Protocol of the intercomparison at ARPA, Aosta, Italy on August 10 to 13, 2009 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 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 ARPA at noon of August 10, 2009. 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 four days, from afternoon of August 10 to noon of August 13.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T68522, T68524, and T61251) 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 25.8±0.1 °C. The diffuser head was heated to a temperature of 29.4±2.2 °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.

[†] The QASUME spectroradiometer B5503 is made available by the Physical and Chemical Exposure Unit of the Joint Research Centre of the European Commission, Ispra, Italy through a collaboration agreement with PMOD/WRC.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 15 minutes from 290 to 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

DOY	Date	DAY	Weather	Comment
222	10. Aug	Monday	mix of sun and clouds	Installed at 10:00 UT Calibrated: 16:43 UT using T68524 13:30-16:10: Lamp calibrations using the AAO- and PMOD-CMS calibrator
223	11. Aug	Tuesday	Clear sky	Calibrated: 9:43 and 11:14 UT using T68524 and T68522
224	12. Aug	Wednesday	Clear sky	Calibrated: 13:28 UT using T68522 9:00-13:15: Slit-function measurement of AAO and AAB using the UV-Laser
225	13. Aug	Thursday	Clear sky	Calibrated: 7:13 and 7:44 UT using T68522 and T61251 End of Campaign: 8:43 UT

Results:

In total 113/53 synchronised simultaneous spectra from QASUME and AAO/AAB are available from the measurement period. Measurements between 4:15 and 18:30 UT have been analysed (SZA smaller than 90°).

Remarks:

I. AAO

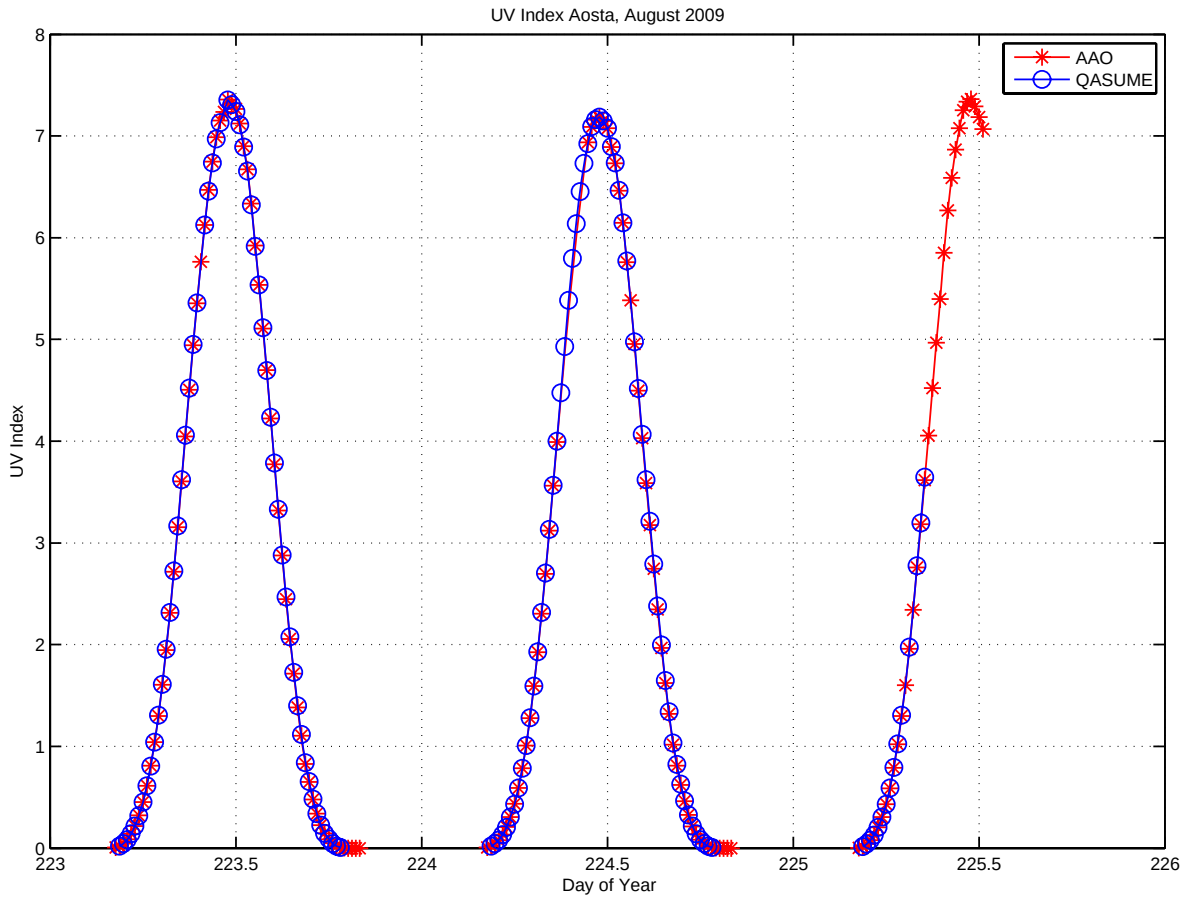
1. The ratios between AAO and QASUME have on average an offset of +0 %.
2. The good agreement between AAO to QASUME can be explained by the correction of the lamp certificate of the AAO lamp based on the irradiance measurements of the AAO lamp responsivity mounted into the ARPA CMS field calibrator and the travel standard T68524 mounted into the PMOD field calibrator.
3. The diurnal variation of the AAO to QASUME ratio is below 2 % on the clear sky days.
4. For all solar scans the wavelength shifts of the AAO are between ±20 pm.

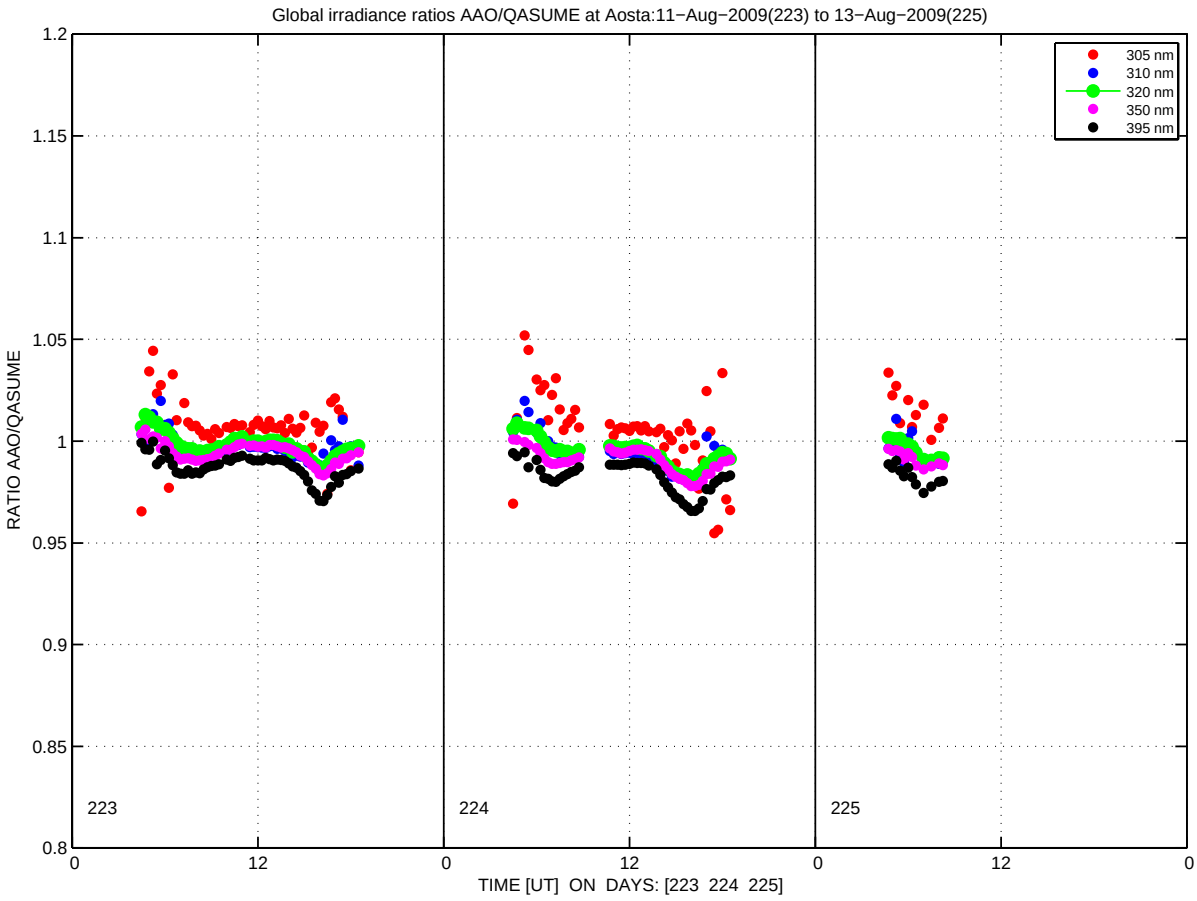
II. AAB

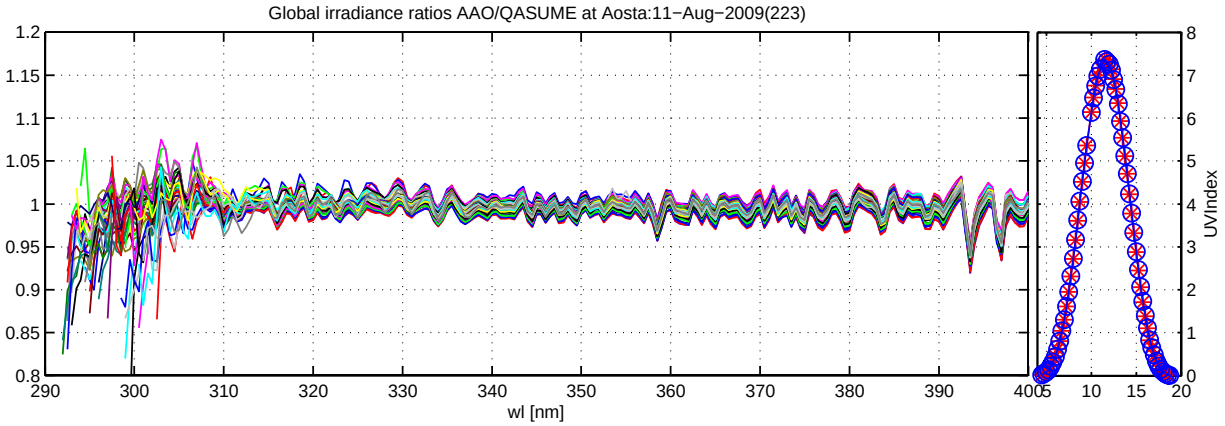
1. The ratios between AAB and QASUME have on average an offset of +2.5 % for wavelengths longer than 305 nm.
2. The AAB Brewer #066 was calibrated by Ken Lamp prior to the intercomparison.
3. Below 305 nm, the measurements of AAB shows higher irradiances which are due to internal stray light of the single monochromator. At 300 nm the ratio of irradiances measured by AAB and QASUME is between 0.95 and 1.3.
4. The diurnal variation of the AAB to QASUME ratio is around 3 % on the clear sky days.
5. For all solar scans the wavelength shifts of the AAB are below ±40 pm.

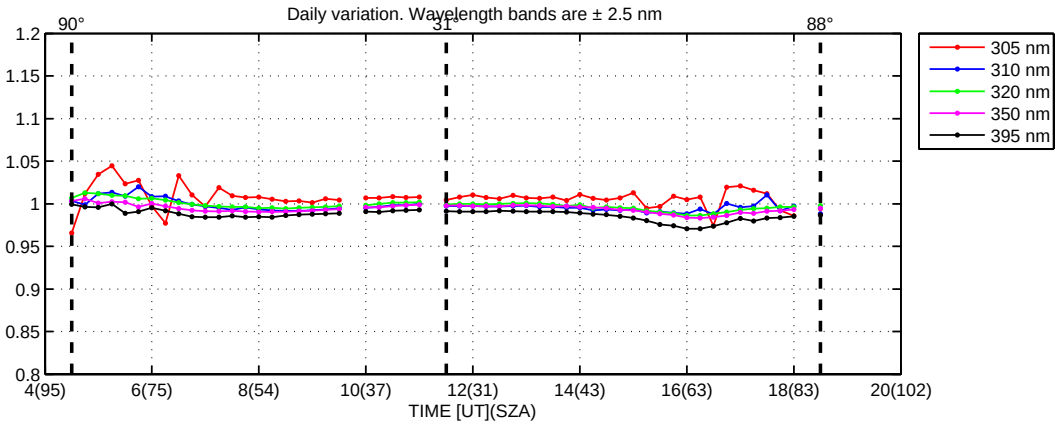
III. Additional Measurements

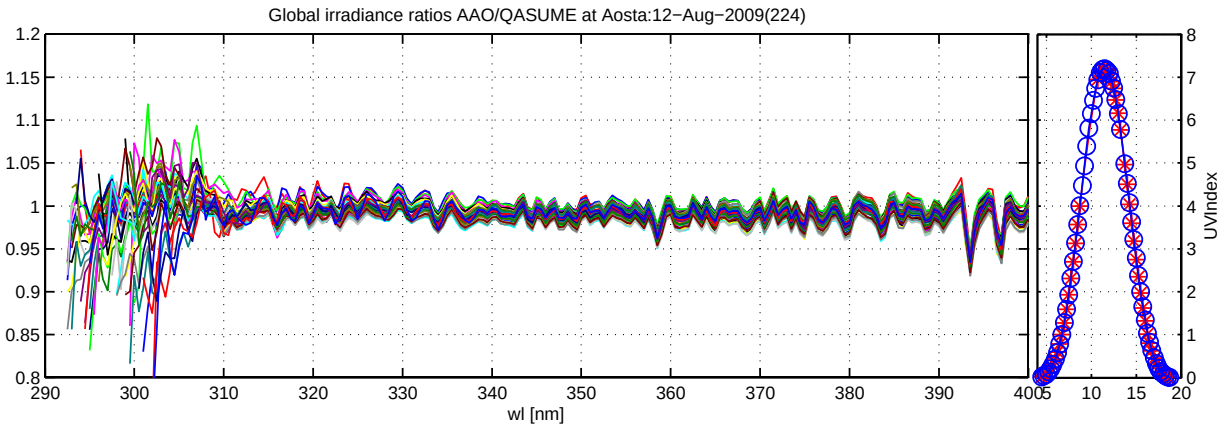
1. The Lamp calibrations were performed with the AAO Bentham spectroradiometer. The KS023 standard lamp was mounted inside the field calibrator from Schreder-CMS. Lamp calibrations were performed with the calibrator from ARPA and PMOD/WRC. A difference of 1.15% between the measurements was found (see figure).
2. The Slit Functions of the AAO and AAB spectroradiometers were measured using a HeCd-Laser. The results are summarized in the figure.

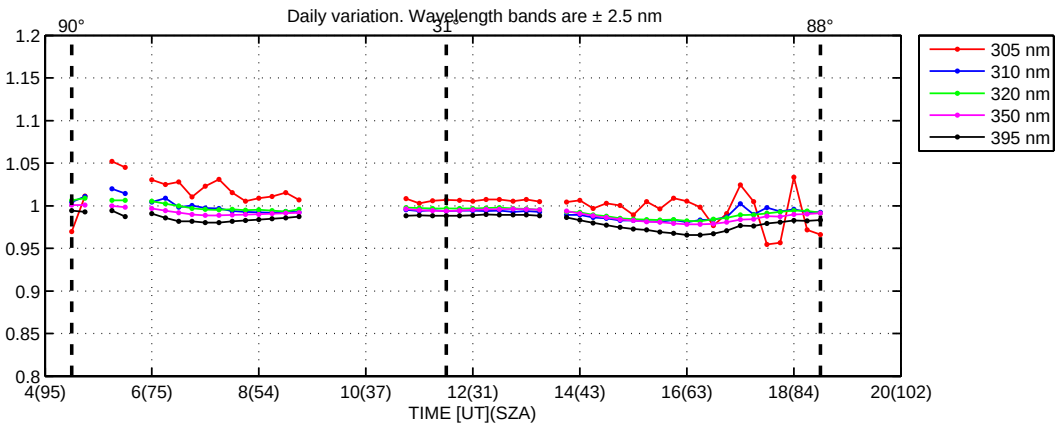

UV Index Aosta, August 2009
AAO
QASUME
UV Index
Day of Year
0
1
2
3
4
5
6
7
8
223
223.5
224
224.5
225
225.5
226

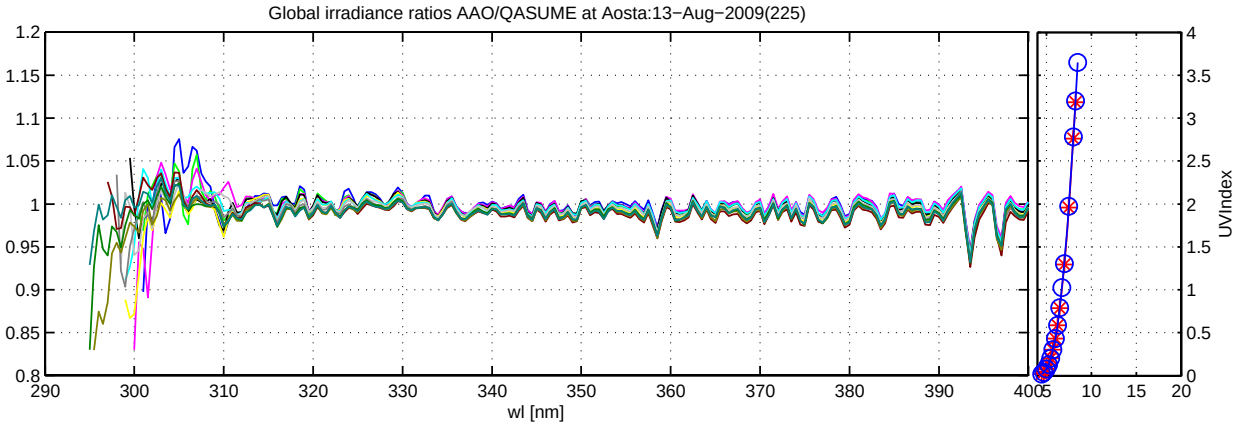

Global irradiance ratios AAO/QASUME at Aosta:11−Aug−2009(223) to 13−Aug−2009(225)
305 nm
310 nm
320 nm
350 nm
395 nm
RATIO AAO/QASUME
TIME [UT] ON DAYS: [223 224 225]
223
224
225
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
0
12

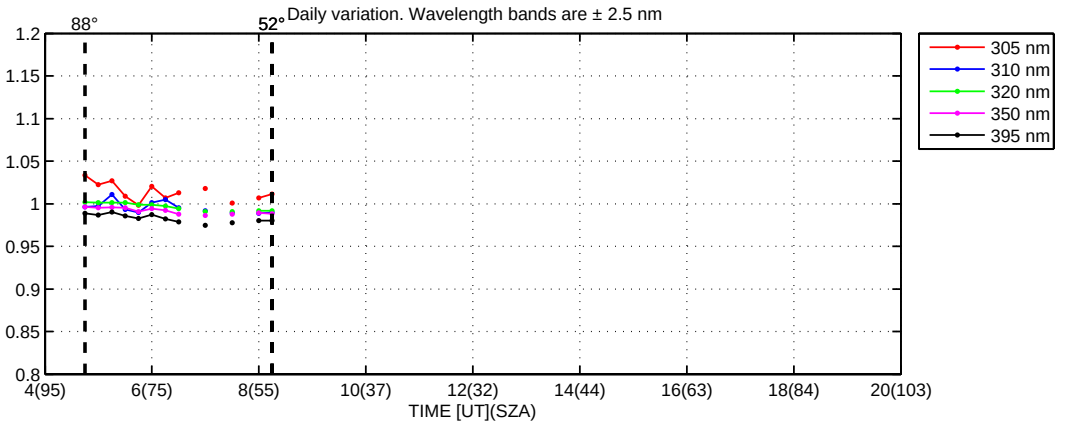

Global irradiance ratios AAO/QASUME at Aosta:11−Aug−2009(223)
wl [nm]
UVIndex

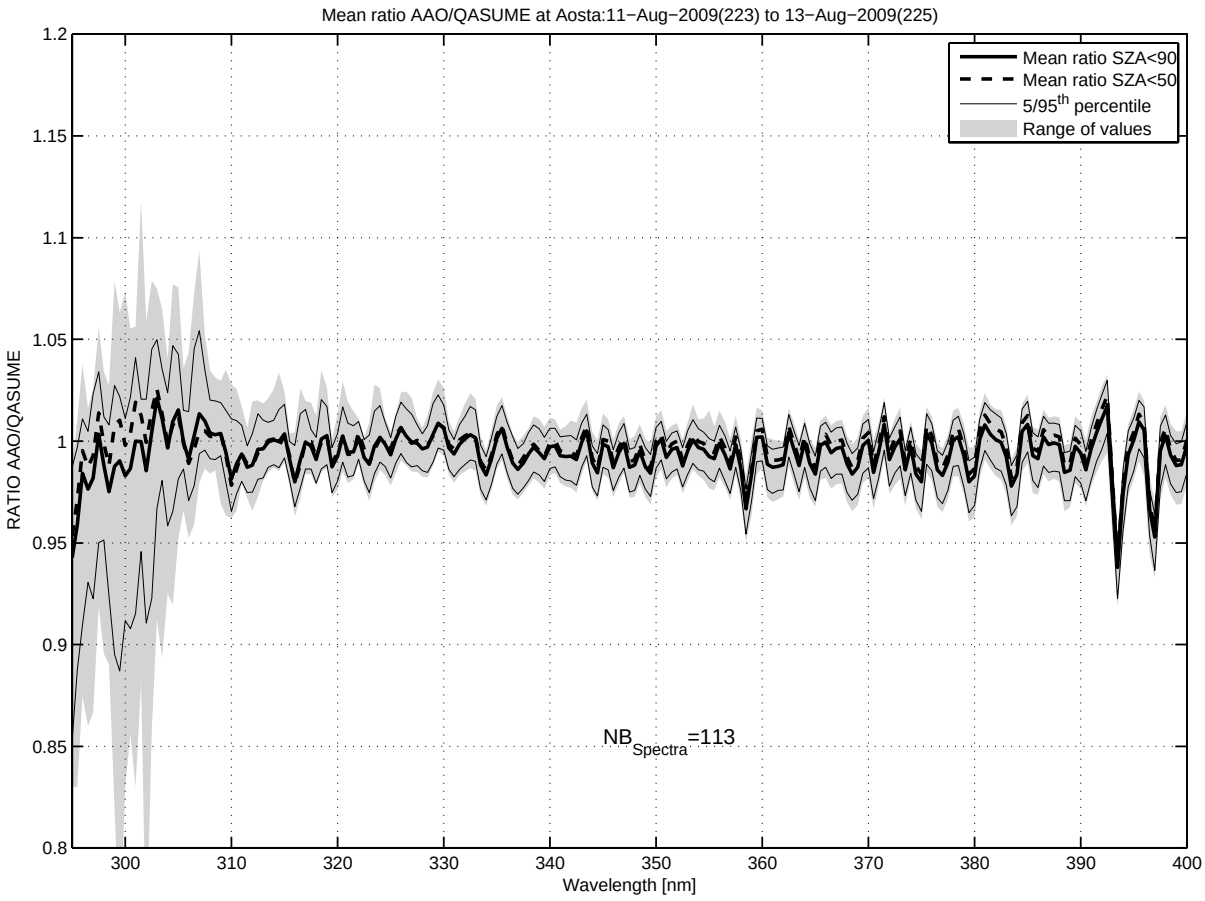

Daily variation. Wavelength bands are ± 2.5 nm
90°
31°
88°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

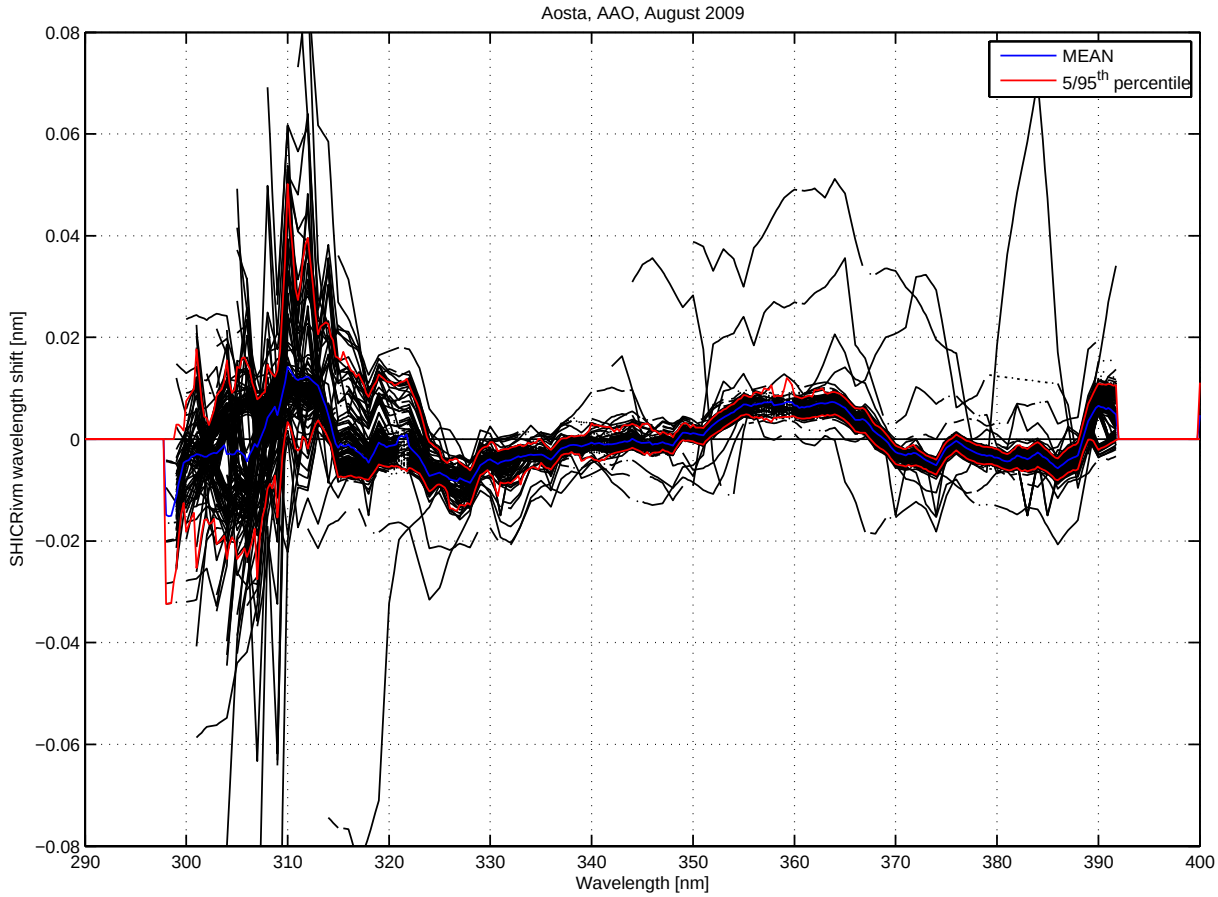

Global irradiance ratios AAO/QASUME at Aosta:12−Aug−2009(224)
wl [nm]
UVIndex

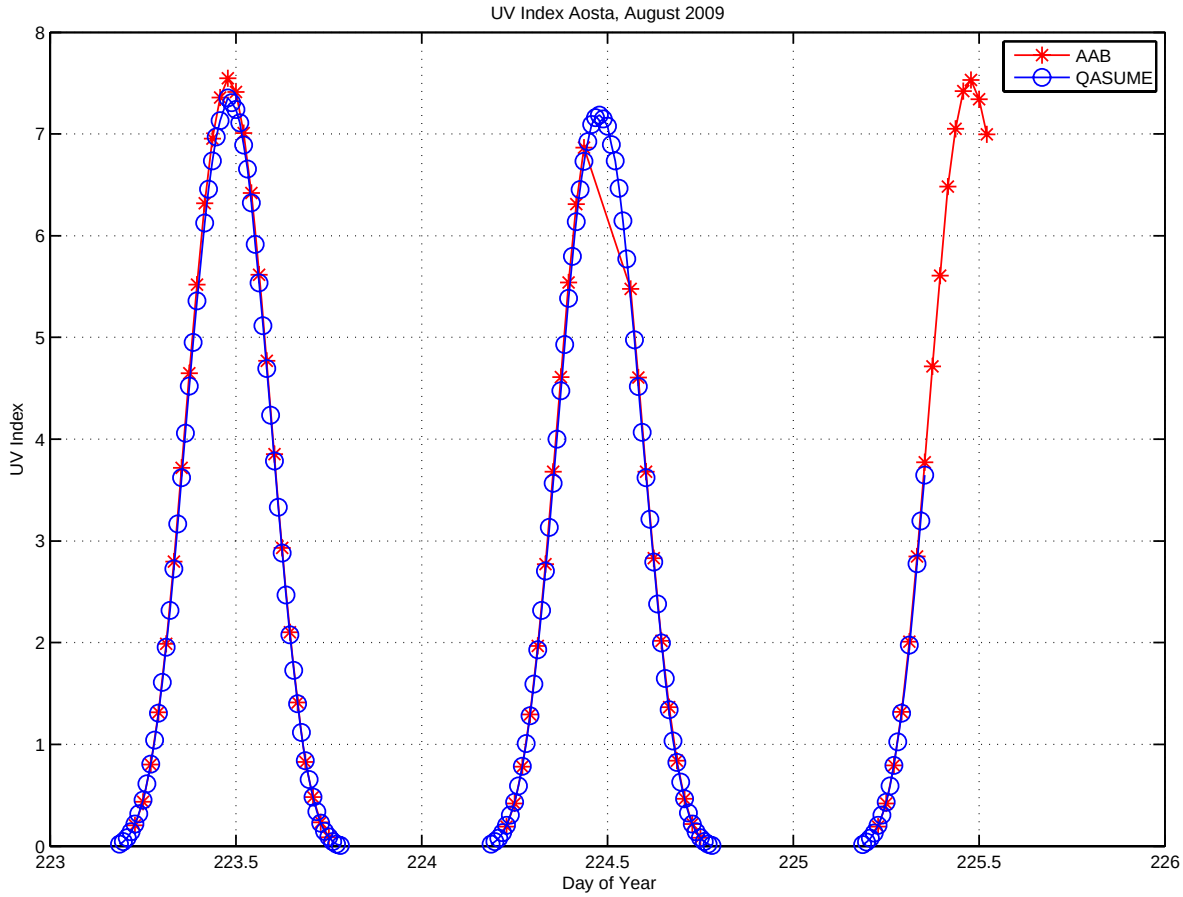

Daily variation. Wavelength bands are ± 2.5 nm
90°
31°
88°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

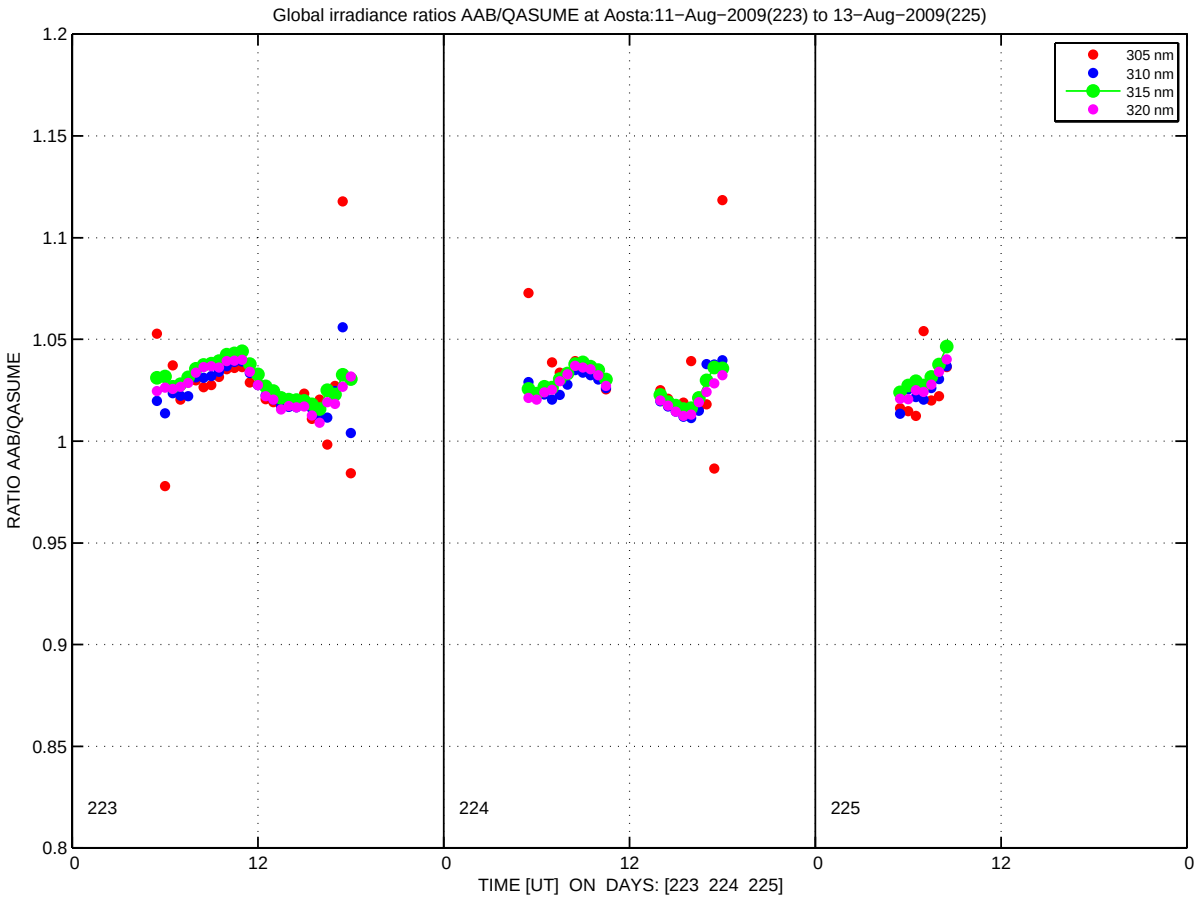

Global irradiance ratios AAO/QASUME at Aosta:13−Aug−2009(225)
wl [nm]
UVIndex

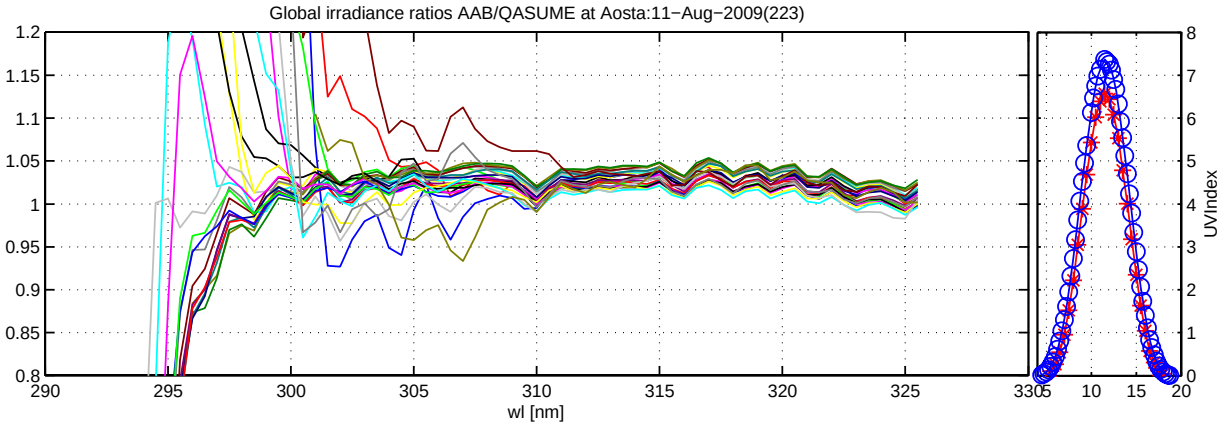

Daily variation. Wavelength bands are ± 2.5 nm
88°
52°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

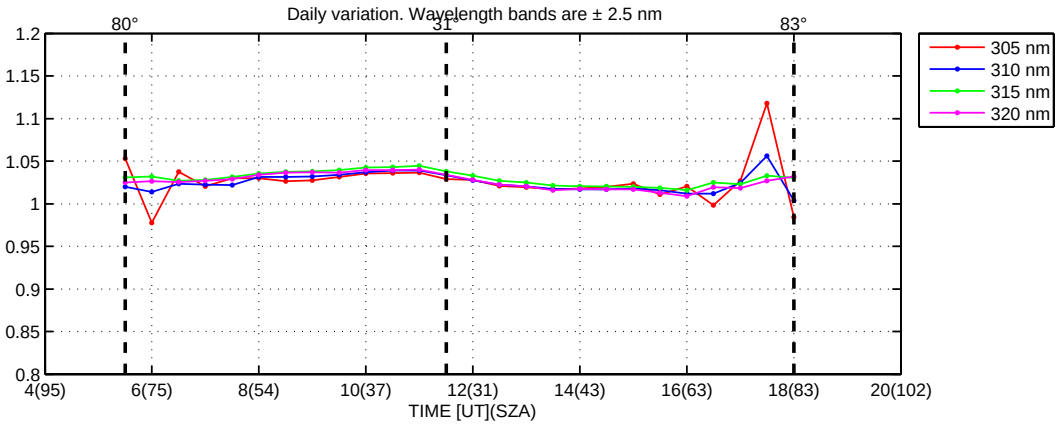

Mean ratio AAO/QASUME at Aosta:11−Aug−2009(223) to 13−Aug−2009(225)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAO/QASUME
NBSpectra=113
Wavelength [nm]

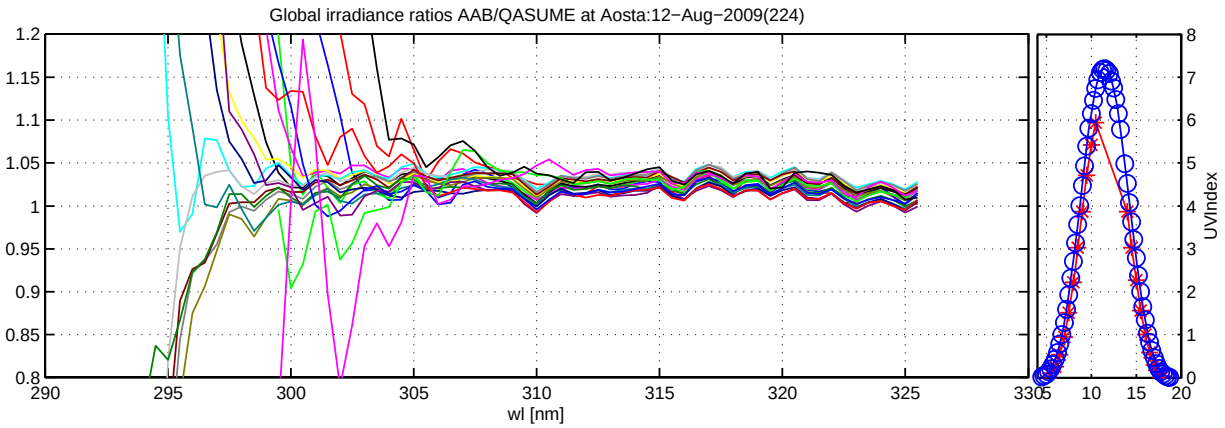

Aosta, AAO, August 2009
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
290
300
310
320
330
340
350
360
370
380
390
400

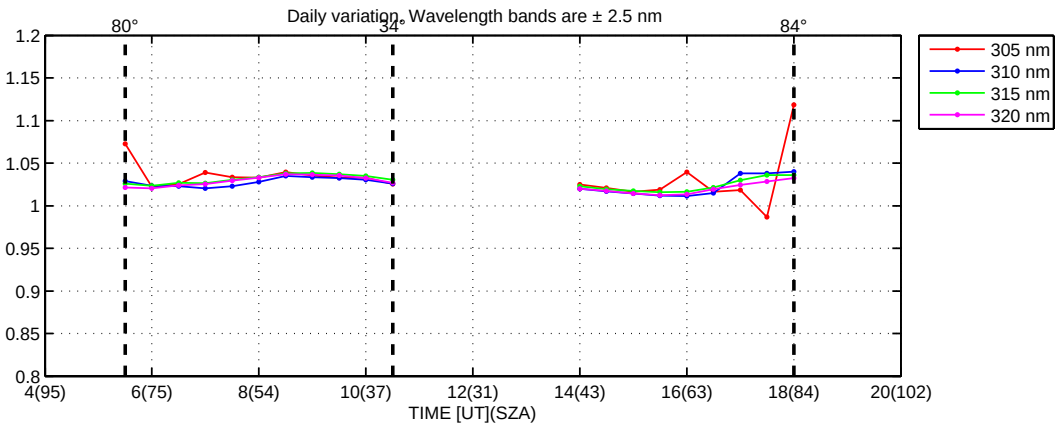

UV Index Aosta, August 2009
AAB
QASUME
UV Index
Day of Year
0
1
2
3
4
5
6
7
8
223
223.5
224
224.5
225
225.5
226

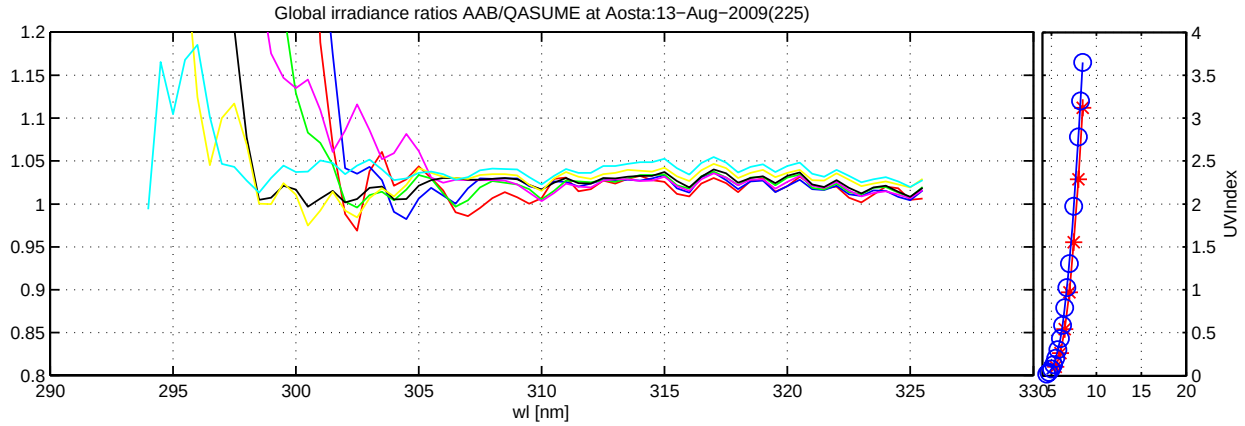

Global irradiance ratios AAB/QASUME at Aosta:11−Aug−2009(223) to 13−Aug−2009(225)
305 nm
310 nm
315 nm
320 nm
RATIO AAB/QASUME
TIME [UT] ON DAYS: [223 224 225]
223
224
225
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
0
12

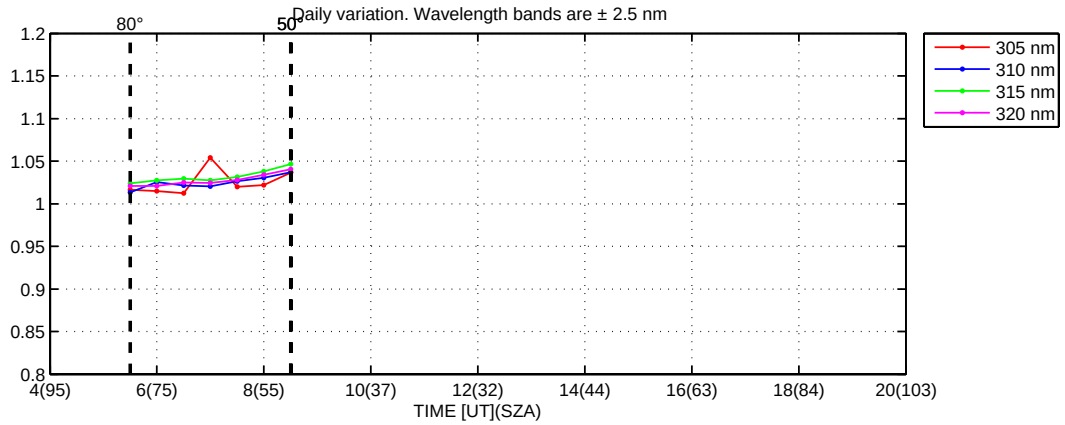

Global irradiance ratios AAB/QASUME at Aosta:11−Aug−2009(223)
wl [nm]
UVIndex

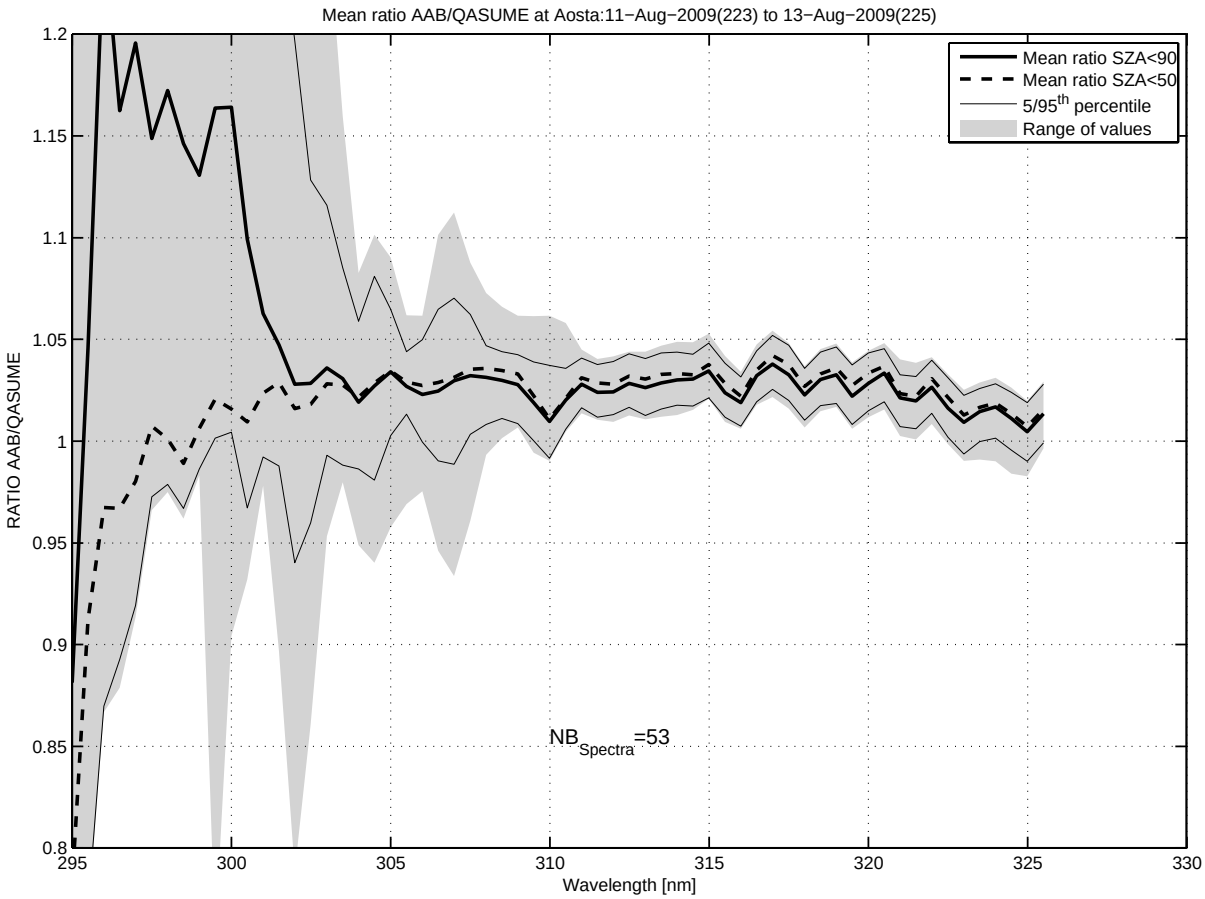

Daily variation. Wavelength bands are ± 2.5 nm
80°
31°
83°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

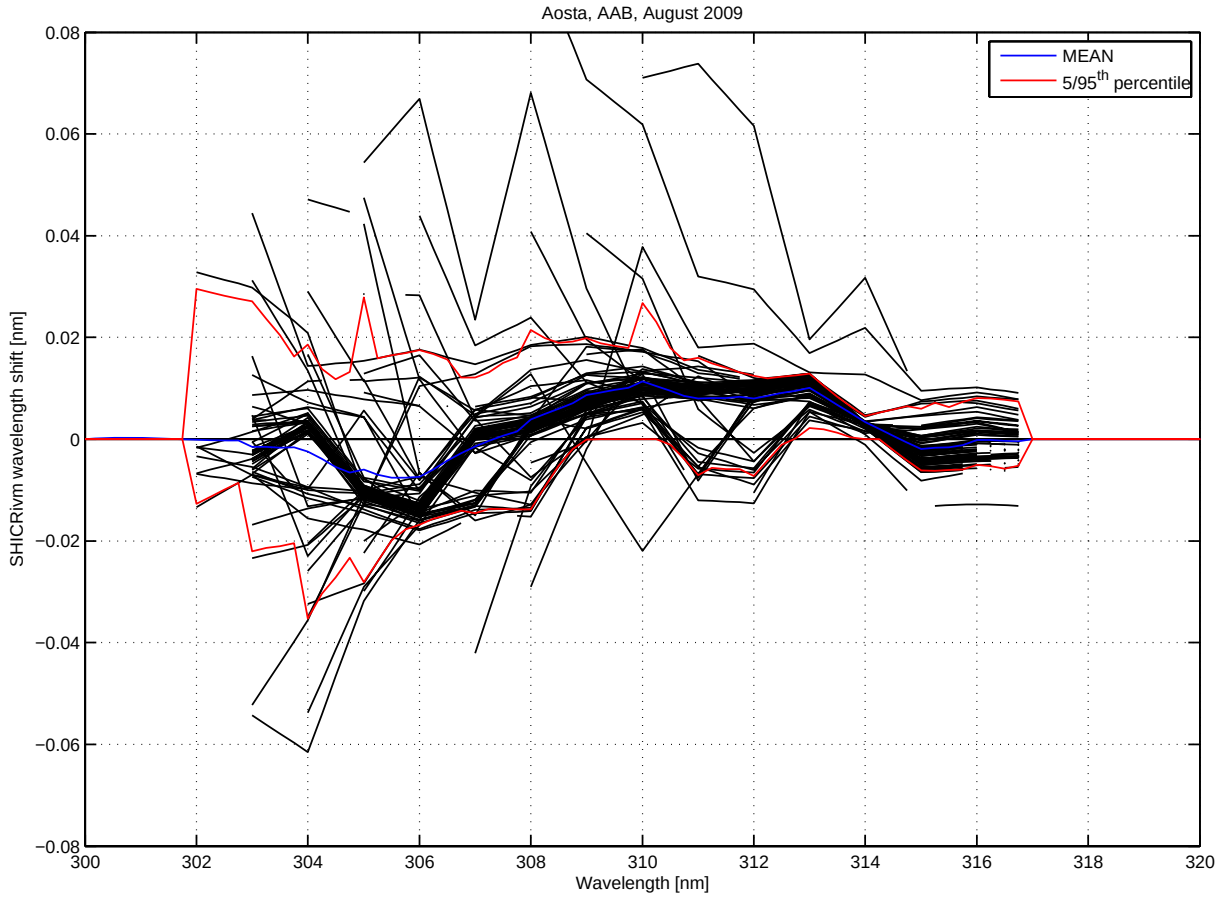

Global irradiance ratios AAB/QASUME at Aosta:12−Aug−2009(224)
wl [nm]
UVIndex

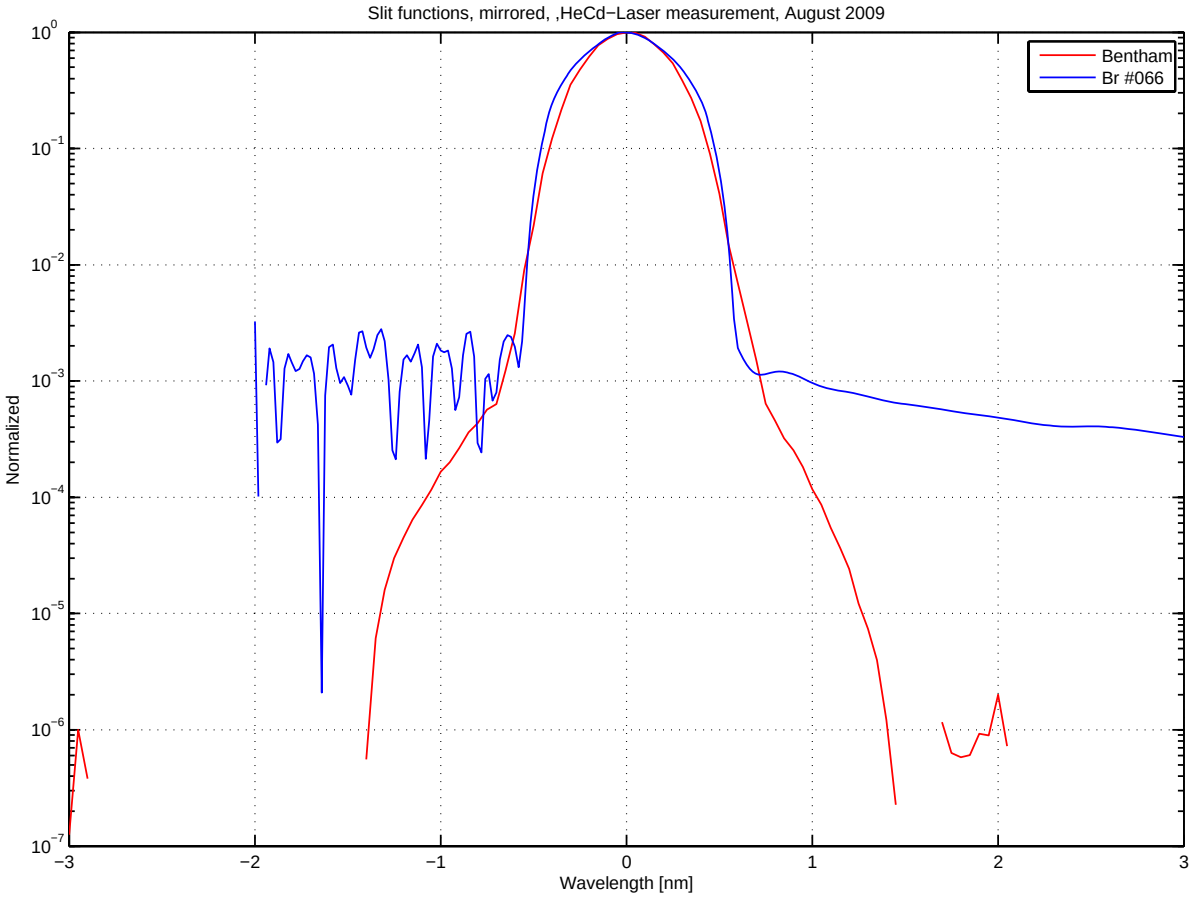

Daily variation. Wavelength bands are ± 2.5 nm
80°
34°
84°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

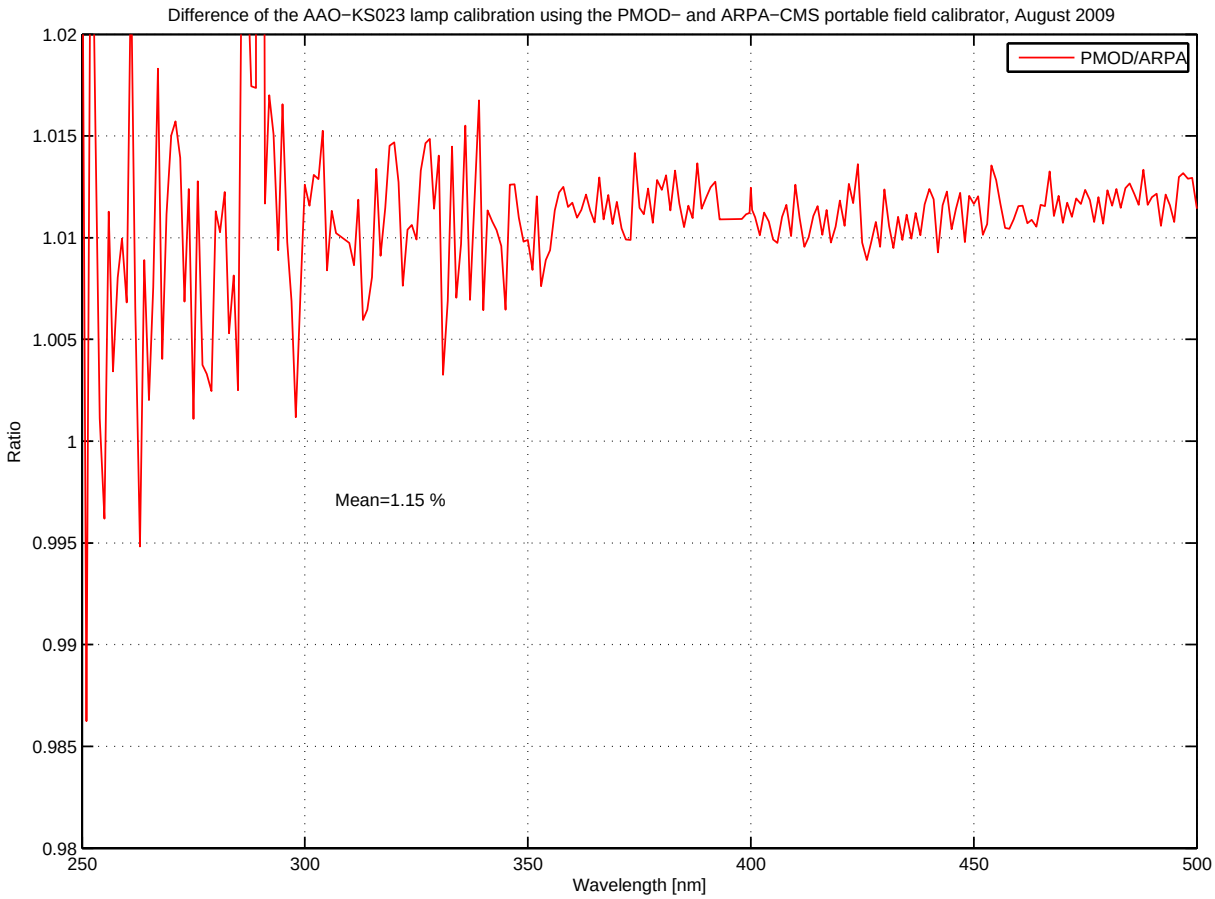

Global irradiance ratios AAB/QASUME at Aosta:13−Aug−2009(225)
wl [nm]
UVIndex

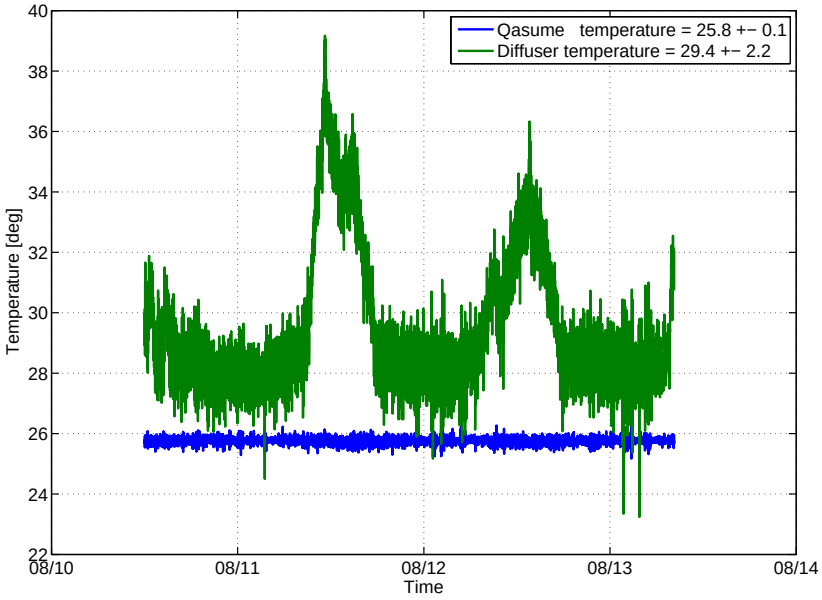

Daily variation. Wavelength bands are ± 2.5 nm
80°
50°
305 nm
310 nm
315 nm
320 nm
TIME [UT](SZA)

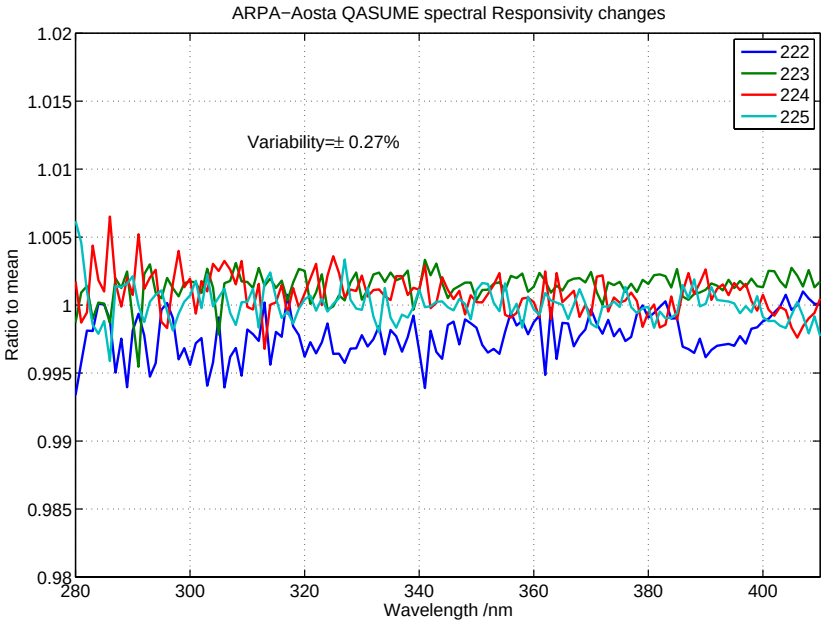

Mean ratio AAB/QASUME at Aosta:11−Aug−2009(223) to 13−Aug−2009(225)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAB/QASUME
NBSpectra=53
Wavelength [nm]

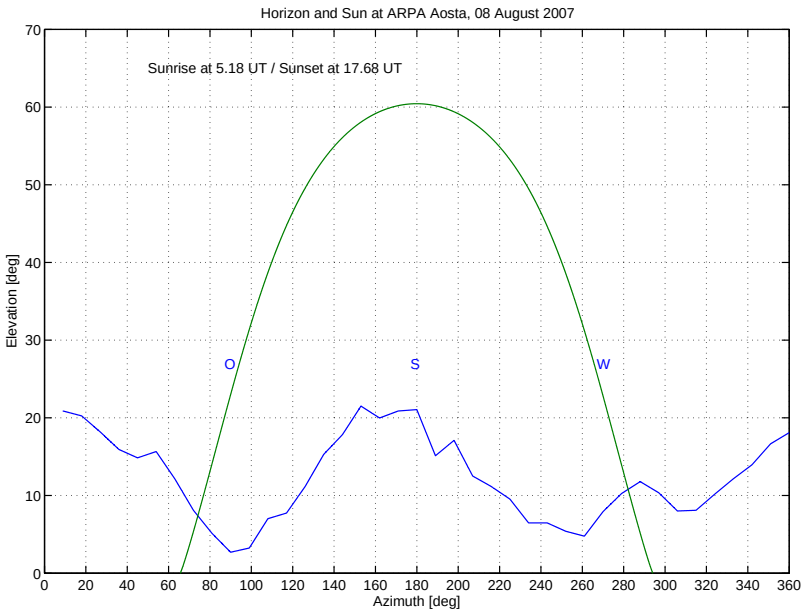

Aosta, AAB, August 2009
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
300
302
304
306
308
310
312
314
316
318
320


Slit functions, mirrored, ,HeCd−Laser measurement, August 2009
Bentham
Br #066
Normalized
Wavelength [nm]


Difference of the AAO−KS023 lamp calibration using the PMOD− and ARPA−CMS portable field calibrator, August 2009
PMOD/ARPA
Mean=1.15 %
Ratio
Wavelength [nm]


Qasume temperature = 25.8 +− 0.1
Diffuser temperature = 29.4 +− 2.2
Temperature [deg]
Time
08/10
08/11
08/12
08/13
08/14


ARPA−Aosta QASUME spectral Responsivity changes
222
223
224
225
Variability=± 0.27%
Ratio to mean
Wavelength /nm


Horizon and Sun at ARPA Aosta, 08 August 2007
Sunrise at 5.18 UT / Sunset at 17.68 UT
O
S
W
Elevation [deg]
Azimuth [deg]


AAB Brewer #066
QASUME
AAO