Protocol of the intercomparison at ARPA, Aosta, Italy on September 9 to 12, 2013 with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Luca Egli

Operator: Luca Egli

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 5:30 UT and 16:30 UT have been analysed.

QASUME was installed at ARPA Aosta at noon of September 9, 2013. 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) single monochromator. The intercomparison between QASUME and the ARPA spectroradiometer lasted three days, from the morning of September 10 to evening of September 12.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T68523 and T685240 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 % (confirmed with the lamps T6125240 and T61251) during the last 2 days of the intercomparison period. During the first day (252) the instrument showed a diurnal variation of about 2% compared morning to noon, caused by the fact that the instrument requires 24h for stabilization. After 12 UTC at day 253 the instrument is stable and no diurnal variation is observed. The data of day 253 was corrected accounting for the diurnal variation. Moreover lamp T68523 showed an offset of about 1-2% compared to the other lamps. As a consequence for the days 253 and 254 this lamp was excluded for the calibration.
The internal temperature of QASUME was 23.9±0.2 °C and the diffuser head was heated to a temperature of 29.9±1.3 °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 500 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)
252	09. Sep	Monday	Sun	Installed at 14:33
253	10. Sep	Tuesday	Clear Sky	8:15 - calibration using T68523 10:40 - calibration using T68523 16:35 - calibration using T68523
254	11. Sep	Wednesday	Cloudy conditions	8:10 calibration using T68523 8:45 calibration using T685240 15:12 calibration using T68523 15:40 calibration using T61251
255	12. Sep	Thursday	Cloudy conditions	08:05 calibration using T61251 08:38 calibration using T685240 16:36 calibration using T685240 End of Campaign: 17:20

Results:

In total 62 (AAO) and 61 (AAB) synchronised simultaneous spectra from QASUME and AAO/AAB are available from the measurement period. Measurements between 5:30 and 18:30 UT have been analysed (SZA smaller than 90°).

Remarks:

General: The synchronization at day 253 was ensured from 290 – 364 nm. Therefore the comparison did not include the entire measured spectrum. For days 254 and 255 the synchronization was provided for the full spectrum.

I. AAO

1. The ratios between AAO and QASUME have on spectral slope in the average ratio from 0.98% to 1%,
2. The diurnal variation of the AAO to QASUME ratio is around 2-5 % on the clear and cloudy days, indicating an azimuth error of the AAO entrance optics.
3. For all solar scans the wavelength shifts of the AAO are between ±10 pm.

II. AAB

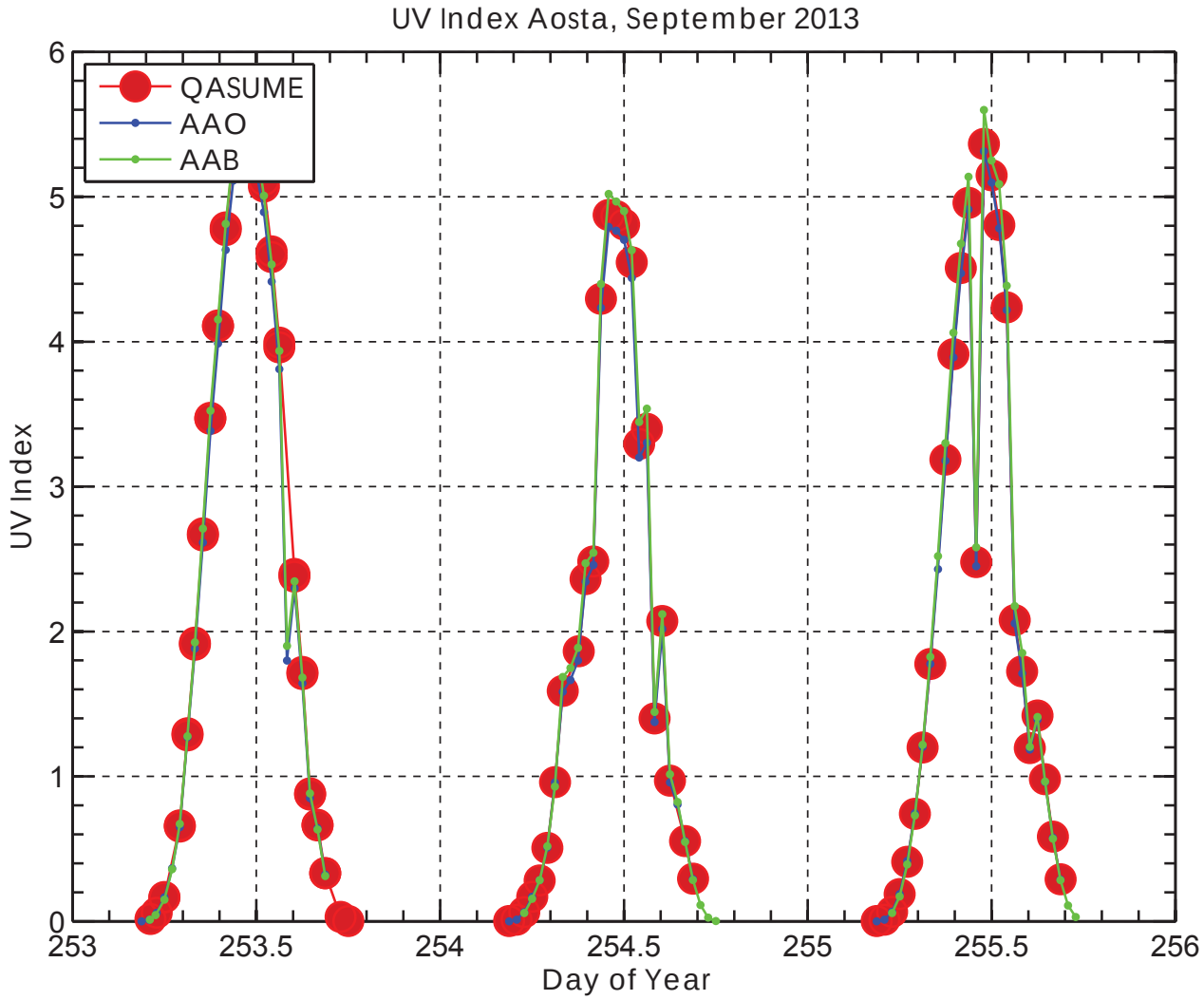
1. The ratios between AAB and QASUME have on average an offset of +2-3 % for wavelengths longer than 305 nm.
2. The irradiance calibration of AAB was performed at end of May 2013 by IOS.
3. Below 305 nm, the measurements of AAB show higher variability because of the strong straylight. The diurnal variation of the AAB to QASUME ratio is around 5 %, due to the cosine error of the Brewer entrance optics.
4. For all solar scans the wavelength shifts of the AAB are below ±20 pm.

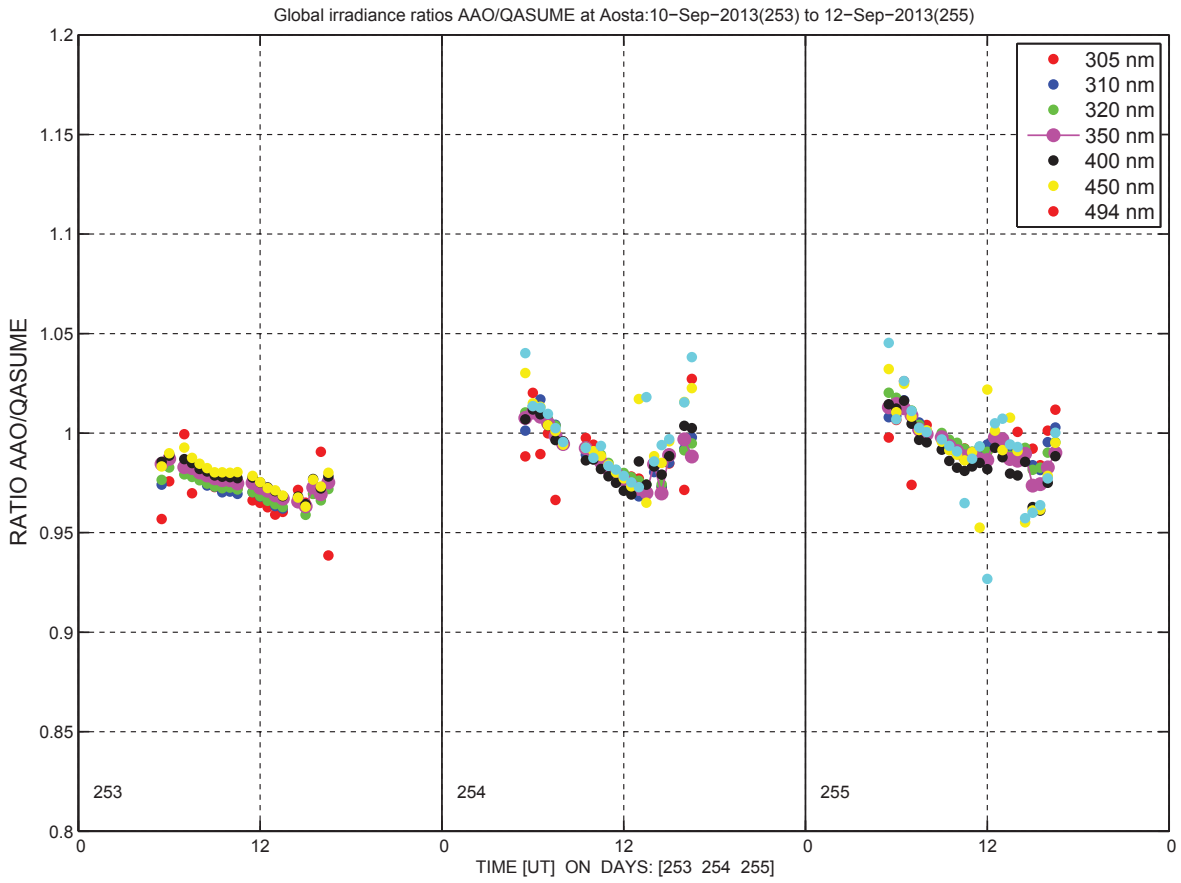
III. Additional Measurements

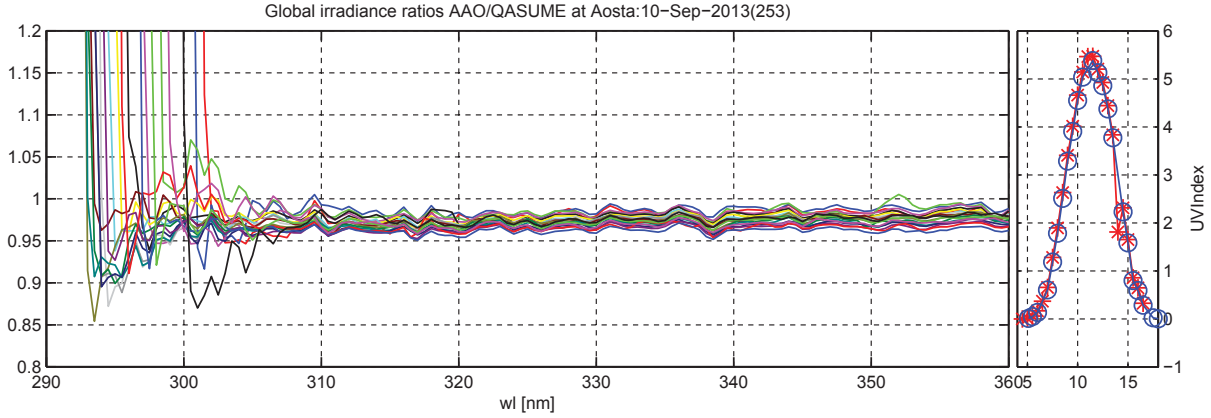
1. In order to additionally test the assumption of an azimuth error, the AAO entrance optics was horizontally turned by 180° on day 255 at 12:30 UTC and turned back at 13.00 UTC. The observed bias of about 1% suggests that an azimuth error from the entrance optics is likely.
2. Laboratory measurements of the QASUME entrance optics after the campaign revealed that the observed spectral slope of the QASUME AAO comparison does not stem from an azimuth error from the QASUME optics.

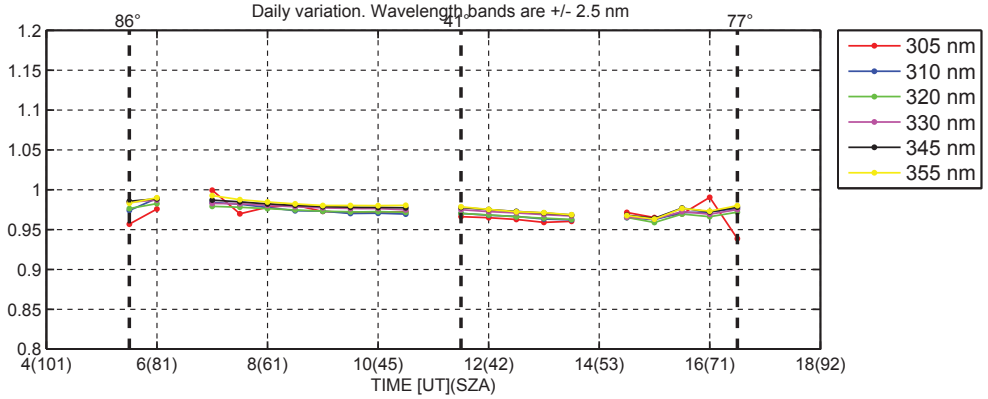
Comments from the local operator

Investigations on the azimuth dependence will be carried out in a laboratory and the necessary adjustments to the optics will be performed as soon as possible.


UV Index Aosta, September 2013
QASUME
AAO
AAB
UV Index
Day of Year
0
1
2
3
4
5
6
253
253.5
254
254.5
255
255.5
256







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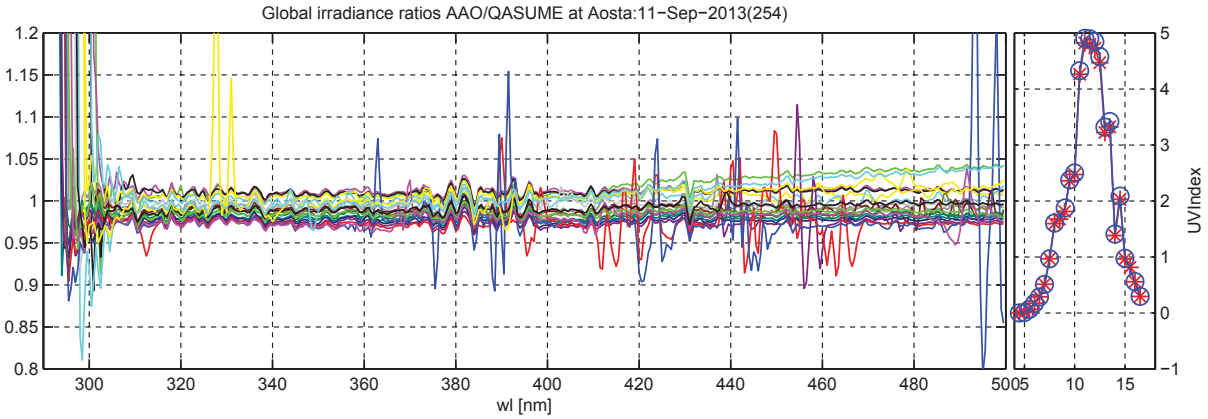

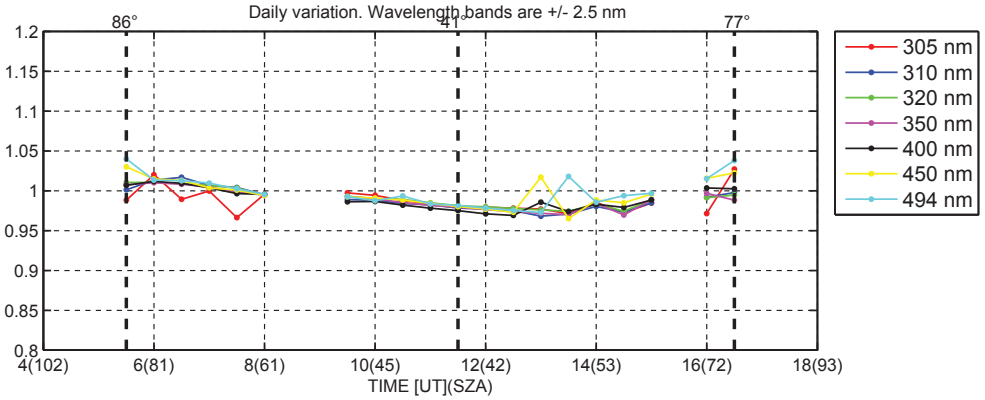

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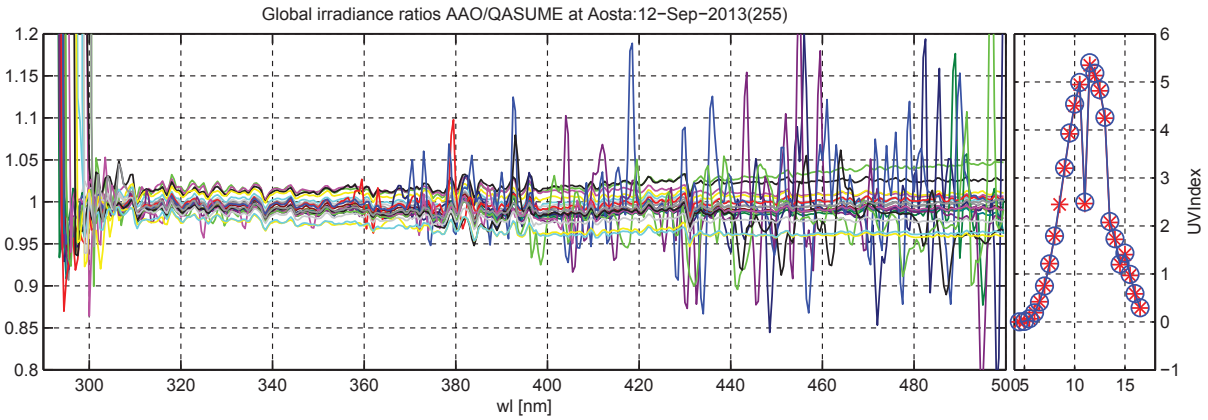

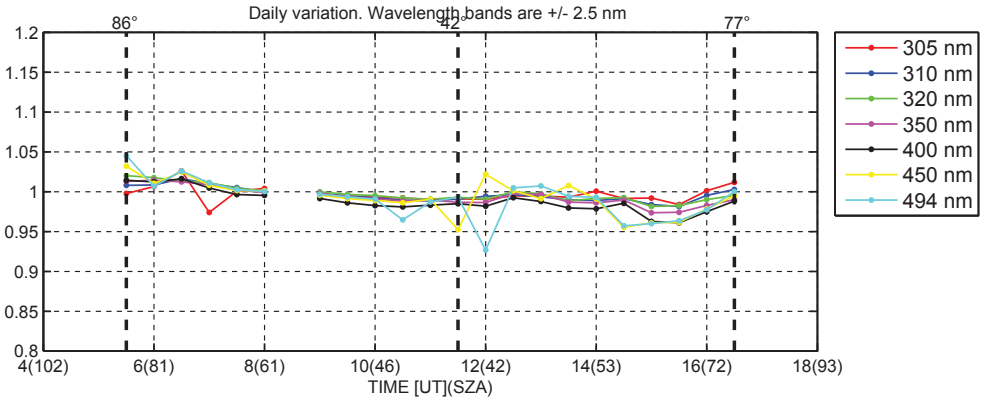

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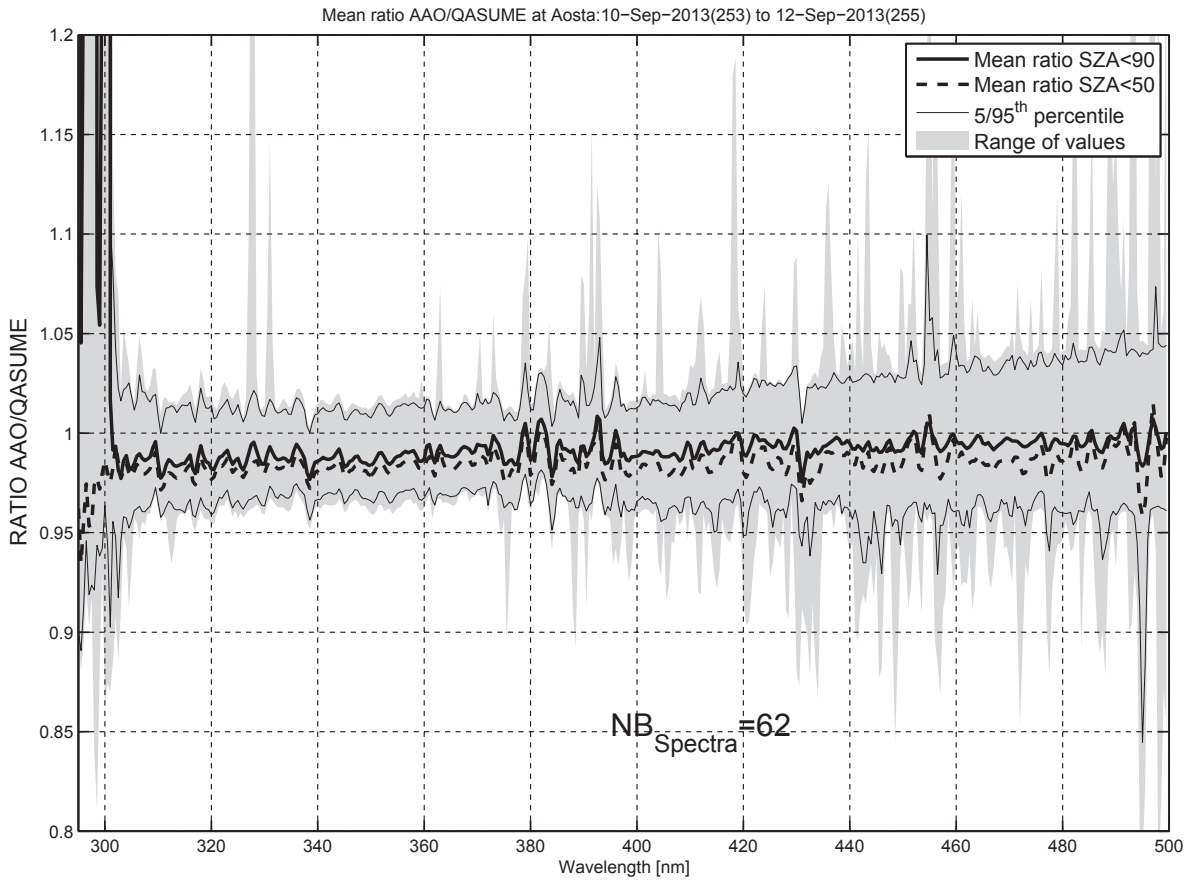
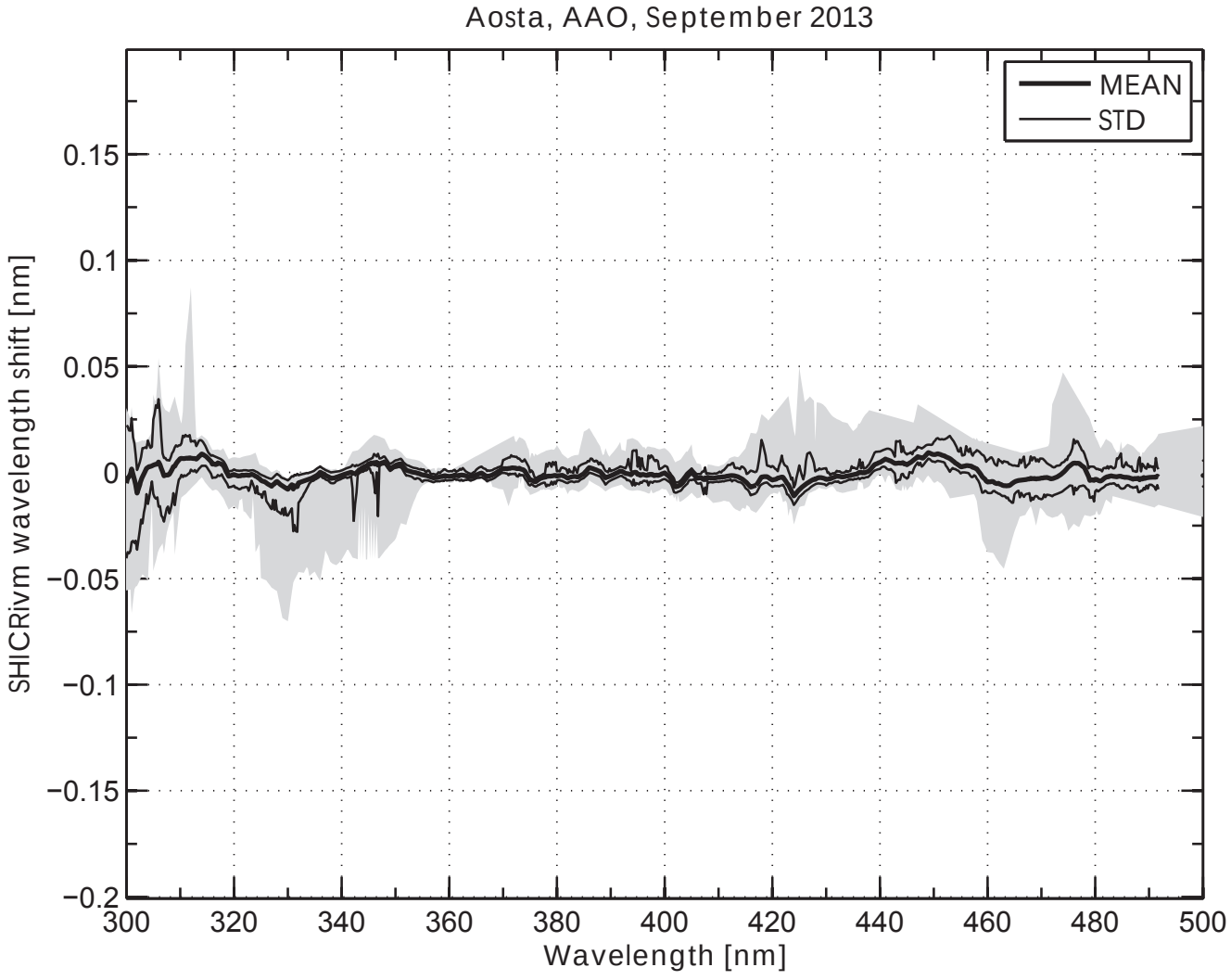
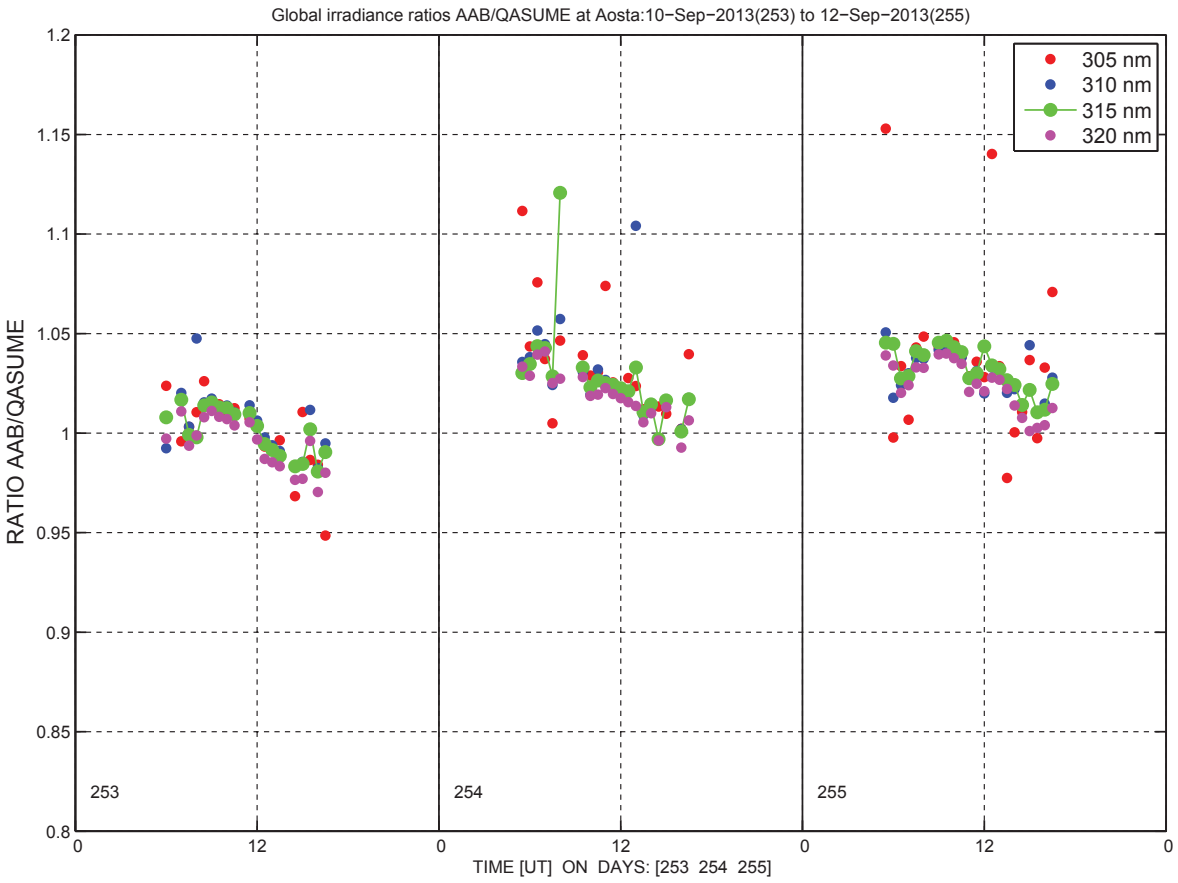
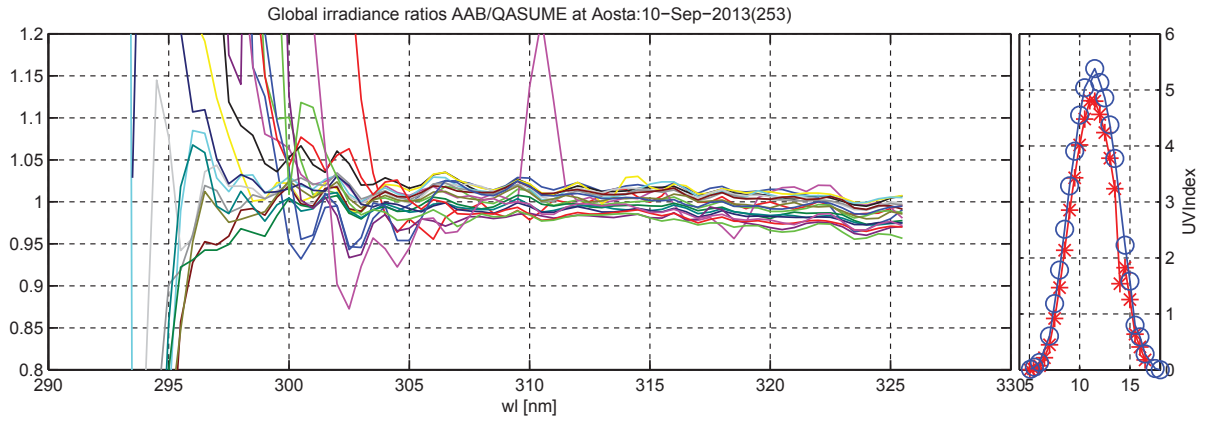
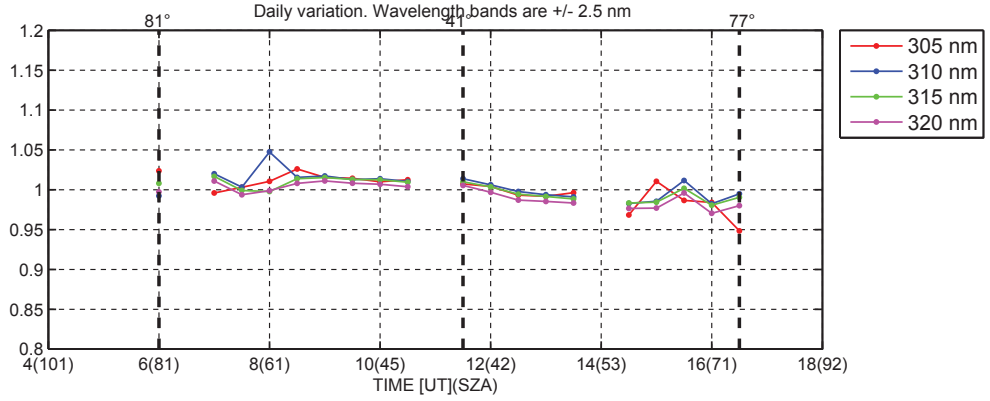
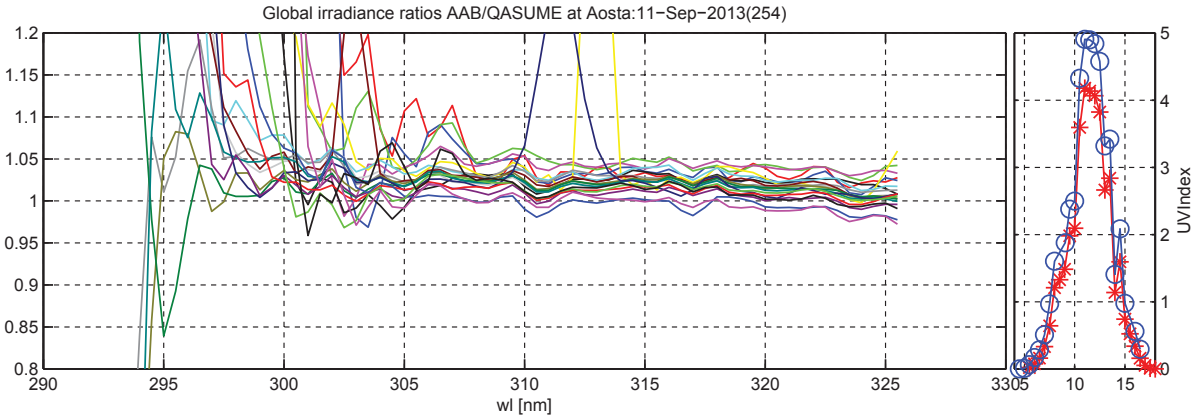

Mean ratio AAO/QASUME at Aosta:10−Sep−2013(253) to 12−Sep−2013(255)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAO/QASUME
NBSpectra=62
Wavelength [nm]

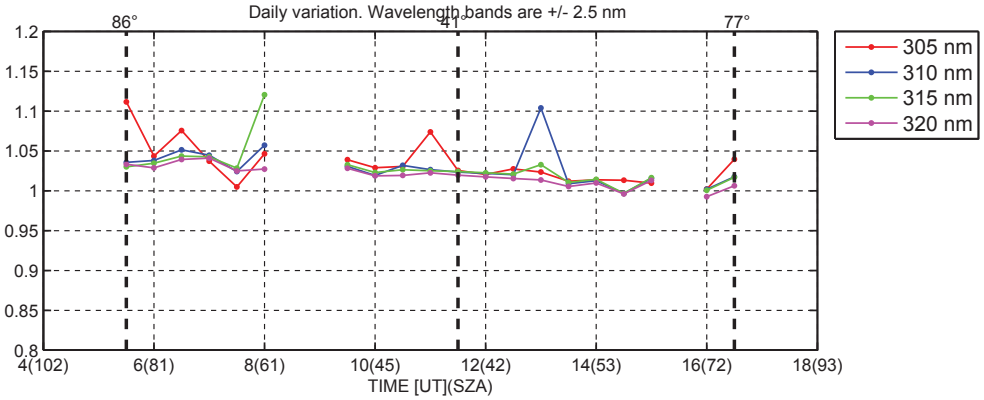

Aosta, AAO, September 2013
MEAN
STD
SHICRivm wavelength shift [nm]
Wavelength [nm]


Global irradiance ratios AAB/QASUME at Aosta:10−Sep−2013(253) to 12−Sep−2013(255)
RATIO AAB/QASUME
TIME [UT] ON DAYS: [253 254 255]
305 nm
310 nm
315 nm
320 nm
253
254
255
04−Oct−2013 09:57:10


Global irradiance ratios AAB/QASUME at Aosta:10−Sep−2013(253)
wl [nm]
UVIndex


Daily variation. Wavelength bands are +/- 2.5 nm
81°
41
77°
TIME [UT](SZA)
305 nm
310 nm
315 nm
320 nm
04−Oct−2013 09:57:10





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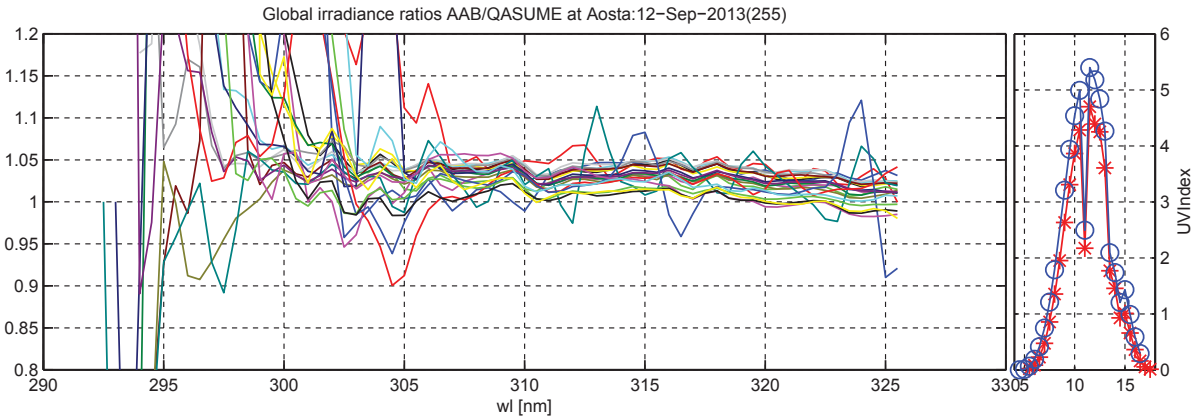

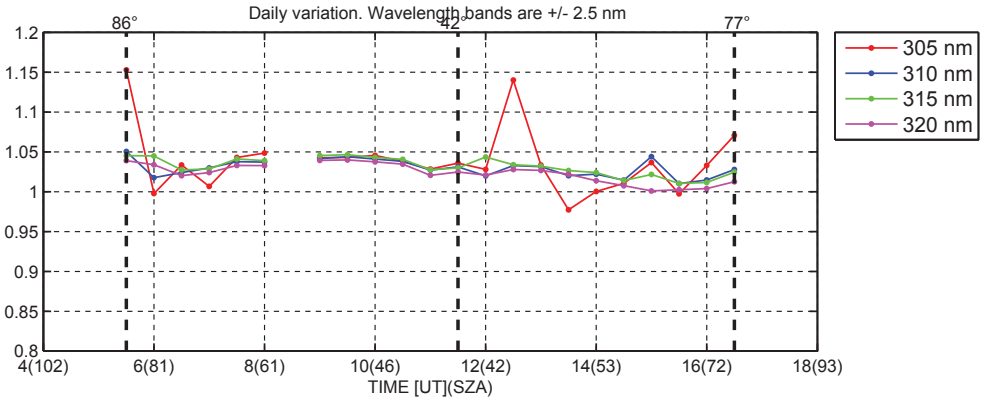

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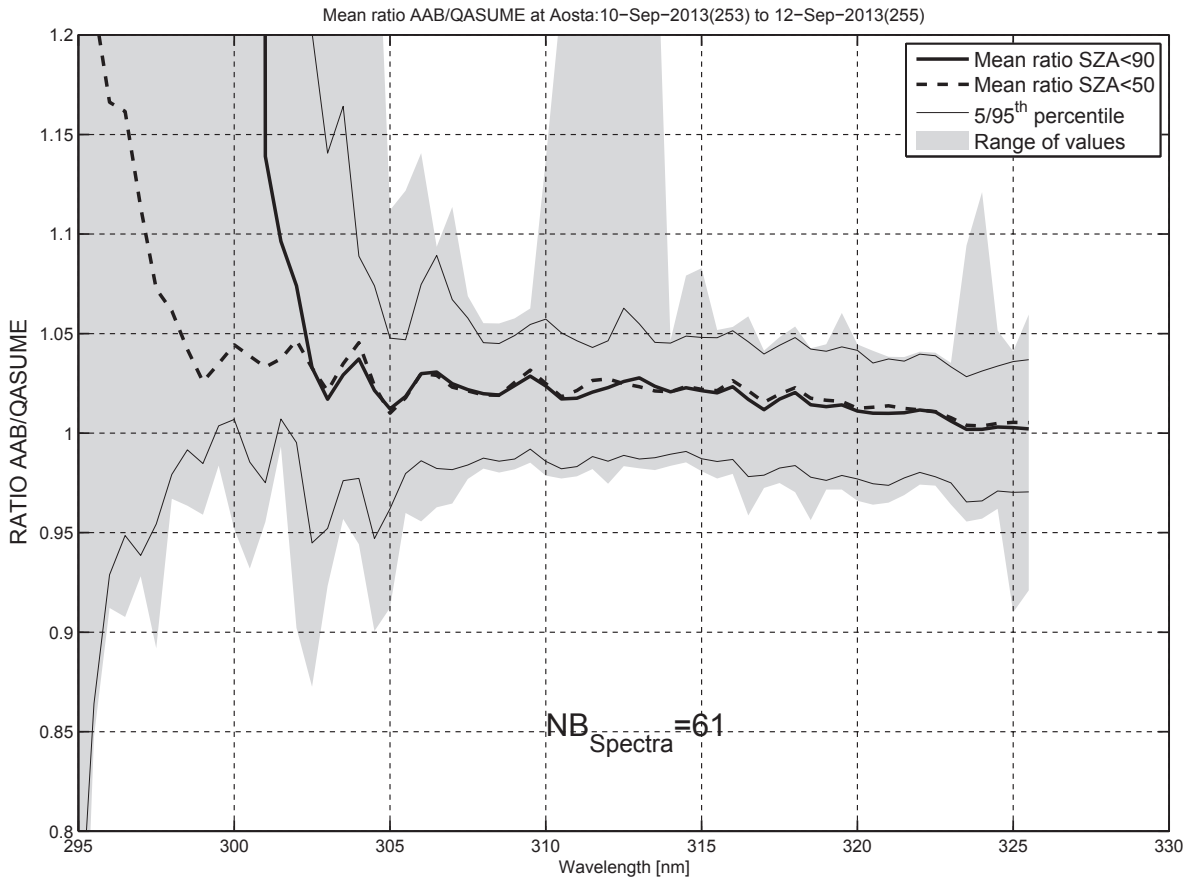
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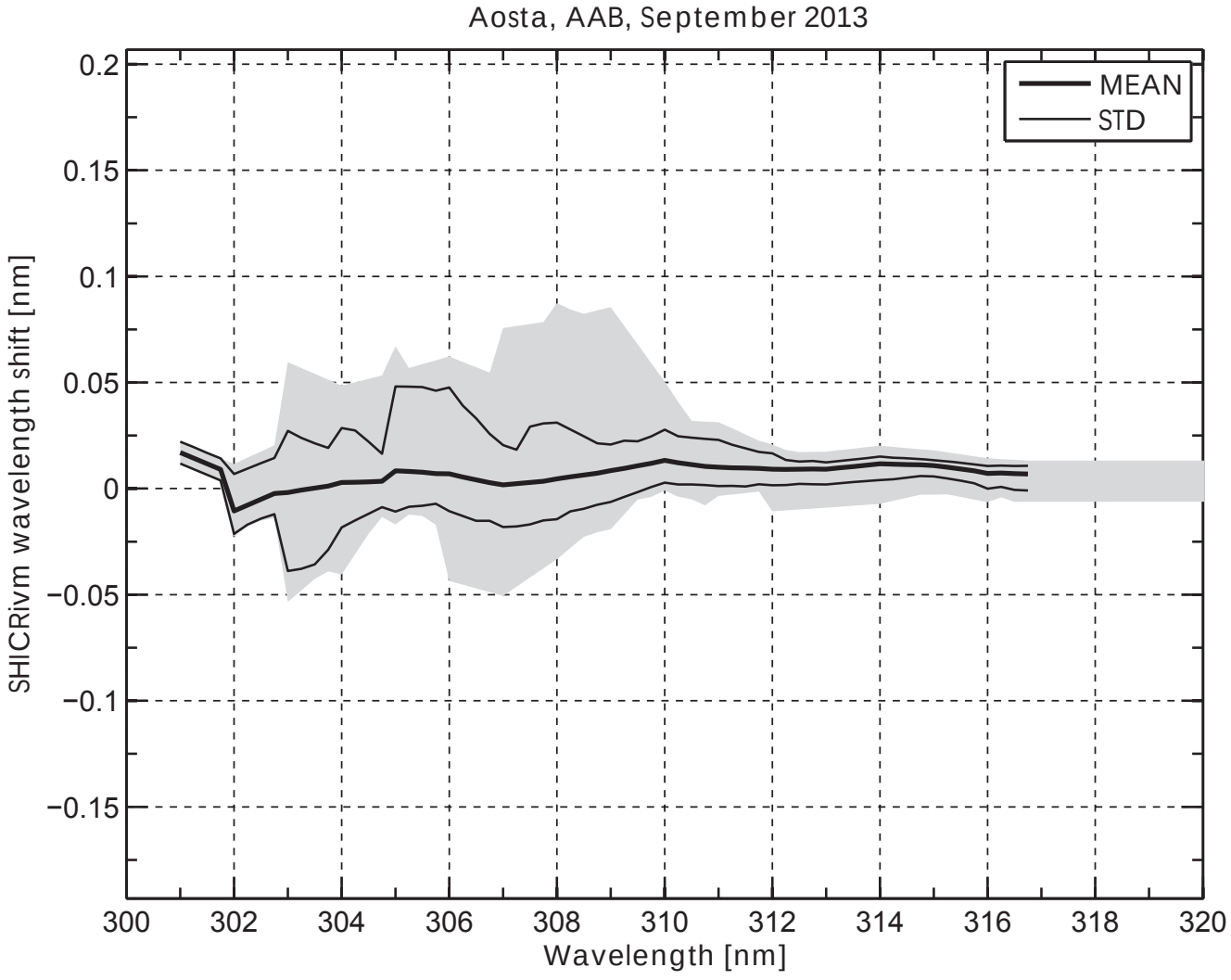
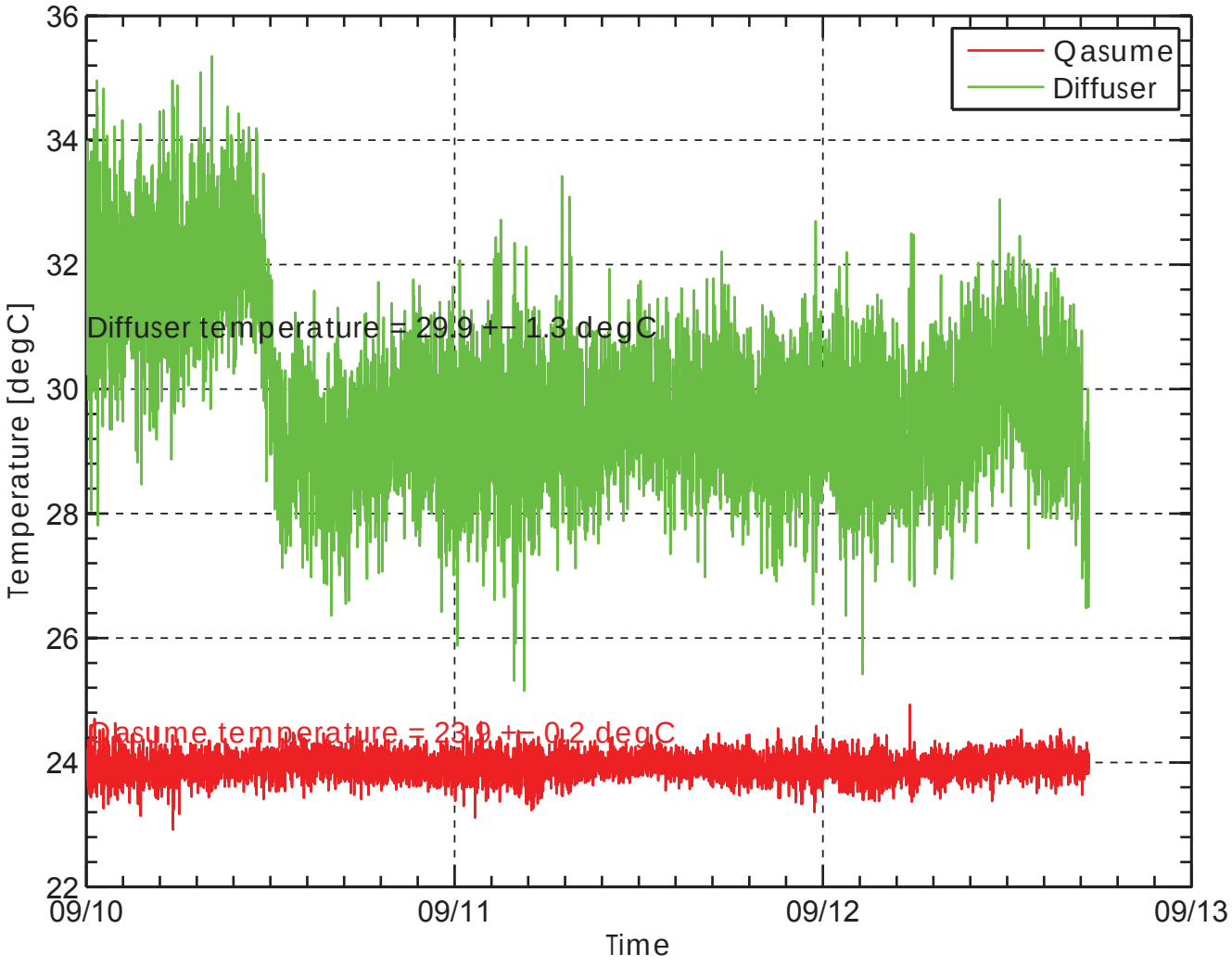
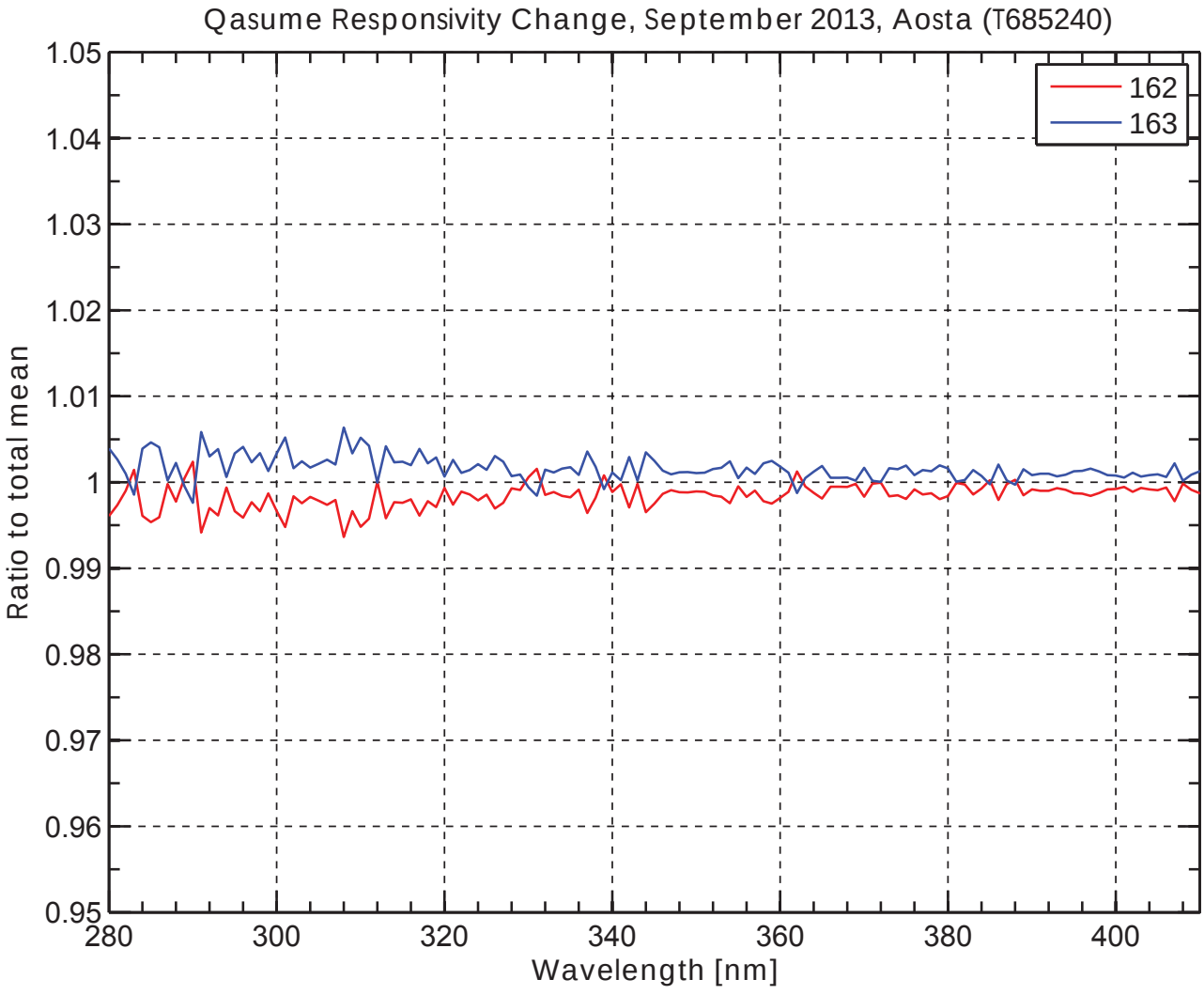

Aosta, AAB, September 2013
MEAN
STD
SHICRivm wavelength shift [nm]
Wavelength [nm]


Qasume
Diffuser
Diffuser temperature = 29.9 +- 1.3 degC
Qasume temperature = 23.9 +- 0.2 degC
Temperature [degC]
Time
36
34
32
30
28
26
24
22
09/10
09/11
09/12
09/13


Qasume Responsivity Change, September 2013, Aosta (T685240)
162
163
Ratio to total mean
Wavelength [nm]
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


AAO
QASUME
AAB