Protocol of the intercomparison at ARPA, Aosta, Italy on August 06 to 10, 2007 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 arrived at ARPA at noon of August 06, 2007. 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 five days, from afternoon of August 06 to noon of August 10.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T68522, T68523 and T68524) 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 28.6±0.7 °C. The diffuser head was heated to a temperature of 26.1±0.9 °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.

Because of the large temperature decrease in Aosta valley in the evening of 08 August 2007, the temperature regulation of QASUME could not maintain the internal temperature. Thus a decrease of ~1.5 C was observed in the two last nights of the intercomparison. The nominal internal temperature was recovered around 9:30 UT on the following morning. This temperature variation leads to a responsivity change of QASUME of less than 0.5 %.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 to 400 nm, every 0.25 nm, and 1.5 seconds between each wavelength increment.

August 06 (218) Monday:

QASUME was installed on the measurement site at 14:00 UT. The internal temperature of QASUME reached its nominal temperature at 16:00 UT. Synchronised measurements are available from 14:30 to 18:00 UT. Weather conditions were mix of sun and clouds with cirrus and cumulus clouds.

QASUME was calibrated at 15:25 UT. The scan at 15:30 UT is missing.

August 07 (219) Tuesday:

Synchronised measurements are available from 5:00 to 19:00 UT. Weather conditions were overcast sky with cumulus clouds and occasional rain showers. The scans at 7:00-8:00 UT and 11:30-13:00 UT are affected by rain; the scans 13:30 and 14:00 UT by a few drops.

QASUME was calibrated at 9:44 and 15:13UT.

August 08 (220) Wednesday:

Synchronised scans are available from 4:30 to 19:30 UT. Weather conditions were overcast sky with alto stratus clouds and rain showers. The scans at 11:00-12:00 UT and 13:30-19:00 UT are affected by rain.

August 09 (221) Thursday:

Synchronised scans are available from 4:30 to 19:30 UT. Weather conditions were overcast sky with alto stratus clouds and light rain drops. The scans at 9:30-10:00 UT and 12:30-14:30 UT are affected by a few drops.

QASUME was calibrated at 15:14 UT. The AAO measured T68522 at 15:30 UT.

August 10 (222) Friday:

Synchronised scans are available from 4:30 to 10:00 UT. Weather conditions were clear sky.

The AAO diffuser head was rotated by 180° at 7:27 UT and rotated back to 0° at 8:27 UT.

QASUME was calibrated at 9:13, 9:42 and 10:12 UT.

End of the campaign at 10:30 UT.

Results:

In total 88/79 synchronised simultaneous spectra from QASUME and AAO/AAB are available from the measurement period (excluding spectra affected by rain). Measurements between 6:00 and 17:00 UT have been analysed (SZA smaller than 85°).

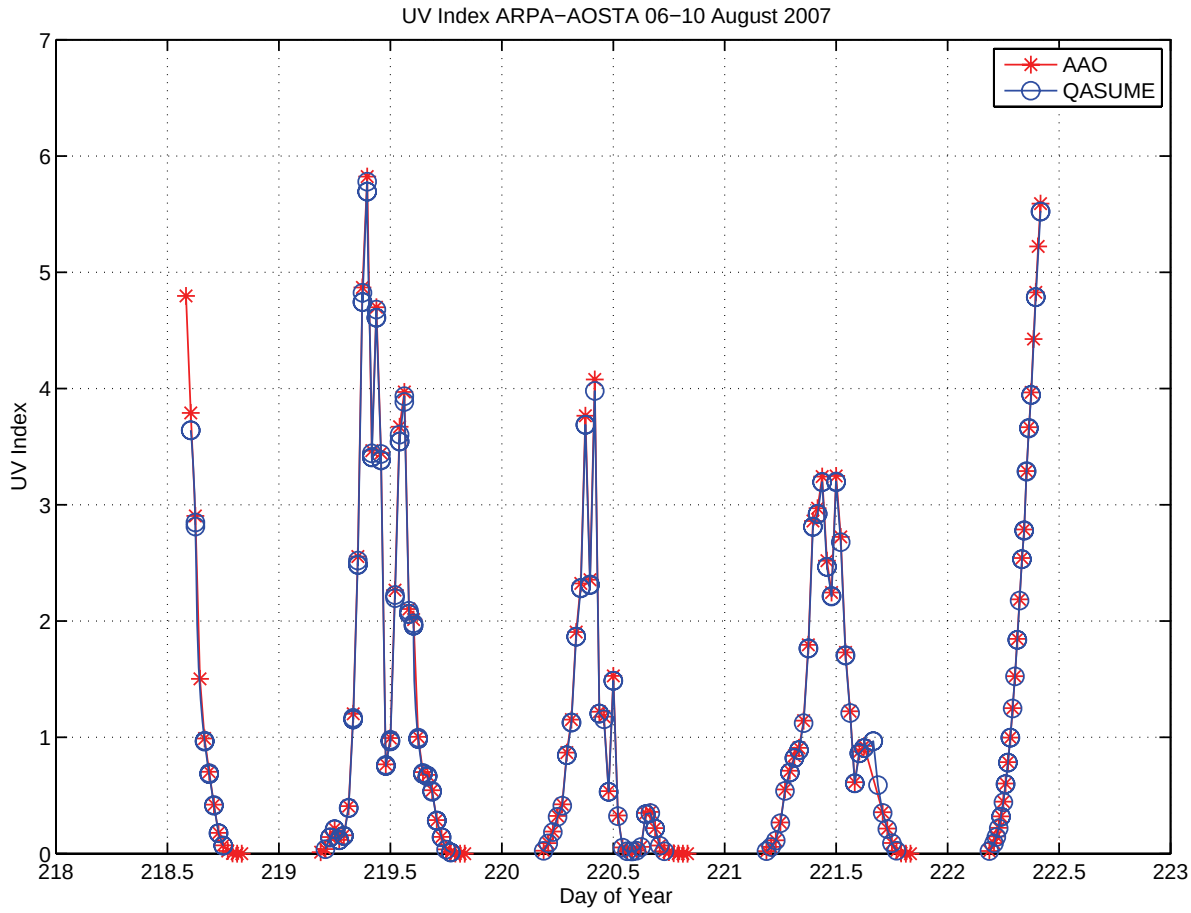
Remarks:

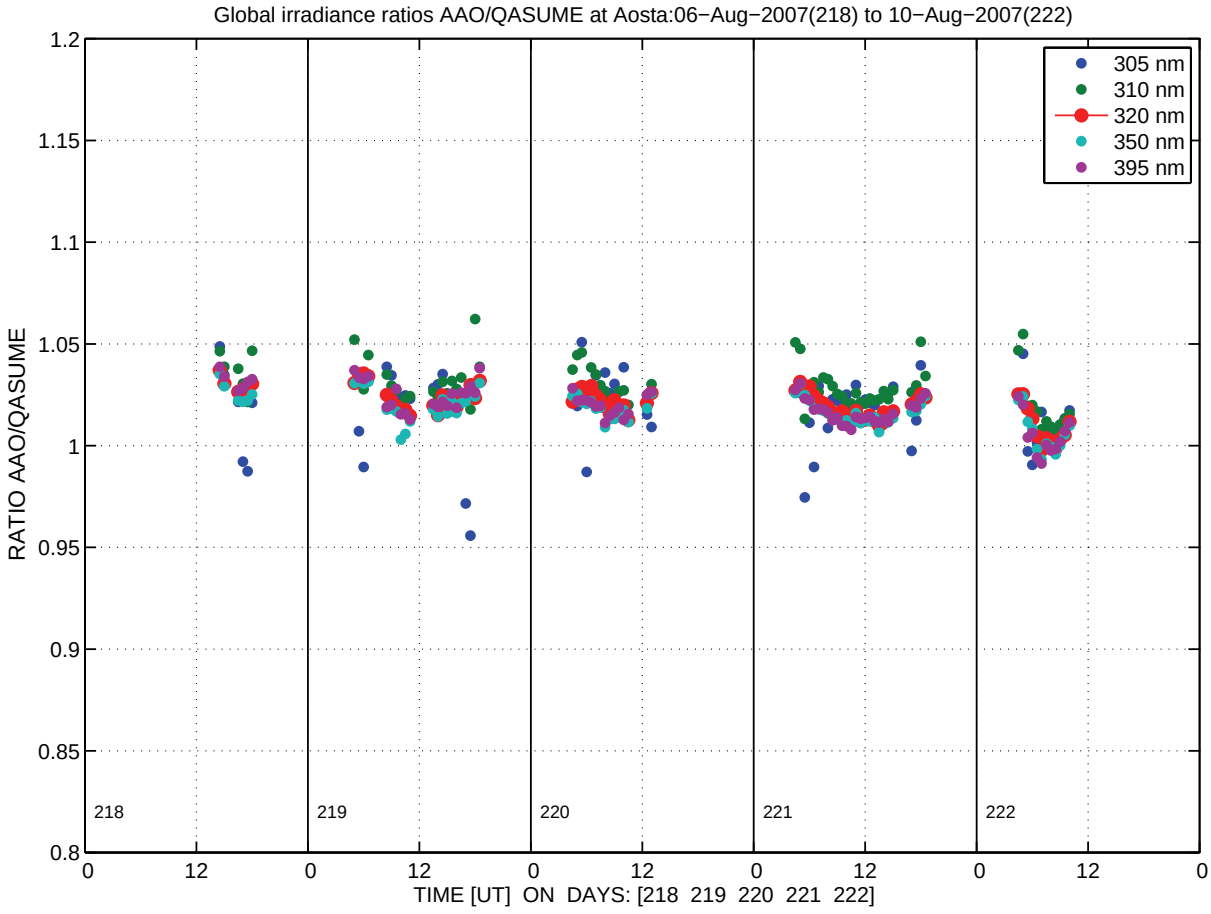
I. AAO

1. The ratios between AAO and QASUME have on average an offset of +2 %.
2. The AAO diffuser head was rotated by 180° on day 222 for the scans at 7:30- 8:15 UT. These scans visualise the azimuth error of the AAO diffuser. The azimuth dependence of the directional response of the AAO diffuser head observed in 2006 is now smaller than 0.5 % as shown in the figure.
3. The mean offset of AAO to QASUME can be explained by the difference in the lamp certificate of the AAO lamp to the QASUME reference, which was confirmed with a measurement of T68522 with the AAO instrument as shown in the figure.
4. The diurnal variation of the AAO to QASUME ratio is below 2 % on the diffuse sky days and around 3.5 % on the clear sky day.
5. For all solar scans the wavelength shifts of the AAO are between +20 and -80 pm.

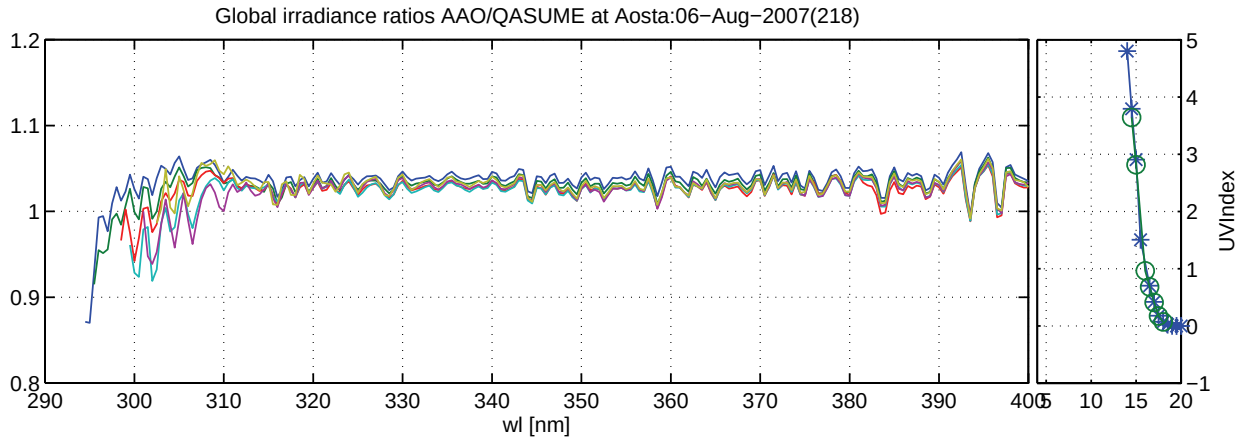
II. AAB

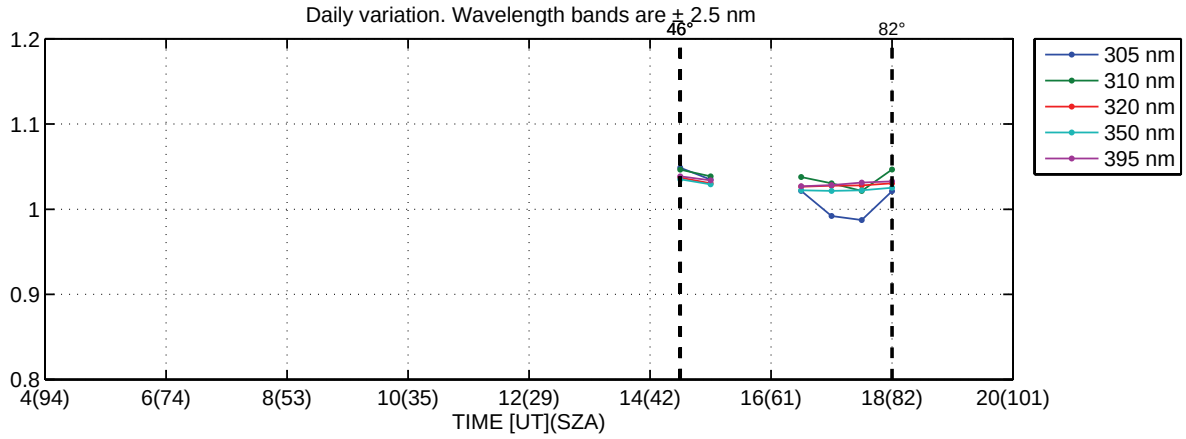
1. The ratios between AAB and QASUME have on average an offset of +2.5 % for wavelengths longer than 305 nm.
2. Below 305 nm, the measurements of AAB shows higher irradiances which are due to internal stray light of the single monochromator. At 300 nm the ratio of irradiances measured by AAB and QASUME is between 0.95 and 1.3.
3. The diurnal variation of the AAB to QASUME ratio is around 3 % on the diffuse sky days and above 5 % on the clear sky day.
4. The spectrum of AAB on August 08 at 5:00 shows unexplained variability between 317-320 nm; on August 09 at 9:00 UT a spike at 312 nm could be observed in the spectrum of AAB.
5. For all solar scans the wavelength shifts of the AAB are below ±40 pm.



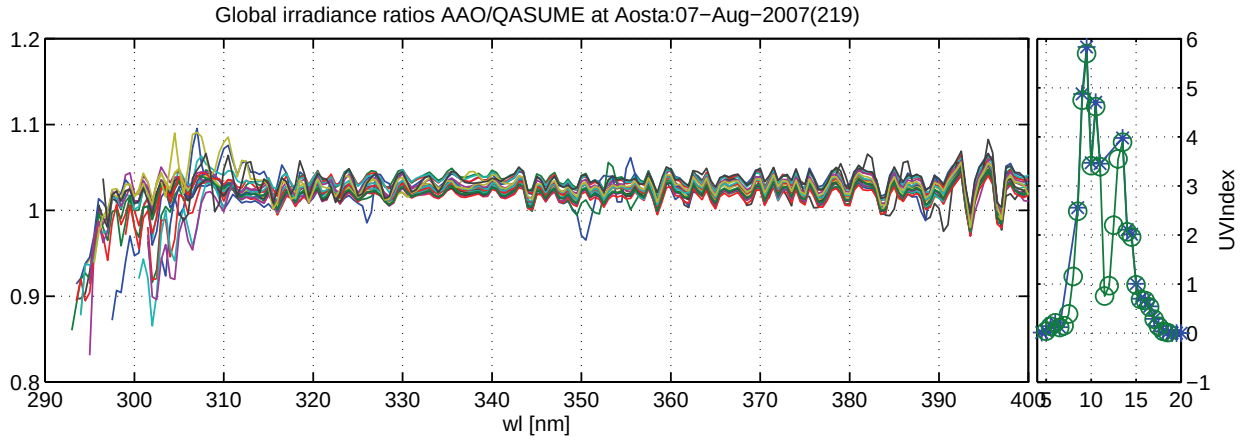


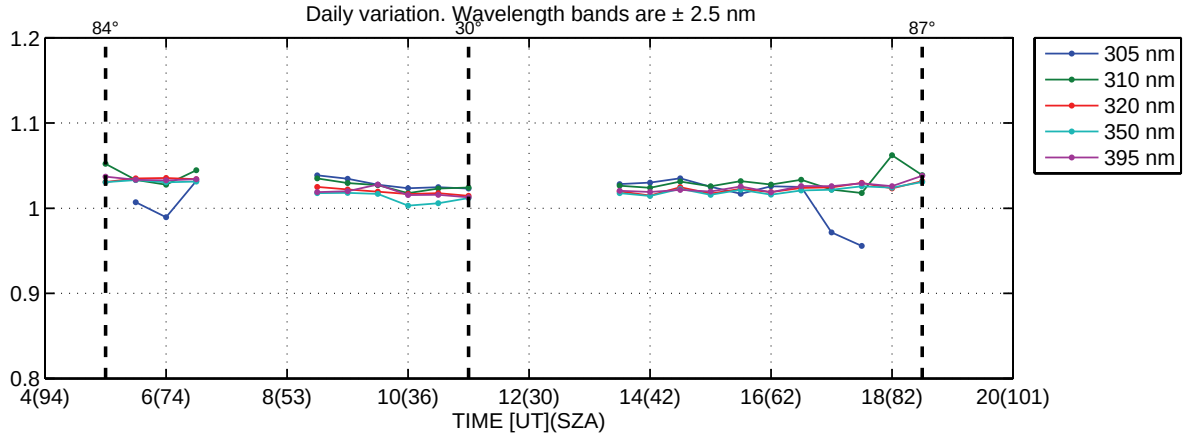
14−Aug−2007 09:01:26



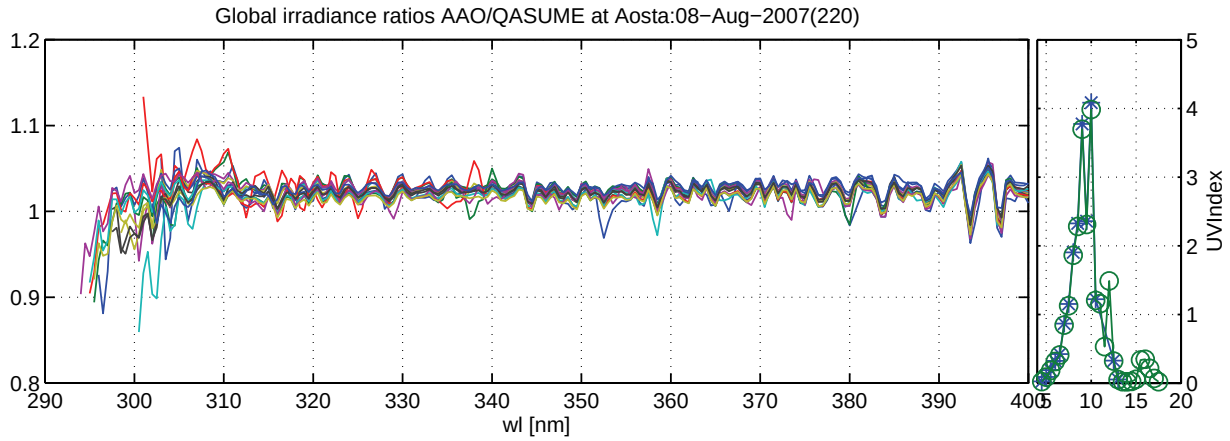


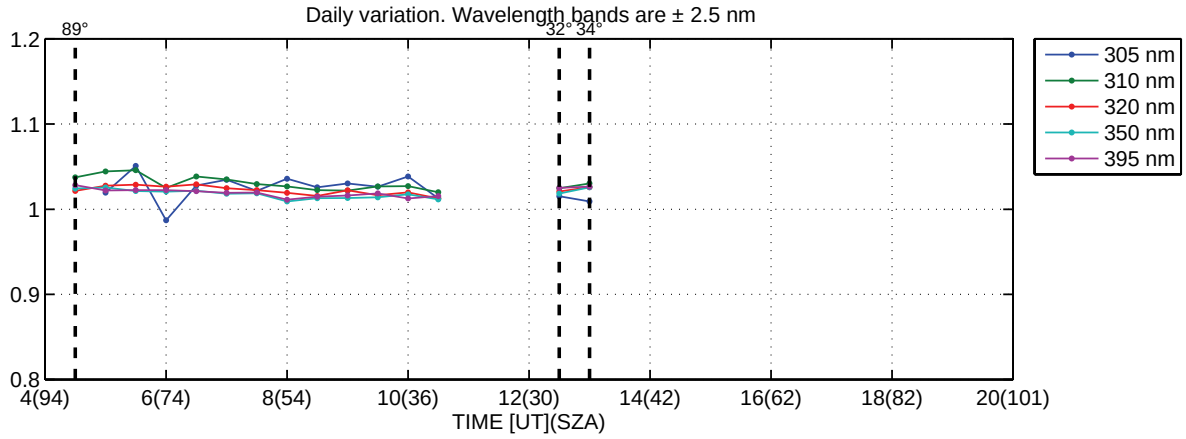
14−Aug−2007 09:01:26



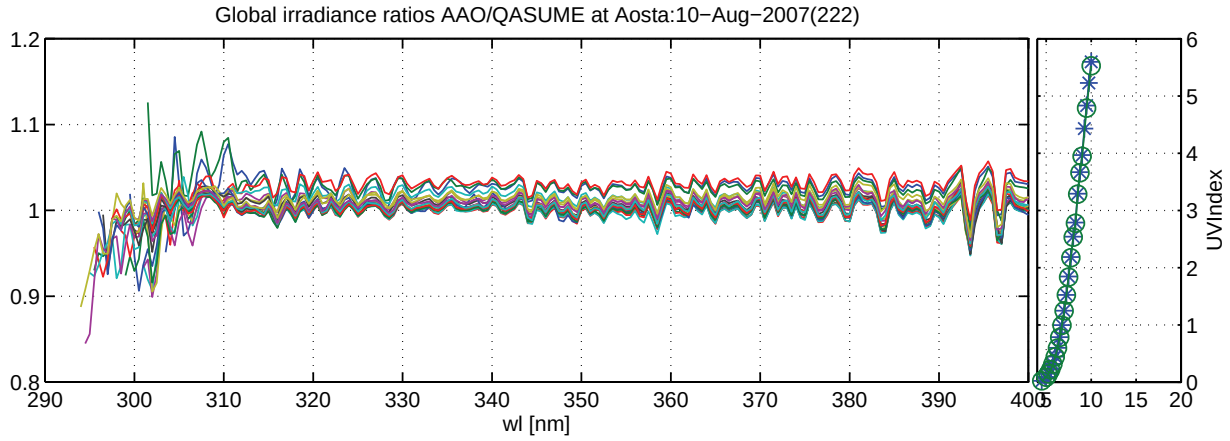


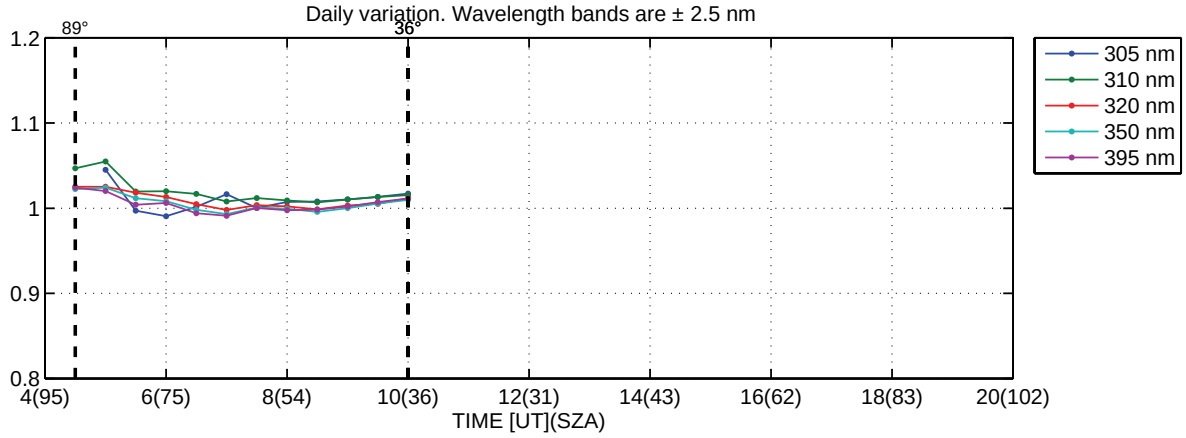
14−Aug−2007 09:01:26



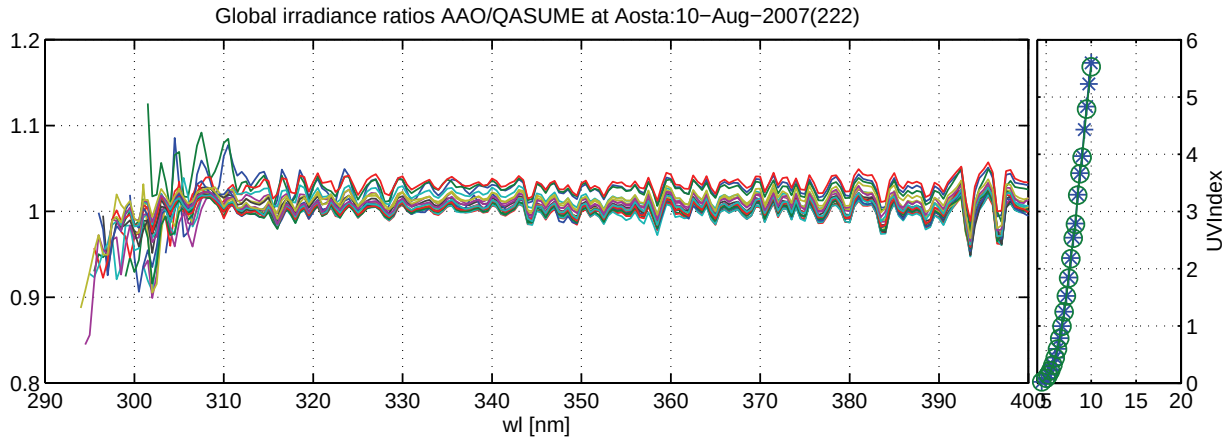


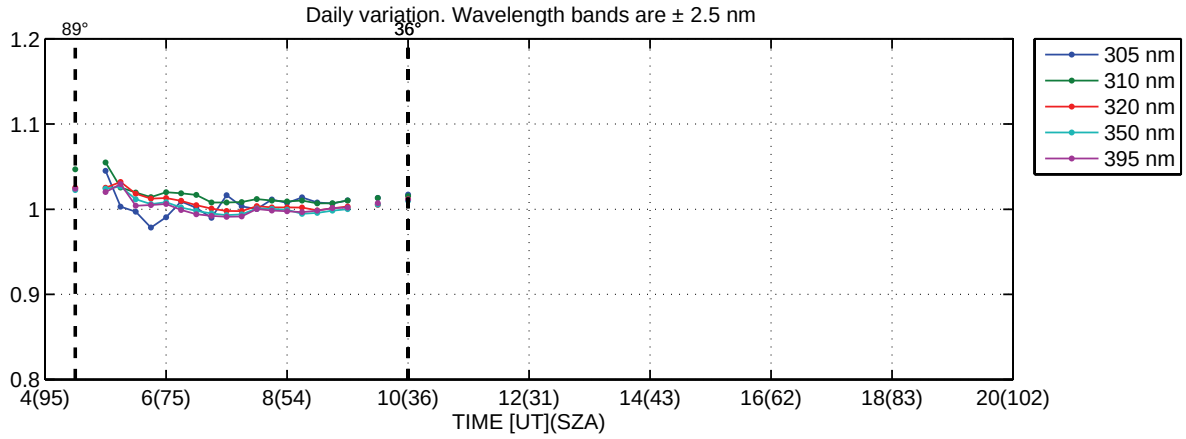
14−Aug−2007 09:01:26



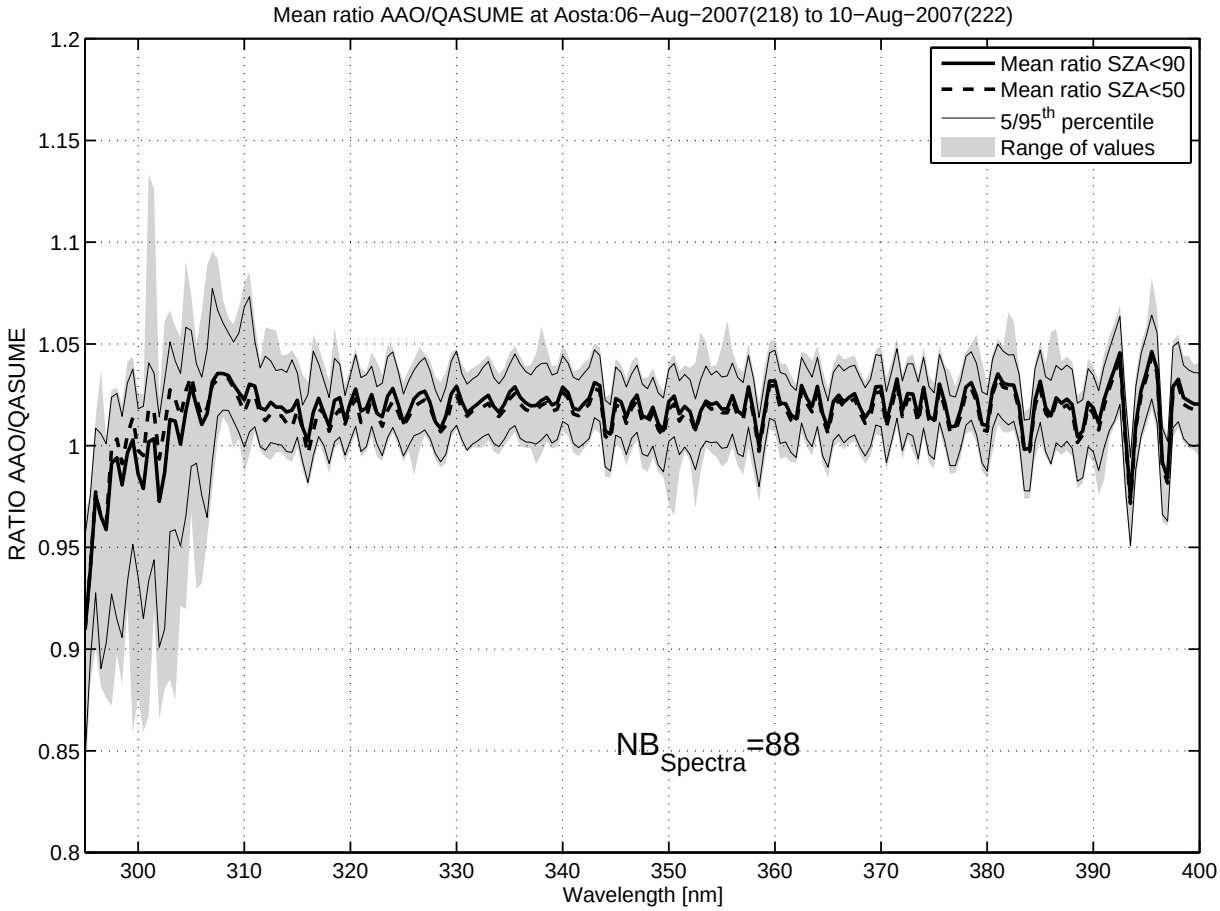


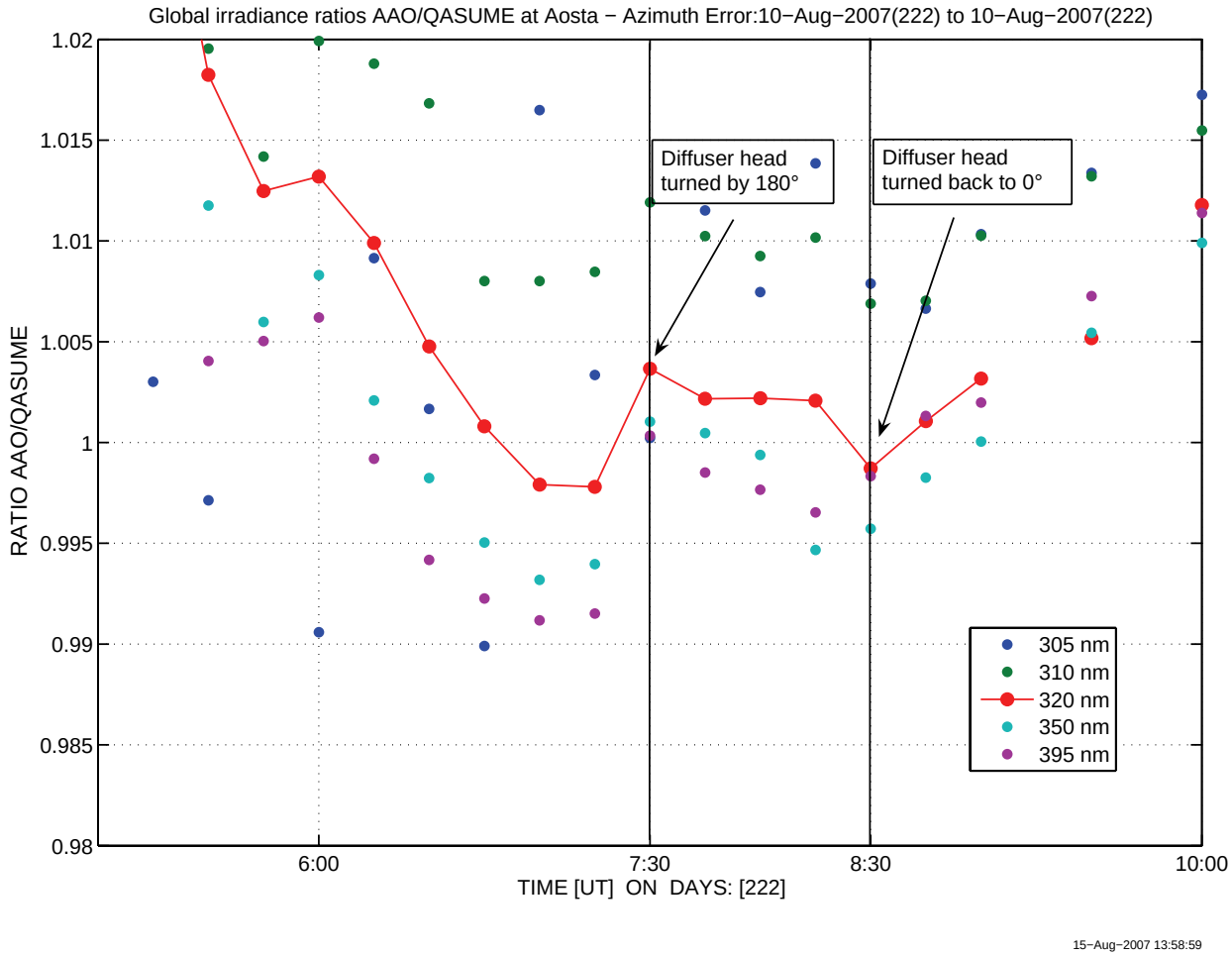
14−Aug−2007 09:01:26

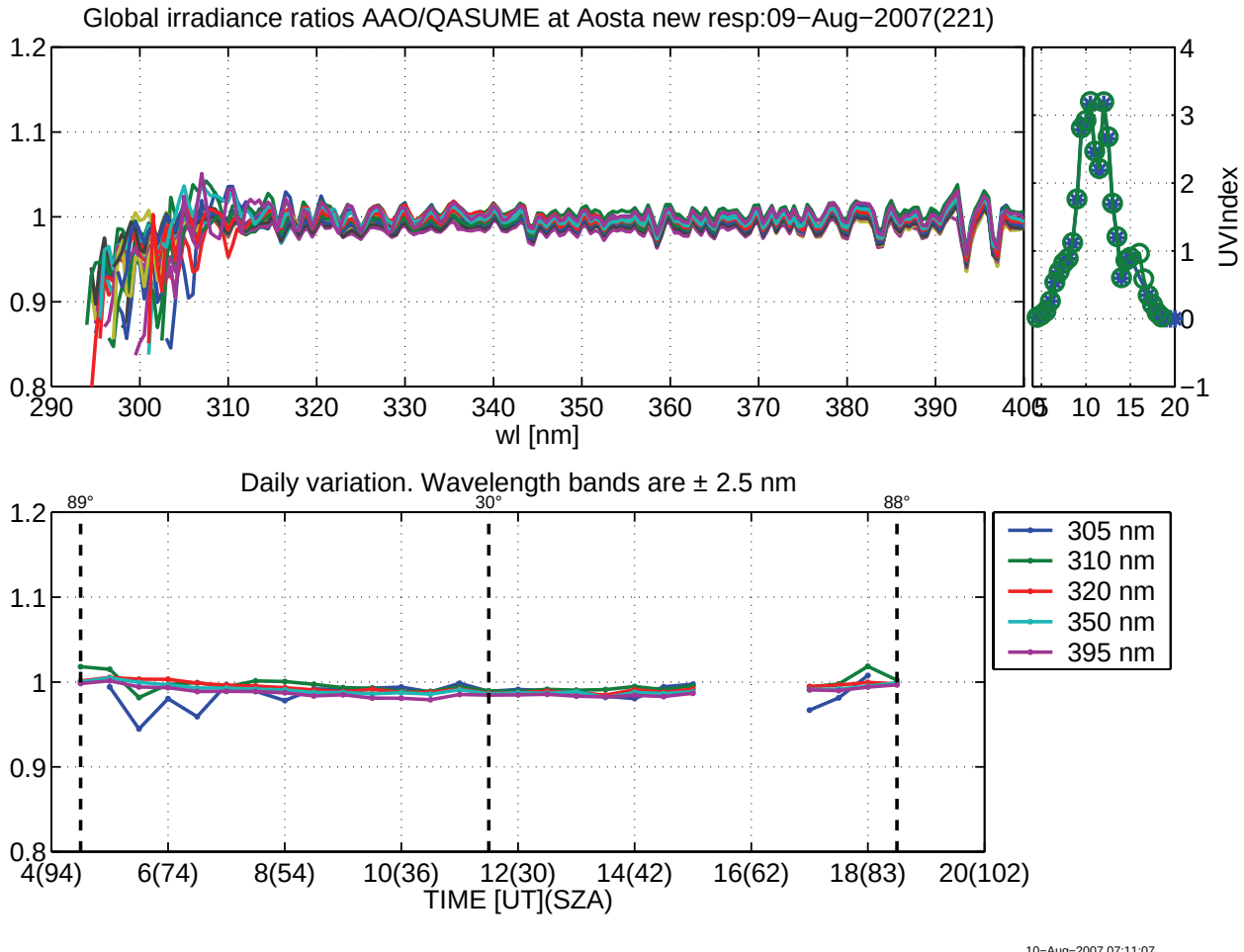


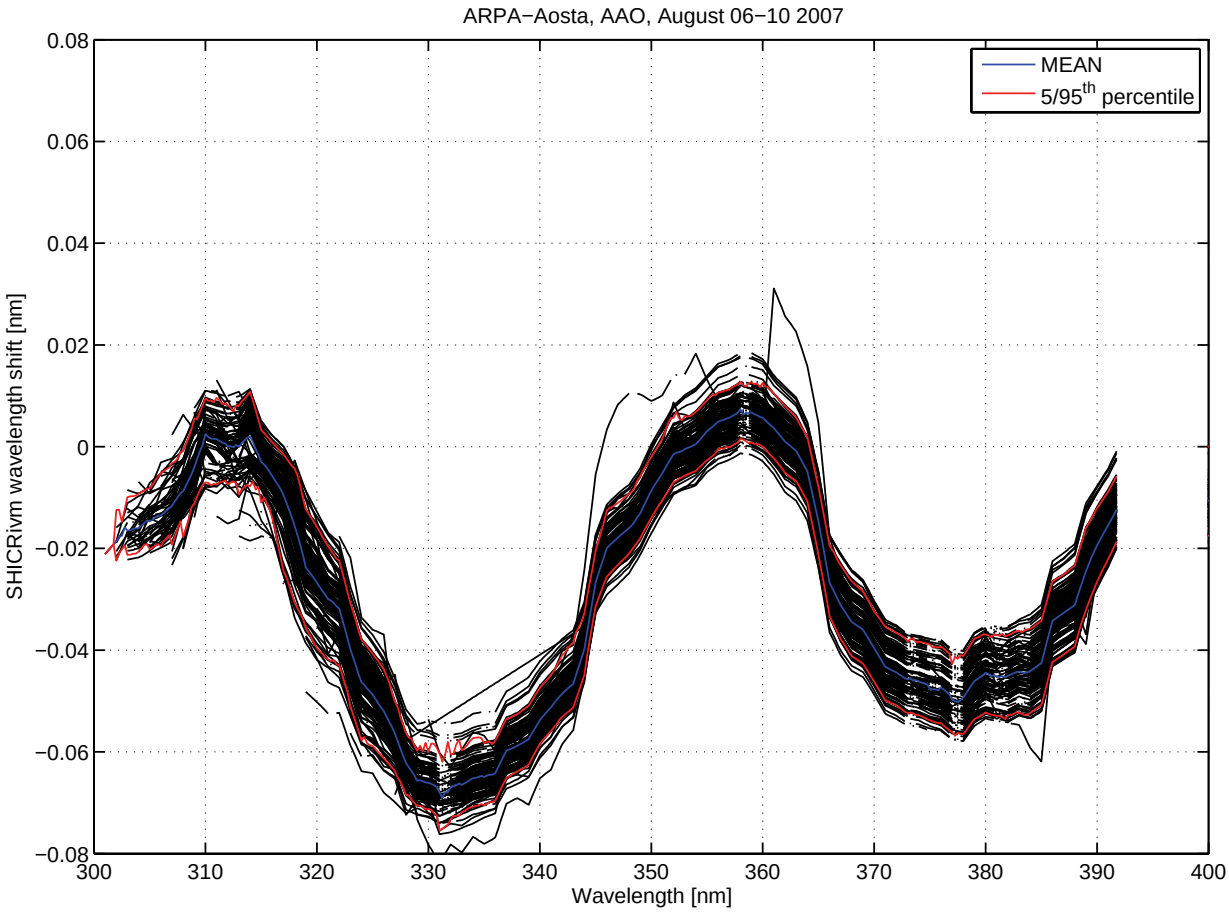


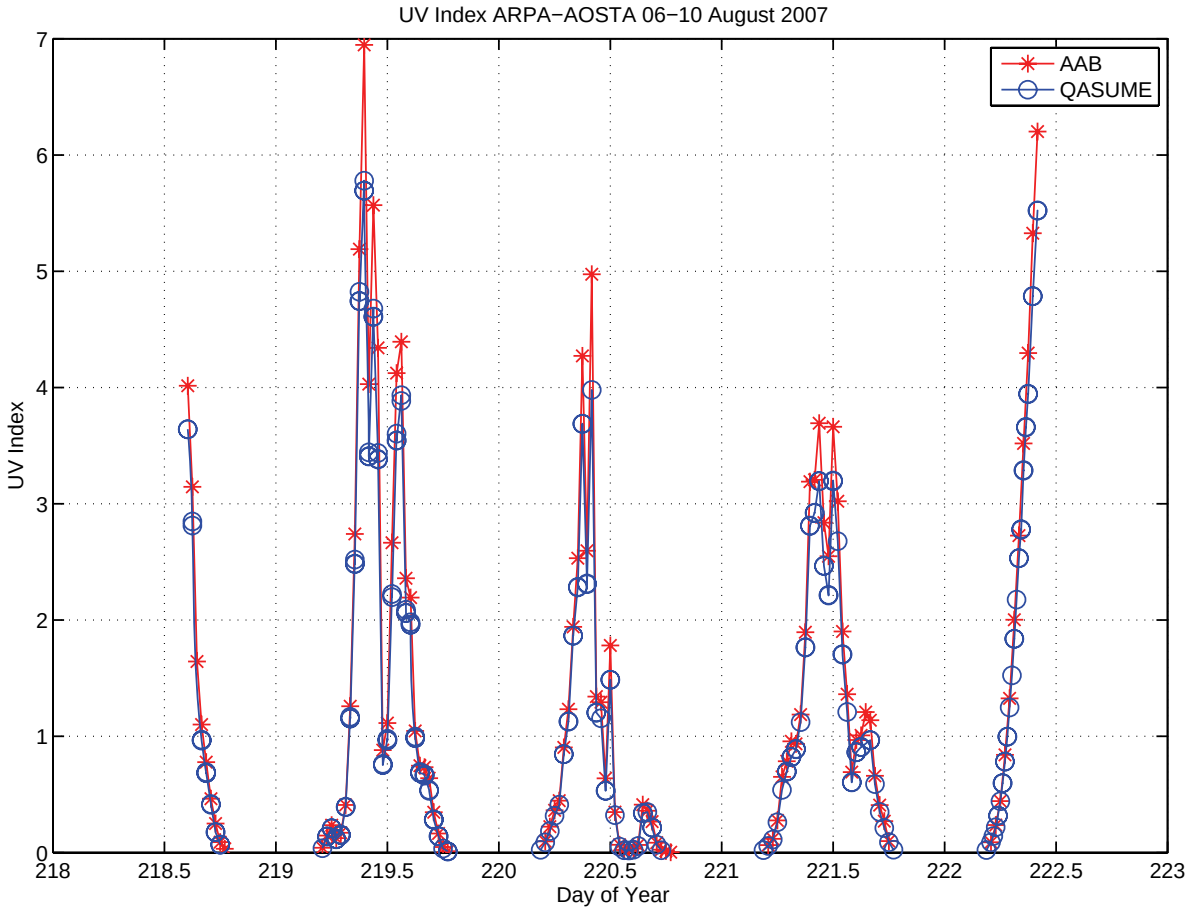
14−Aug−2007 07:56:07

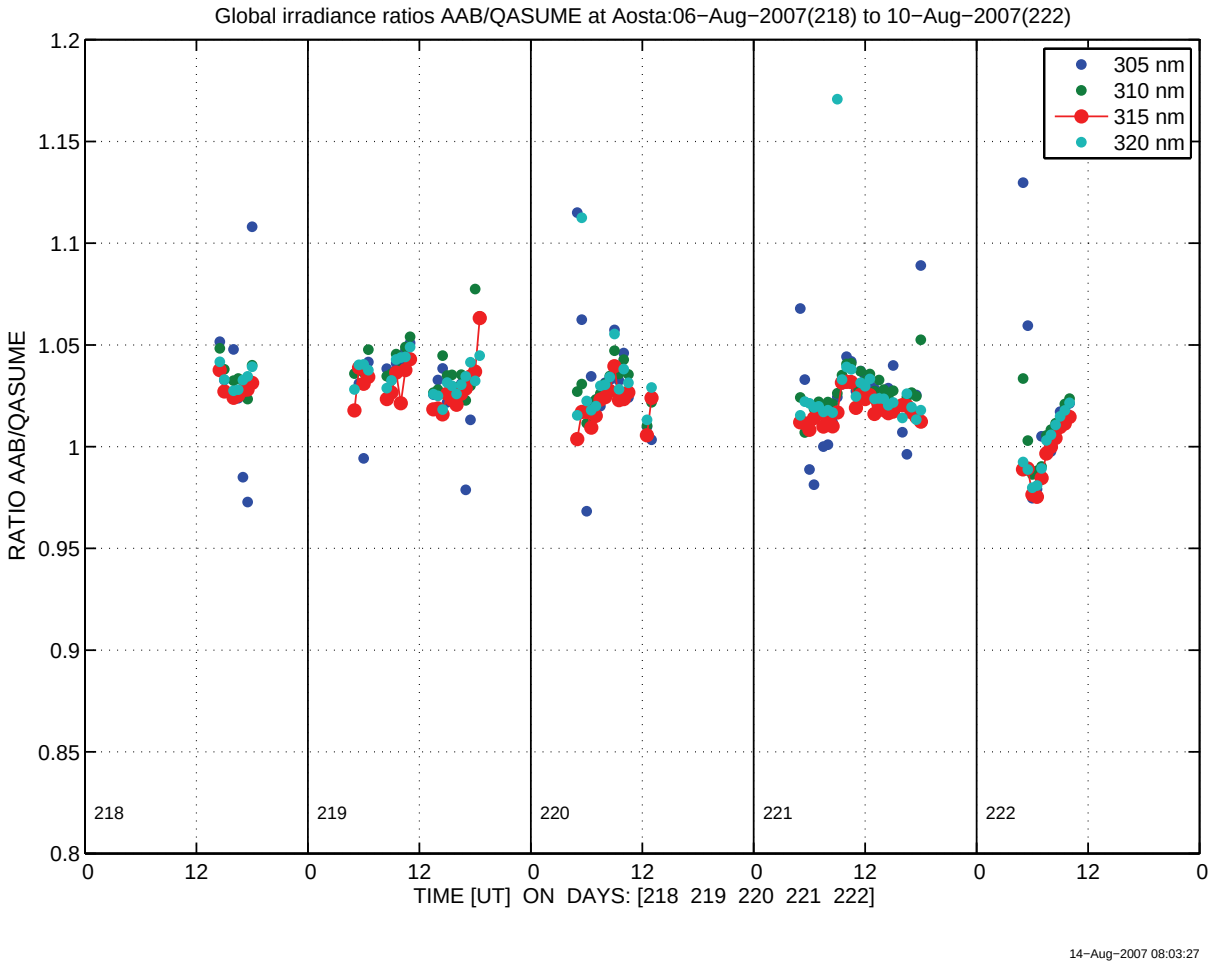


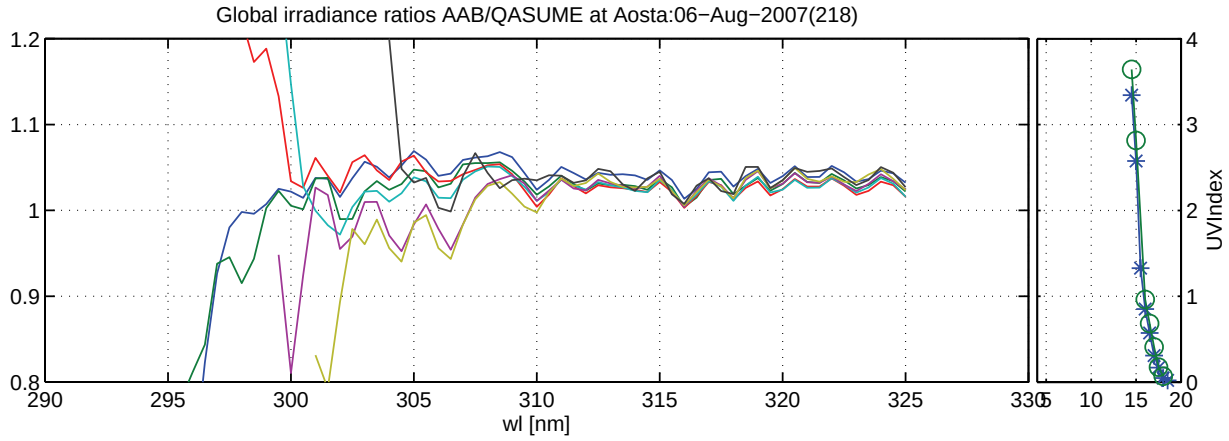

Global irradiance ratios AAO/QASUME at Aosta − Azimuth Error:10−Aug−2007(222) to 10−Aug−2007(222)
RATIO AAO/QASUME
TIME [UT] ON DAYS: [222]
Diffuser head turned by 180°
Diffuser head turned back to 0°
305 nm
310 nm
320 nm
350 nm
395 nm
15−Aug−2007 13:58:59

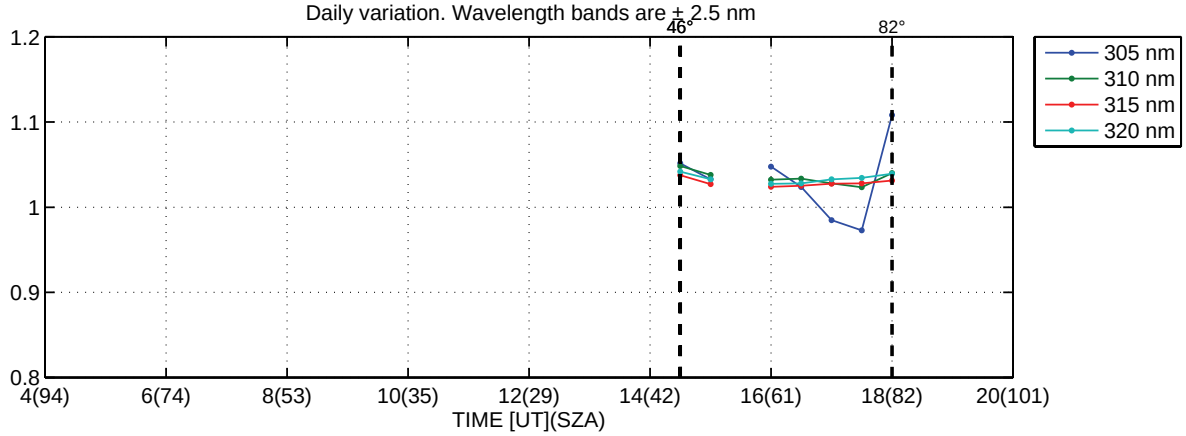

Global irradiance ratios AAO/QASUME at Aosta new resp:09−Aug−2007(221)
wl [nm]
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
89°
30°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
395 nm
10−Aug−2007 07:11:07

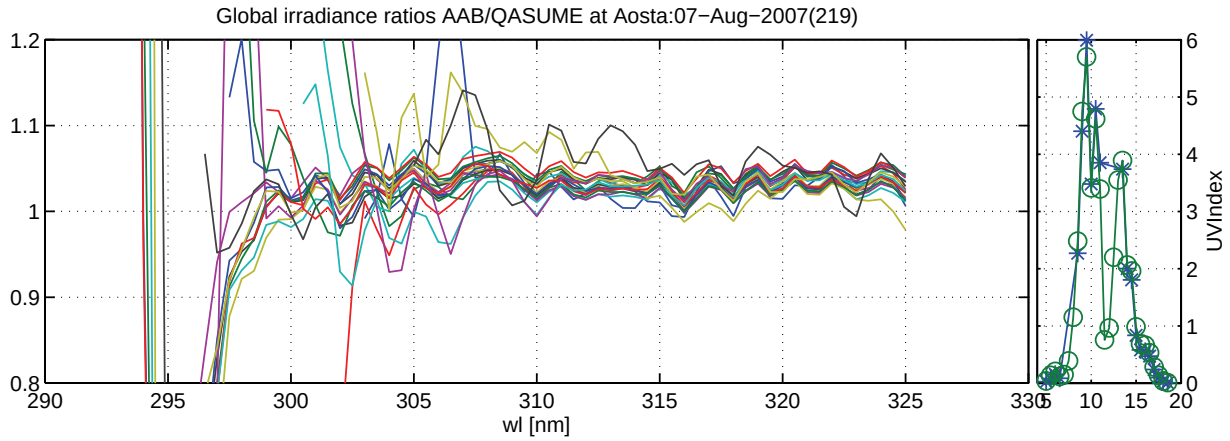

ARPA−Aosta, AAO, August 06−10 2007
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
300
310
320
330
340
350
360
370
380
390
400

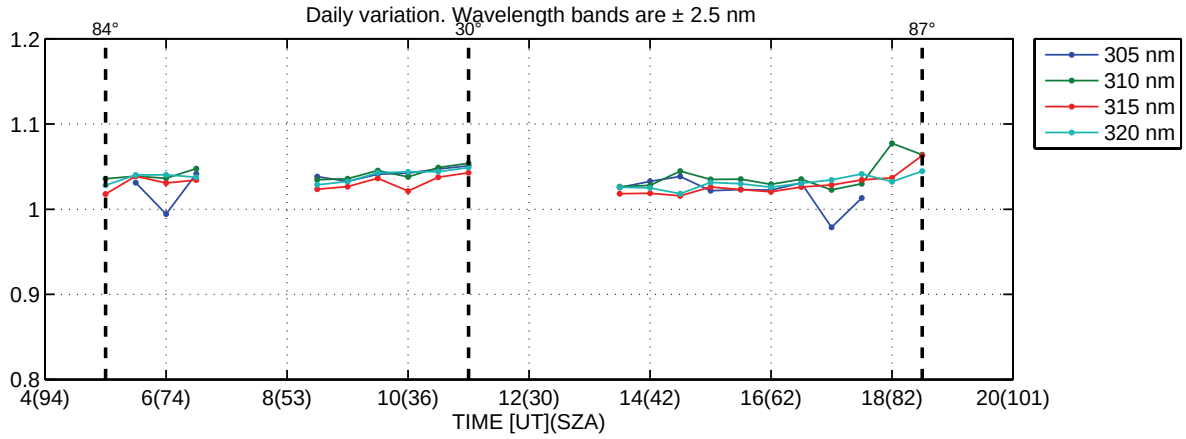

UV Index ARPA−AOSTA 06−10 August 2007
AAB
QASUME
UV Index
Day of Year
7
6
5
4
3
2
1
0
218
218.5
219
219.5
220
220.5
221
221.5
222
222.5
223


Global irradiance ratios AAB/QASUME at Aosta:06−Aug−2007(218) to 10−Aug−2007(222)
RATIO AAB/QASUME
TIME [UT] ON DAYS: [218 219 220 221 222]
305 nm
310 nm
315 nm
320 nm
218
219
220
221
222
14−Aug−2007 08:03:27

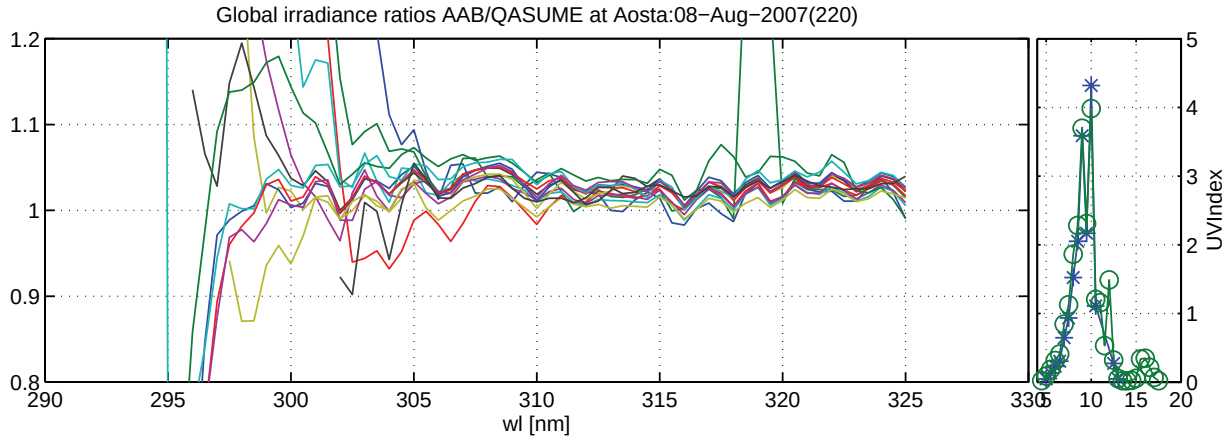

Global irradiance ratios AAB/QASUME at Aosta:06−Aug−2007(218)
wl [nm]
UVIndex

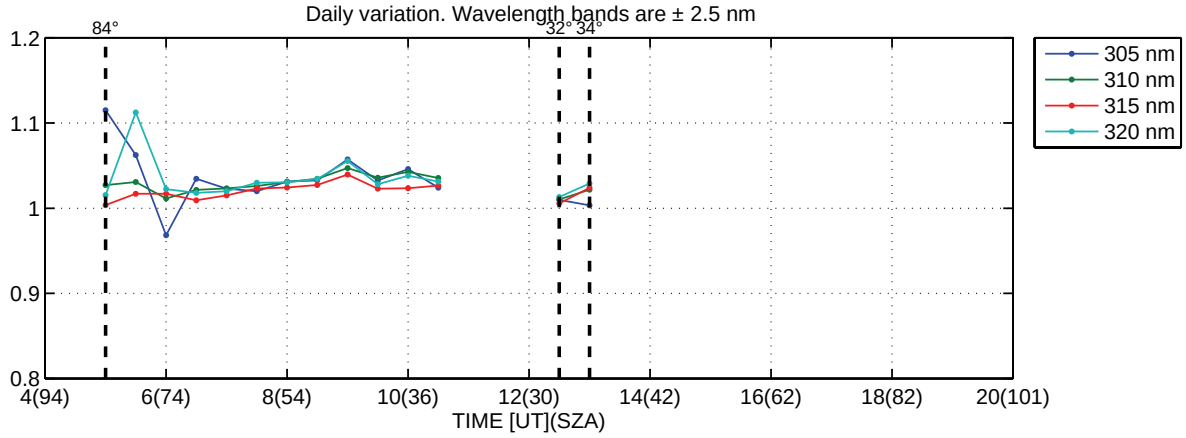

Daily variation. Wavelength bands are ± 2.5 nm
46°
82°
TIME [UT](SZA)
305 nm
310 nm
315 nm
320 nm
14−Aug−2007 08:03:27



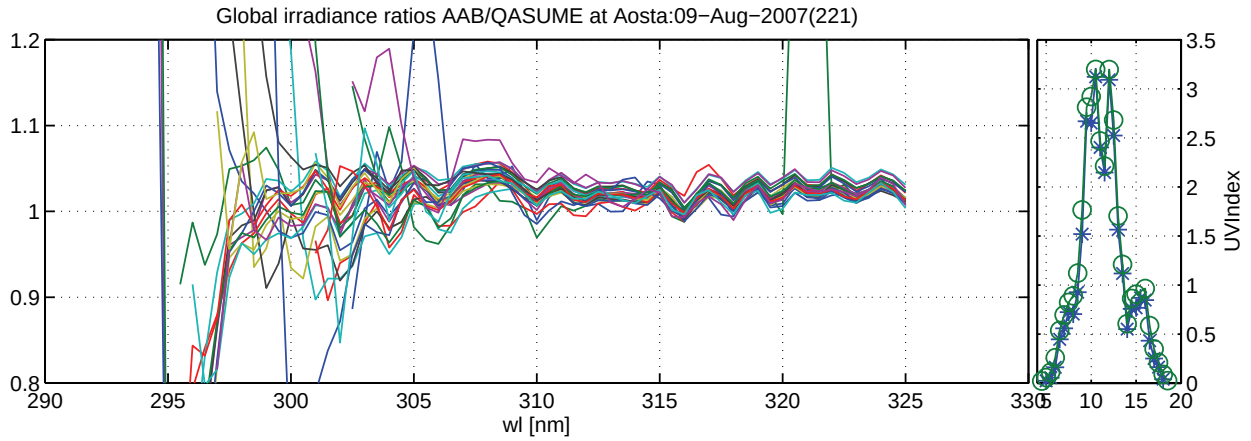


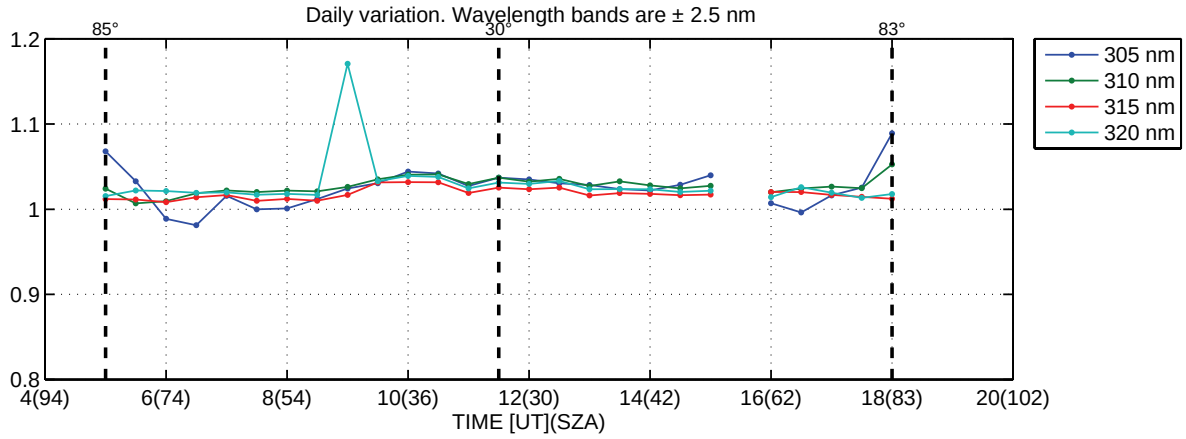
14−Aug−2007 08:03:27



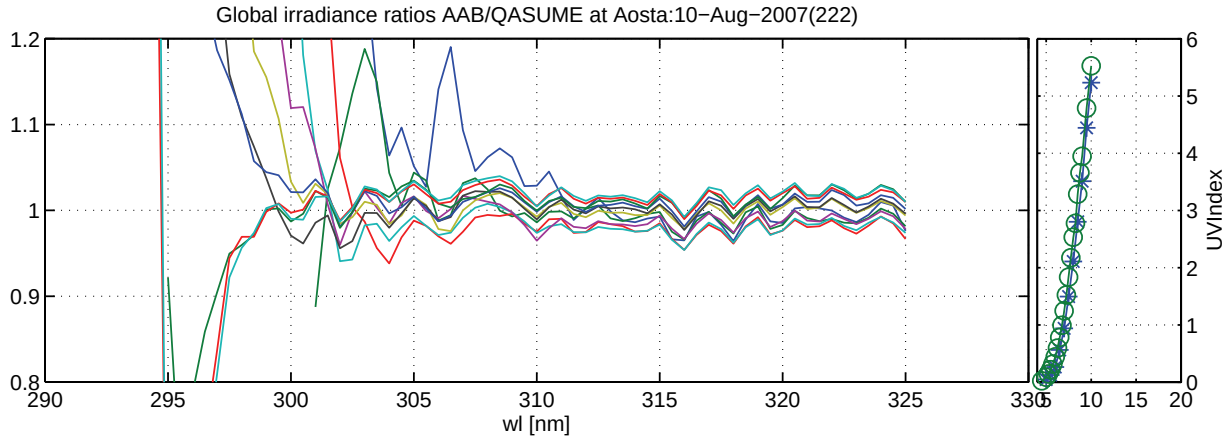


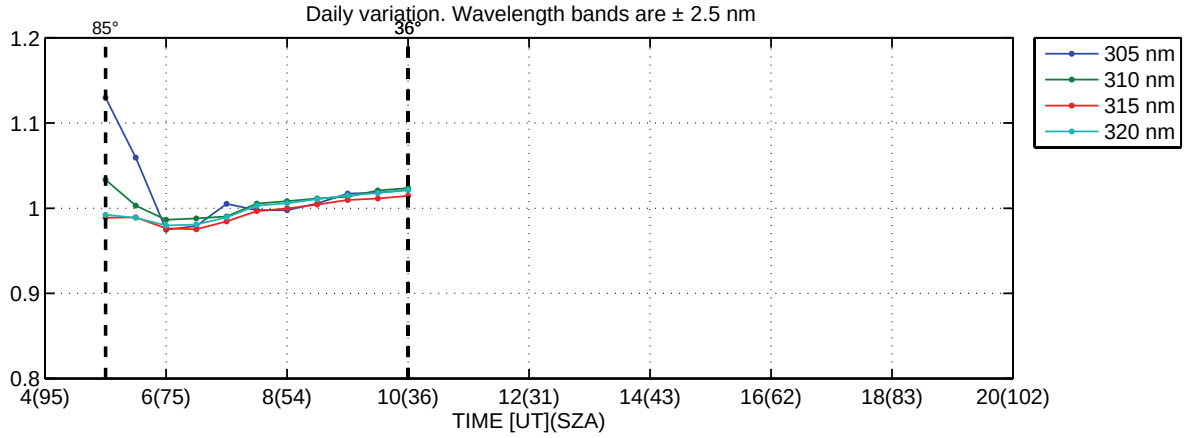
14−Aug−2007 08:03:27



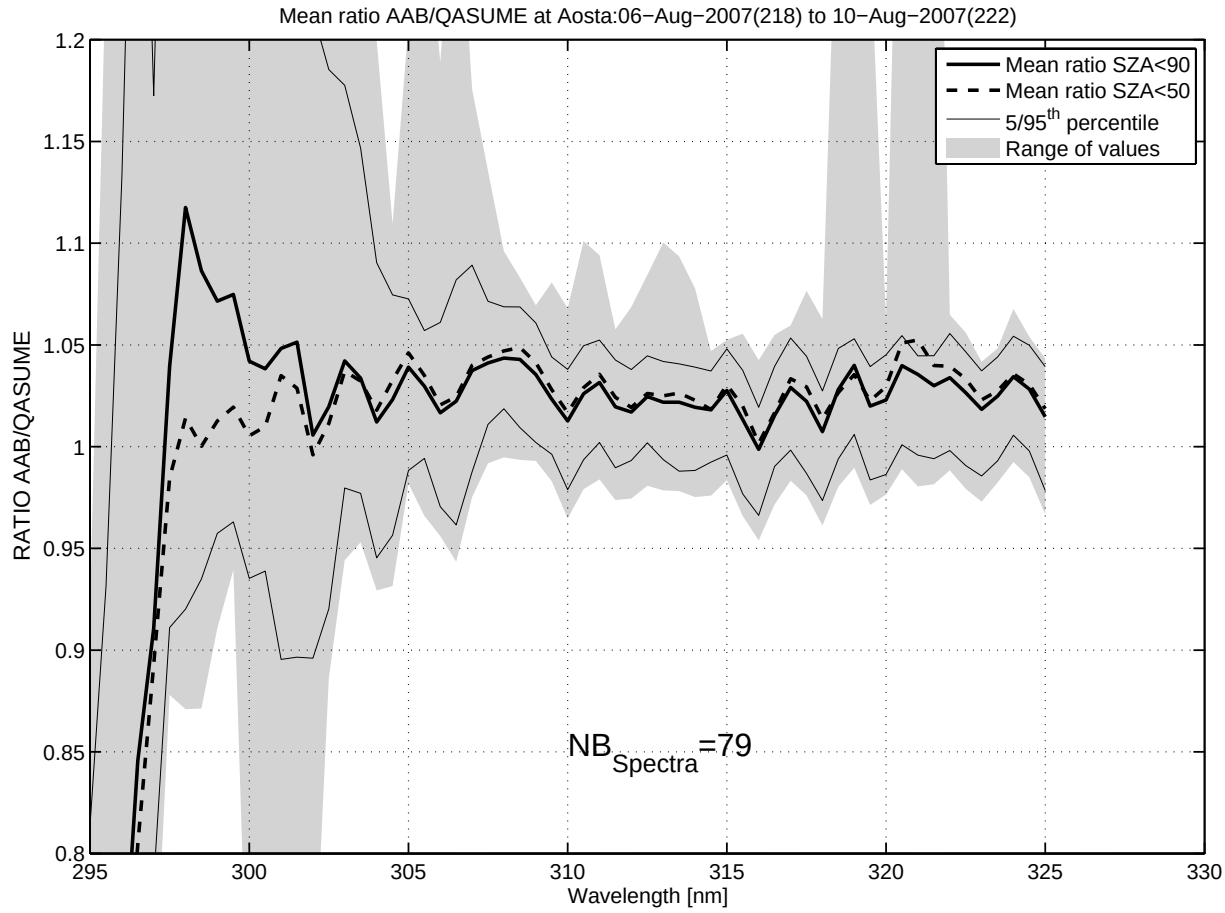


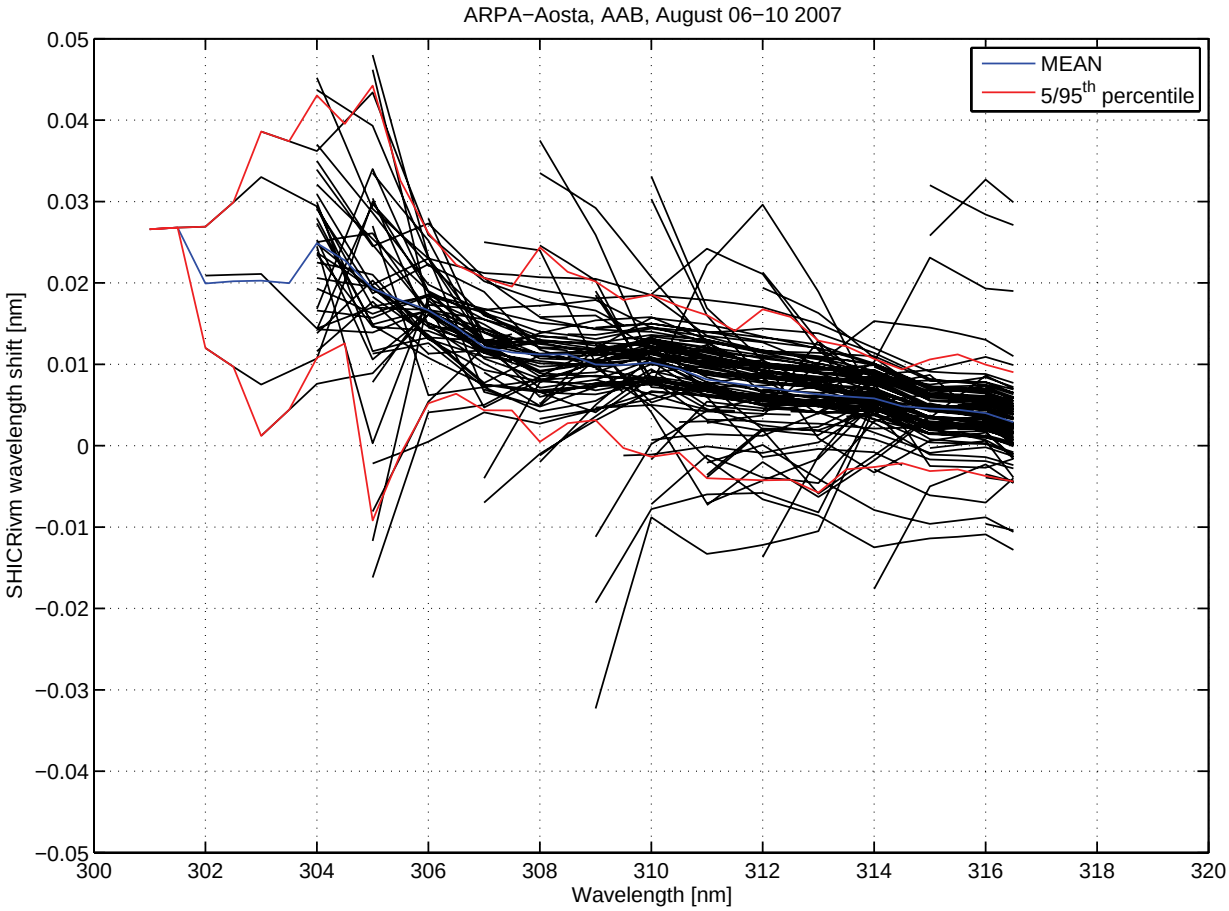
14−Aug−2007 08:03:27

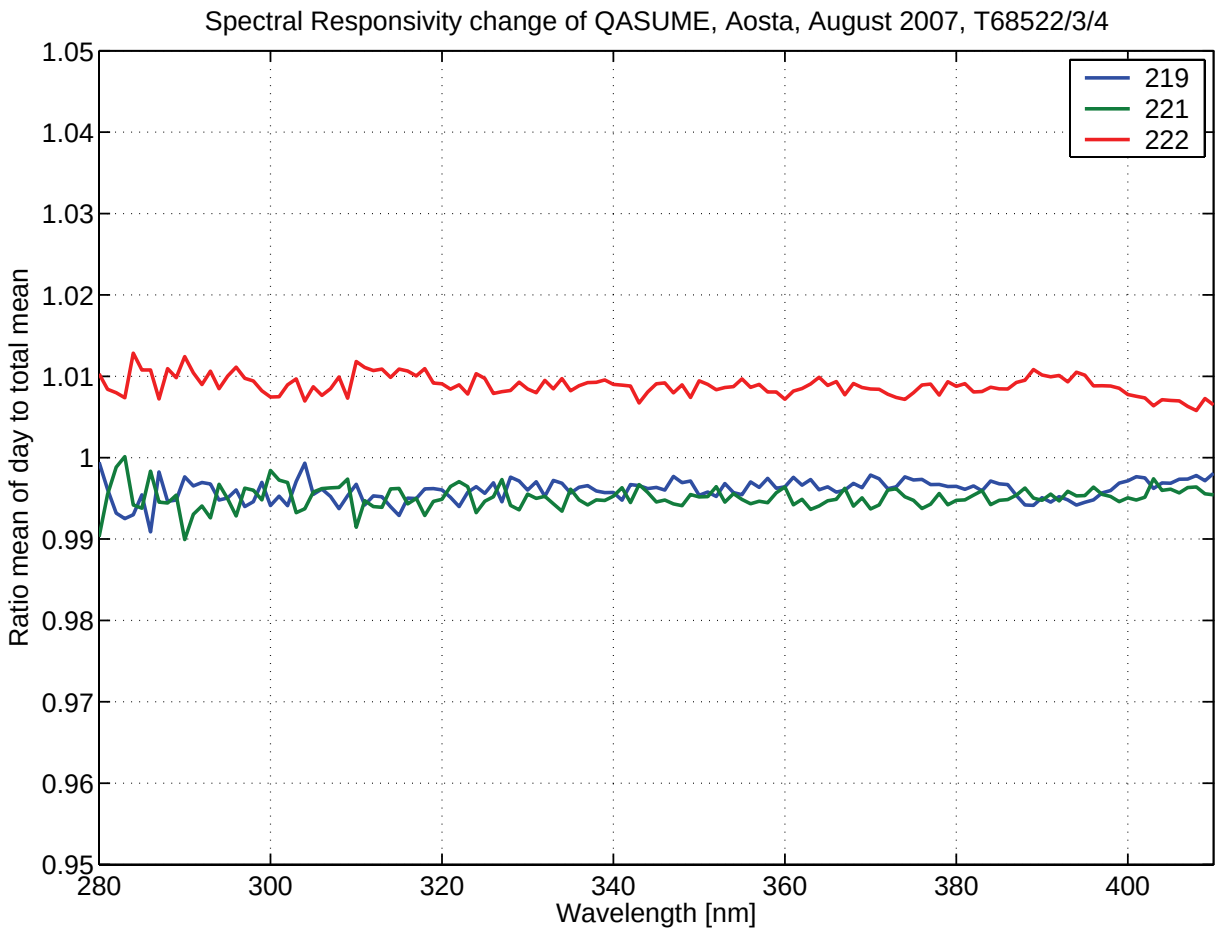


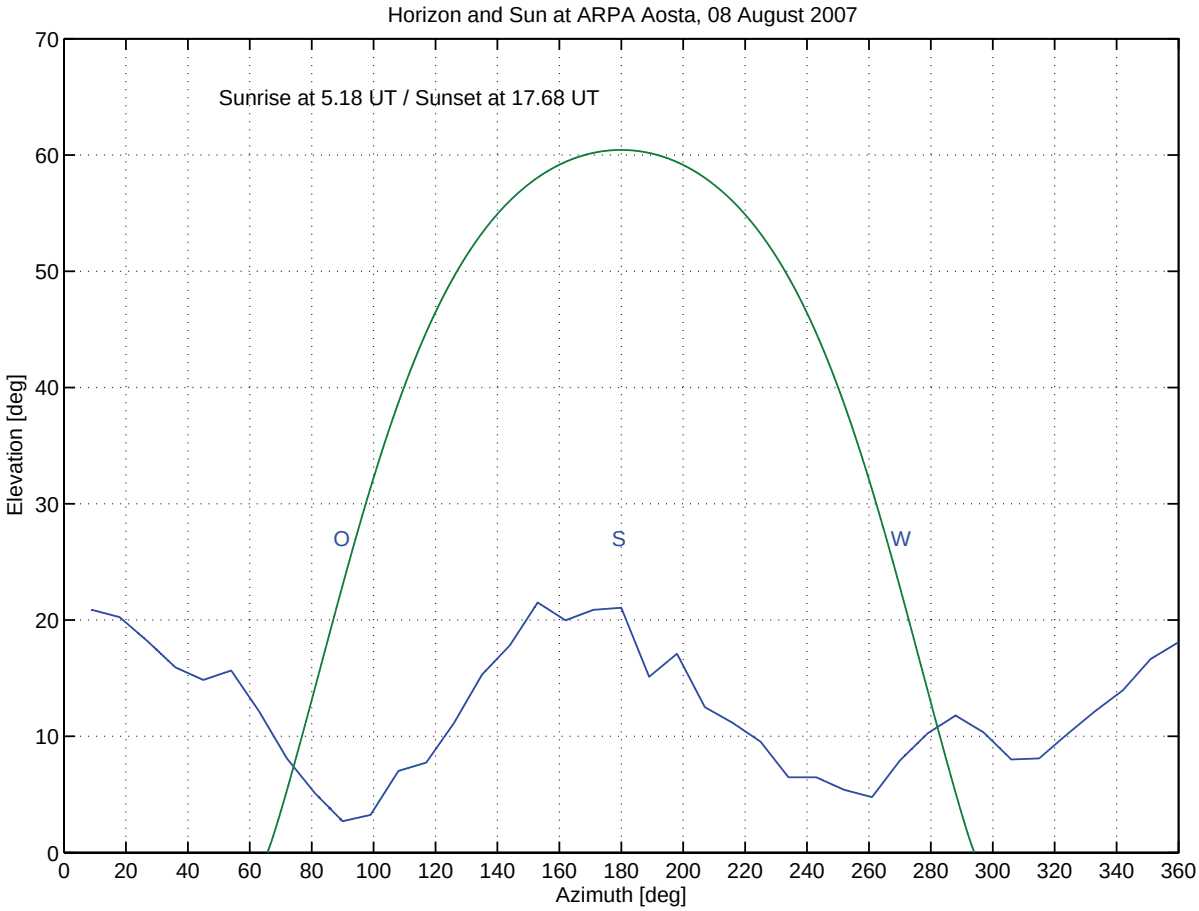


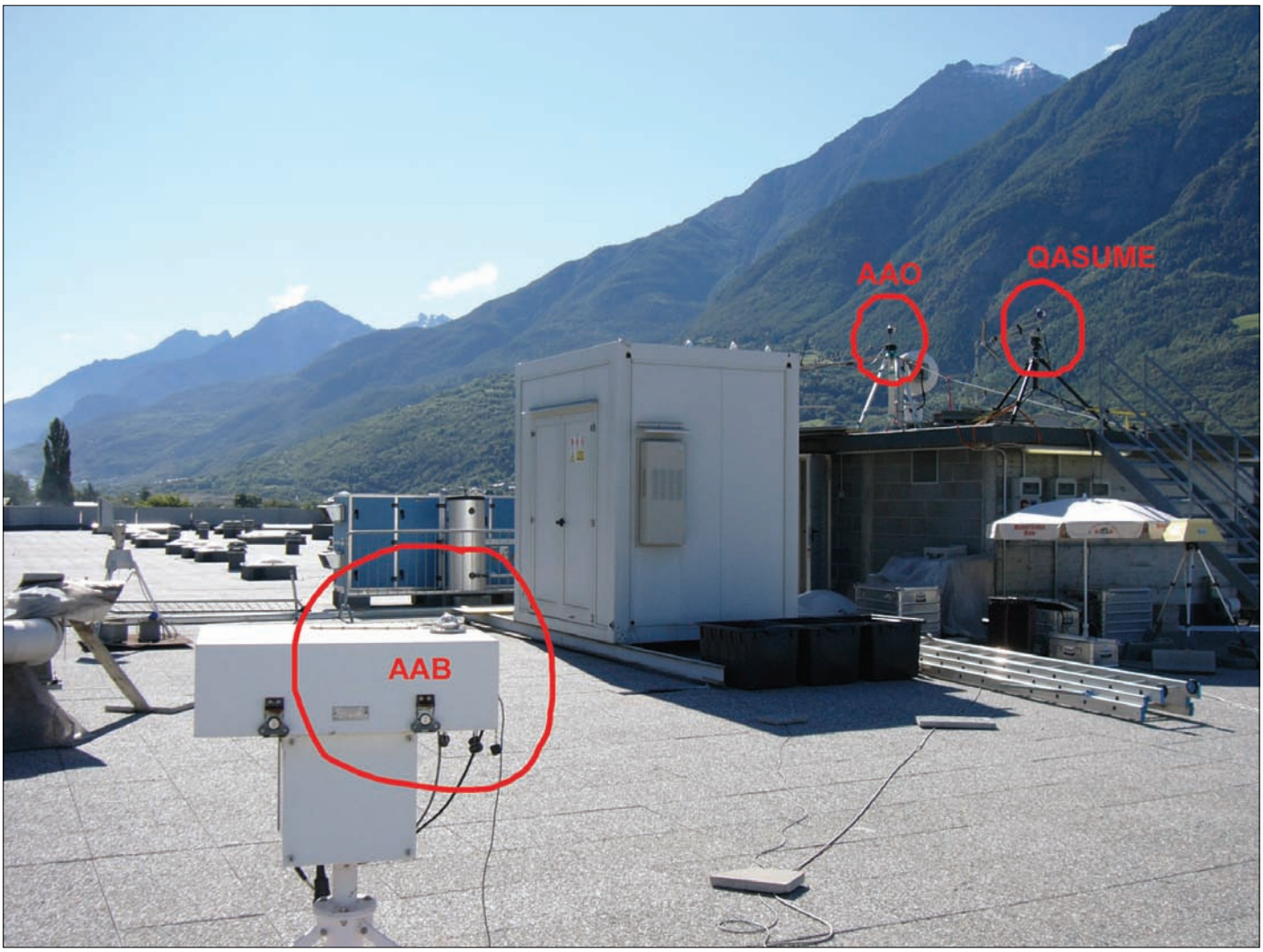
14−Aug−2007 08:03:27


Mean ratio AAB/QASUME at Aosta:06−Aug−2007(218) to 10−Aug−2007(222)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AAB/QASUME
NBSpectra=79
Wavelength [nm]


ARPA−Aosta, AAB, August 06−10 2007
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]


Spectral Responsivity change of QASUME, Aosta, August 2007, T68522/3/4
Ratio mean of day to total mean
Wavelength [nm]
219
221
222
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


Horizon and Sun at ARPA Aosta, 08 August 2007
Sunrise at 5.18 UT / Sunset at 17.68 UT
Elevation [deg]
Azimuth [deg]
O
S
W
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360


AAO
QASUME
AAB


QASUME
AAO
AAB