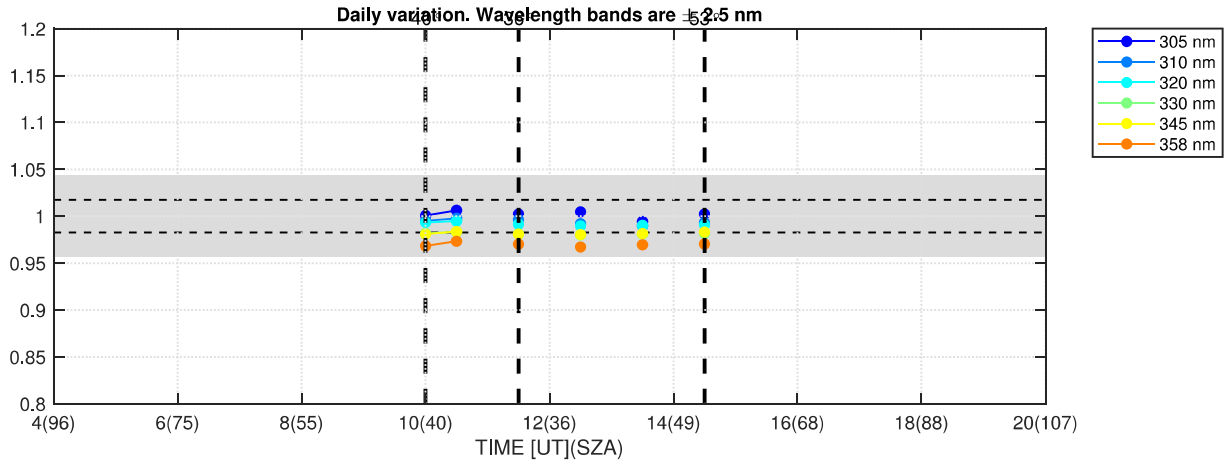

WL=330.00 nm
Wavelength shift /nm
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
08/24
08/25
08/26
08/27
08/28
Date & time

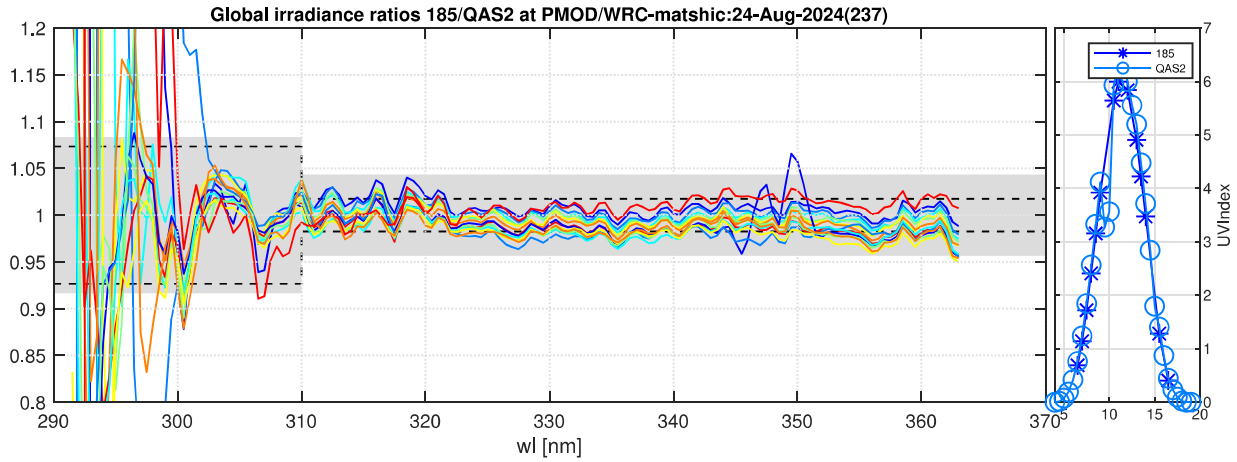

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
Level 1.6
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO 185/QAS2
TIME [UT] ON DAYS: [236 237 238 239]
236
237
238
239

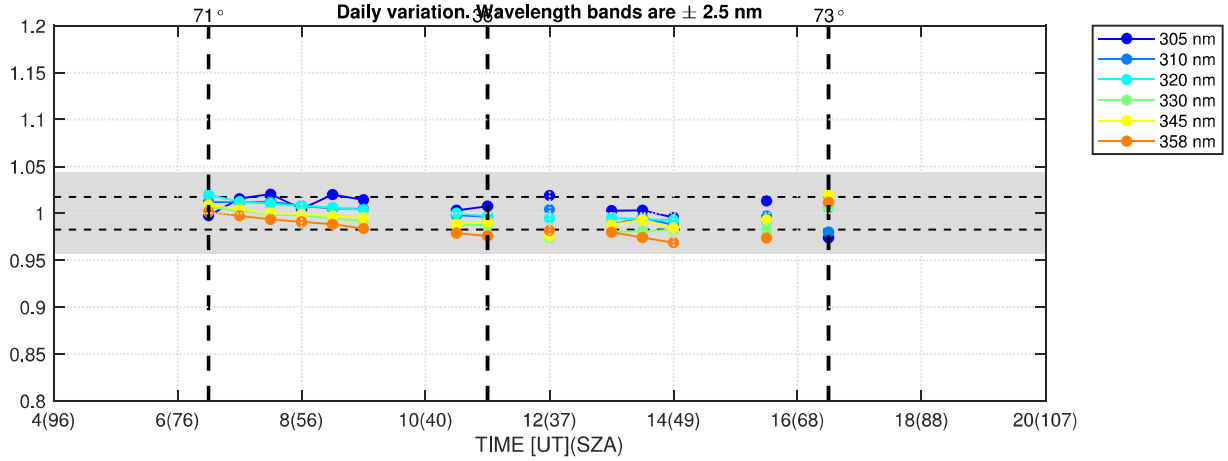

Mean ratio 185/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
N185 Spectra=61
NSync-Spectra=38
RATIO 185/QAS2
Wavelength [nm]

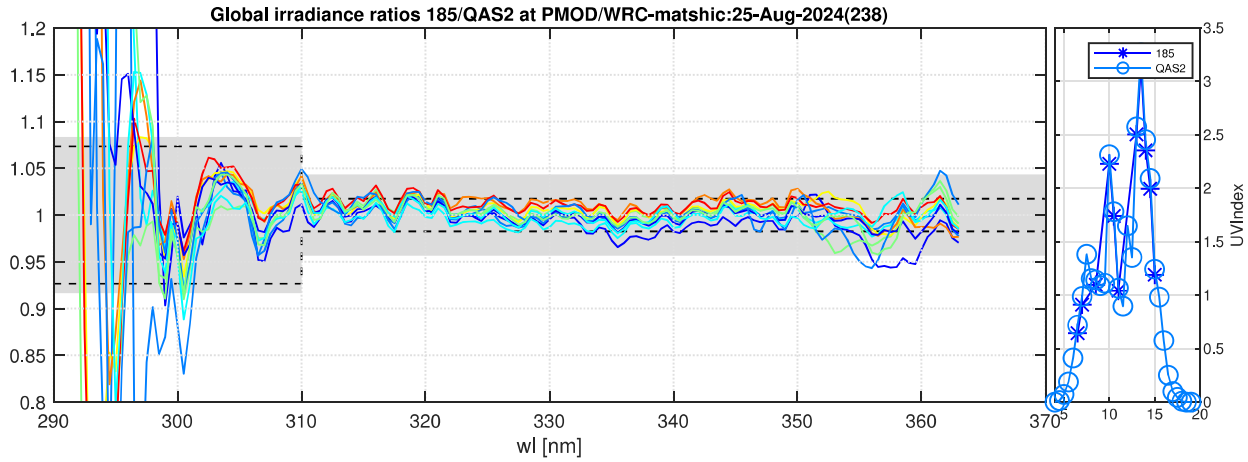

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO 185/QAS2
236
237
238
239
TIME [UT] ON DAYS: [236 237 238 239]

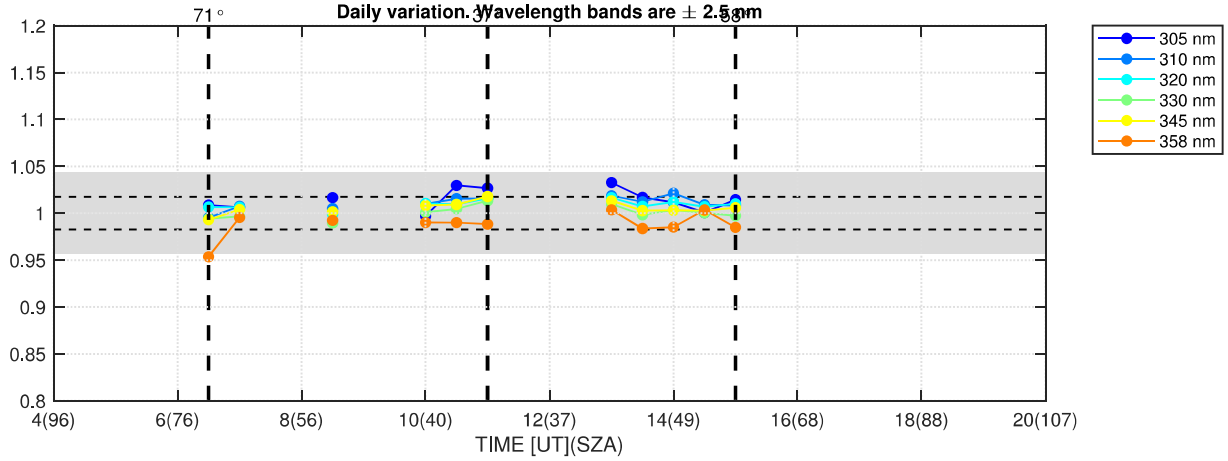

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236)
185
QAS2
UVIndex
wl [nm]

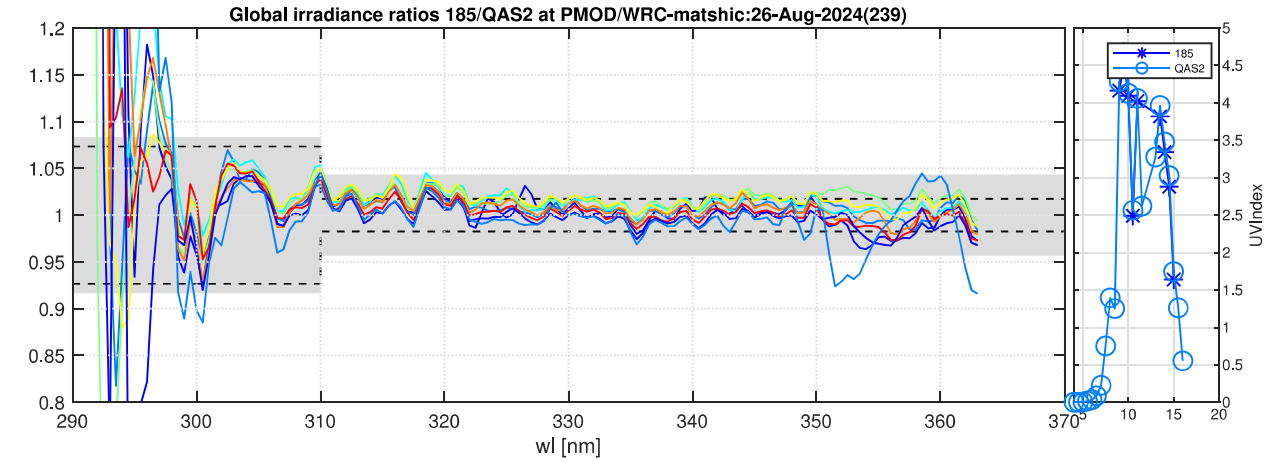

Daily variation. Wavelength bands are ±2.5 nm
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

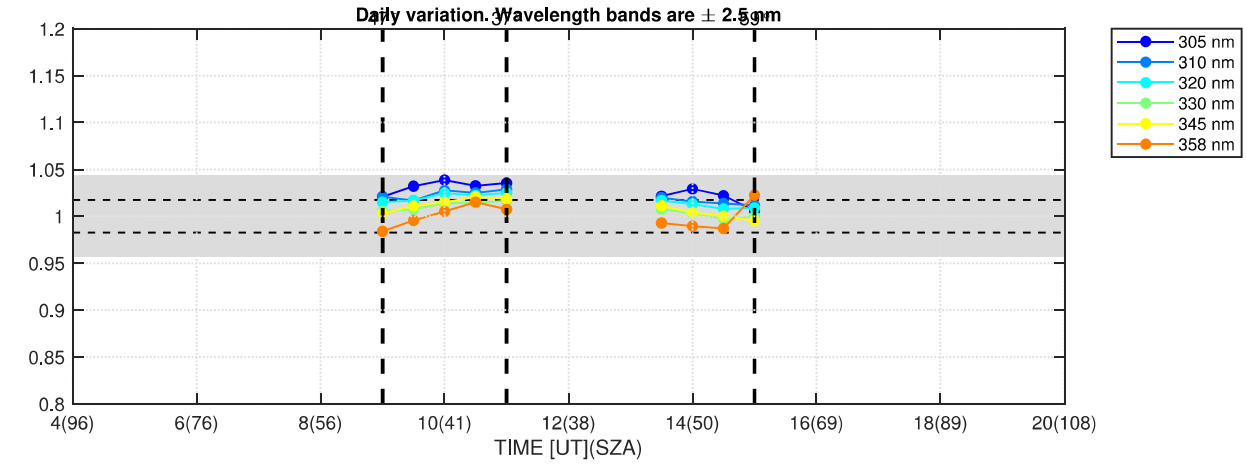

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
wl [nm]
UVIndex
185
QAS2

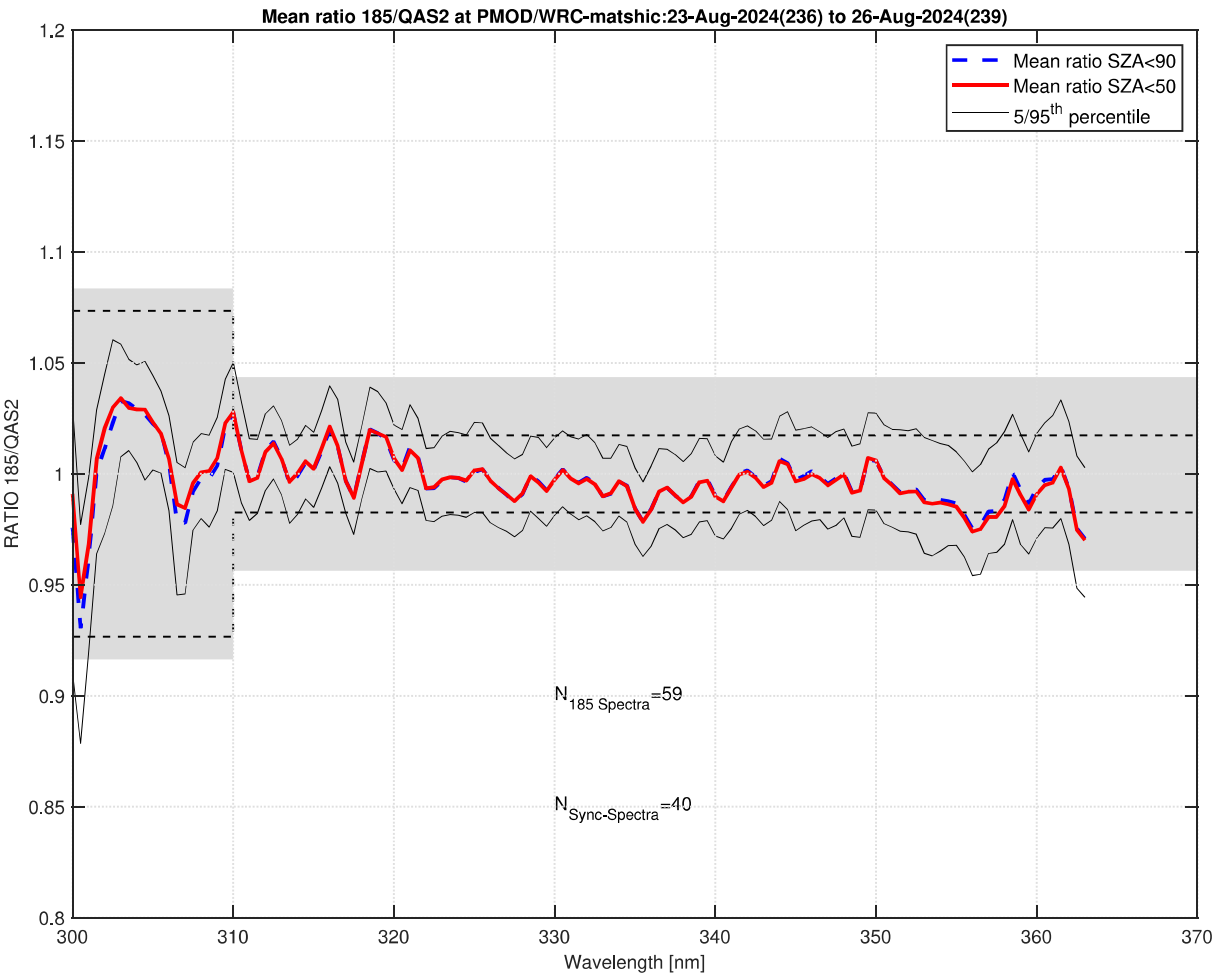

Daily variation. Wavelength bands are ± 2.5 nm
71°
73°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

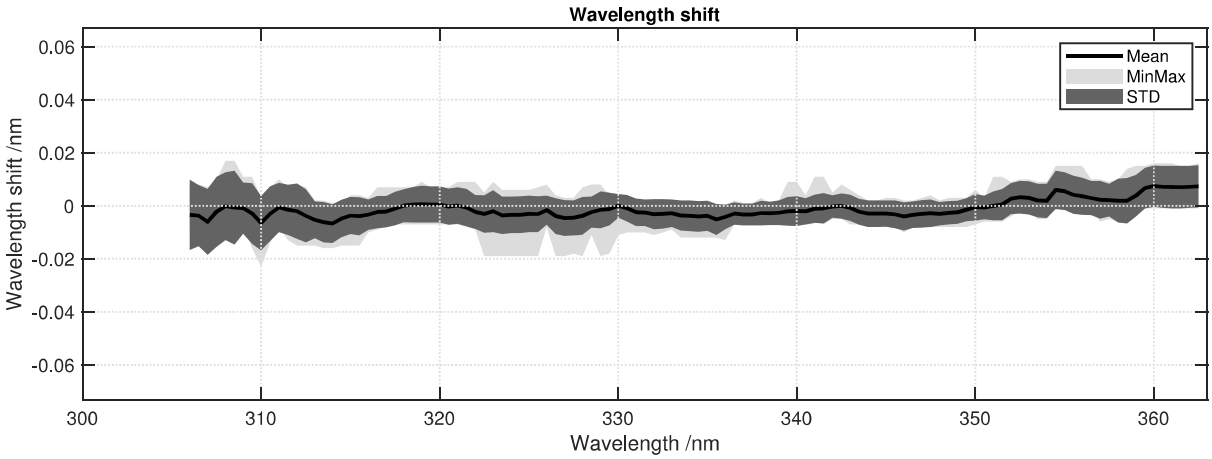

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
185
QAS2

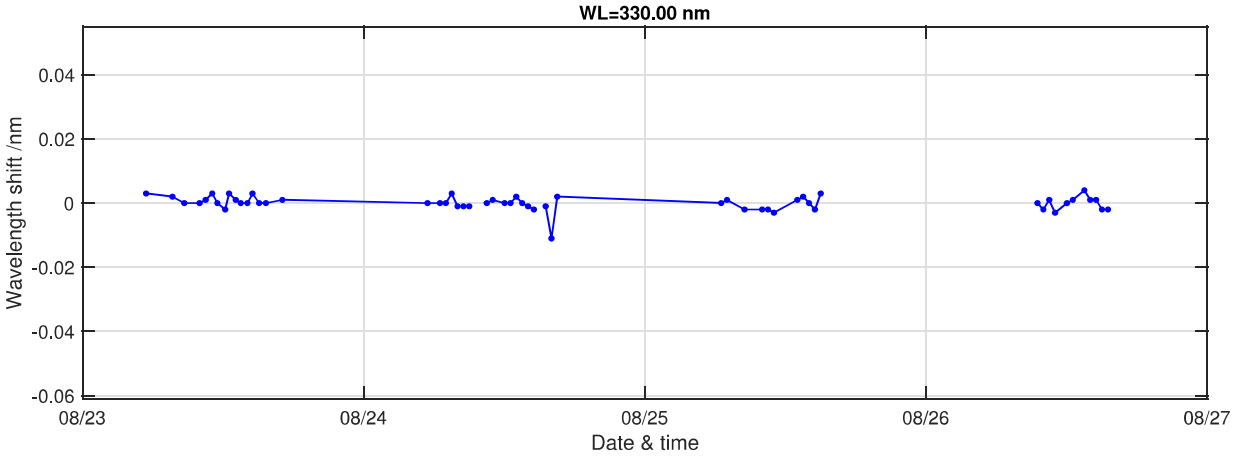

Daily variation. Wavelength bands are ± 2.5 nm
71°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

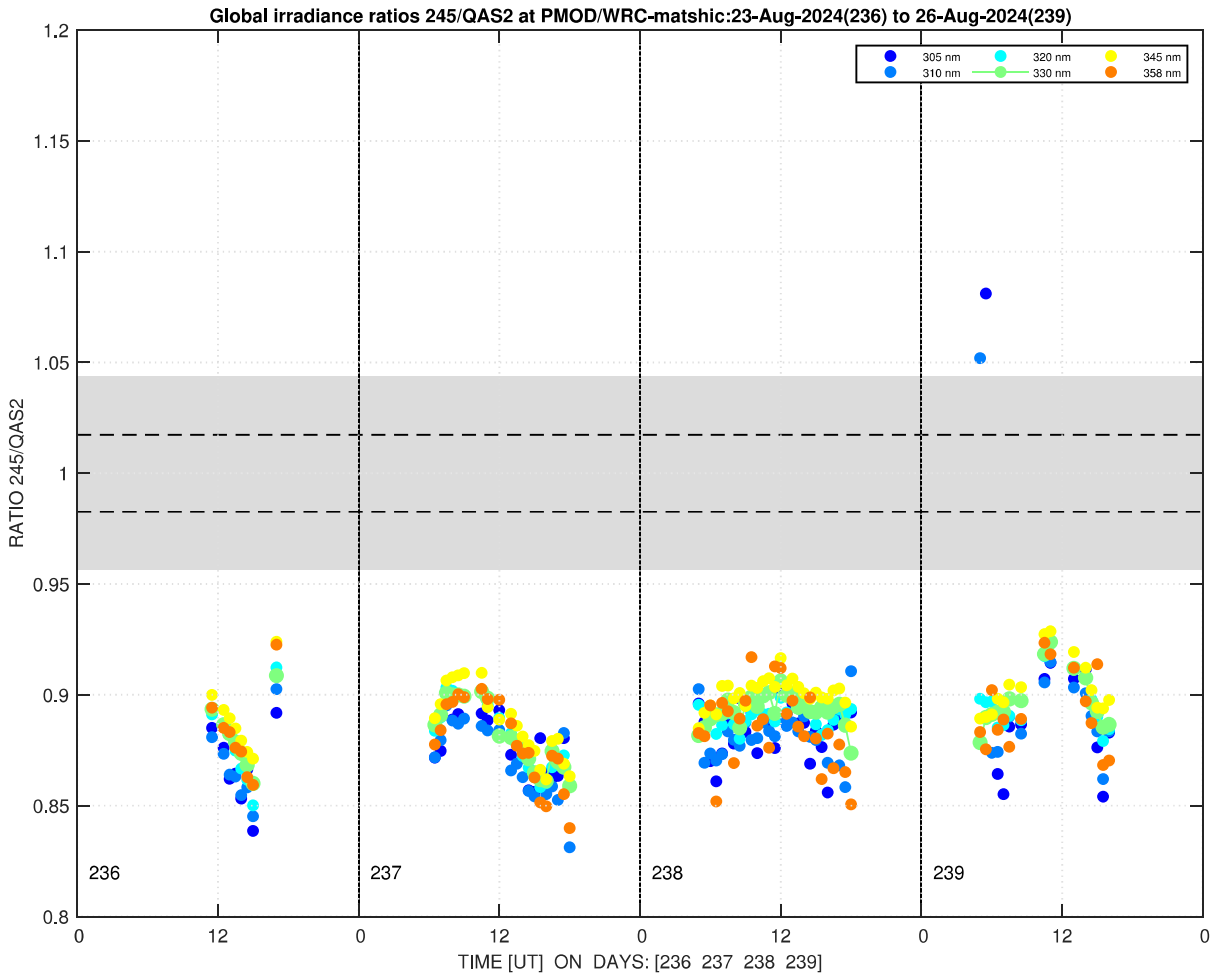

Global irradiance ratios 185/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
185
QAS2

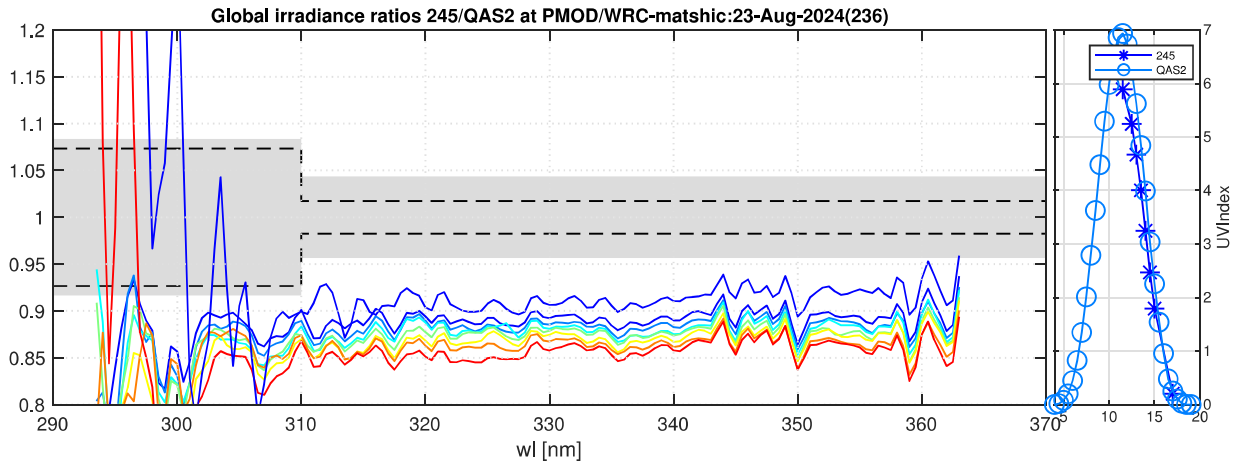

Daily variation. Wavelength bands are ± 2.5 nm
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

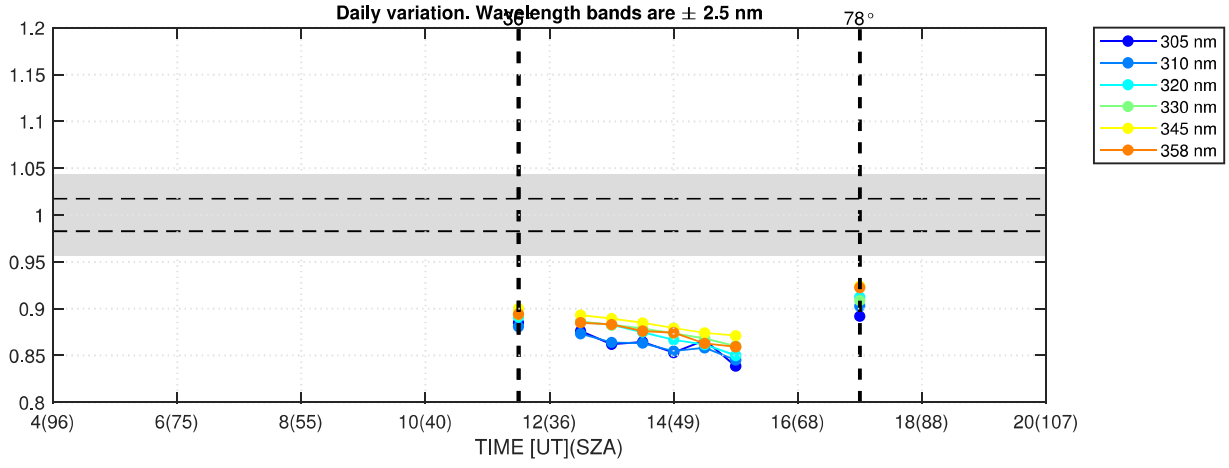

Mean ratio 185/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
RATIO 185/QAS2
Wavelength [nm]
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
N185 Spectra=59
NSync-Spectra=40

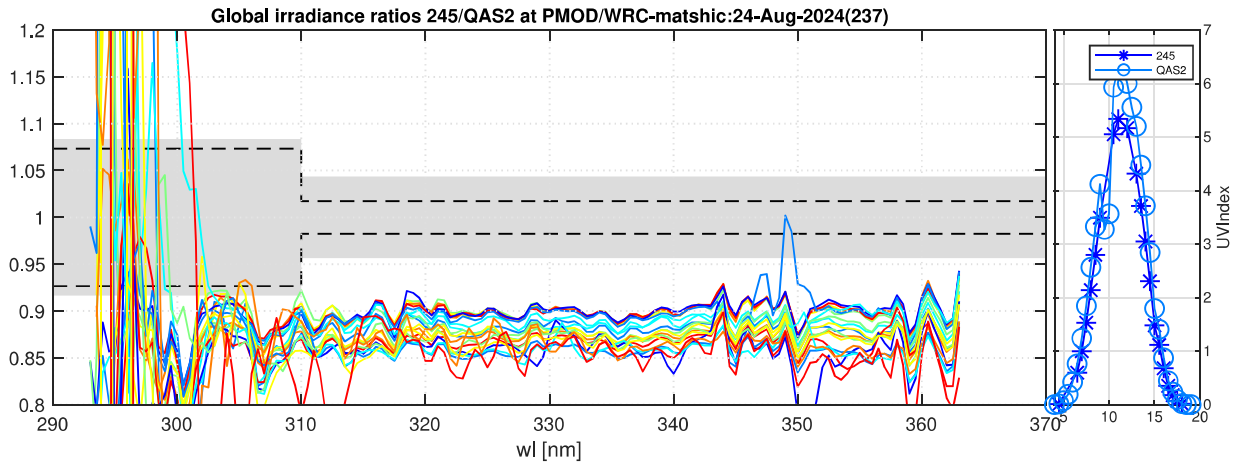

Wavelength shift
Mean
MinMax
STD
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
Wavelength shift /nm
300
310
320
330
340
350
360
Wavelength /nm

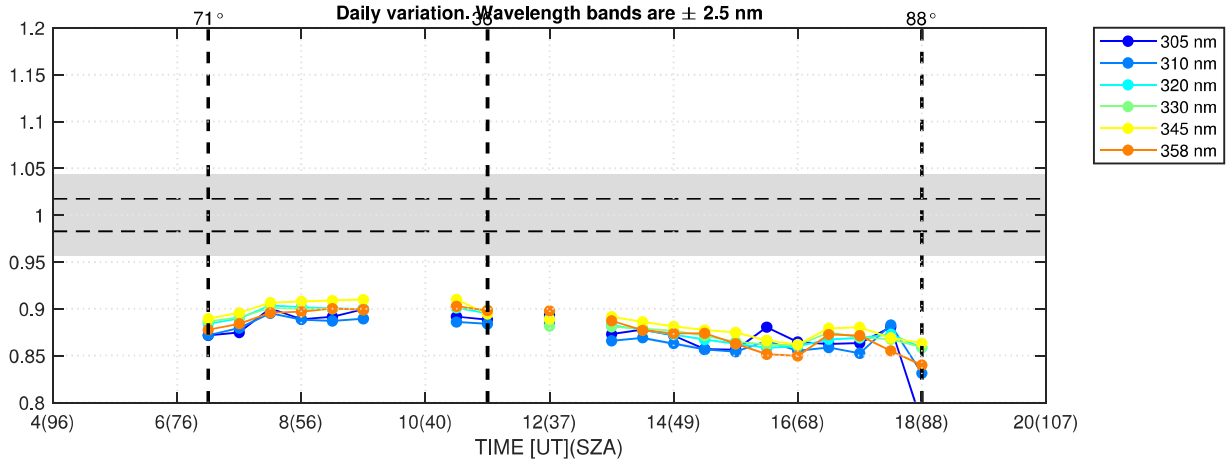

WL=330.00 nm
0.04
0.02
0
-0.02
-0.04
-0.06
Wavelength shift /nm
08/23
08/24
08/25
08/26
08/27
Date & time

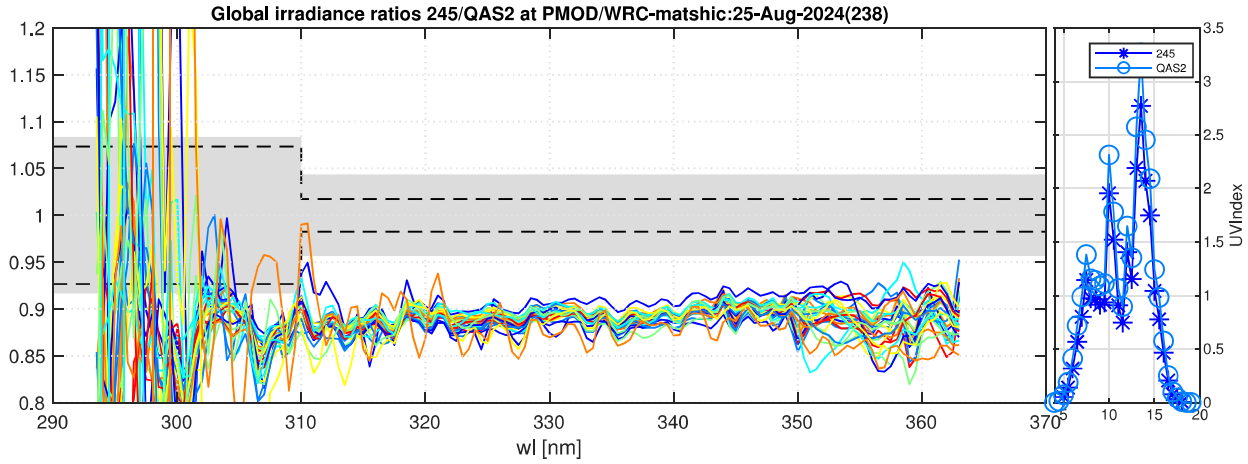

Global irradiance ratios 245/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO 245/QAS2
236
237
238
239
TIME [UT] ON DAYS: [236 237 238 239]

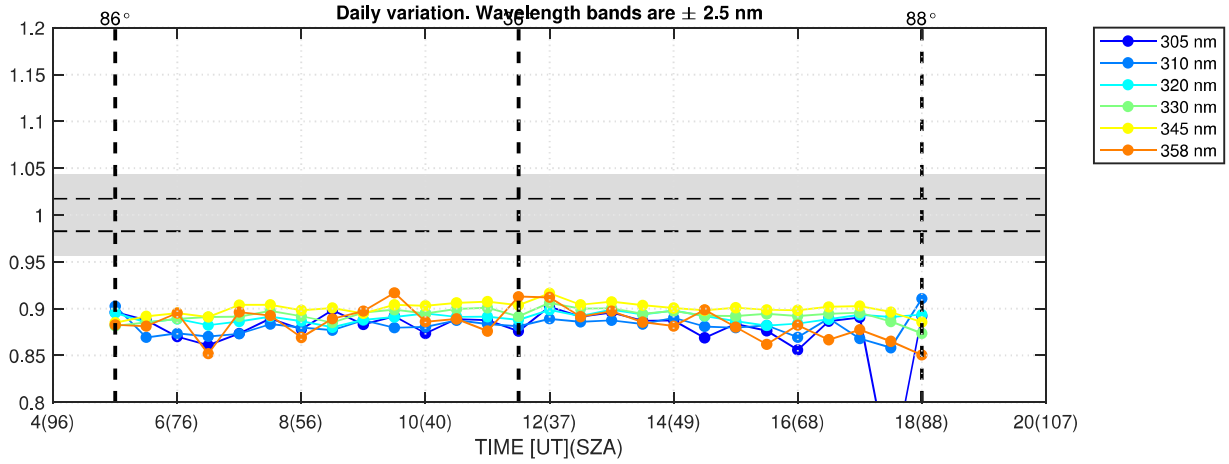

Global irradiance ratios 245/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236)
245
QAS2
UVIndex
wl [nm]

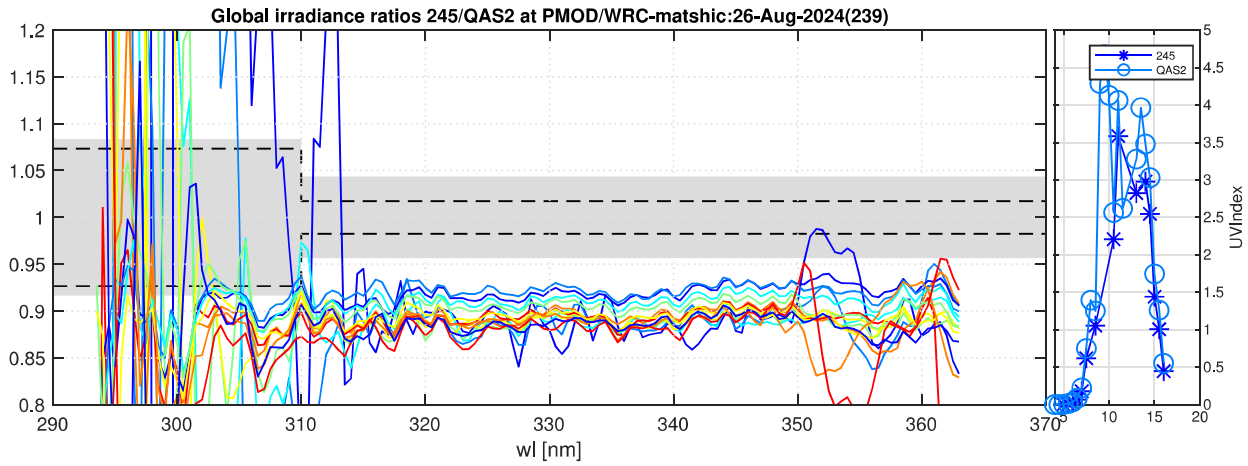

Daily variation. Wavelength bands are ± 2.5 nm
36
78°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

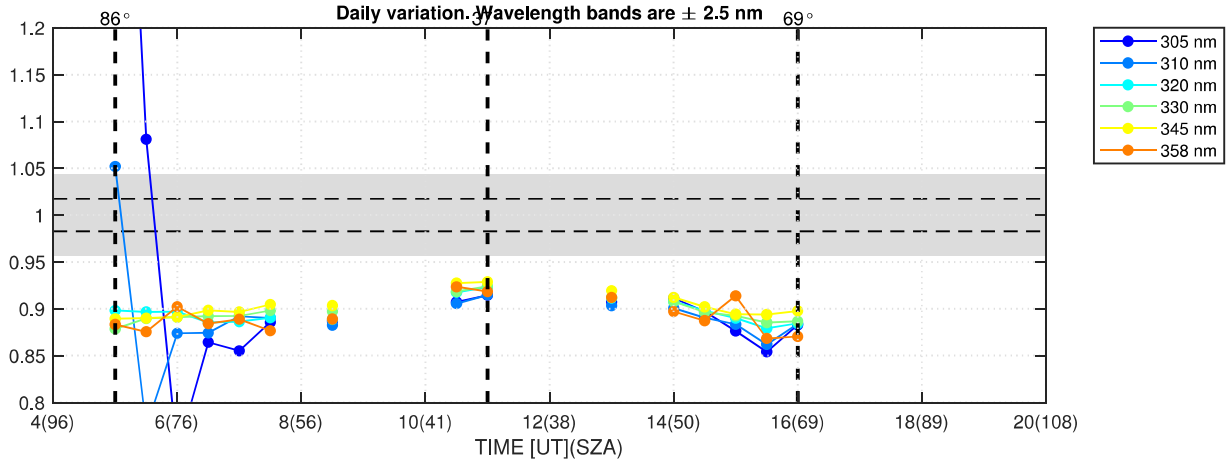

Global irradiance ratios 245/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
wl [nm]
UVIndex
245
QAS2

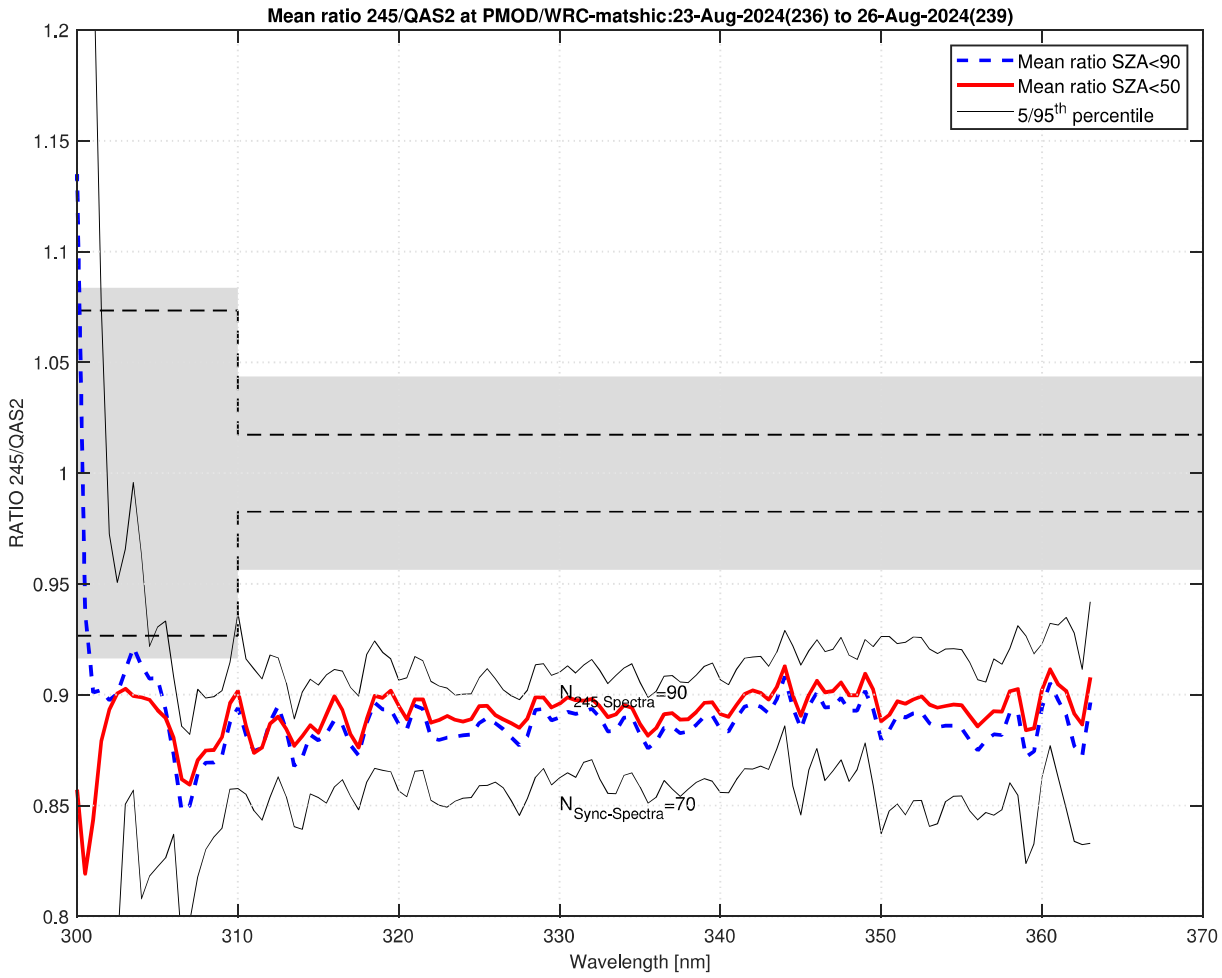

Daily variation. Wavelength bands are ± 2.5 nm
71°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

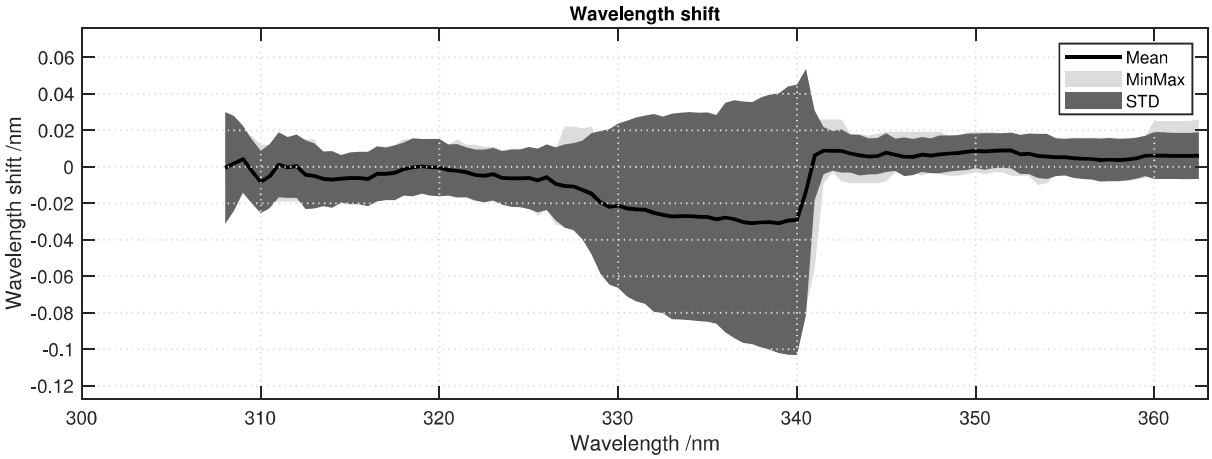

Global irradiance ratios 245/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
245
QAS2

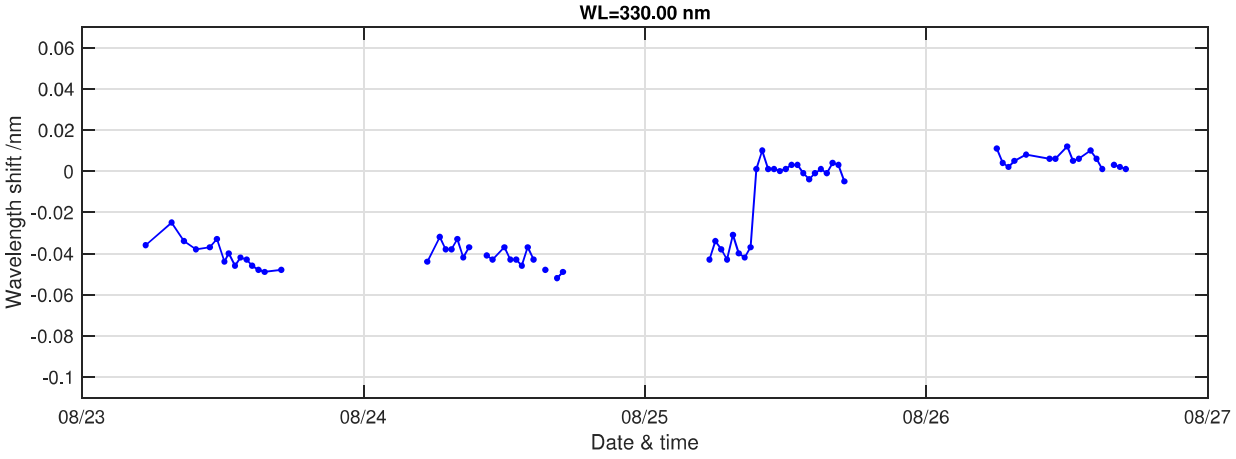

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

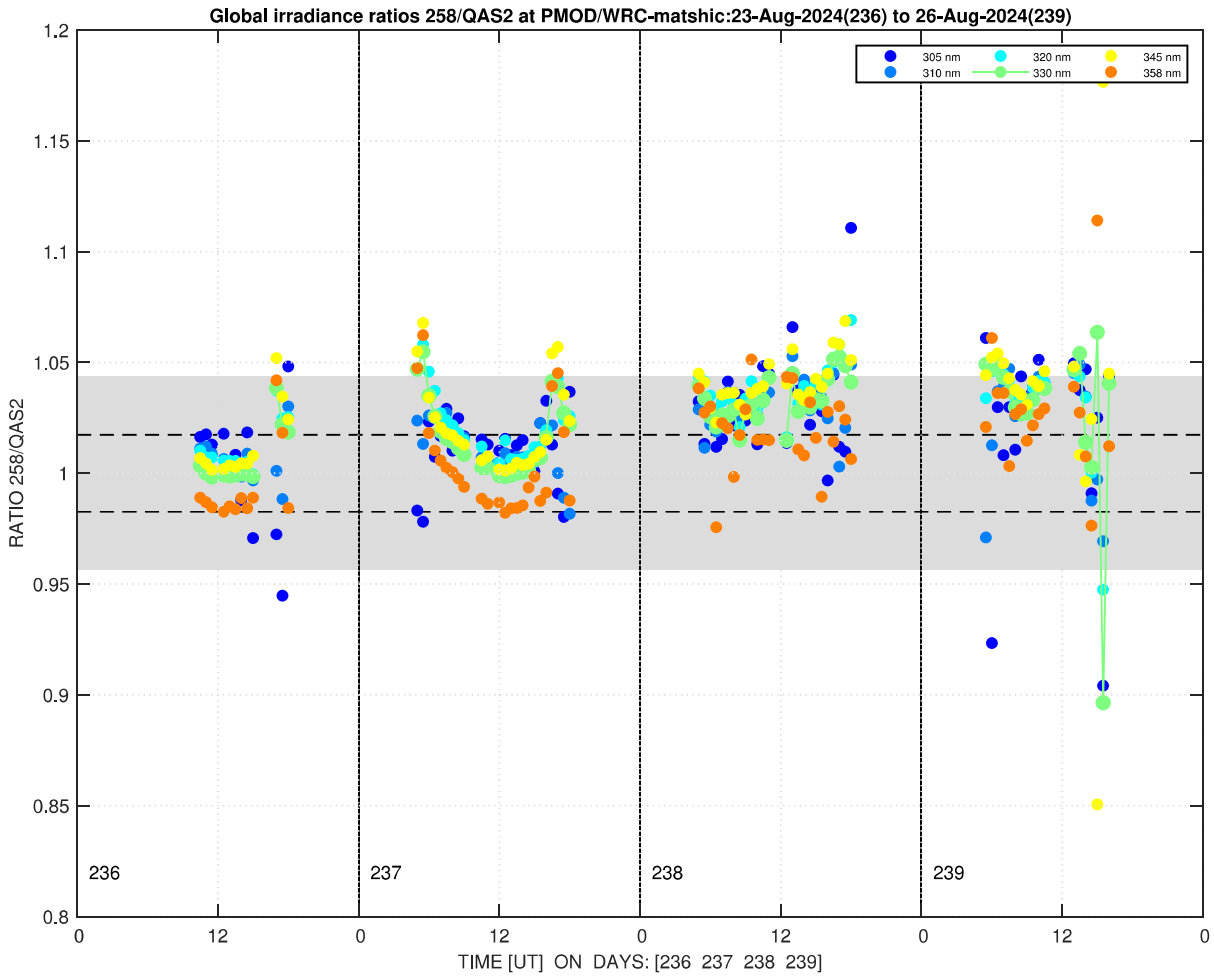

Global irradiance ratios 245/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
245
QAS2

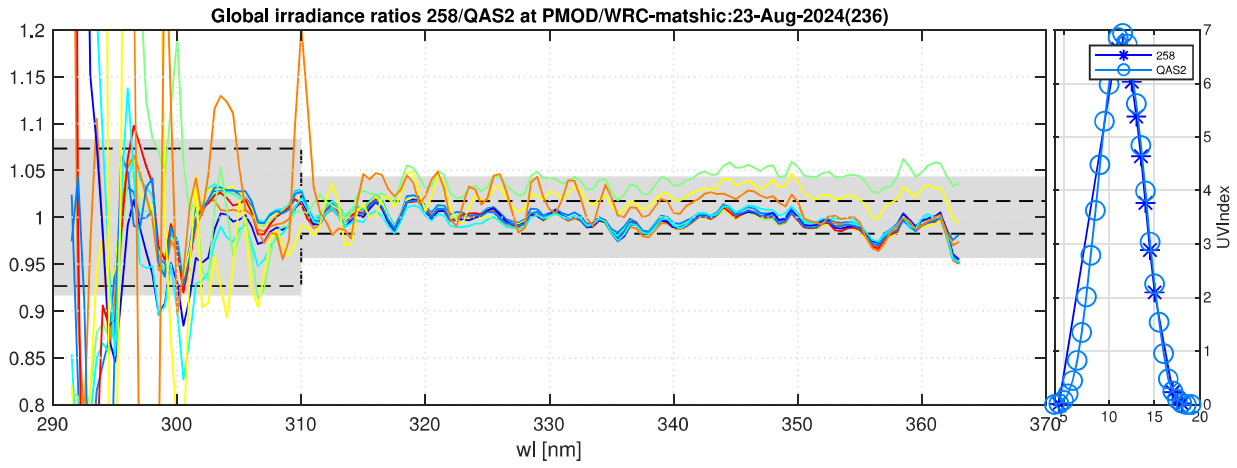

Daily variation. Wavelength bands are ± 2.5 nm
86°
37°
69°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

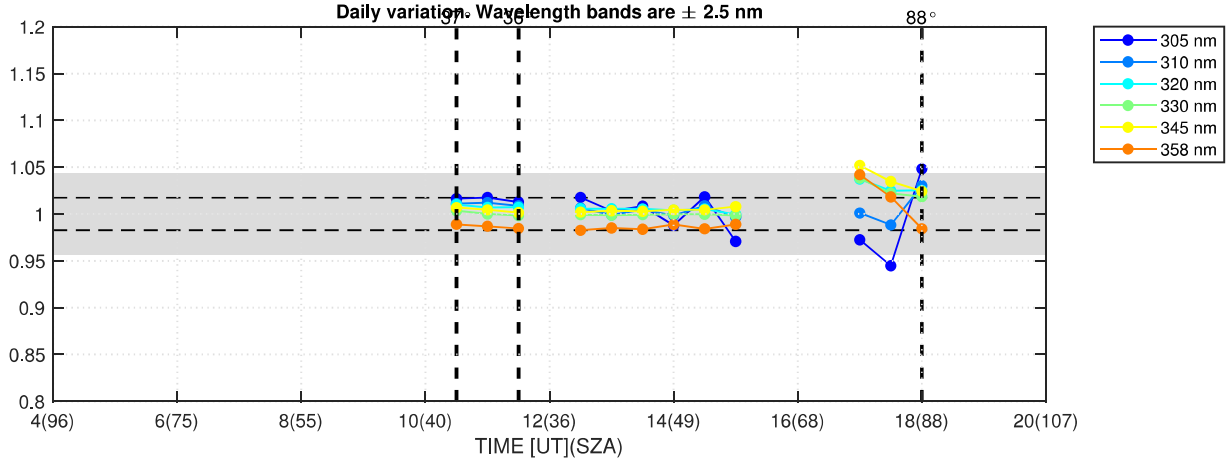

Mean ratio 245/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
RATIO 245/QAS2
Wavelength [nm]
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
N245 Spectra=90
NSync-Spectra=70

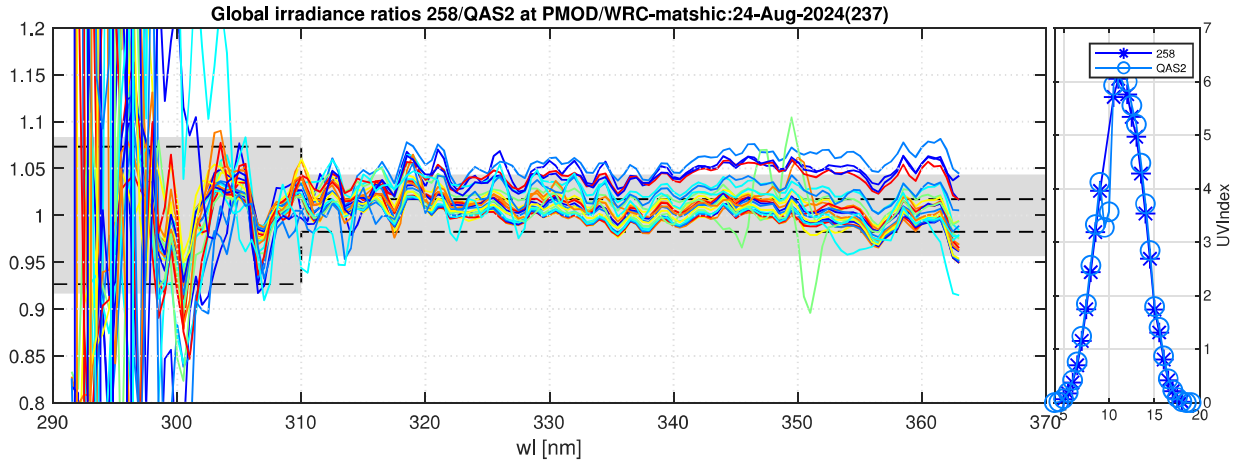

Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
300
310
320
330
340
350
360
Wavelength /nm

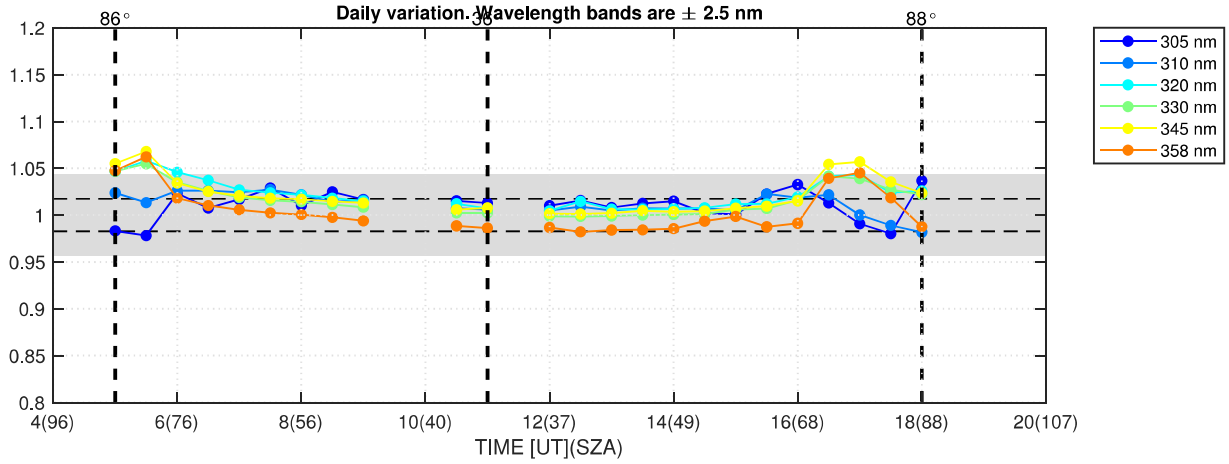

WL=330.00 nm
Wavelength shift /nm
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
08/23
08/24
08/25
08/26
08/27
Date & time

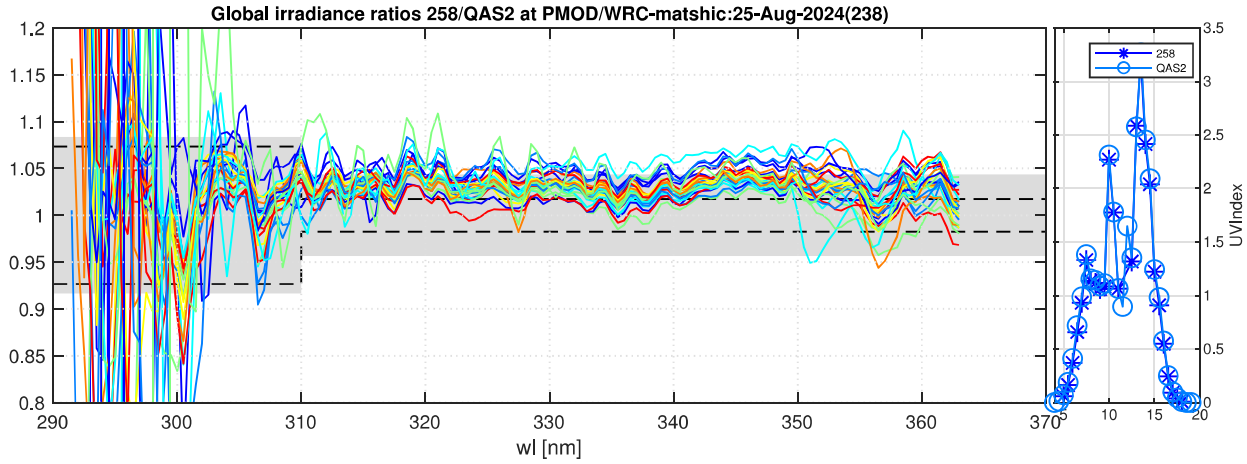

Global irradiance ratios 258/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
RATIO 258/QAS2
236
237
238
239
TIME [UT] ON DAYS: [236 237 238 239]

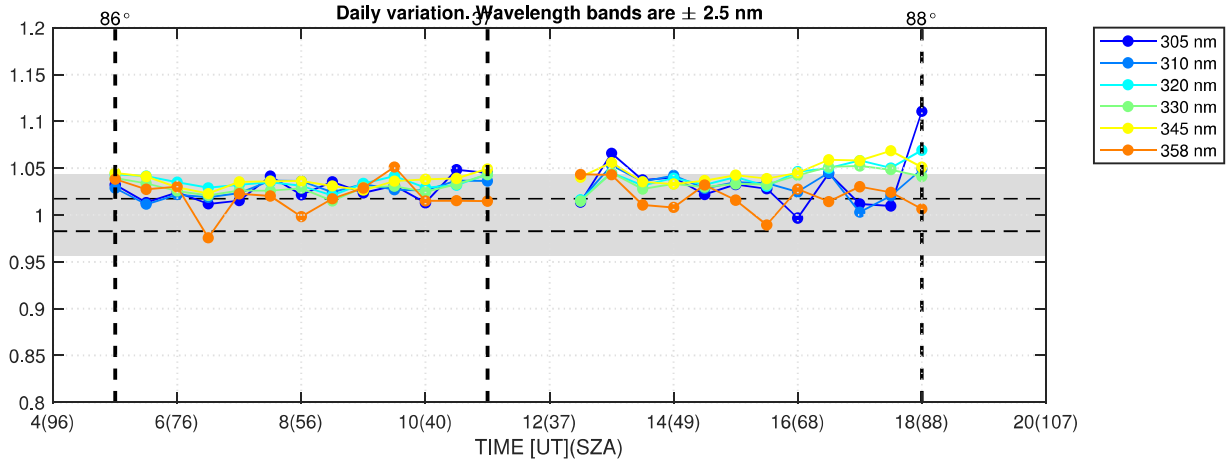

Global irradiance ratios 258/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236)
258
QAS2
UVIndex
wl [nm]

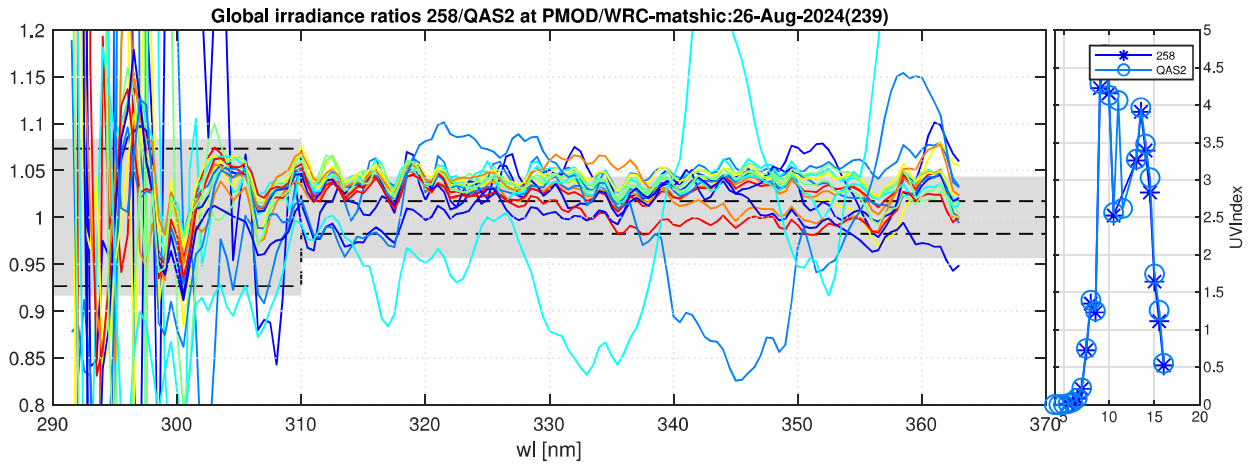

Daily variation. Wavelength bands are ± 2.5 nm
88°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

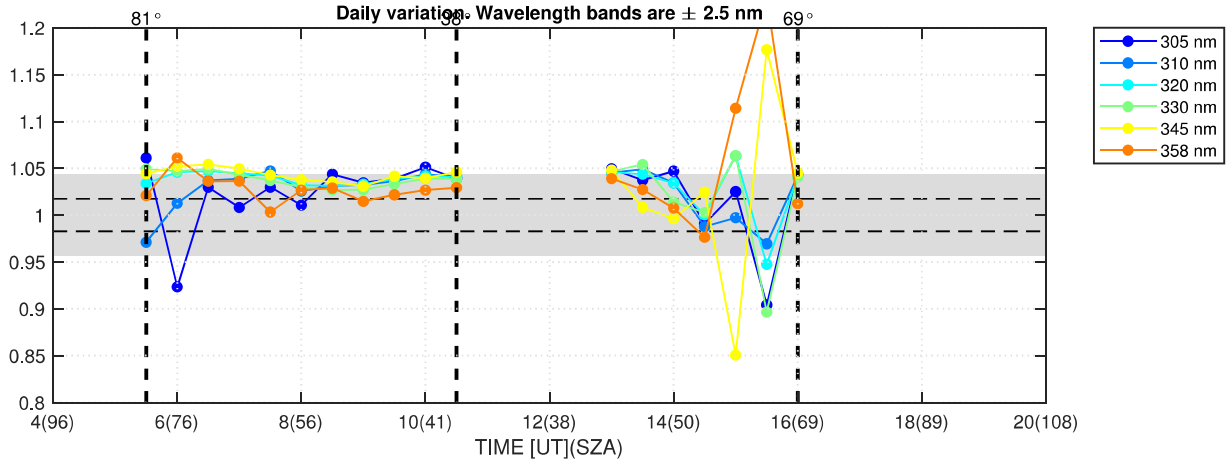

Global irradiance ratios 258/QAS2 at PMOD/WRC-matshic:24-Aug-2024(237)
wl [nm]
UVIndex
258
QAS2

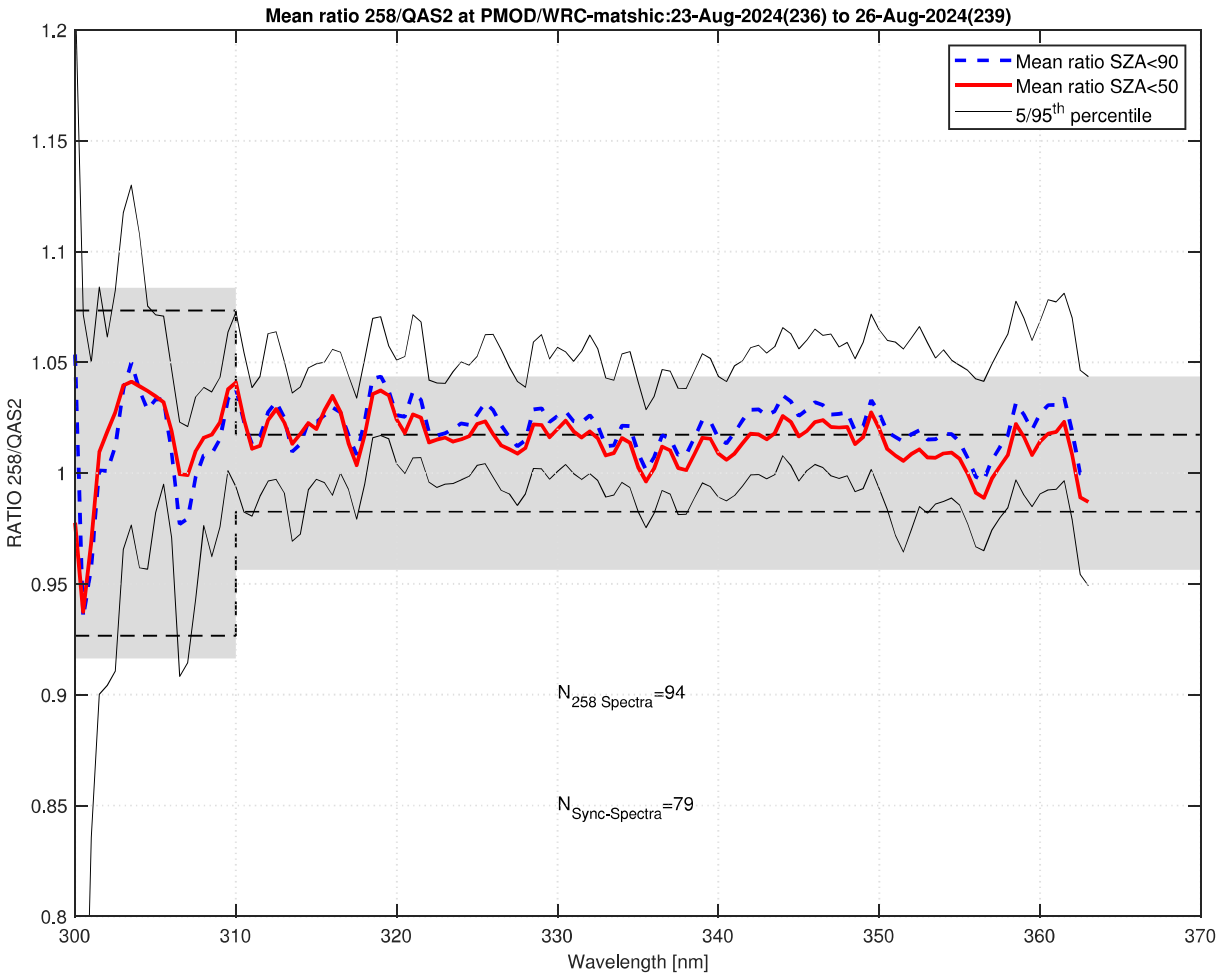

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

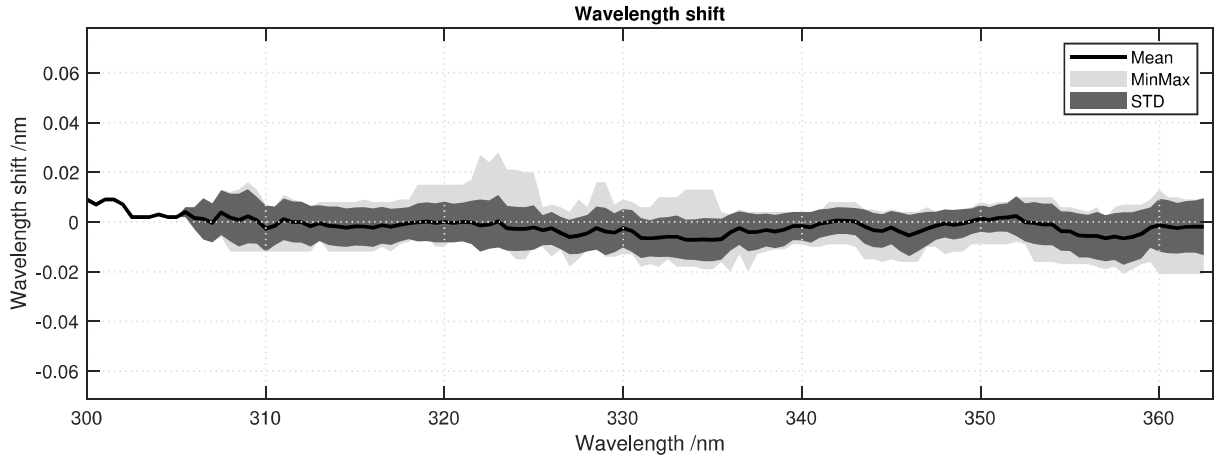

Global irradiance ratios 258/QAS2 at PMOD/WRC-matshic:25-Aug-2024(238)
wl [nm]
UVIndex
258
QAS2

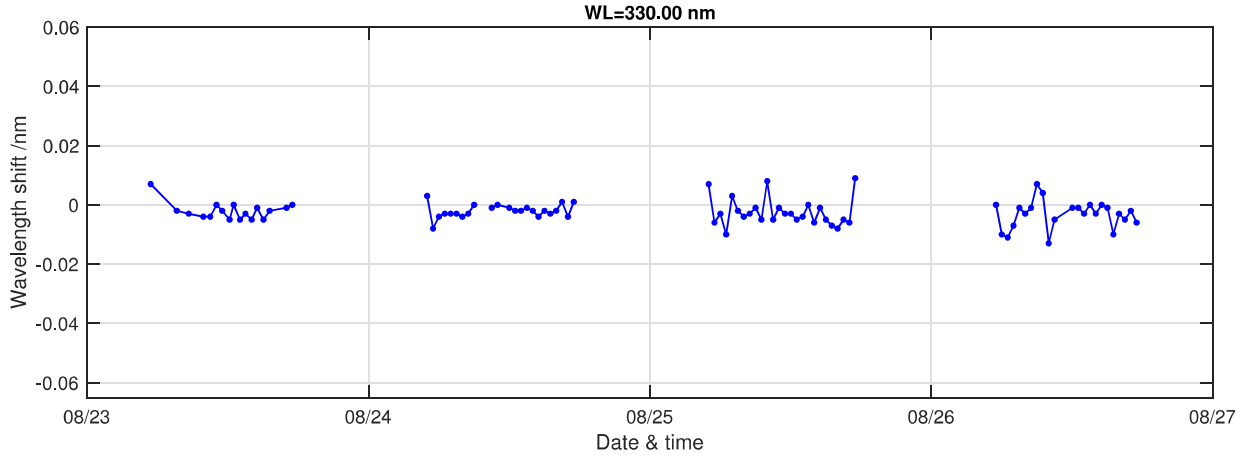

Daily variation. Wavelength bands are ± 2.5 nm
86°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

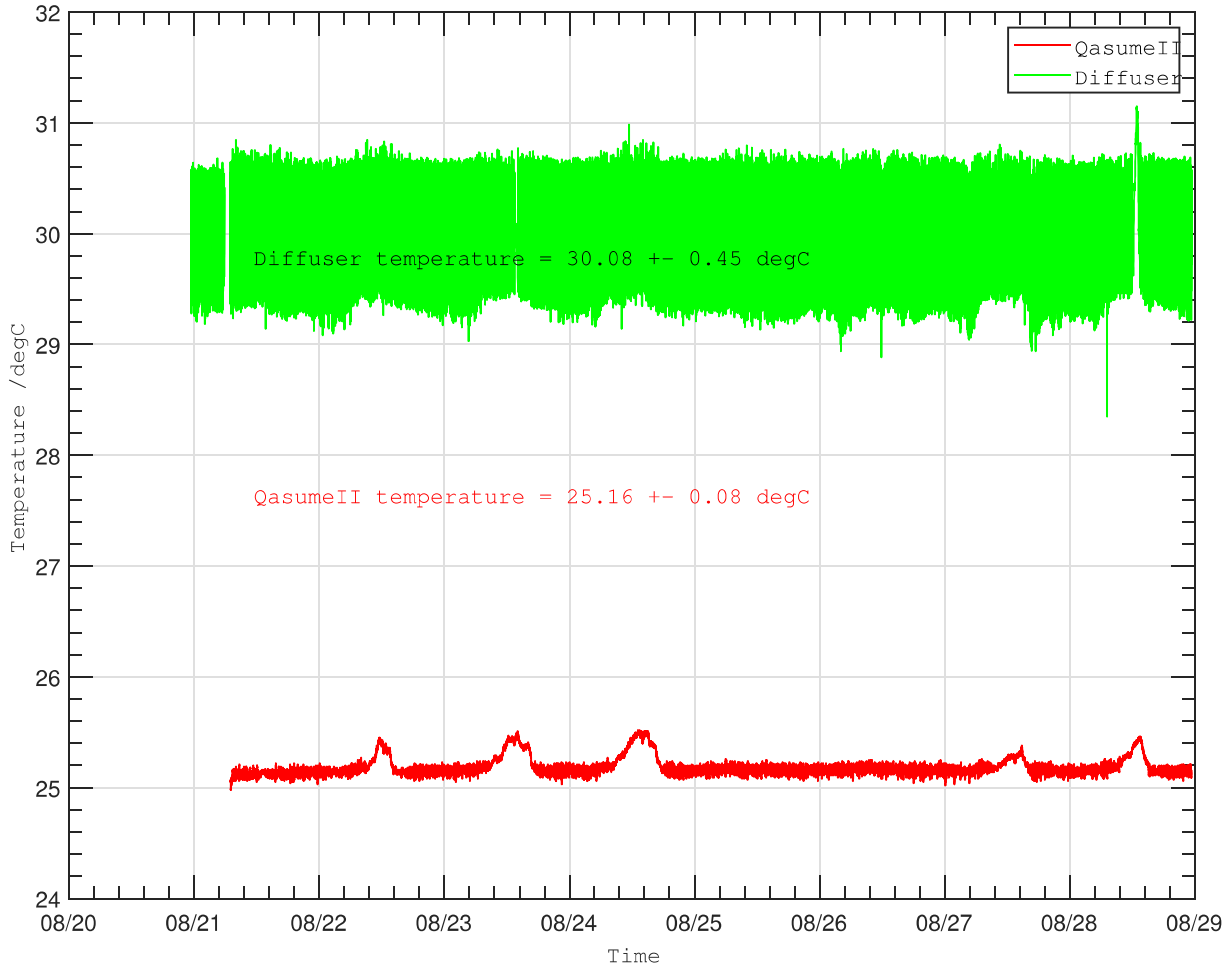

Global irradiance ratios 258/QAS2 at PMOD/WRC-matshic:26-Aug-2024(239)
wl [nm]
UVIndex
258
QAS2

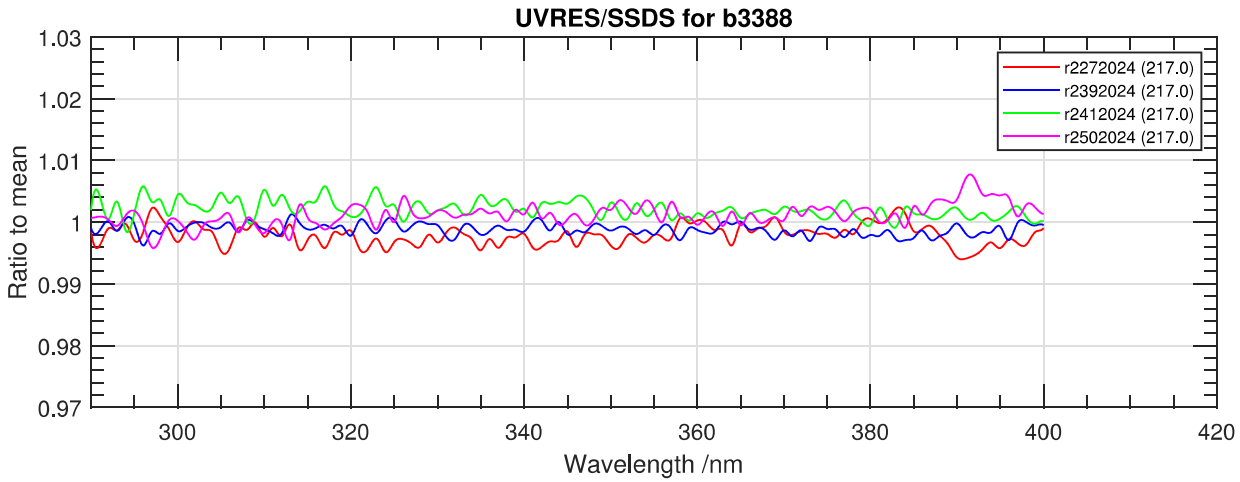

Daily variation. Wavelength bands are ± 2.5 nm
81°
38°
69°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

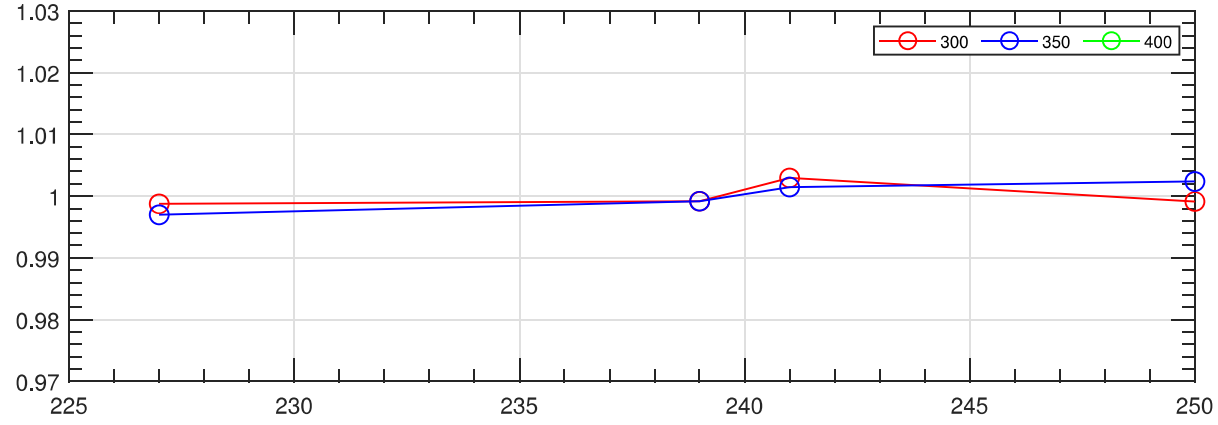

Mean ratio 258/QAS2 at PMOD/WRC-matshic:23-Aug-2024(236) to 26-Aug-2024(239)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
RATIO 258/QAS2
Wavelength [nm]
N258 Spectra=94
NSync-Spectra=79


Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
300
310
320
330
340
350
360
Wavelength /nm


WL=330.00 nm
Wavelength shift /nm
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
08/23
08/24
08/25
08/26
08/27
Date & time


QasumeII
Diffuser
Diffuser temperature = 30.08 +- 0.45 degC
QasumeII temperature = 25.16 +- 0.08 degC
Temperature /degC
Time
32
31
30
29
28
27
26
25
24
08/20
08/21
08/22
08/23
08/24
08/25
08/26
08/27
08/28
08/29


UVRES/SSDS for b3388
r2272024 (217.0)
r2392024 (217.0)
r2412024 (217.0)
r2502024 (217.0)
Ratio to mean
Wavelength /nm
1.03
1.02
1.01
1
0.99
0.98
0.97
300
320
340
360
380
400
420


300
350
400
1.03
1.02
1.01
1
0.99
0.98
0.97
225
230
235
240
245
250


BREWER