Protocol of the intercomparison at ARPA, Aosta, Italy on August 22 to 25, 2011 with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Gregor Hülsen

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The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer AAO and AAB operated by the Sezione Agenti Fisici - Radiazione Ultravioletta Solare, Agenzia Regionale per la Protezione dell'Ambiente (ARPA) and the travel reference spectroradiometer QASUME. The measurement site is located at Valle d'Aosta; Latitude 45.74 N, Longitude 7.34 E and altitude 569 m.a.s.l.
The horizon of the measurement site is free down to at least 80° solar zenith angle (SZA). Measurements between 5:00 UT and 18:00 UT have been analysed.

QASUME was installed at ARPA Aosta at noon of August 22, 2011. The spectroradiometer was installed between the AAO and AAB instrument with the entrance optic of QASUME within 2 m of AAO and about 10 m to AAB. The spectroradiometers in use at ARPA Aosta are a Bentham DTMc300 double monochromator (AAO) and a Brewer #066 (AAB). The intercomparison between QASUME and the ARPA spectroradiometer lasted three days, from the morning of August 23 to evening of August 25.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T68522 and T61253) 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 internal temperature of QASUME was 26.0±0.1 °C and the diffuser head was heated to a temperature of 30.5±3.3 °C.
The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm 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 30 minutes from 290 to 500 nm, every 0.25 nm, and 1.5 seconds between each wavelength increment.

DOY	Date	DAY	Weather	Comment (times are in UT)
234	22. Aug	Monday	Sun & Clouds	Installed at 11:30
235	23. Aug	Tuesday	Clear sky in the morning Increasing clouds during the day	8:47 - calibration using T68523
236	24. Aug	Wednesday	Clear sky in the morning Increasing clouds during the day	12:39 calibration using T68523
237	25. Aug	Thursday	Mostly clear sky	11:44 and 12:11 calibration using T68523 and T61253 9:52 irradiance measurement KS024 10:22 irradiance measurement KS023 End of Campaign: 17:00

Results:

In total 71 (AAO) and 60 (AAB) synchronised simultaneous spectra from QASUME and AAO/AAB are available from the measurement period. Measurements between 4:30 and 18:00 UT have been analysed (SZA smaller than 90°).

Remarks:

I. AAO

1. The ratios between AAO and QASUME have on average an offset of +0.5 %.
2. The diurnal variation of the AAO to QASUME ratio is below 2 % on the clear sky days.
3. For all solar scans the wavelength shifts of the AAO are between ±20 pm.

II. AAB

1. The ratios between AAB and QASUME have on average an offset of +0 % for wavelengths longer than 305 nm.
2. The irradiance calibration of AAB is based on an irradiance transfer from the AAB Bentham system to the Brewer #066.
3. Below 305 nm, the measurements of AAB shows higher variability because of the straylight correction, needed to reduce the internal stray light of the single monochromator. See: Comments of the operator.
4. The diurnal variation of the AAB to QASUME ratio is around 3 %.
5. For all solar scans the wavelength shifts of the AAB are below ±40 pm.

III. Additional Measurements

1. The irradiance calibration of two ARPA transfer standards (KS023 and KS024) was checked during the campaign (ARPA calibrator and PMOD power supply). KS023 is identical to the transfer standard T68523 whereas KS024 shows a 2 % lower irradiance (see figure).
2. The ARPA irradiance calibrator and power supply was tested using KS023 as light source and the Qasume spectroradiometer as irradiance monitor. No difference between this measurement and the previous (section III 1.) was found.

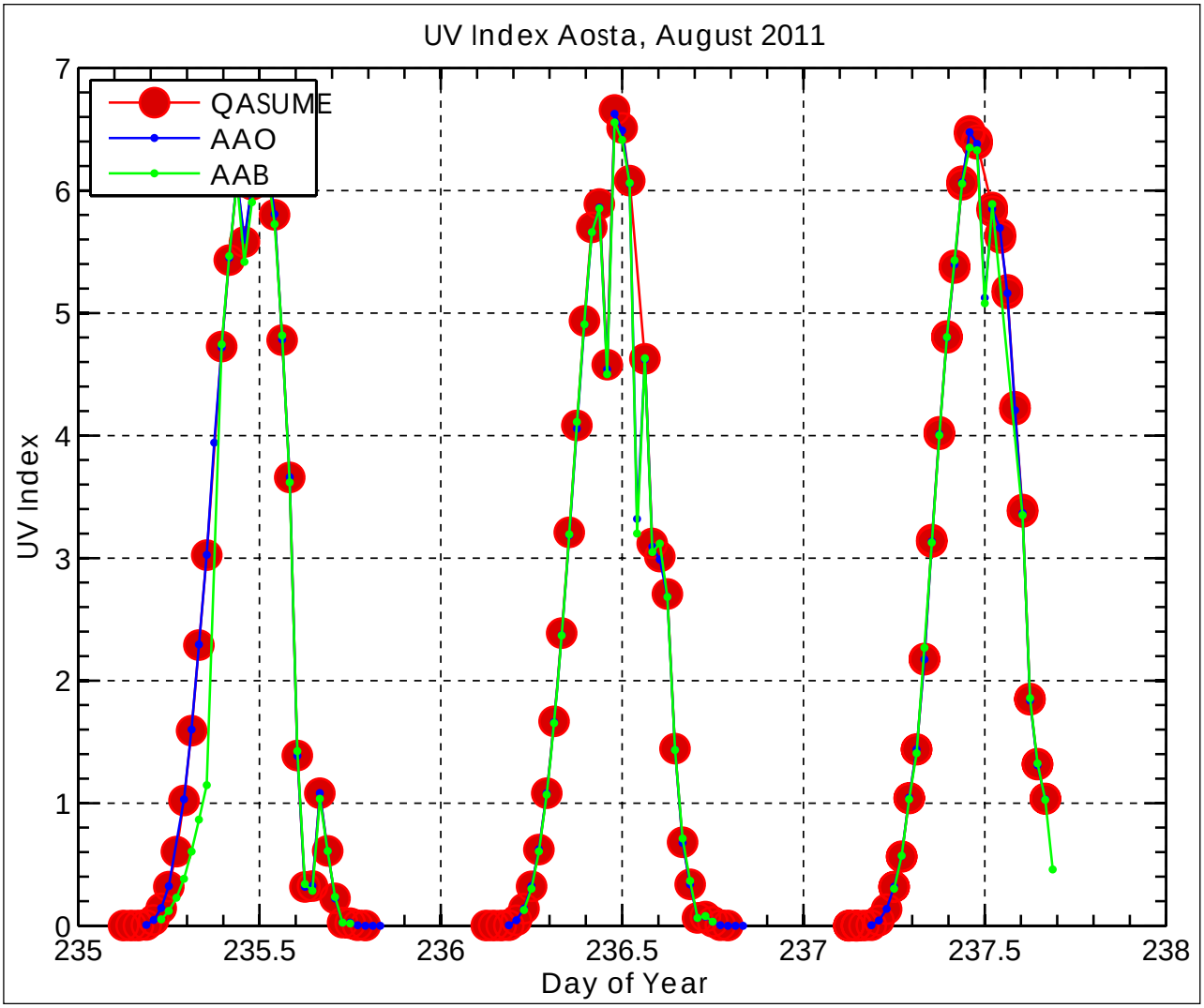
Comments from the local operator

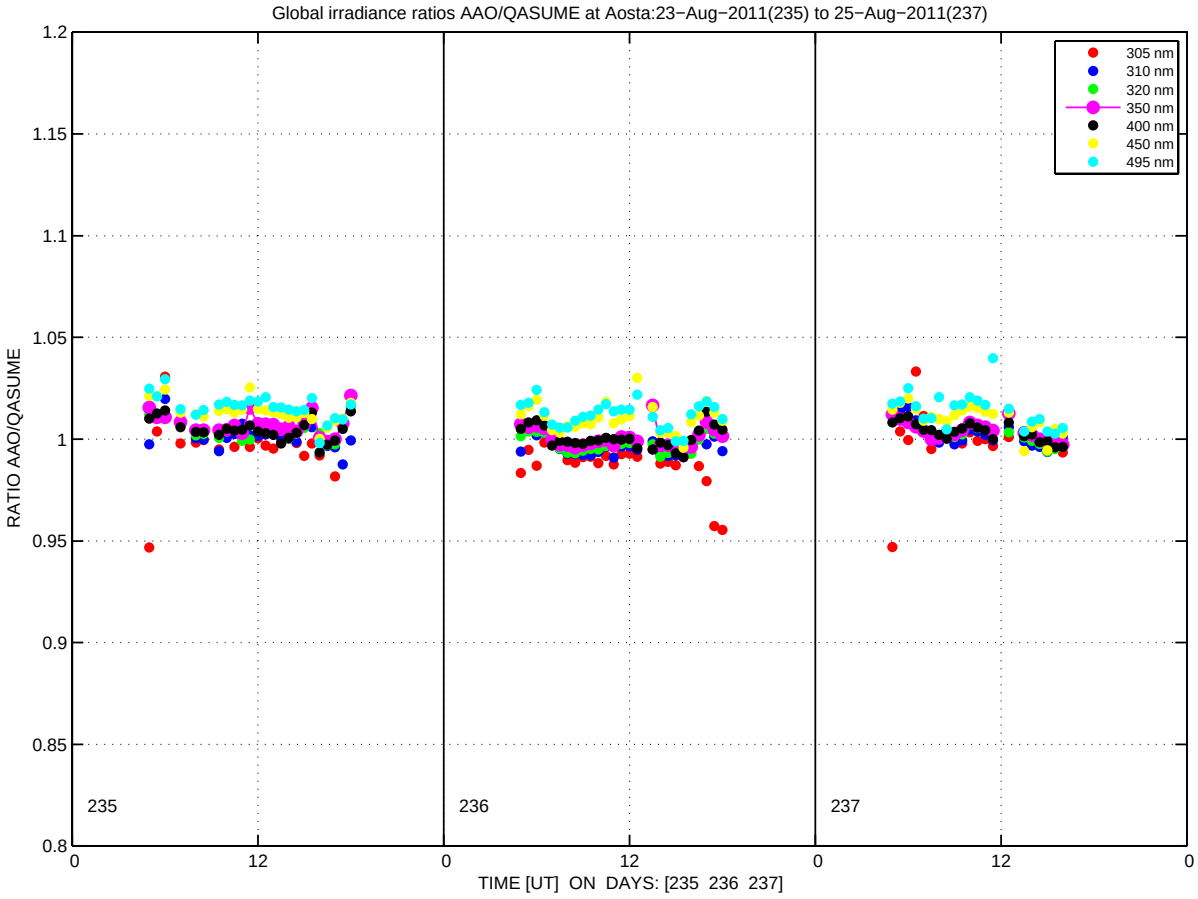
The straylight correction used by ARPA is an adaptation from the widely used "5-wavelengths algorithm" (Fioletov et al., 2000). In the original algorithm, light measured at wavelengths below 292.5 nm is considered as straylight and the average irradiance in that interval is subtracted to the measured signal at larger wavelengths. The limit was raised to 296 nm by ARPA.

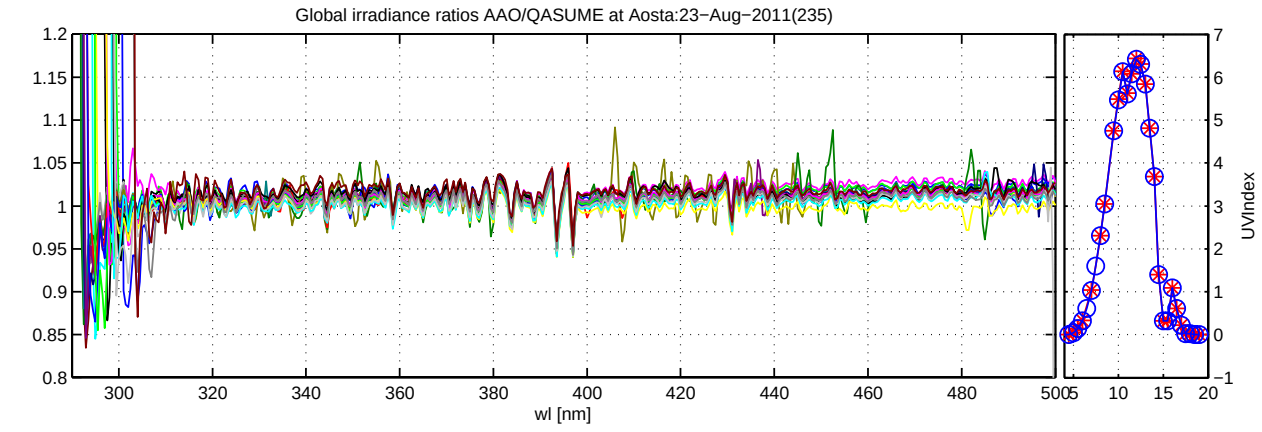
Also, the Brewer calibration is performed by transfer from the Bentham, using the sun as a source. Simultaneous spectra are acquired for a couple of days and their ratio is calculated. It is likely that a part of the responsivity obtained in such a way takes into account most of the strayligh. The procedure is repeated on a monthly basis.

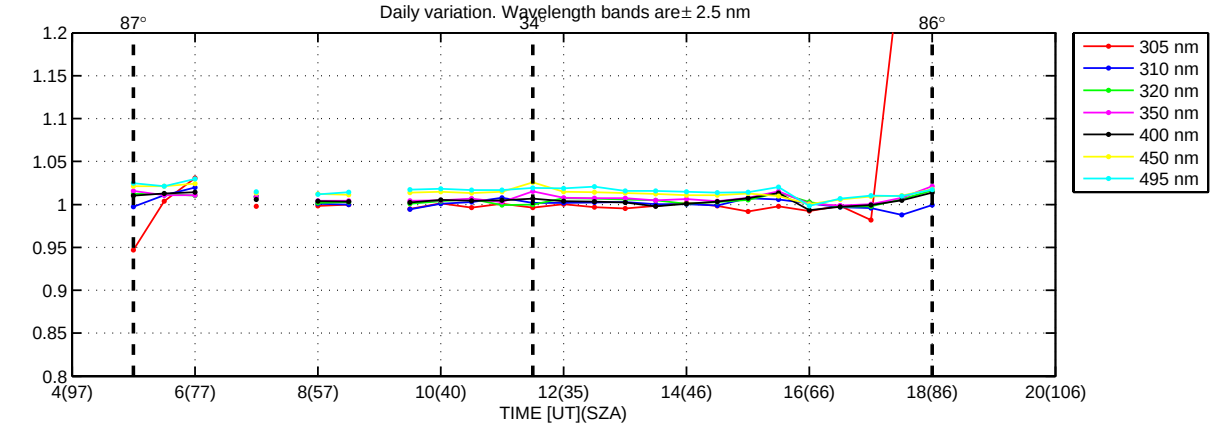
References

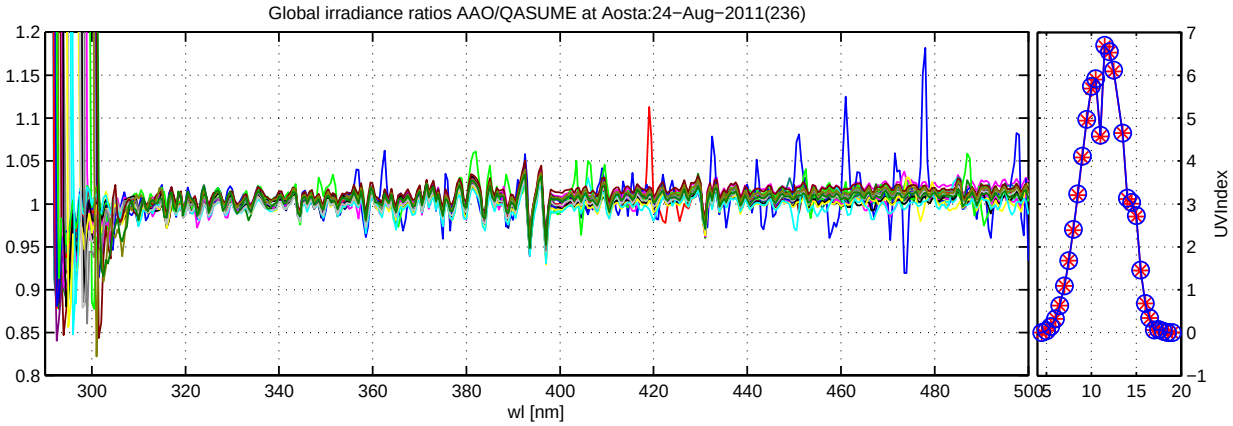
Fioletov, V.E., J.B. Kerr, D.I. Wardle and E. Wu, Correction of stray light for the Brewer single monochromator, Proc. Quadrennial Ozone Symposium, Sapporo 2000, Japan, 369-37

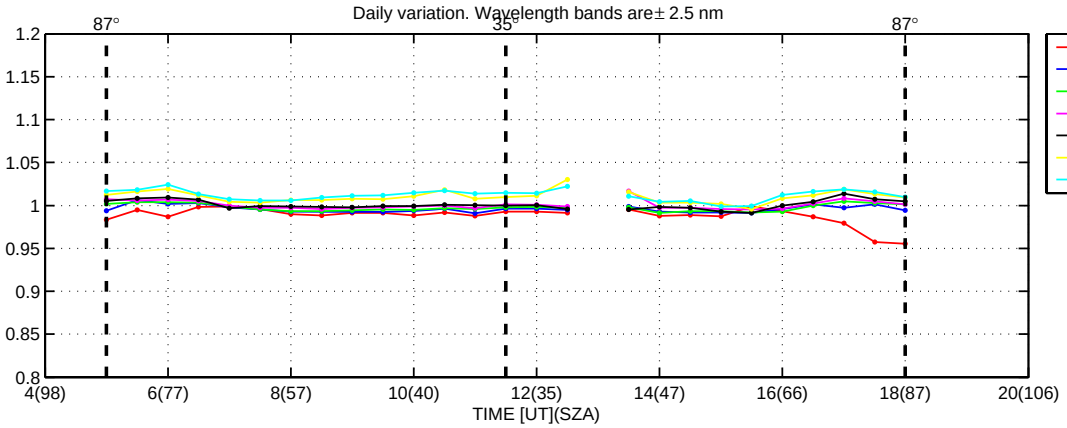

UV Index Aosta, August 2011
QASUME
AAO
AAB
UV Index
Day of Year
0
1
2
3
4
5
6
7
235
235.5
236
236.5
237
237.5
238

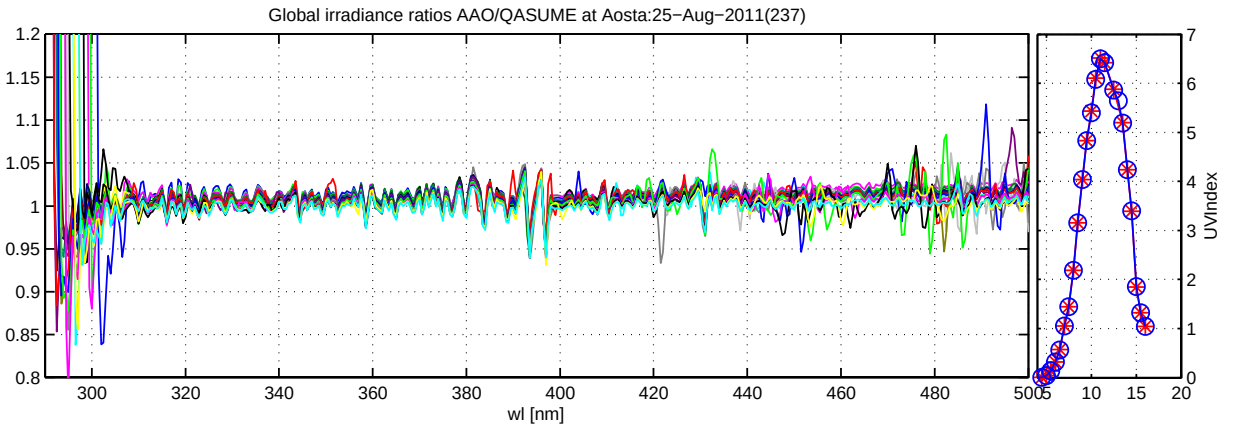

Global irradiance ratios AAO/QASUME at Aosta:23−Aug−2011(235) to 25−Aug−2011(237)
RATIO AAO/QASUME
TIME [UT] ON DAYS: [235 236 237]
235
236
237
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm

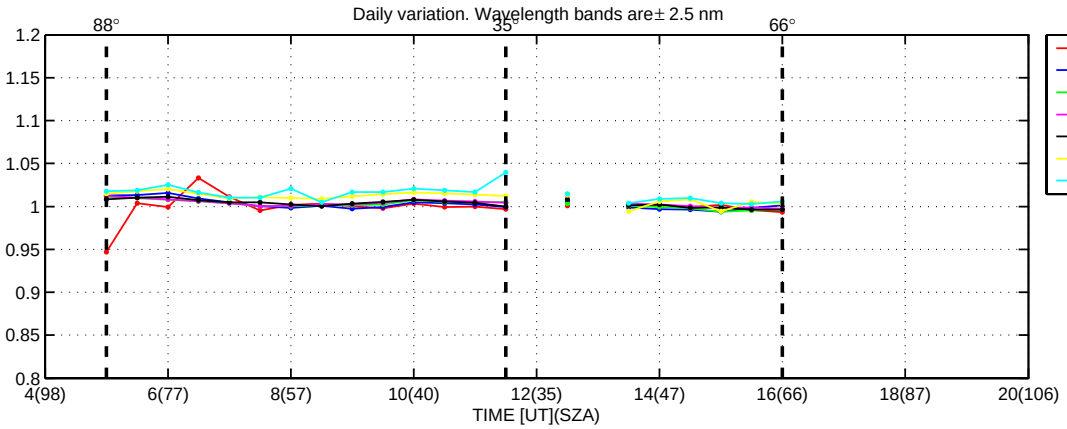

Global irradiance ratios AAO/QASUME at Aosta:23−Aug−2011(235)
wl [nm]
UVIndex

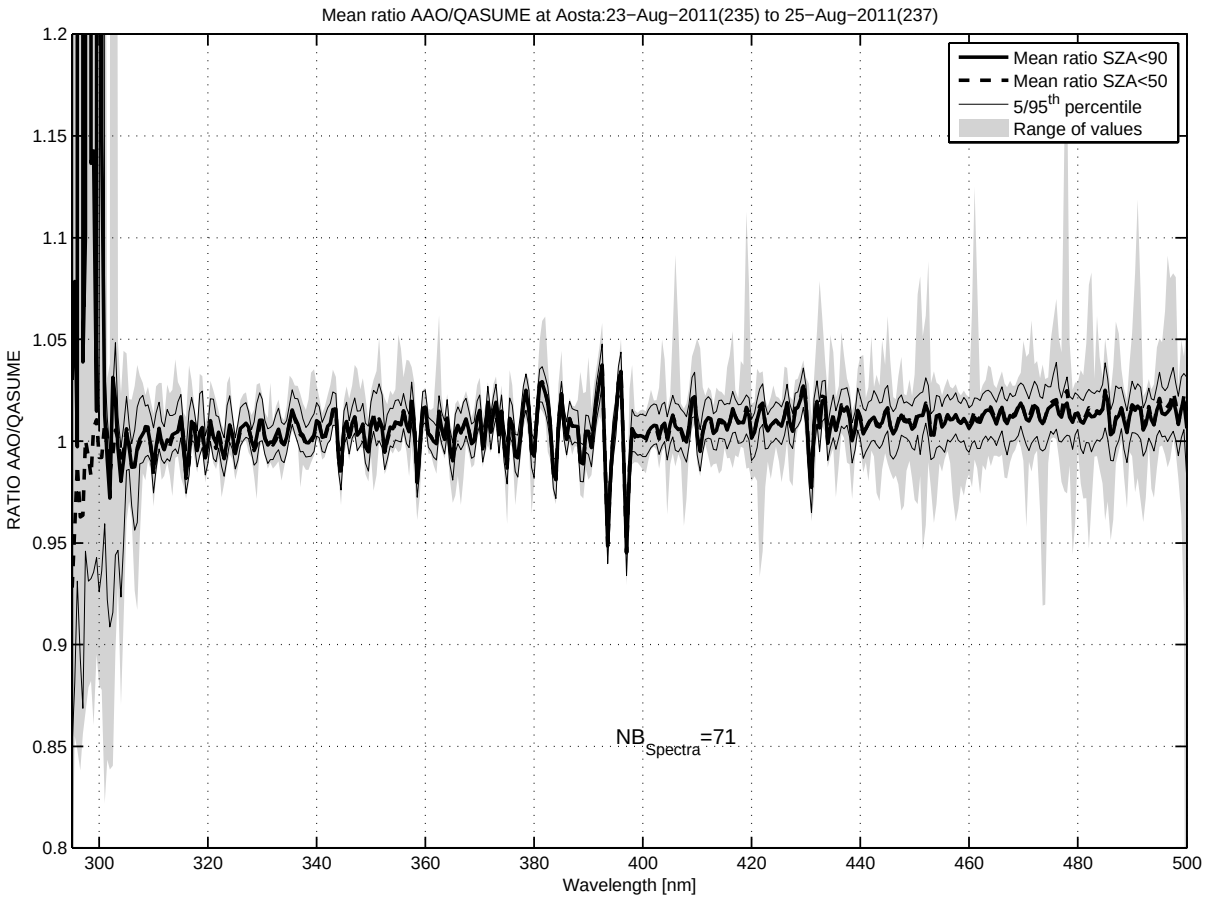

Daily variation. Wavelength bands are± 2.5 nm
87°
34°
86°
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm

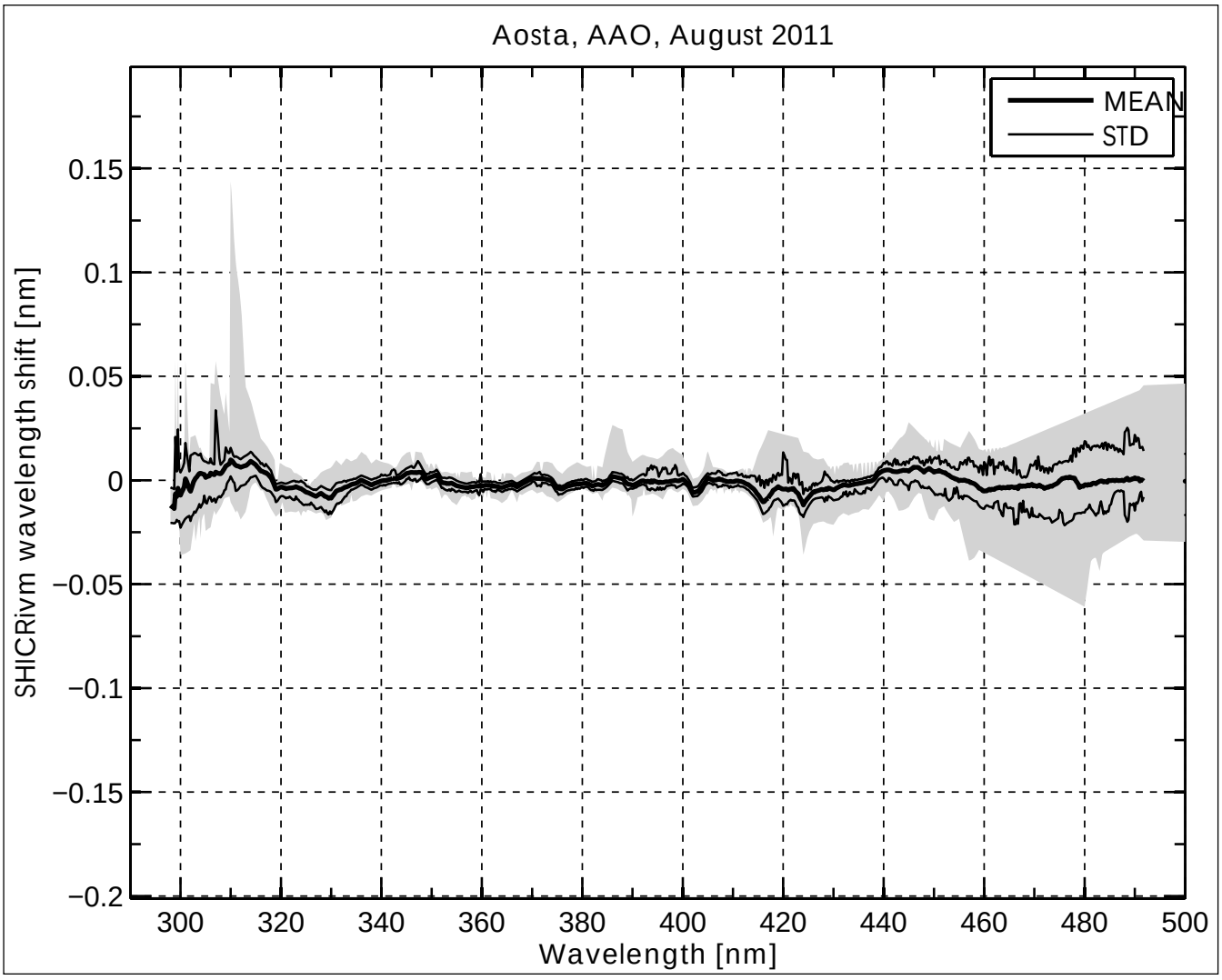

Global irradiance ratios AAO/QASUME at Aosta:24−Aug−2011(236)
wl [nm]
UVIndex

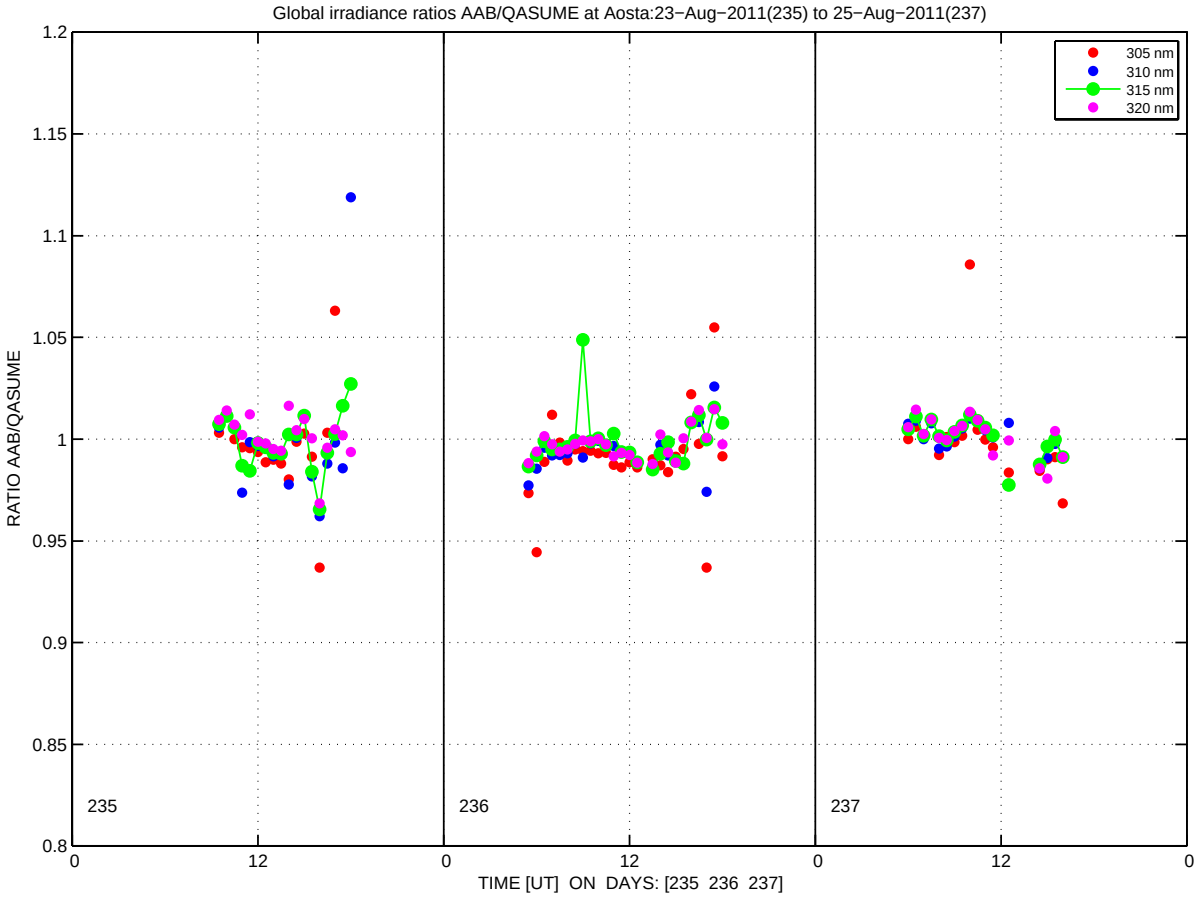

Daily variation. Wavelength bands are± 2.5 nm
87°
35°
87°
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm
TIME [UT](SZA)

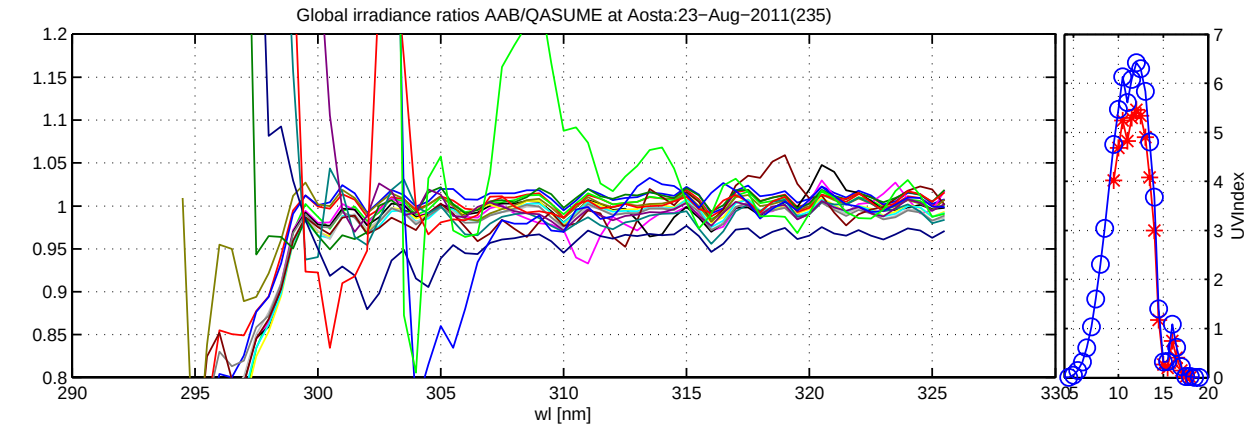

Global irradiance ratios AAO/QASUME at Aosta:25−Aug−2011(237)
wl [nm]
UVIndex

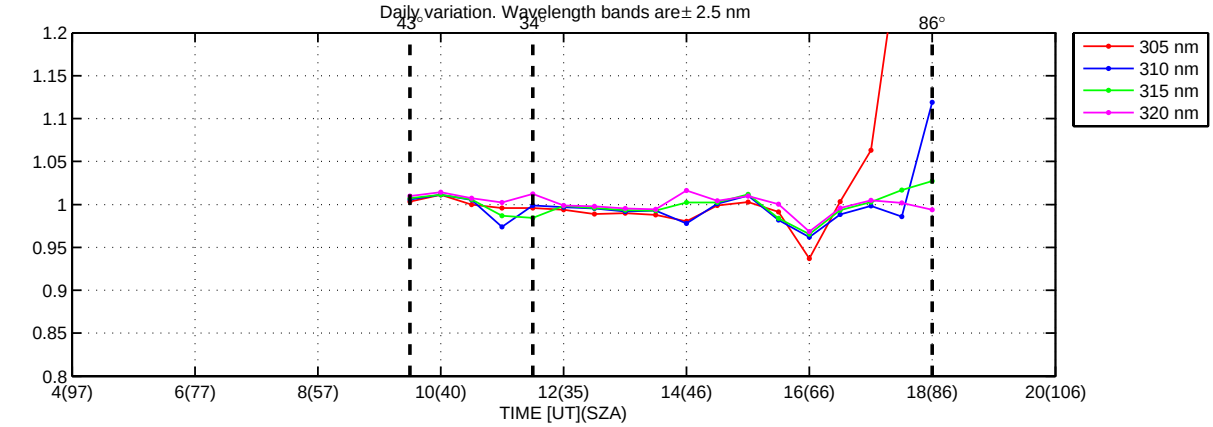

Daily variation. Wavelength bands are± 2.5 nm
88°
35°
66°
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm
TIME [UT](SZA)

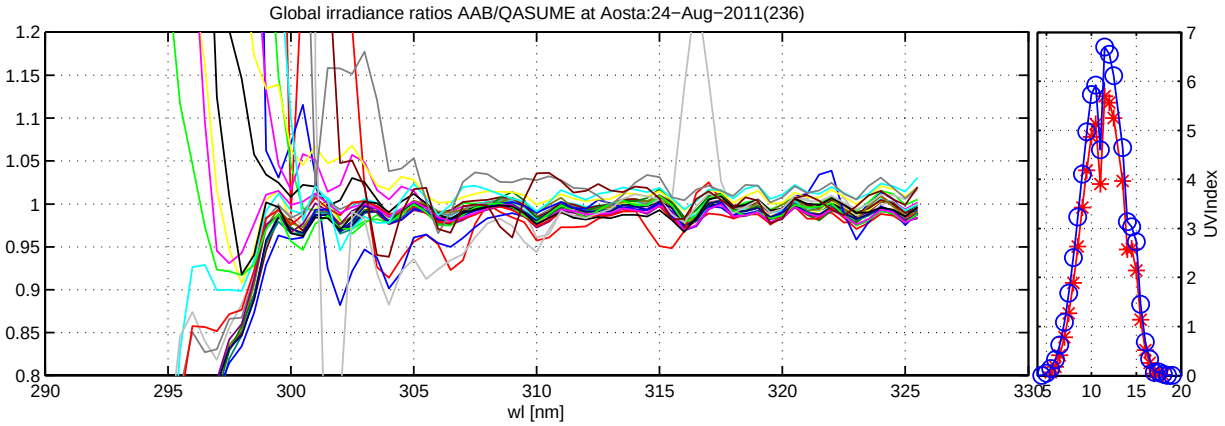

Mean ratio AAO/QASUME at Aosta:23−Aug−2011(235) to 25−Aug−2011(237)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAO/QASUME
NBSpectra=71
Wavelength [nm]

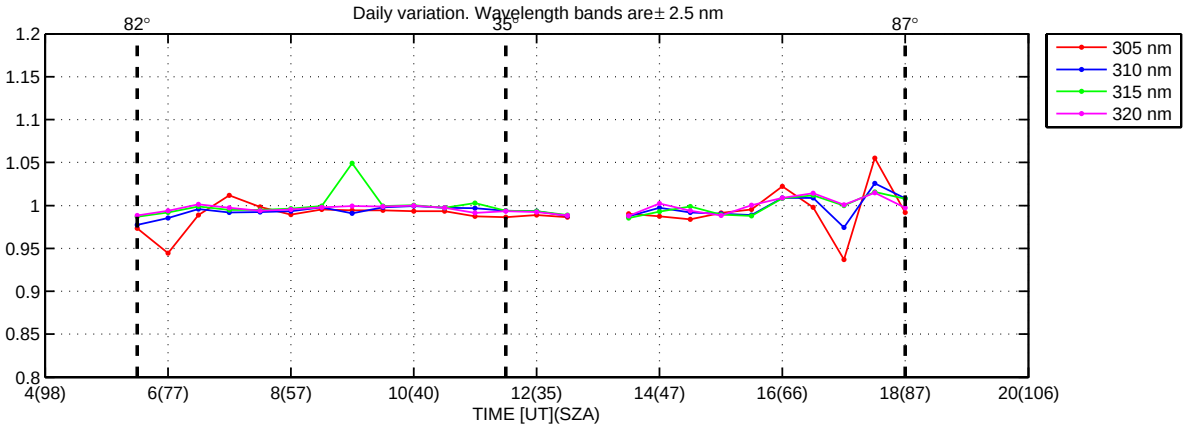

Aosta, AAO, August 2011
MEAN
STD
SHICRivm wavelength shift [nm]
Wavelength [nm]

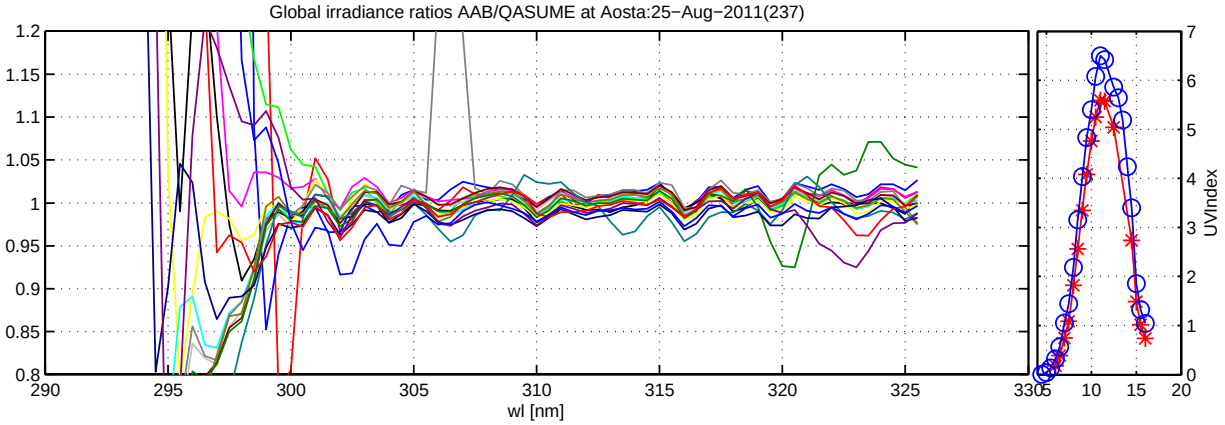

Global irradiance ratios AAB/QASUME at Aosta:23−Aug−2011(235) to 25−Aug−2011(237)
RATIO AAB/QASUME
TIME [UT] ON DAYS: [235 236 237]
305 nm
310 nm
315 nm
320 nm
235
236
237

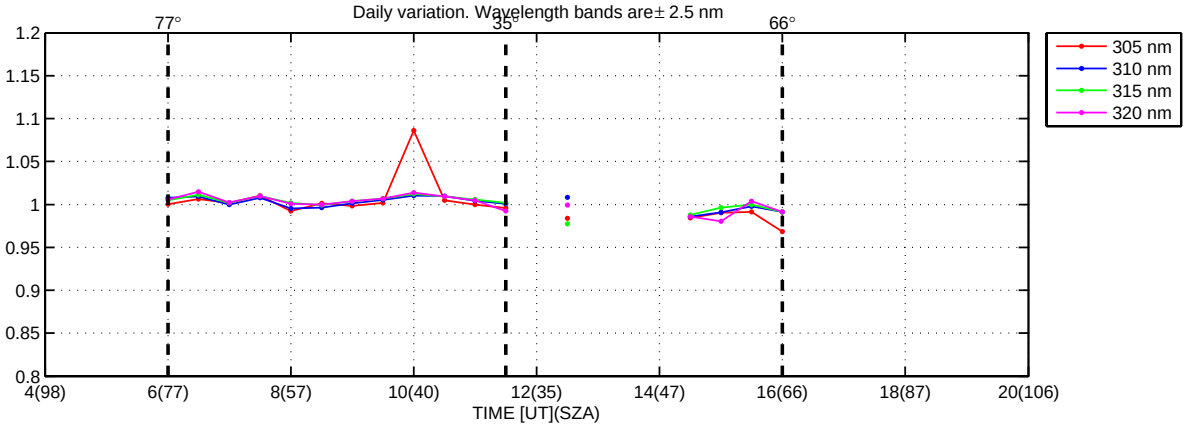

Global irradiance ratios AAB/QASUME at Aosta:23−Aug−2011(235)
wl [nm]
UVIndex

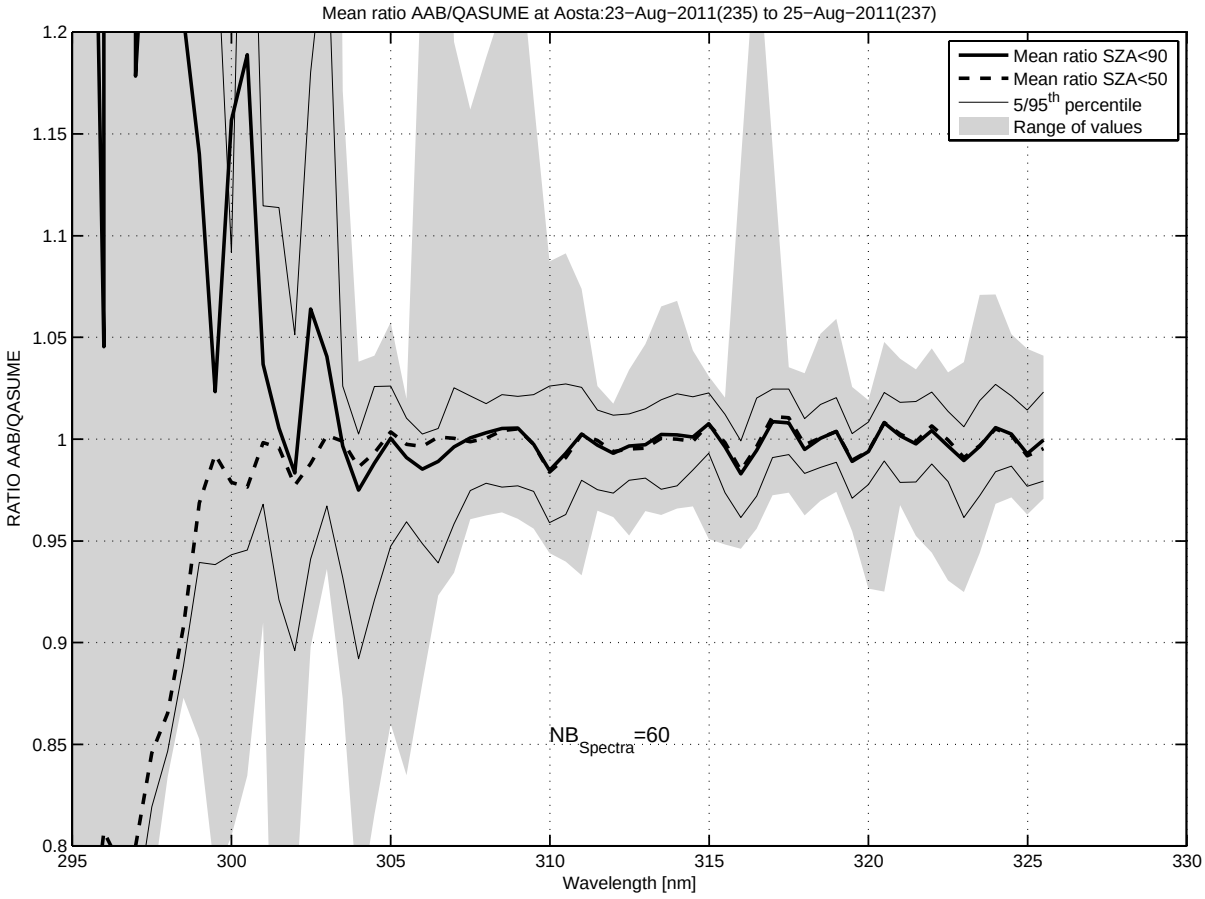

Daily variation. Wavelength bands are± 2.5 nm
43°
34°
86°
TIME [UT](SZA)
305 nm
310 nm
315 nm
320 nm

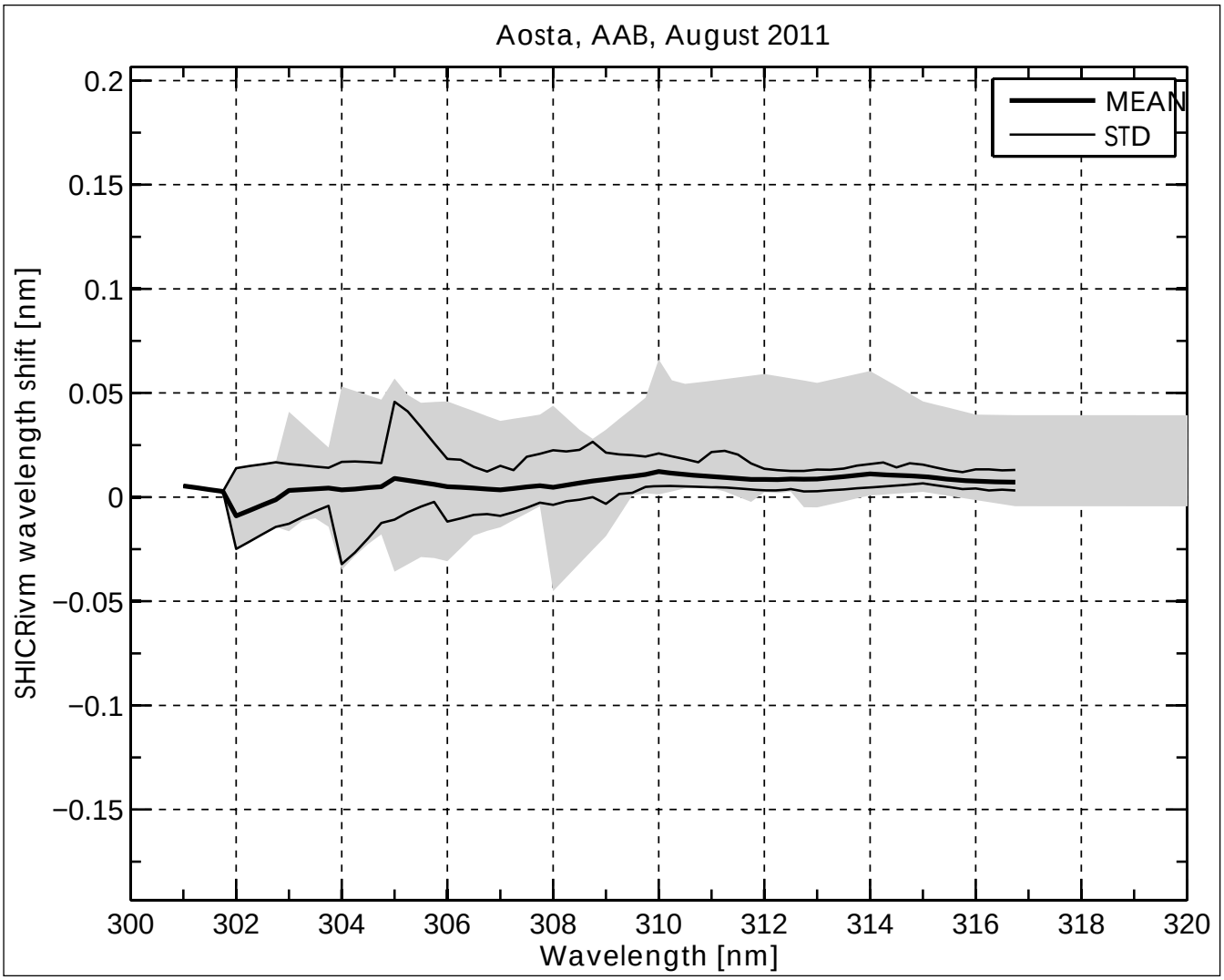

Global irradiance ratios AAB/QASUME at Aosta:24−Aug−2011(236)
wl [nm]
UVIndex


Daily variation. Wavelength bands are± 2.5 nm
82°
35°
87°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

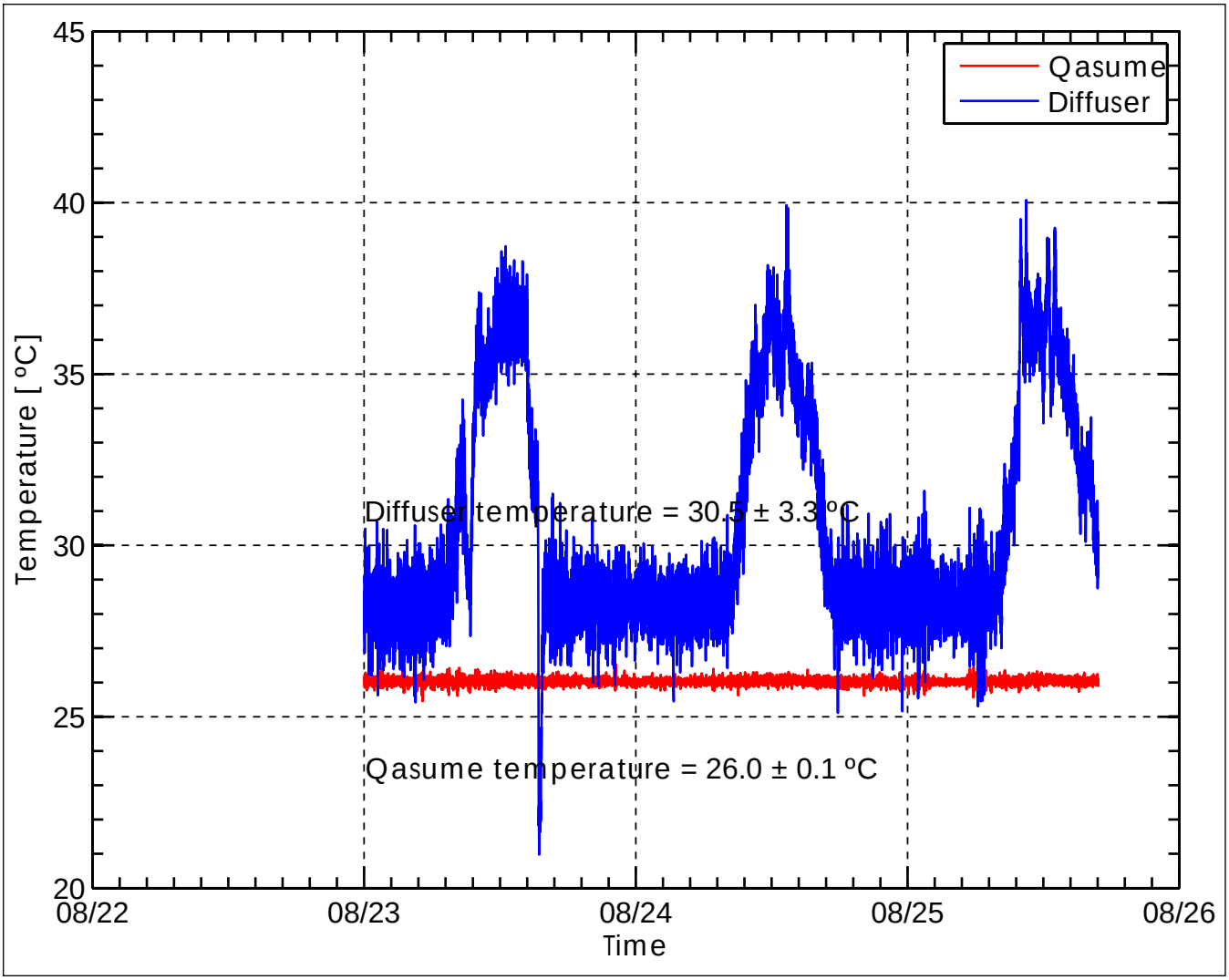

Global irradiance ratios AAB/QASUME at Aosta:25−Aug−2011(237)
wl [nm]
UVIndex

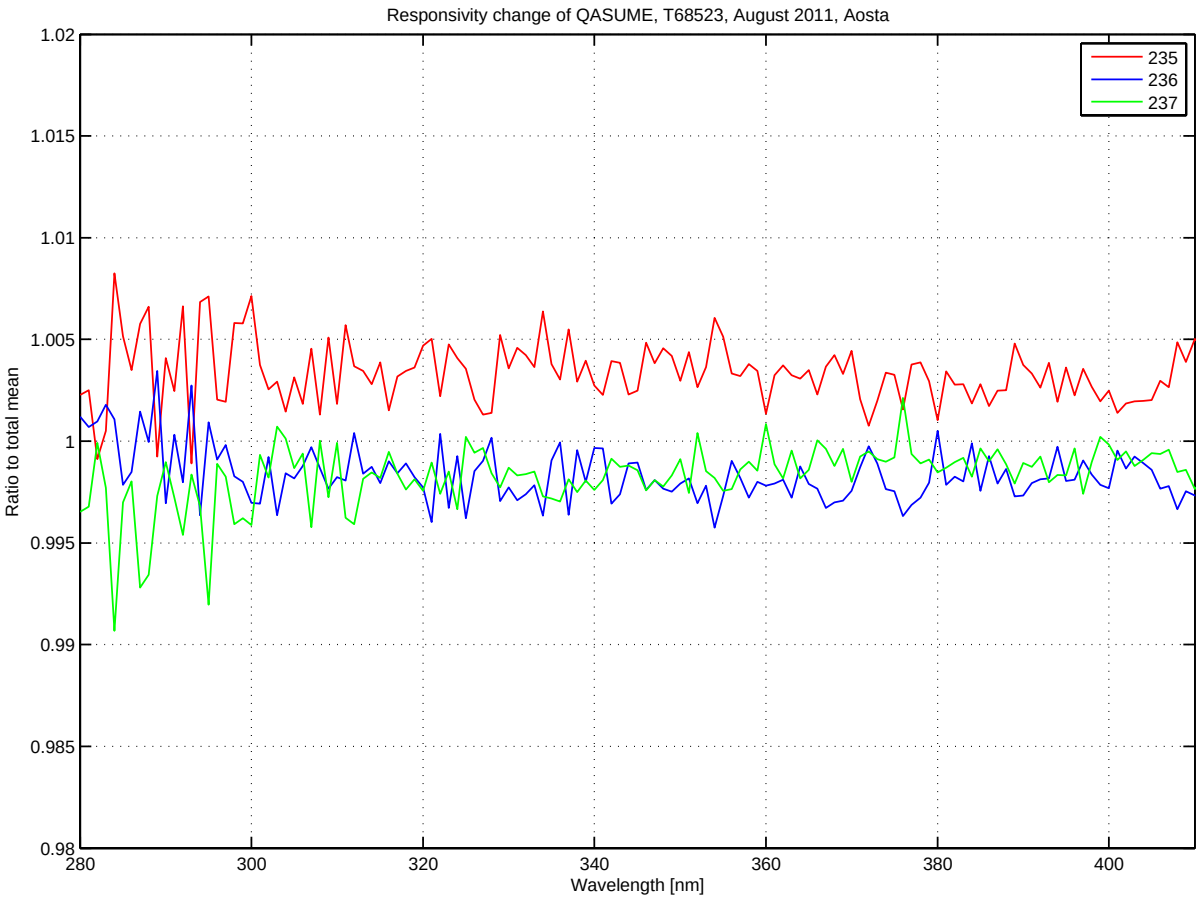

Daily variation. Wavelength bands are± 2.5 nm
77°
35°
66°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

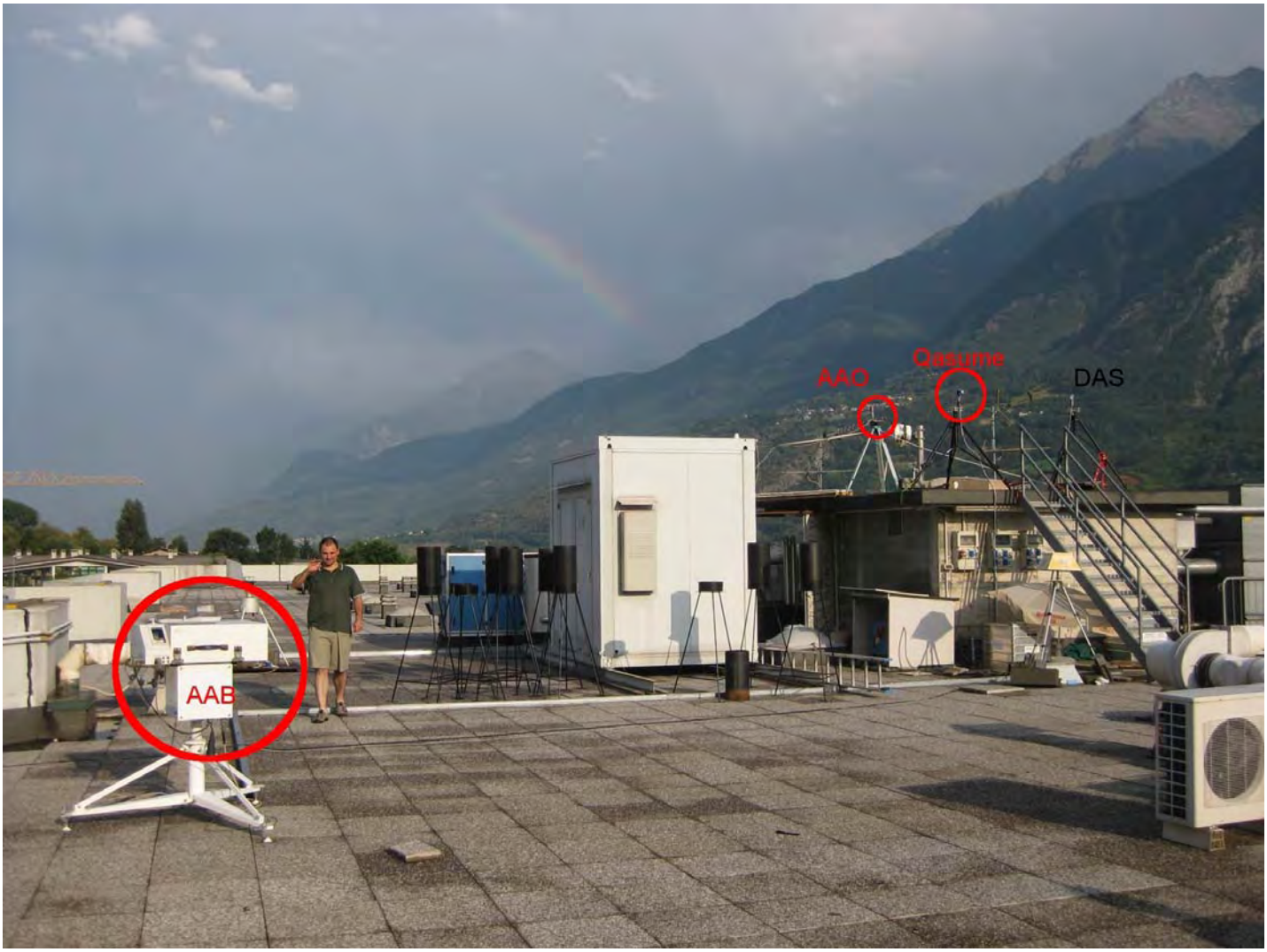

Mean ratio AAB/QASUME at Aosta:23−Aug−2011(235) to 25−Aug−2011(237)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAB/QASUME
Wavelength [nm]
NBSpectra=60


Aosta, AAB, August 2011
MEAN
STD
SHICRivm wavelength shift [nm]
Wavelength [nm]


Irradiance change, ARPA−KS−Lamps relative to Qasume−Scale, August 2011
Ratio to QasumeRef−DOY237
Wavelength [nm]
REF
KS023
KS024
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
0.98
0.975
0.97
280
300
320
340
360
380
400
420


Qasume
Diffuser
Diffuser temperature = 30.5 ± 3.3 ºC
Qasume temperature = 26.0 ± 0.1 ºC
Temperature [ºC]
Time
45
40
35
30
25
20
08/22
08/23
08/24
08/25
08/26


Responsivity change of QASUME, T68523, August 2011, Aosta
235
236
237
Ratio to total mean
Wavelength [nm]
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
0.98
280
300
320
340
360
380
400


AAO
Qasume
DAS
AAB