Protocol of the intercomparison at AEMET, Madrid, Spain on June 8th to 11th June, 2017 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 global solar irradiance measurements between the spectroradiometer AEM and Brewer spectrophotometer operated by AEMET Madrid and the travel reference spectroradiometer QASUME. The measurement site is located at Madrid; Latitude 40.45 N, Longitude 3.72 W and altitude 680 m.a.s.l.
The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 5:00 UT and 20:00 UT have been analysed.

QASUME was installed on the measurement platform of AEMET-Madrid in the evening of June 8, 2017. The spectroradiometer was installed next to the AEM spectroradiometer and Brewer spectrophotometer with the entrance optic of QASUME within 2 m to the other instrument. The spectroradiometer in use at AEMET is a Bentham DM300 double monochromator system. The input optics is from CMS Schreder. The Brewer Spectrometer is a double monochromator MkIII with the ID 186. The intercomparison between QASUME and the AEMET spectroradiometers lasted three days, from morning of June 9 to the afternoon of June 11.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T61252 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 3 days of the intercomparison period (Day of year 160-162). To account for the responsivity change, the responsivity was calculated for each day separately and used for that specific day. The internal temperature of QASUME was 28.04±0.51 °C and the diffuser head was heated to a temperature of 32.63±3.90 °C.
The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the MatSHIC analysis were between ±50 pm in the spectral range 290 to 400 nm.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 15 minutes from 290 to 400 nm, every 0.25 nm, and 1.5 seconds between each wavelength increment.

DOY	Date	DAY	Weather	Comment (times are in UT)
159	08. Jun	Thursday	Clear sky with Cirrus	Installed at 13:30
160	09. Jun	Friday	Clear sky with Cirrus	13:06 calibration (T68523) 19:00 FEL measured on roof
161	10. Jun	Saturday	Clear sky with few Cirrus	13:10 calibration (T68523) 13:28 calibration (T61252)
162	11. Jun	Sunday	Clear sky with few Cirrus	16:12 calibration (T68523) End of Campaign: 18:15

Results:

In total 162 synchronised simultaneous spectra from QASUME and AEM, respectively 78 spectra from Brewer #186 are available from the measurement period. Measurements between 5:00 and 20:00 UT have been analysed (SZA smaller than 90°).

Remarks:

I. AEM:

1. The ratios between AEM and QASUME have on average an offset of -1 %.
2. The diurnal variation of the AEM to QASUME ratio is less than 5 %.
3. For all solar scans the wavelength shifts of the AEM show a shift of +80 to +210 pm, which was stable during the comparison period.
4. Lamp calibrations: Friday night, 9 June, the AEM system was used to transfer the irrdiance scale of the calibrated 1000 W FEL lamp F386 (PMOD/WRC certificate) to the 1000W FEL type working standards of AEMET and the low power transfer standards (KS type). The calibration was performed outdoor on the roof of AEMET.

II. Brewer #186:

1. The dataset of Brewer #186 is based on responsivity file “uvr15317.186”.
2. The ratios between Brewer #186 and QASUME have on average an offset of -8 %.
3. The diurnal variation of the #186 to QASUME ratio is around 4 %.
4. For all solar scans the wavelength shifts of the Brewer #186 show a shift of less than +50pm to -50pm.

Recommendation:

The setup for the 1000W lamp calibration on the roof has been shown as applicable for lamp calibration/comparison at Aemet. The irradiance scale based on the F386 FEL can be transferred to the two working standards FEL lamps of AEMET using this setup.
It is recommended to make the transfer to the 2 other FEL lamps during select night with low humidity and long darkness (autumn, winter or spring.
In the same procedure, the low power CMS KS transfer standards can be recalibrated using the F386 FEL with the setup on the roof.

Once the KS lamps have been re-calibrated, they can be used to monitor and calibrate the AEM system.

Following procedure for long term stability monitoring is recommended:

a. Once a year: Irriadiance scale realisation with the 1000W lamp (F386). Transfer of the irradiance scale to the two FEL working

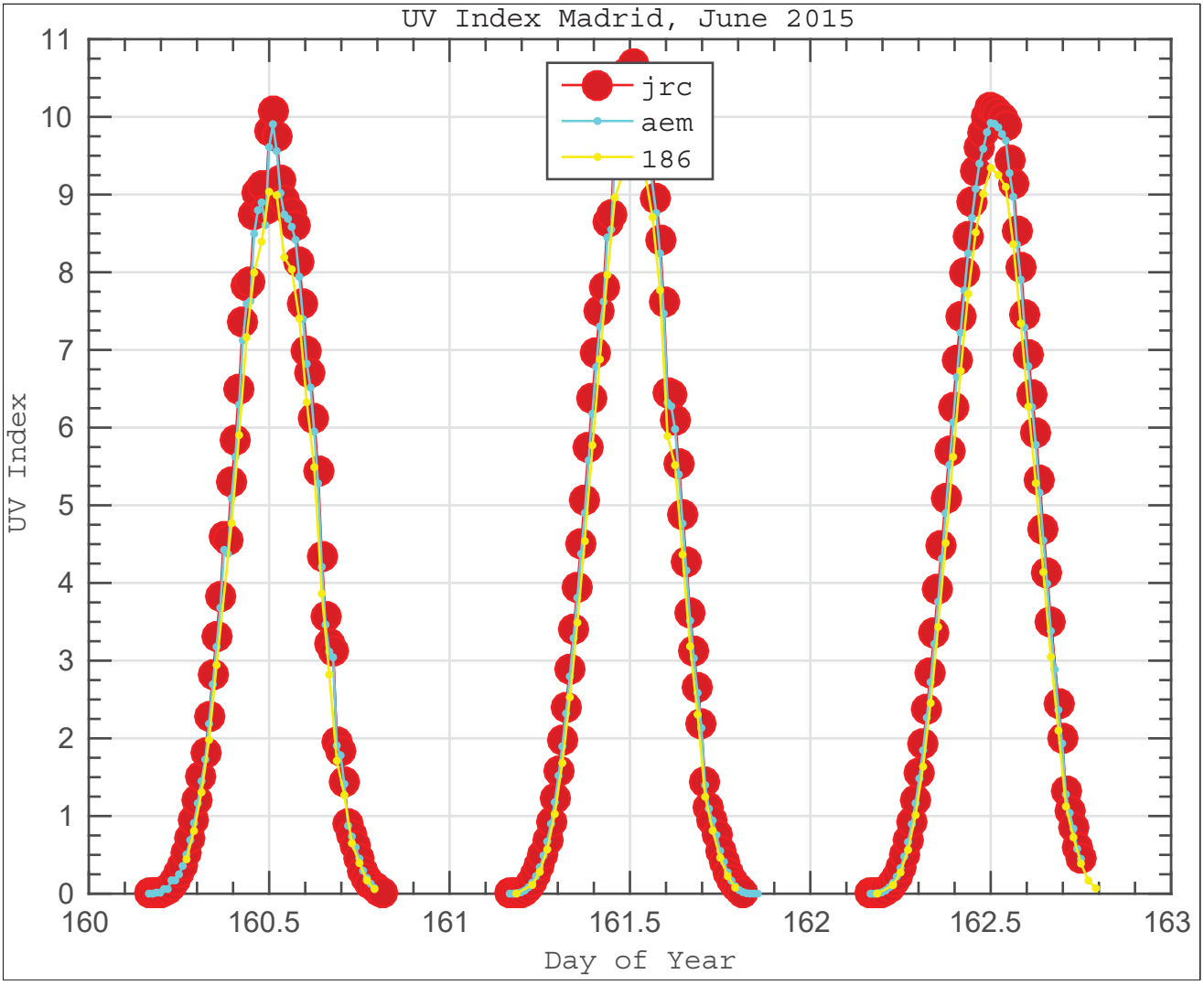
standards and all KS lamps. Analysis of the stability of the set compared to the previous years.

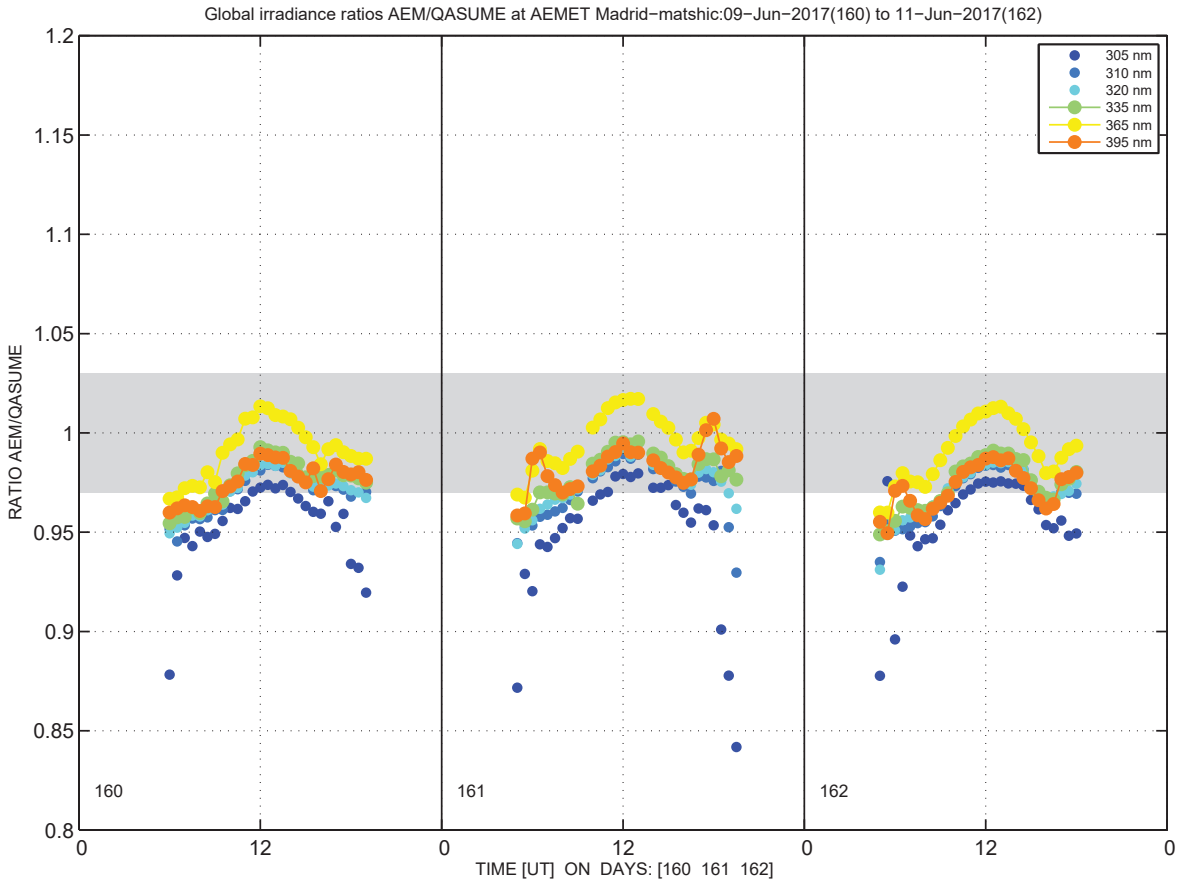
b. Every 2 weeks or every month: monitoring with 1 KS lamp.
c. Comparison of the responsivity of the KS calibrations from the previous measurement.
d. If the responsivity varies more than +/- 1% from the previous measurement: A calibration with a second lamp is recommended.
e. If the second lamp agrees with the first lamp within 1%, the responsivity of the system changed and the KS lamp can be used for a re-calibration of the sensitivity.
f. If the second lamp is more than +/-1% biased, a third lamp can be used to determine which lamp might have changed.
g. If a lamp has changed, the KS lamp should be re-calibrated with the 1000 W FEL lamp F386.

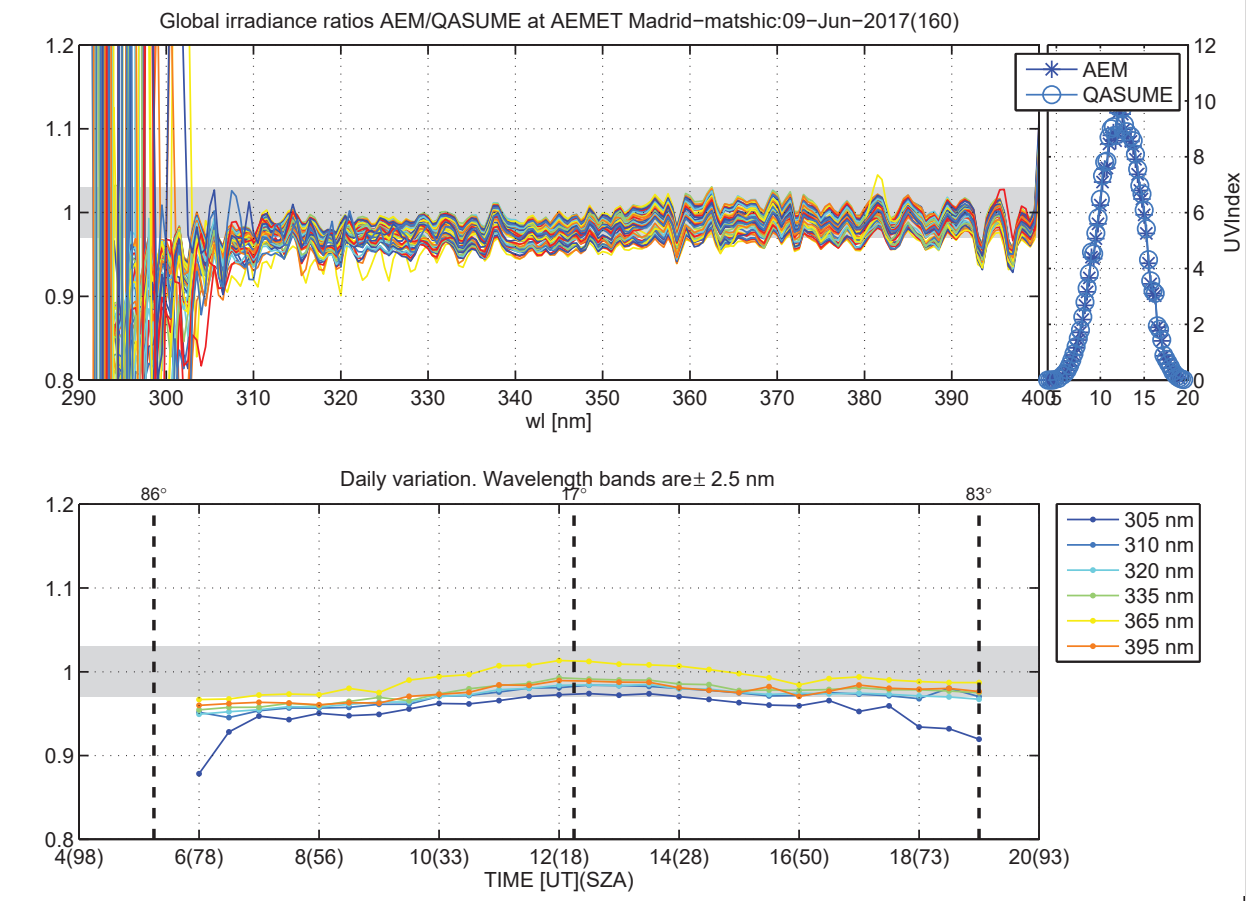
Between the KS lamp measurements, the increase of the temperature of the input optic should minimized. This was successfully achieved during the comparison applying the recommendation of the previous report.

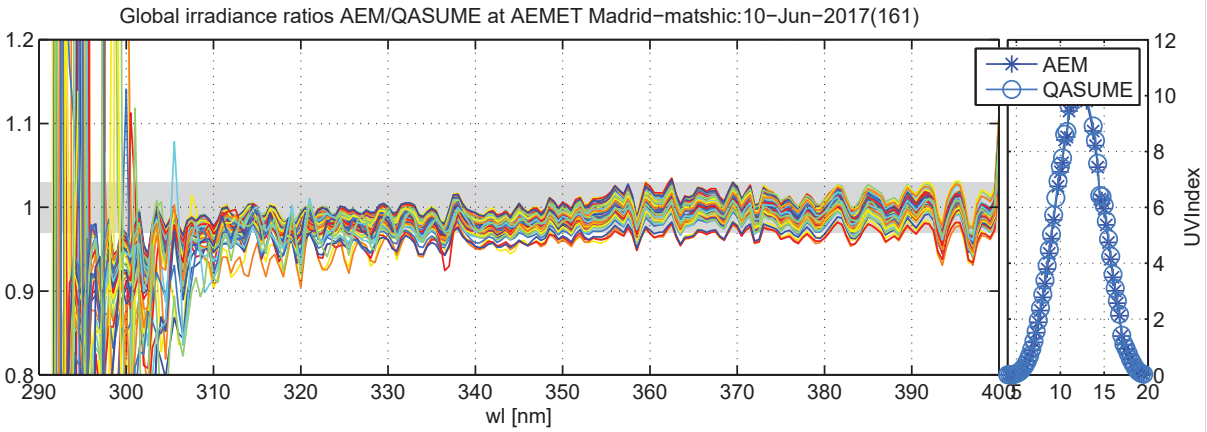
AEMET Operators:

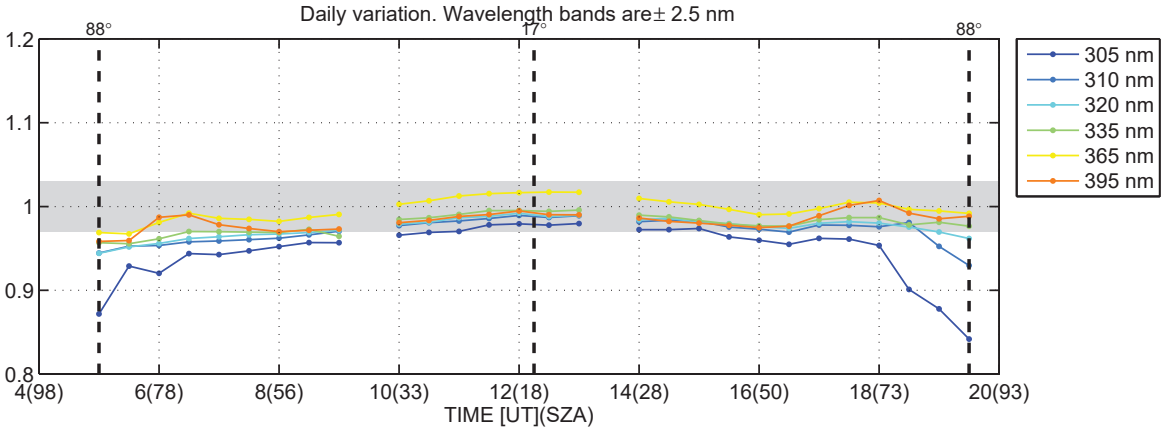
Ana Diaz
Irene Melero
Dario Callau (AFC)

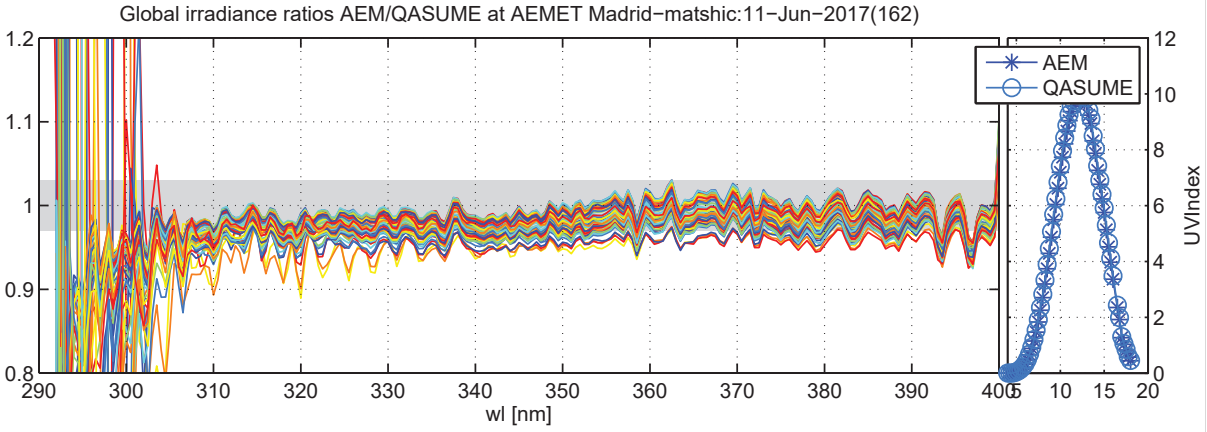

UV Index Madrid, June 2015
jrc
aem
186
UV Index
Day of Year
0
1
2
3
4
5
6
7
8
9
10
11
160
160.5
161
161.5
162
162.5
163

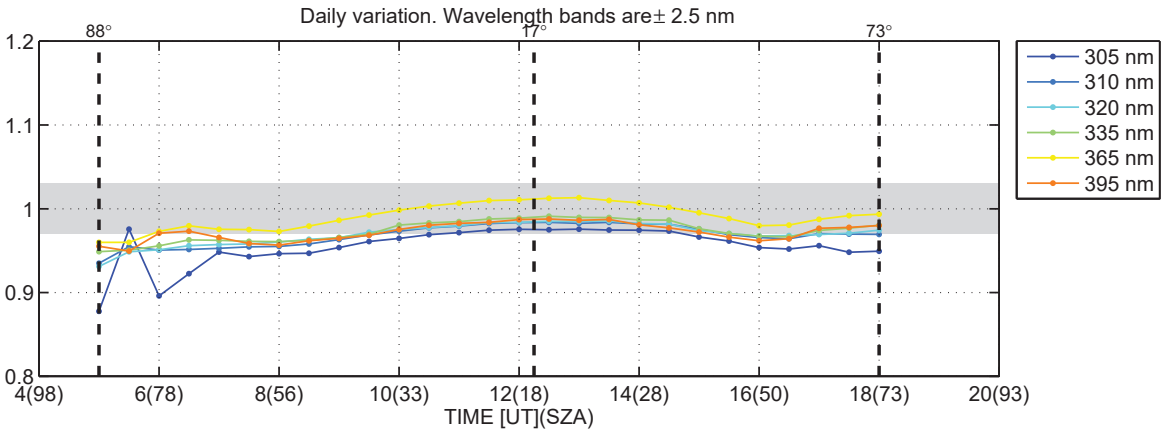

Global irradiance ratios AEM/QASUME at AEMET Madrid−matshic:09−Jun−2017(160) to 11−Jun−2017(162)
RATIO AEM/QASUME
TIME [UT] ON DAYS: [160 161 162]
160
161
162
305 nm
310 nm
320 nm
335 nm
365 nm
395 nm

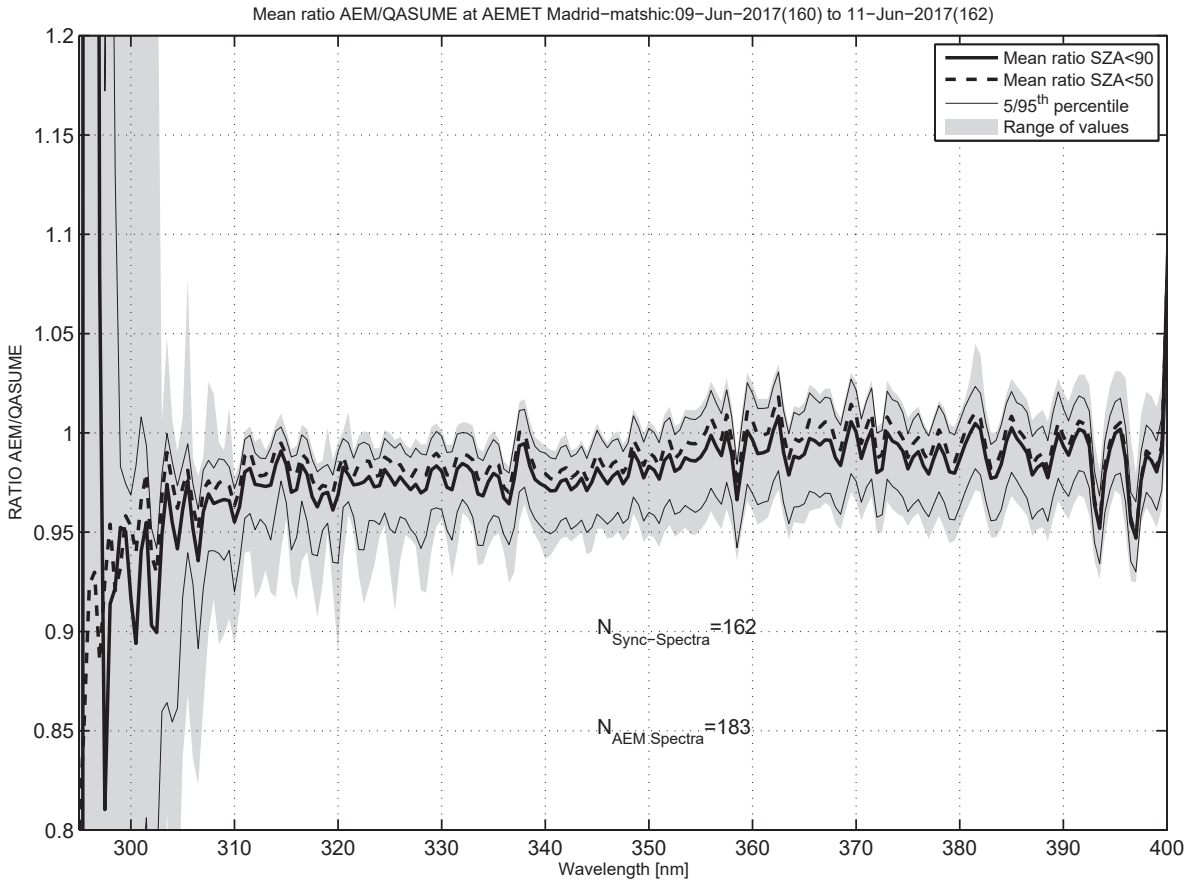

Global irradiance ratios AEM/QASUME at AEMET Madrid−matshic:09−Jun−2017(160)
AEM
QASUME
UVIndex
wl [nm]
Daily variation. Wavelength bands are± 2.5 nm
86°
17°
83°
TIME [UT](SZA)
305 nm
310 nm
320 nm
335 nm
365 nm
395 nm

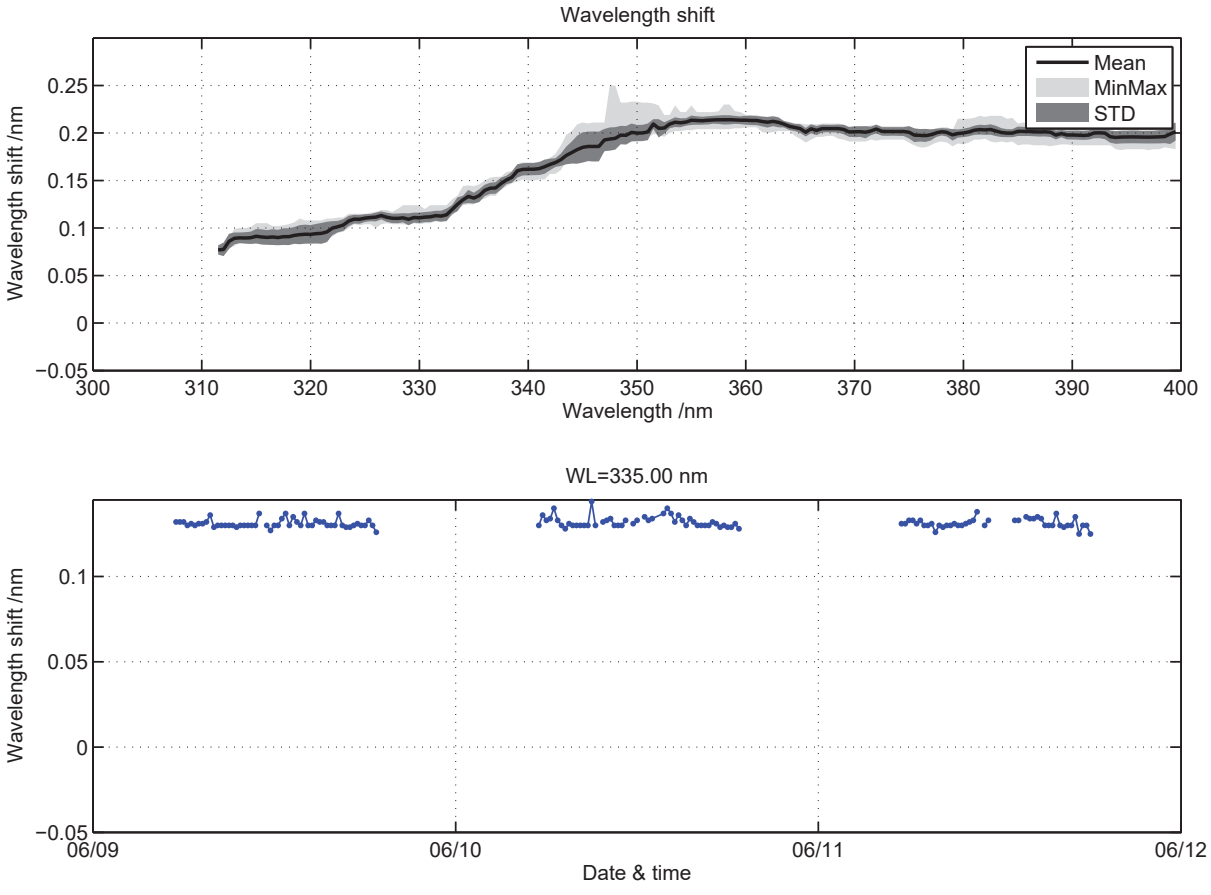

Global irradiance ratios AEM/QASUME at AEMET Madrid−matshic:10−Jun−2017(161)
AEM
QASUME
wl [nm]
UVIndex

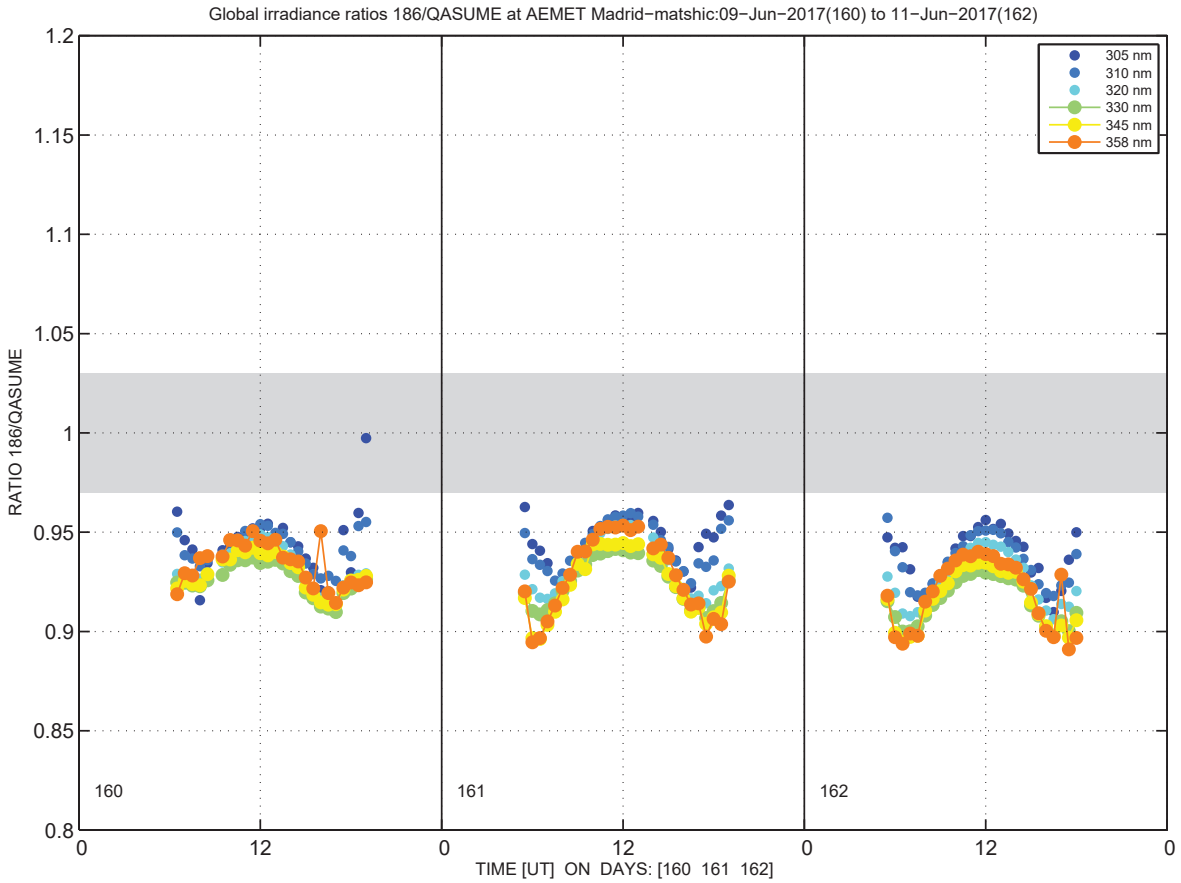

Daily variation. Wavelength bands are± 2.5 nm
88°
17°
88°
305 nm
310 nm
320 nm
335 nm
365 nm
395 nm
4(98)
6(78)
8(56)
10(33)
12(18)
14(28)
16(50)
18(73)
20(93)
TIME [UT](SZA)

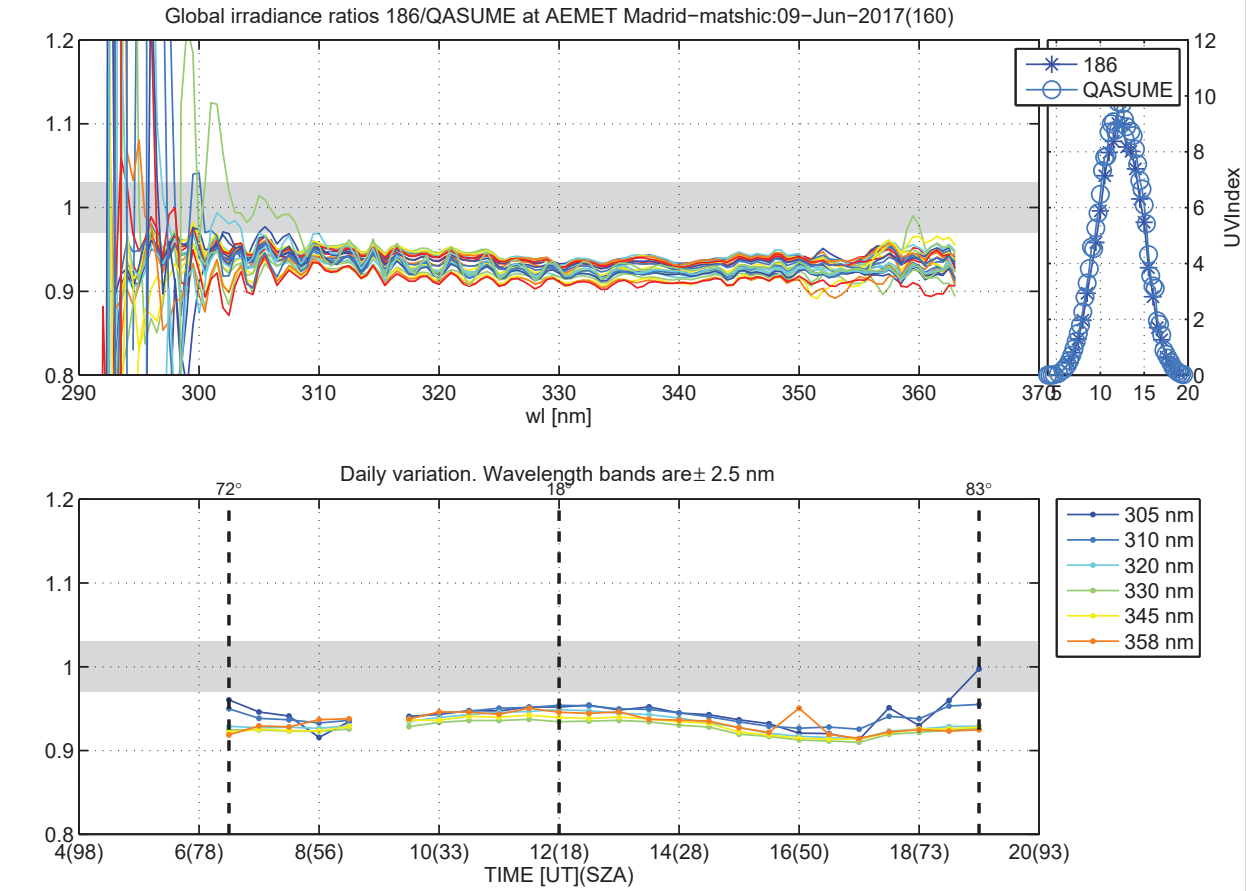

Global irradiance ratios AEM/QASUME at AEMET Madrid−matshic:11−Jun−2017(162)
AEM
QASUME
wl [nm]
UVIndex

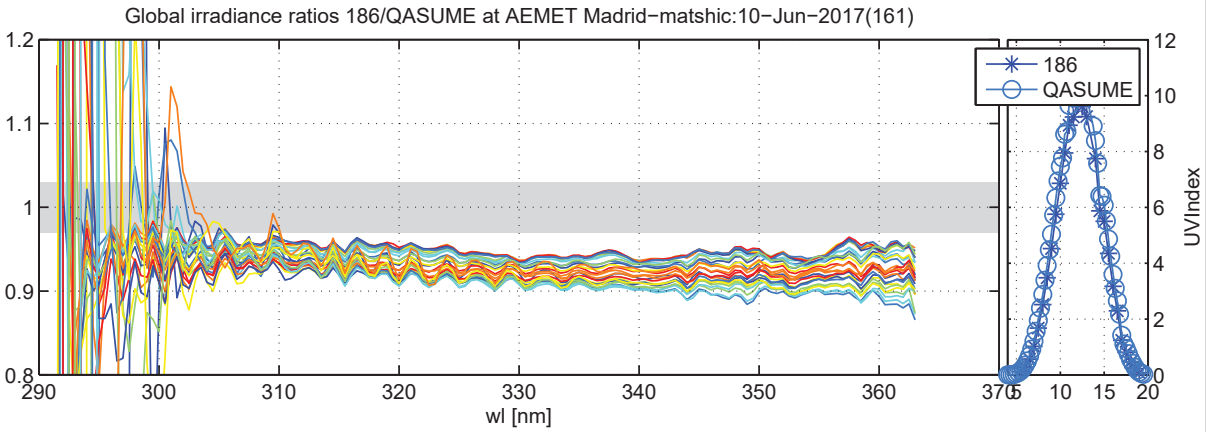

Daily variation. Wavelength bands are± 2.5 nm
88°
17°
73°
305 nm
310 nm
320 nm
335 nm
365 nm
395 nm
4(98)
6(78)
8(56)
10(33)
12(18)
14(28)
16(50)
18(73)
20(93)
TIME [UT](SZA)

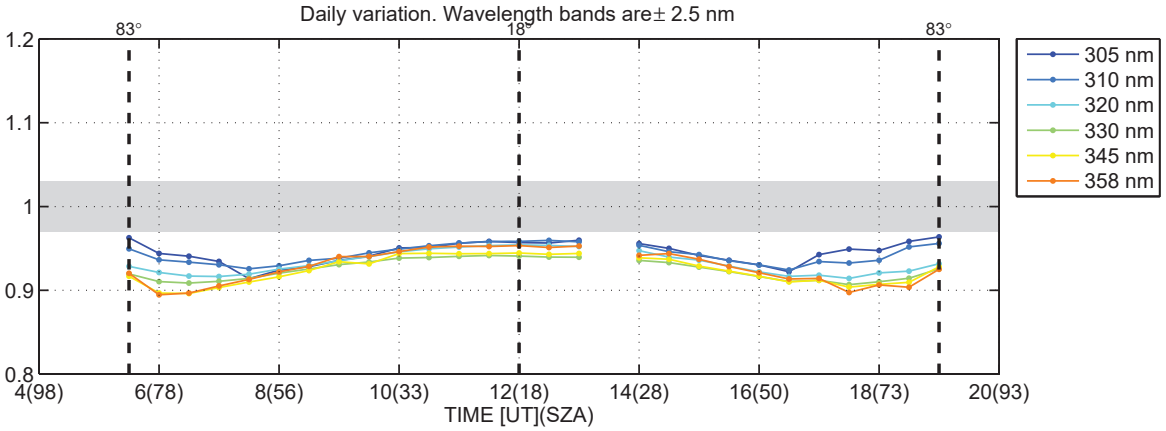

Mean ratio AEM/QASUME at AEMET Madrid−matshic:09−Jun−2017(160) to 11−Jun−2017(162)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AEM/QASUME
Wavelength [nm]
N Sync−Spectra =162
N AEM Spectra =183

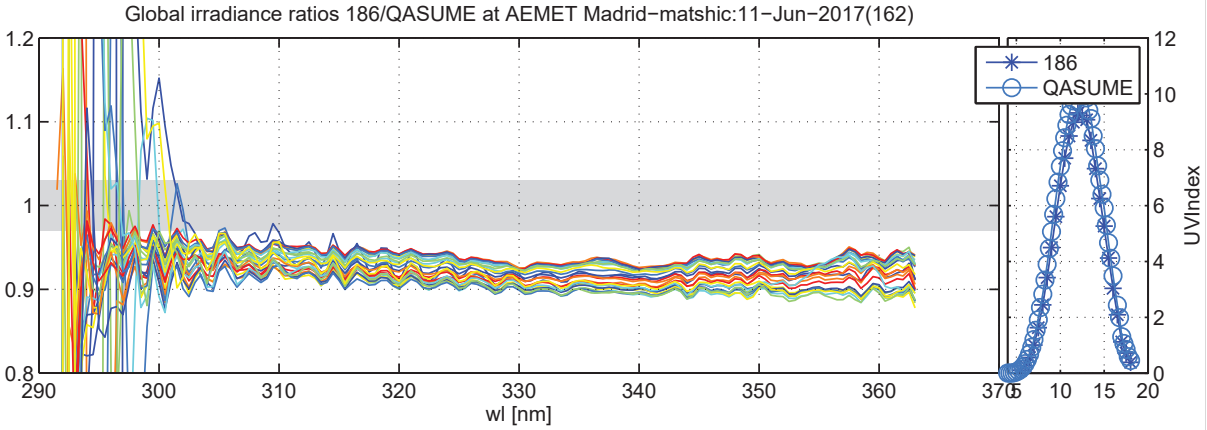

Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
Wavelength /nm
WL=335.00 nm
Wavelength shift /nm
Date & time
06/09
06/10
06/11
06/12

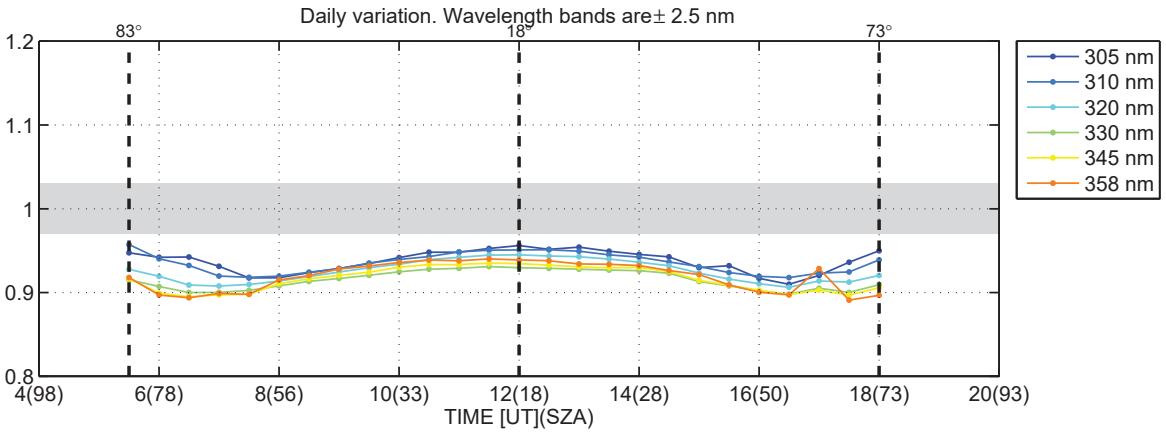

Global irradiance ratios 186/QASUME at AEMET Madrid−matshic:09−Jun−2017(160) to 11−Jun−2017(162)
RATIO 186/QASUME
TIME [UT] ON DAYS: [160 161 162]
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
160
161
162

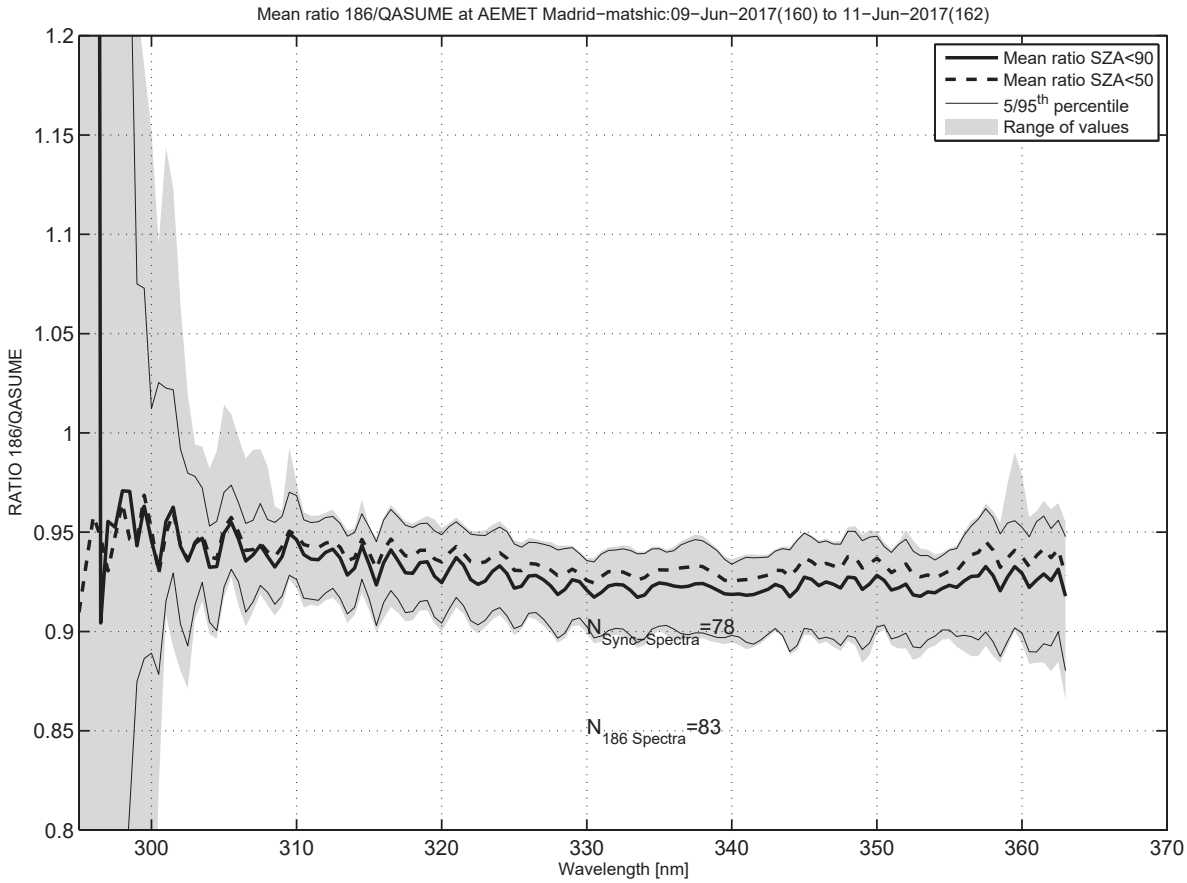

Global irradiance ratios 186/QASUME at AEMET Madrid−matshic:09−Jun−2017(160)
186
QASUME
UVIndex
wl [nm]
Daily variation. Wavelength bands are± 2.5 nm
72°
18°
83°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

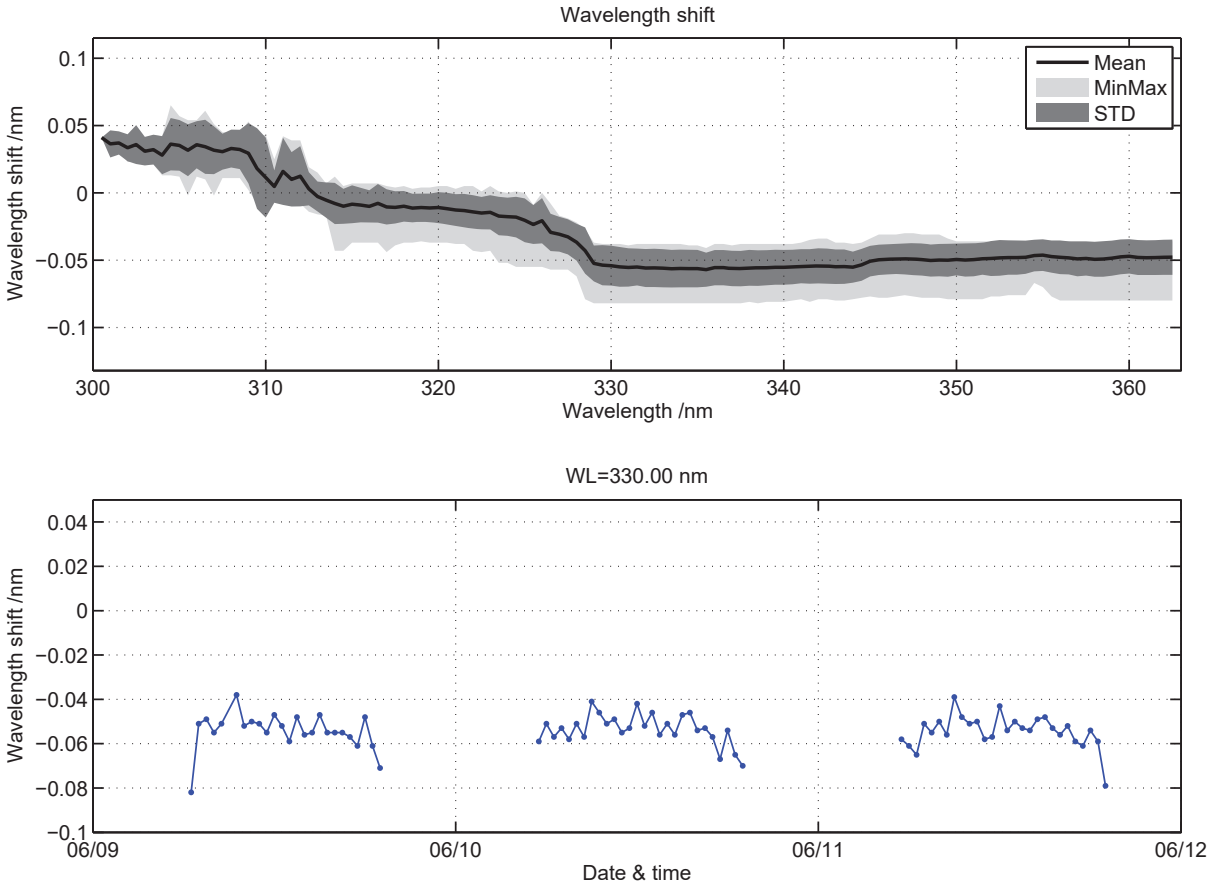

Global irradiance ratios 186/QASUME at AEMET Madrid−matshic:10−Jun−2017(161)
186
QASUME
UVIndex
wl [nm]

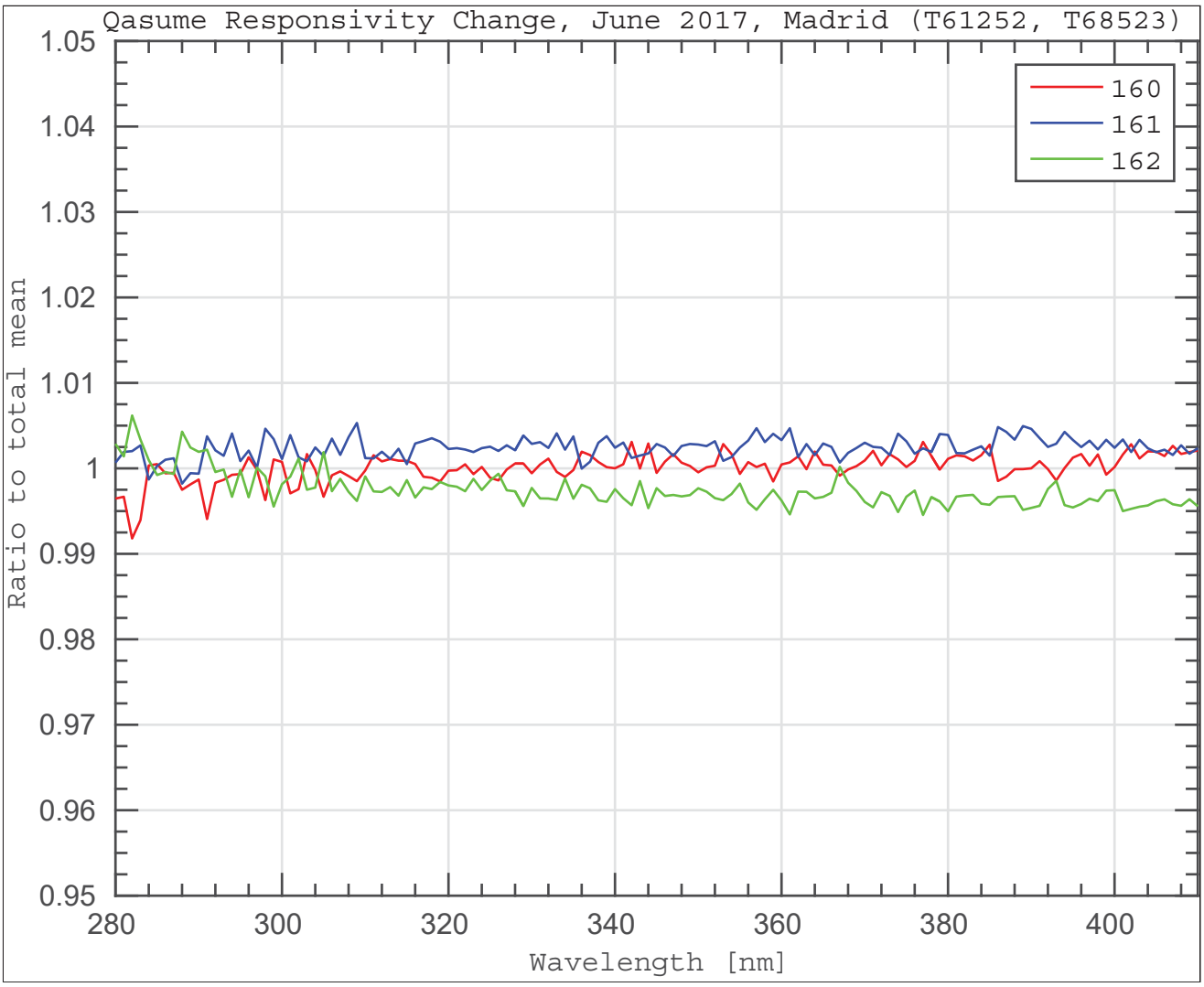

Daily variation. Wavelength bands are± 2.5 nm
83°
18°
83°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

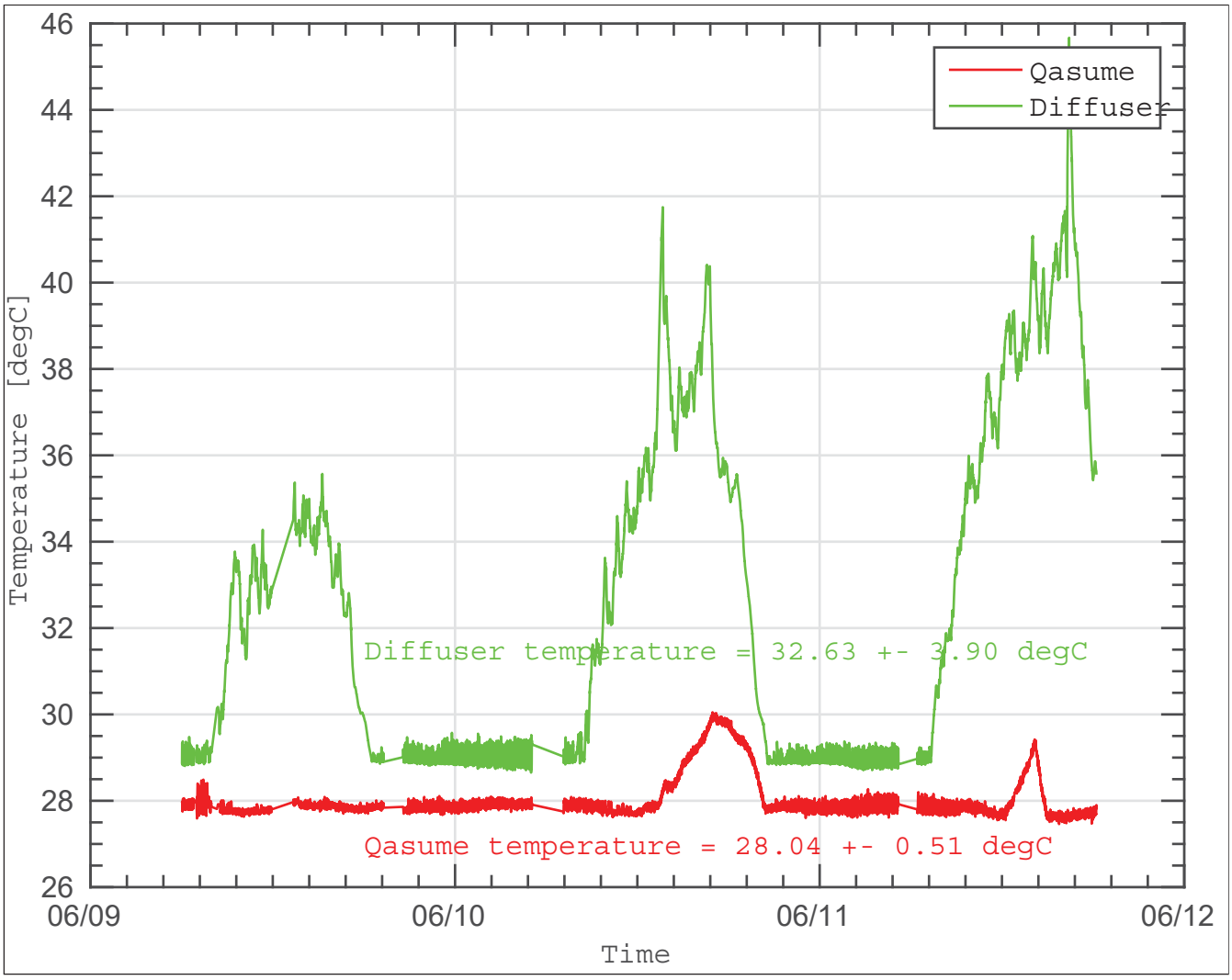

Global irradiance ratios 186/QASUME at AEMET Madrid−matshic:11−Jun−2017(162)
186
QASUME
UVIndex
wl [nm]


Daily variation. Wavelength bands are± 2.5 nm
83°
18°
73°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)


Mean ratio 186/QASUME at AEMET Madrid−matshic:09−Jun−2017(160) to 11−Jun−2017(162)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO 186/QASUME
Wavelength [nm]
N Syno Spectra =78
N 186 Spectra =83


Wavelength shift
Mean
MinMax
STD
Wavelength shift /nm
Wavelength /nm
WL=330.00 nm
Wavelength shift /nm
Date & time
06/09
06/10
06/11
06/12


Qasume Responsivity Change, June 2017, Madrid (T61252, T68523)
160
161
162
Ratio to total mean
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
280
300
320
340
360
380
400
Wavelength [nm]


Qasume
Diffuser
Temperature [degC]
46
44
42
40
38
36
34
32
30
28
26
Diffuser temperature = 32.63 +- 3.90 degC
Qasume temperature = 28.04 +- 0.51 degC
06/09
06/10
06/11
06/12
Time


BREWER