Protocol of the intercomparison at Ny Ålesund, Svalbard, Norway on May 26 to June 6, 2009 with the travelling reference spectroradiometer QASUME[1] from PMOD/WRC

Report prepared by Gregor Hülsen, Julian Gröbner

With contributions from:
Sigrid Wuttke (AWI), Moritz Sieber (AWI), Sara De Simone (ICES), Boyan Petkov (IASC), Kerstin Stebel (NILU), Sanja Forsstrøm (NPI)

QASUME Operator: Gregor Hülsen, Julian Gröbner

The purpose of the visit was the comparison of global solar irradiance measurements from two spectroradiometers and one filter radiometer (UV-RAD) participating in the QAARC-Campaign (ARCFAC-026129-2008-44) with the travel reference spectroradiometer QASUME. In addition one GUV filter radiometers and 2 UV broadband radiometer were compared with the reference data. The measurement site is located on the measurement platform of the Sverdrup Research Station, at the Norsk Polarinstitutt (NPI) in Ny Ålesund; Latitude 78.92 N, Longitude 11.93 E and altitude 45 m.a.s.l.. The horizon of the measurement site is free down to about 85° solar zenith angle (SZA).

QASUME arrived at NPI via air and ship Cargo Transport in the middle of Mai, 2009. The spectroradiometer was installed on the roof platform of NPI with the entrance optic of QASUME between 2 and 50 m away from the other instruments. The measurement campaign lasted 11 days, from morning of May 27 to the afternoon of June 6.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T68522 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 intercomparison period. The internal temperature of QASUME was 20.8±0.1 °C. The diffuser head was heated to a temperature of 27.6±3.0 °C. On 29 May the diffuser heater did not function for several hours. Excluding this period the temperature of the diffuser was 28.0±0.6 °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 450 nm.

Table 1: Participating Instruments.

Instrument ID	Institution	Operator	Country
#050-MKIV	ICES, CNR Rome	Sara De Simone	Italy
Bentham DM150	AWI	Moritz Sieber	Germany
UV RAD	ISAC, CNR Bologna	Boyan Petkov	Italy
SL501 1450d	NPI	GH	Norway
SL501 3874d	NPI	Sanja Forsstrøm	Norway
GUV7275	NILU	Kerstin Stebel	Norway
QASUME	PMOD/WRC	GH, JG	Switzerland

Alfred Wegener Institute (AWI), Centro Nationale di Ricerca (CNR), International Center for Earth Sciences (ICES), Institute of Atmospheric Sciences and Climate (ISAC), Norwegian Polar Institute (NPI), Norwegian Institute for Air Research (NILU).

[1]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 from 290 to 450 nm, every 0.5 nm, and 1.5 seconds between each wavelength increment. The scans were performed every 30 min all day round (24 hours).

DOY	Date	DAY	Weather	Comment
146	26 May	Tuesday	mix of sun and clouds	Installed at 10:00 UT Calibrated: 13:41 and 13:51 UT using T68522 and T68523
147	27 May	Wednesday	Overcast sky, little snow showers	Synchron with AWI 9:00 UT Synchron with Br 050 9:00 UT
148	28 May	Thursday	Overcast sky snow	Calibrated: 8:50 UT, T68522
149	29 May	Friday	mix of sun and clouds, but clear sky in the morning	Head Tem failure: 2-9 UT Calibrated: 6:46 and 13:16 UT using T68522
150	30 May	Saturday	Overcast sky windy and cold	
151	31 May	Sunday	Mostly overcast sky, but more sun in the evening	Calibrated: 9:46 UT, T68522
152	1 June	Monday	mix of sun and clouds, with clear sky periods	Install SL1450
153	2 June	Tuesday	Mostly clear sky	Calibrated: 12:16 UT, T68522
154	3 June	Wednesday	Mostly clear sky Clouds from 7:30-19:00 UT	Comparison with SolarLight Handheld Dosimeter (AWI)
155	4 June	Thursday	Mostly clear sky with cirrus c.	Calibrated: 8:46 UT, T68522
156	5 June	Friday	Mostly overcast sky	
157	6 June	Saturday	Overcast sky	Calibrated: 10:16, 10:35, 10:46 using T68522,23,24 End of Campaign: 15:30

Results:

In total 229 to 375 synchronised simultaneous spectra from QASUME and the other spectroradiometers are available from the measurement period. All measurements have been analysed.

General Remarks:

1. For the production of the calibration certificates all solar scans are excluded which are affected by precipitation (snow).

Specific Remarks on the various instruments:

A. Spectroradiometer

1. AWI UV Spectroradiometer
    a. An original and revised dataset is available from the AWI Spectroradiometer.
    b. Original dataset: The average ratio between AWI and QASUME is 0.97, i.e. about 3% less. The ratios vary between 0.93 and 1.02 during the whole period.
    c. A slight spectral dependence of 5% is seen in the spectral ratios.
    d. The measurements are very stable during the whole period; However on 29 May, 31 May and 1st June the measurements show abrupt increases of about 3% during midday followed by a gradual decrease to the overall average.
    e. The initial comparisons were used to resolve the above-mentioned issues and resulted in a revised dataset (called 'AWK'). This dataset was obtained using a second irradiance reference lamp and took the varying diffuser temperature into account.
    f. The second irradiance reference is 2% higher than the primary reference used in the preliminary datset. The diffuser temperature varied between 5 and 28°C which results in transmission changes of the Teflon diffuser of up to 3%.
    g. Revised dataset (AWK): The average ratio between AWI and QASUME is 0.99. The ratios vary between 0.96 and 1.02 during the whole period.
    h. The diurnal variability is noticeably decreased relative to the original dataset indicating that the diffuser temperature correction is reliable.
    i. Missing data is due to instable control software from the manufacturer which needed to be manually restarted several times in the course of the campaign.
    j. In this version of the document, data after June 4 (doy 155), 19:00 UT was multiplied by an average spectral factor of 0.9825 to correct for an erroneous spectral responsivity file.

2. Brewer Spectrophotometer
    a. The average ratio between the Brewer and QASUME is 0.88, i.e. about 14% less. The ratios vary between 0.80 and 0.92 during the whole period.
    b. On 27 and 28 May, snow on the dome of Brewer 050 caused a 5 to 10% drop in irradiance (21 to 23 UT and 4:30 to 9:30 UT).

c. The overall offset of 12% is probably due to a combination of angular response errors and differences in the reference lamp irradiances used for the calibration.
d. The cosine error is visible on the clear sky days, 2 to 4 June. The variability at 358 nm is between 2 and 3% while it is nearly absent at short wavelengths, indicating a dependence on the respective direct and diffuse irradiance components. This variability is not visible on 30 May which was fully overcast with no direct irradiance component.
e. 13 Spikes are visible in the irradiance spectra of Br050.
f. Spectral irradiances below 305 nm are affected by stray light due to the single monochromator instrument.

B. Filter Radiometer

3. UV-RAD Filter Radiometer
    a. The UV-RAD Radiometer had hardware problems before the campaign (water intrusion in the entrance optics) and required maintenance. For the following intercomparison the UV-RAD radiometer was therefore uncalibrated and used initial measurements from QASUME to retrieve its instrumental calibration constants.
    b. The period of May 26 to May 31 was used to calibrate UV-RAD based on the QASUME measurements. The remaining intercomparison period, June 1 to 6 was used to assess the radiometer.
    c. The 300 nm channel did not perform reliably and was not used in the intercomparison.
    d. The remaining channels were compared individually to the spectral QASUME irradiances at 306, 310, 314, 325, 338, and 364 nm. The average ratio to QASUME is around one, which is due to the use of the QASUME instrument to calibrate the UV-RAD radiometer in the first days of the intercomparison. The variability of the measurements with respect to QASUME is of the order of ±10%, in part influenced by not being able to fully synchronise the measurements between the two instruments.
    e. The erythemal dose rates retrieved from UV-RAD are on average 1% lower than the ones from QASUME and vary by ±8% during the second part of the campaign (1-5 June).

4. GUV9275
    a. The GUV9275 multifilter Radiometer is part of the Norwegian UV Monitoring Network and is operated by NILU.
    b. The average ratio of erythemal dose rates between the GUV9275 and QASUME is 1.00 with a variability of ±2.4% between 27 May and 5 June.
    c. Erythemal dose rates are underestimated by up to 10% during midnight at high solar zenith angles, especially during the first days of the campaign.
    d. The calibration is from June 2009. The previous calibration from June 2007 produced irradiances 2% lower than with the most recent calibration.

C. Broadband Radiometer

5. SL501d 1450
    a. The radiometer measurements were processed by Gregor Hülsen with the calibration performed at PMOD/WRC in August 2006 using the recommended instrument equation[2]. The required total column ozone values were obtained from Brewer 050.
    b. The average ratio between the SL1450 and QASUME is 0.94, i.e. about 6% less. The ratios vary between 0.88 and 0.97 during the whole period.
    c. The diurnal variability is probably due to a change in the spectral responsivity of the instrument. Therefore the instrument should be recalibrated.

6. SL501d 3874
    a. The radiometer measurements were processed by the optical ingeneur of NPI. A calibration factor of 0.212 was used to convert the data to irradiance units, as provided by Solar Light.
    b. The average ratio between the SL3874 and QASUME is 0.77, i.e. about 30% less. The ratios vary between 0.57 and 0.93 during the whole period.
    c. A calibration and characterisation of the radiometer is recommended.

[2] *G. Hülsen, J. Gröbner*: Characterization and calibration of ultraviolet broadband radiometers measuring eryhtemally weighted irradiance, Applied Optics, Volume 46, 5877-5886, 2007
A. Webb, J. Gröbner, M. Blumthaler: A practical guide to operating broadband instruments measuring erythemally weighted irradiance, EU Publications Office, No. EUR22595, 2006

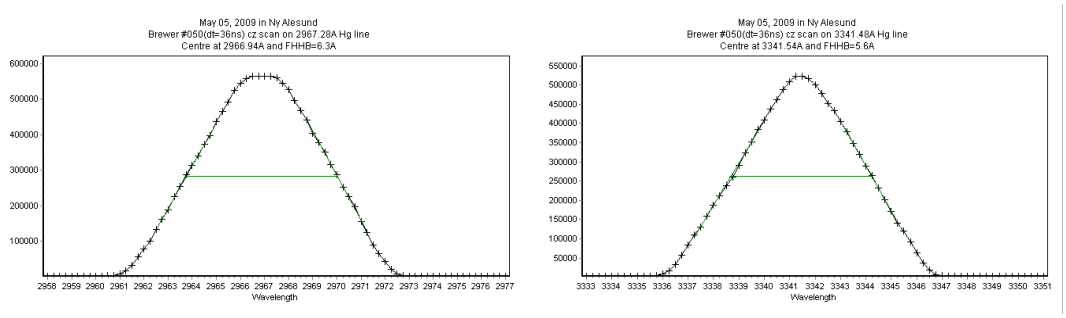
Comments from the local operators

1.) The AWI UV spectroradiometer

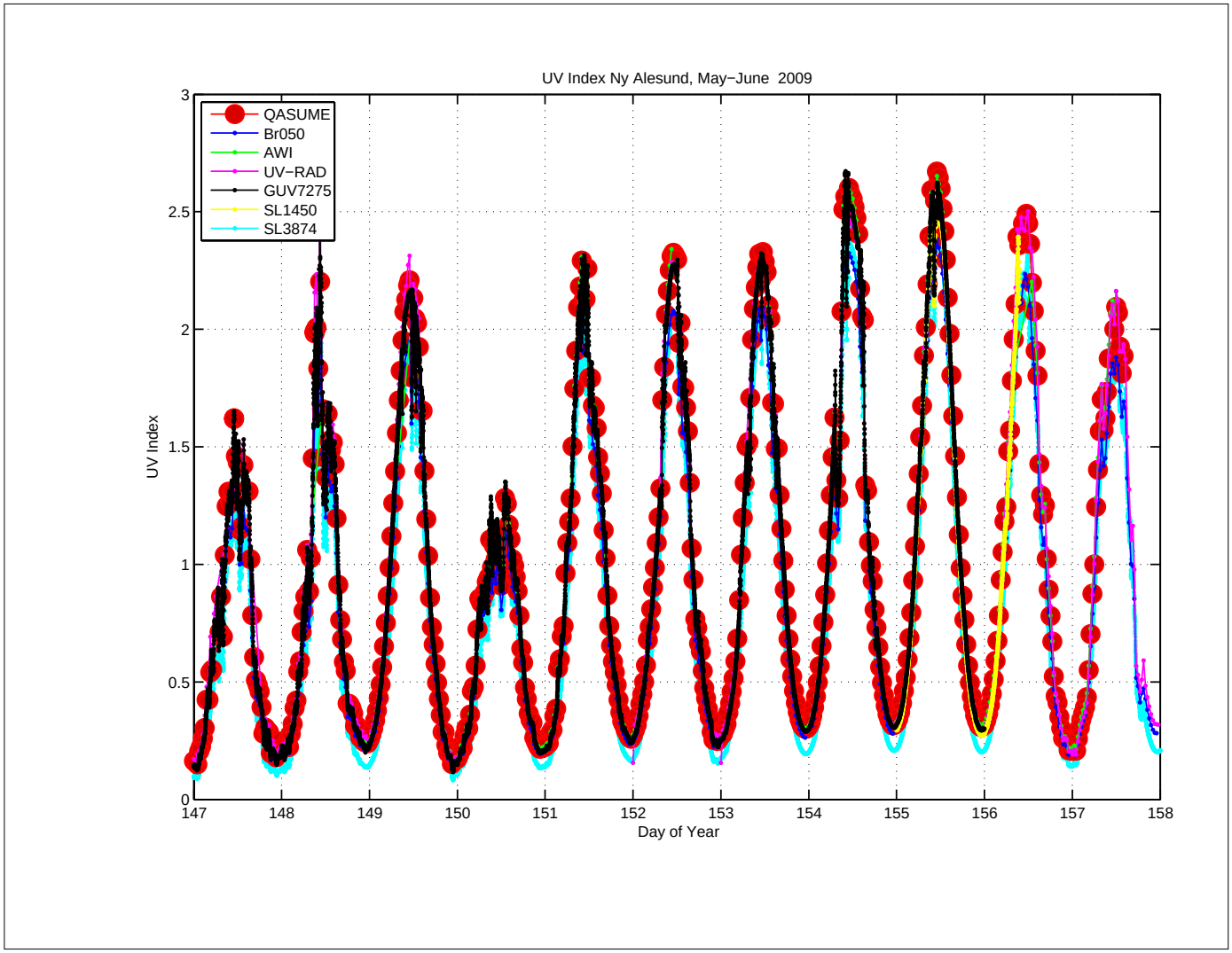
The new AWI UV spectroradiometer was installed at Ny Alesund in March 2009 in order to perform measurements complying with the data requirements of the Network for the Detection of Atmospheric Composition Change (NDACC). The ARCFAC intercomparison is a valuable quality assurance exercise to show its performance.
The entrance optics of the new AWI UV spectroradiometer consists of a shaped Teflon diffuser, which is protected by a quartz dome. The radiation is guided into the entrance slit of the monochromator through an optical fiber. The diffuser is operated at a constant temperature of 27°C. The central element of the spectroradiometer is a model DMc150 double monochromator from Bentham Instruments, Ltd., with a focal length of 150 mm. The double monochromator consists of two identical single Czerny-Turner monochromators. The entrance and exit slits have a fixed width of 0.56 mm. The middle slit is set to 1.48 mm. Holographic reflection gratings with 2400 grooves/mm are employed in each monochromator. A Bi-alkali end window photomultiplier tube (PMT) is used as a detector. The output current of the PMT is processed by a decadal current amplifier. This signal is converted to a digital signal, which can be further processed by a computer.
To operate the spectroradiometer in a stable manner, it is placed inside a temperature-controlled box. During the intercomparison campaign the temperature inside this weatherproof box was between 19.5 and 21°C. The temperature of the entrance optics also needs to be constant at 27°C (±3°C) in order to perform stable measurements, but it ranged from 7°C to 27°C during the campaign. Therefore a temperature correction was applied (see Section “specific remarks to the various instruments”). The relative humidity inside the box is also monitored and reached 22-30%.
During the campaign the initial wavelength shift varied within ±0.6 nm for all wavelengths between 290 and 390 nm. The spectral response changed within 1.8% on a spectral average. The data for the intercomparison was adjusted for the change in radiometric response, corrected for the wavelength shift (with ShicRIVM by Julian Gröbner and Gregor Hülsen) as well as for the changing temperature of the input optics.

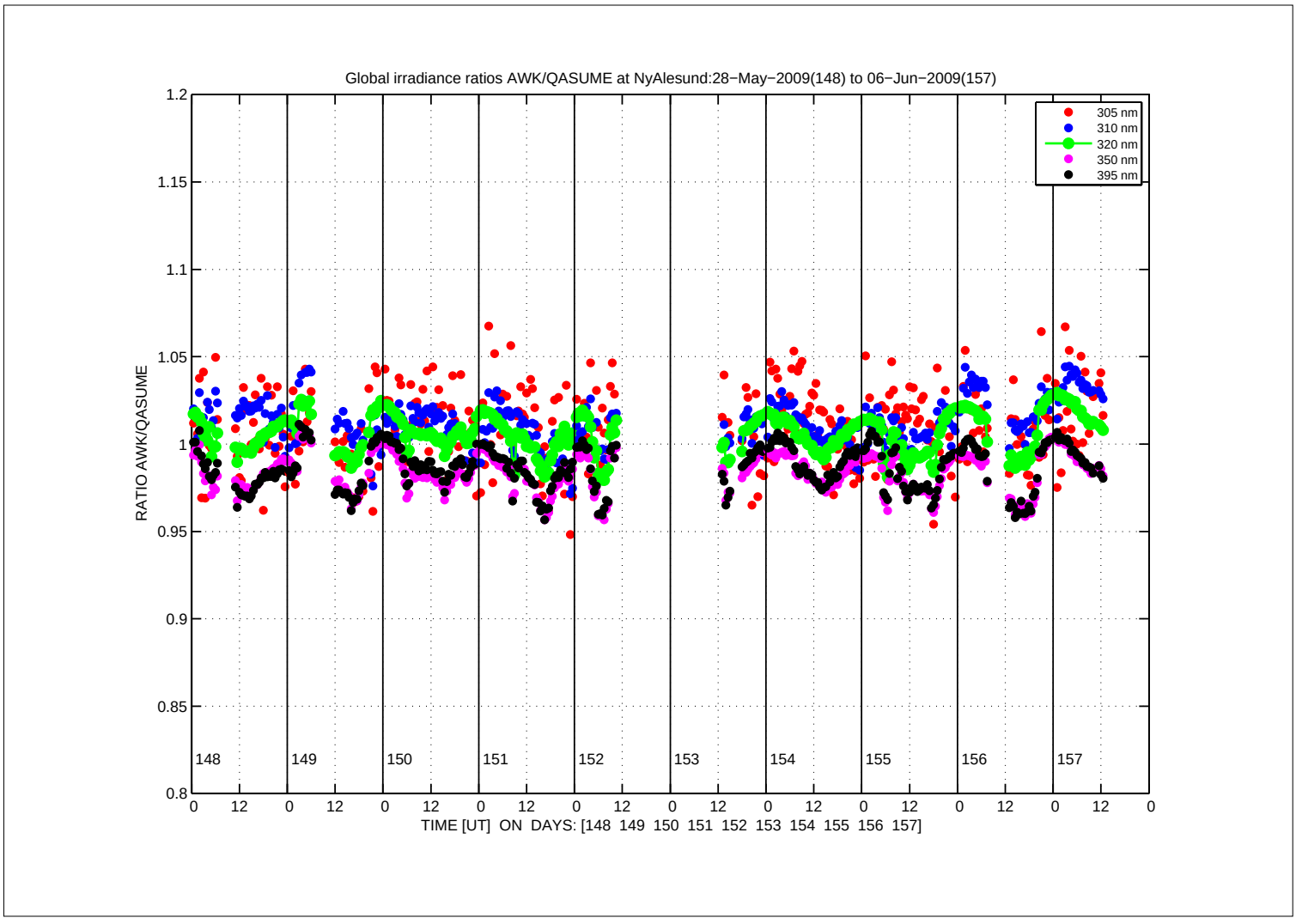
2.) The Brewer #050 spectrophotometer

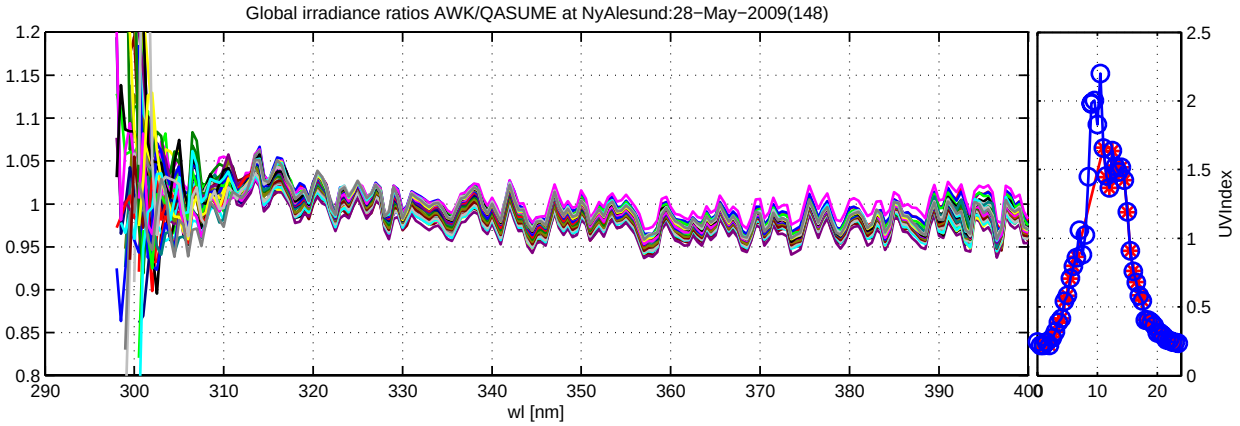
The Brewer #050 has been calibrated by Ken Lamb, International Ozone Services, Inc. (IOS), in Ny-Ålesund, May 4-11, 2009.
The UV calibration was checked with IOS 50w lamps 201, 202, 203 using QL (quick lamp scan) routine and file UVR12509.104 was calculated using Lampspro program. Two of the five local 50w lamps were measured and their results compared very well to QL scans in 2006. The analysis of the results shows that the instrument has remained very stable.
Below are two graphs of CZ scans on two HG lamp lines:

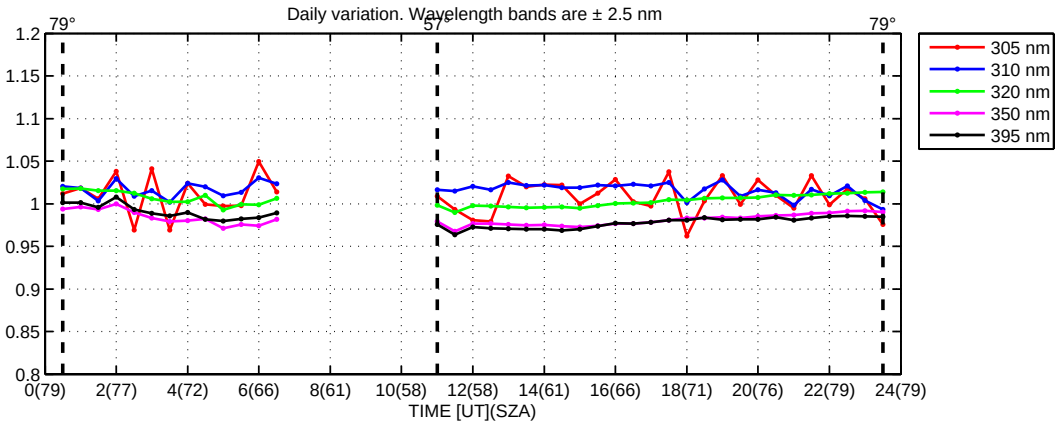


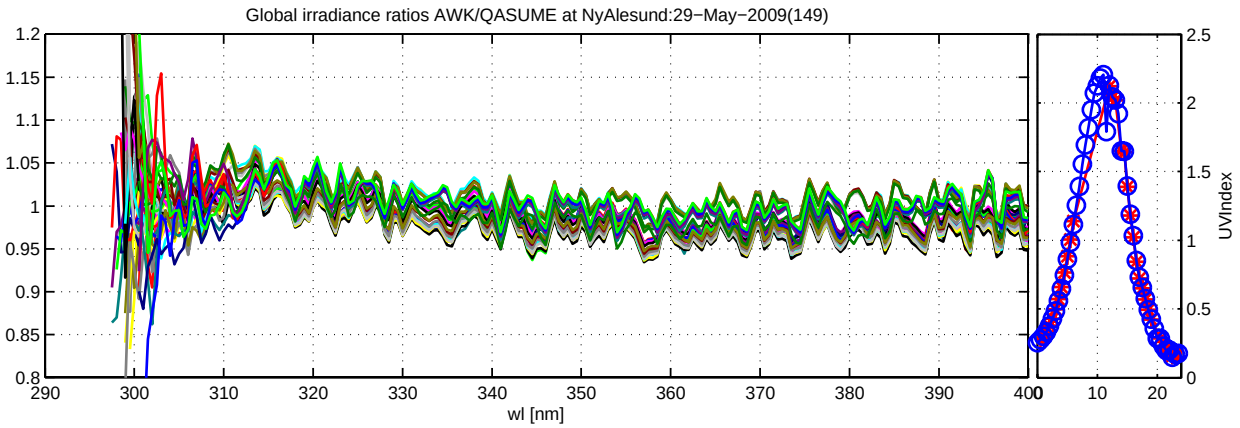
After 14 days of intercomparison, the spectral difference between our instrument and Quasume is constant during the cloudy days. Instead there is variability, during the blue sky.
The Brewer was measuring global UV-B and portion of UV-A by the UV dome, where a thin disc of teflon as diffuser and a cosine collector. After this comparison we noticed that the UV difference depends on cosine response. This is underlined by difference in measurements during the totally cloudy sky (diffuse) versus blue ones (direct). The comparison showed that UV routines needs a correction of the cosine error algorithm, we will contact PMOD/WRC to improve the measurements.
Our Brewer is in Ny Ålesund as node of World Ozone Network, so it would be important for us to carry out a new intercomparison campaign next year to calibrate, on site, the tools to correct the cosine error.

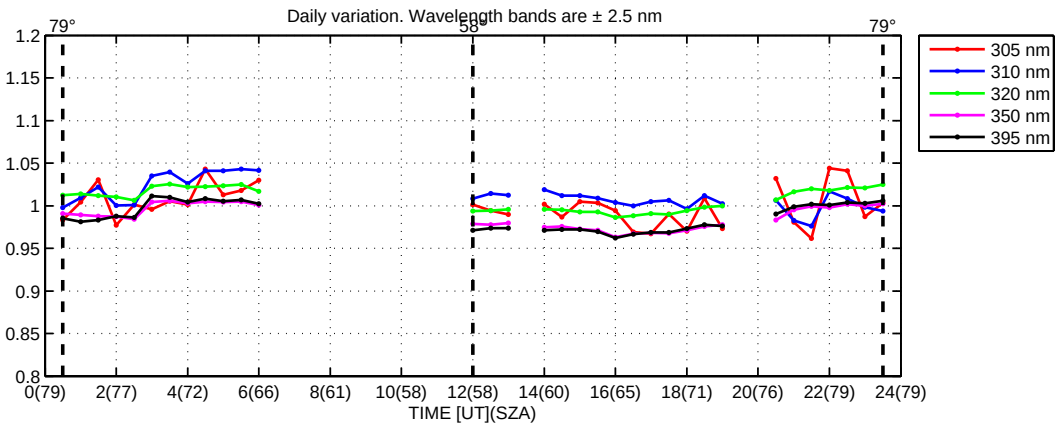

UV Index Ny Alesund, May−June 2009
QASUME
Br050
AWI
UV−RAD
GUV7275
SL1450
SL3874
UV Index
Day of Year
0
0.5
1
1.5
2
2.5
3
147
148
149
150
151
152
153
154
155
156
157
158

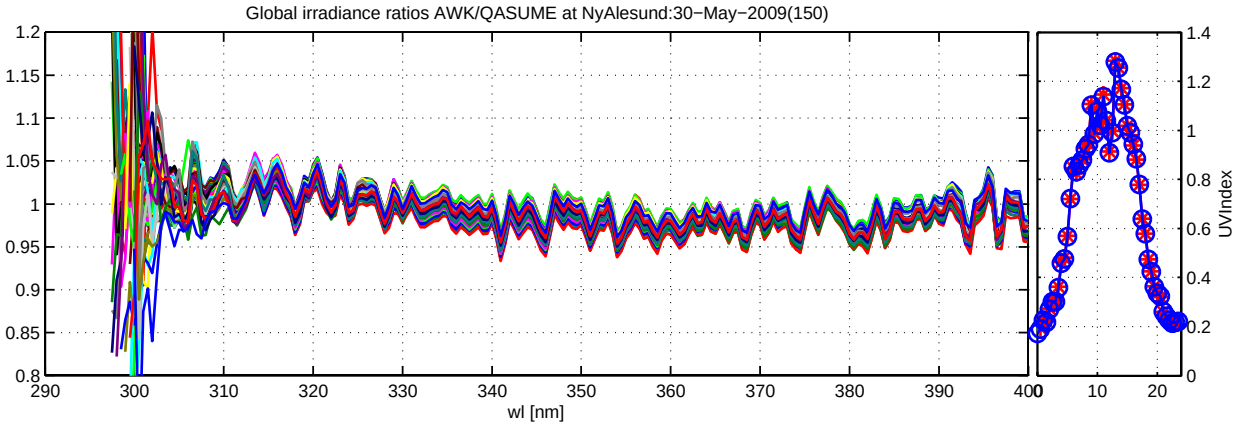

Global irradiance ratios AWK/QASUME at NyAlesund:28−May−2009(148) to 06−Jun−2009(157)
305 nm
310 nm
320 nm
350 nm
395 nm
RATIO AWK/QASUME
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
148
149
150
151
152
153
154
155
156
157
0
12
TIME [UT] ON DAYS: [148 149 150 151 152 153 154 155 156 157]

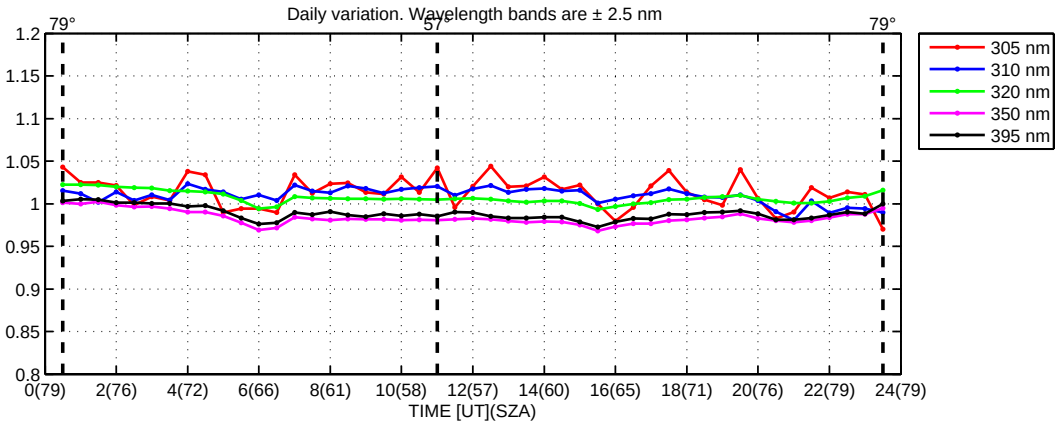

Global irradiance ratios AWK/QASUME at NyAlesund:28−May−2009(148)
wl [nm]
UVIndex


Daily variation. Wavelength bands are ± 2.5 nm
79°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
0(79) 2(77) 4(72) 6(66) 8(61) 10(58) 12(58) 14(61) 16(66) 18(71) 20(76) 22(79) 24(79)
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:29−May−2009(149)
wl [nm]
UVIndex


Daily variation. Wavelength bands are ± 2.5 nm
79°
58°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
0(79) 2(77) 4(72) 6(66) 8(61) 10(58) 12(58) 14(60) 16(65) 18(71) 20(76) 22(79) 24(79)
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:30−May−2009(150)
wl [nm]
UVIndex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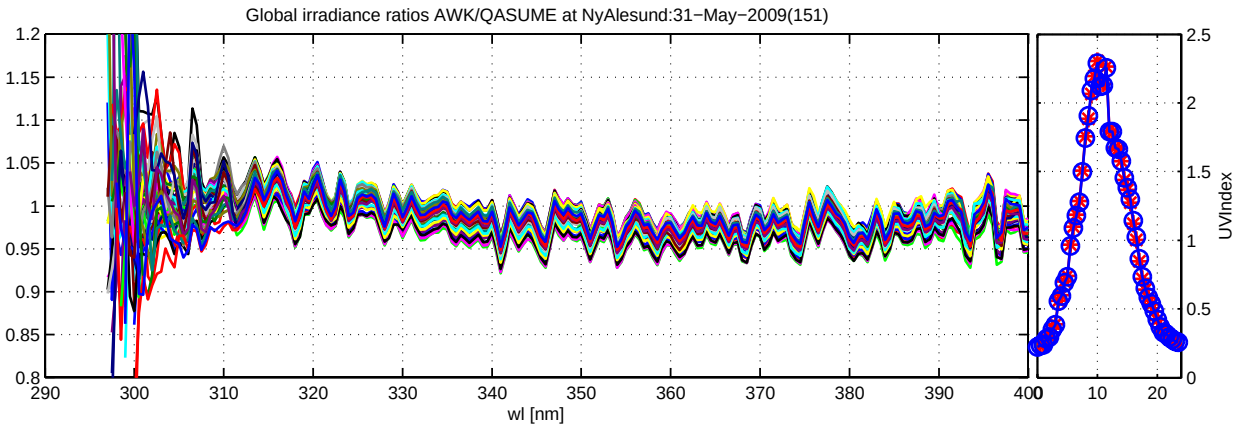
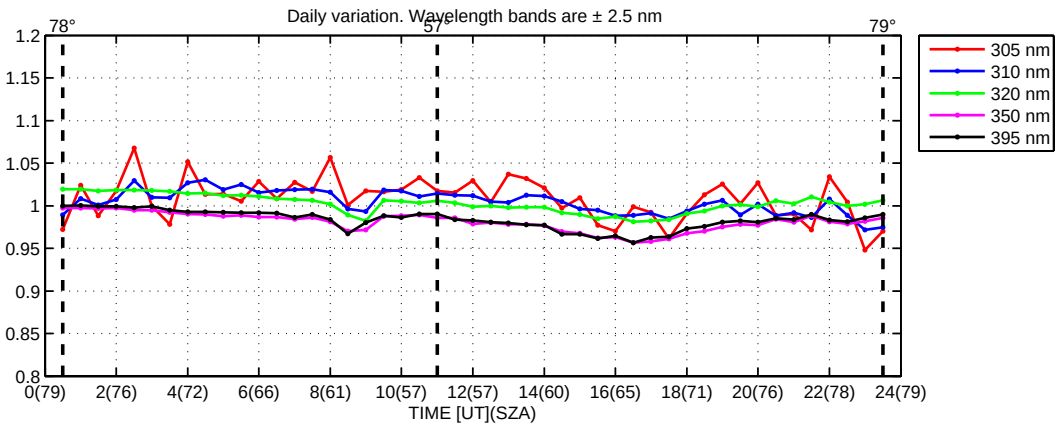
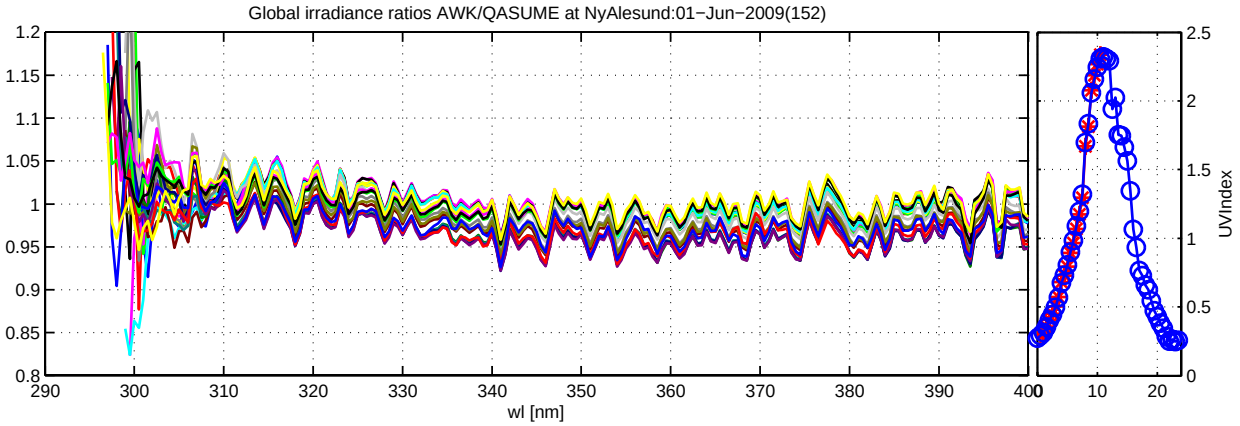
79°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:31−May−2009(151)
wl [nm]
UVIndex


Daily variation. Wavelength bands are ± 2.5 nm
78°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)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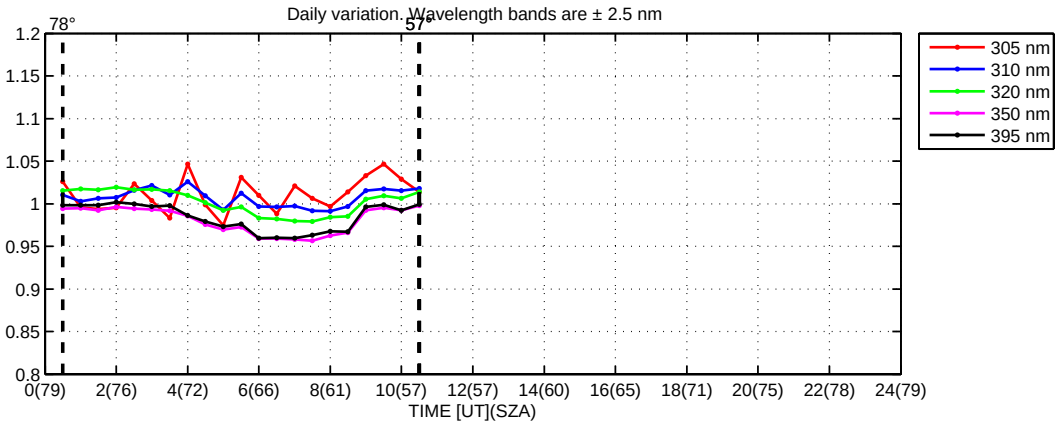
wl [nm]
UVIndex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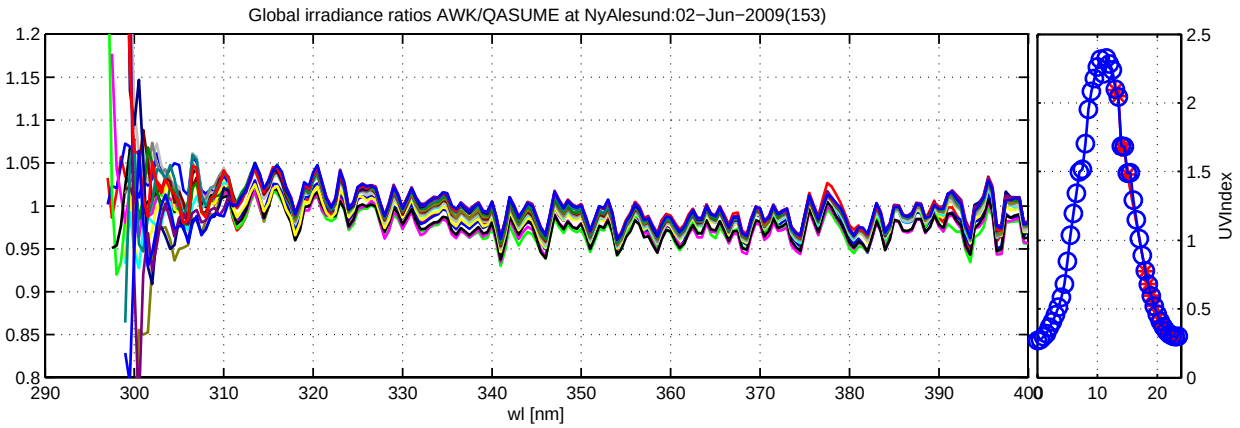
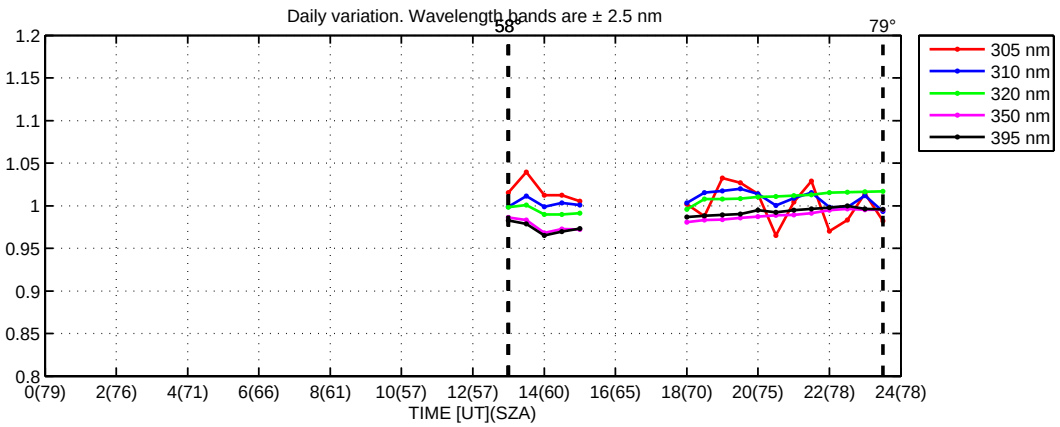
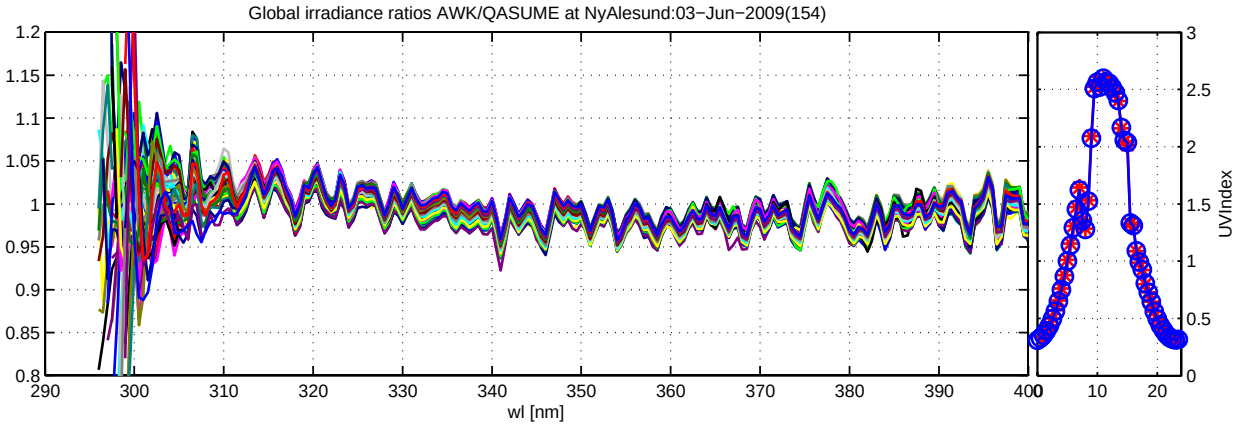
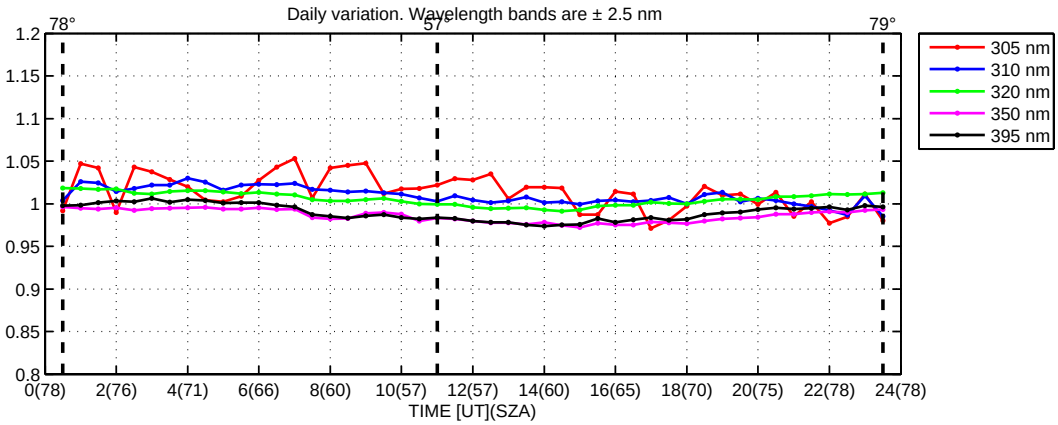
78°
57°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:02−Jun−2009(153)
wl [nm]
UVIndex


Daily variation. Wavelength bands are ± 2.5 nm
58°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:03−Jun−2009(154)
wl [nm]
UVIndex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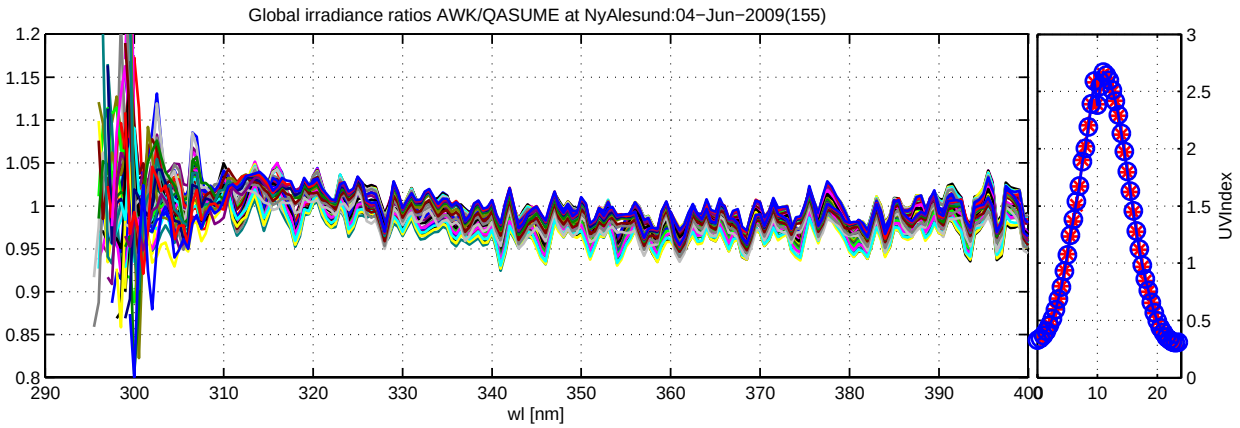
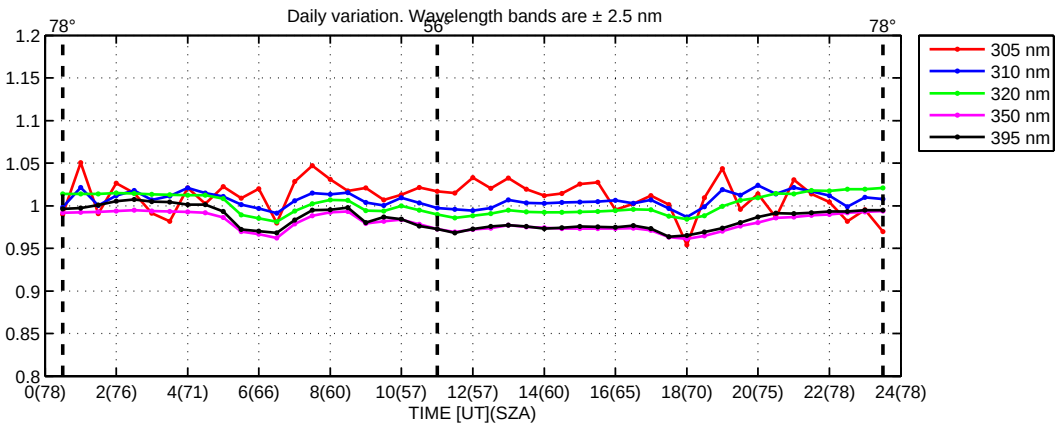
78°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:04−Jun−2009(155)
wl [nm]
UVIndex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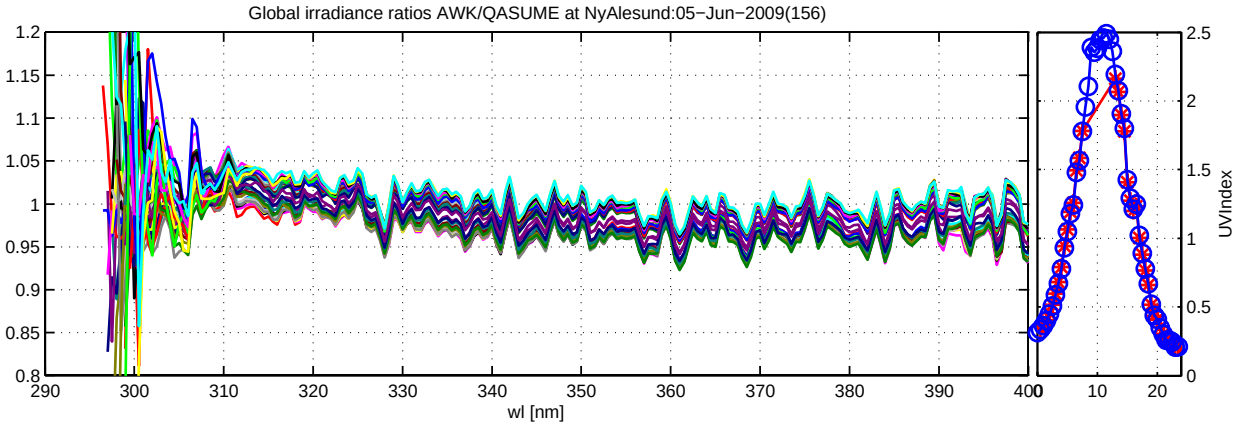
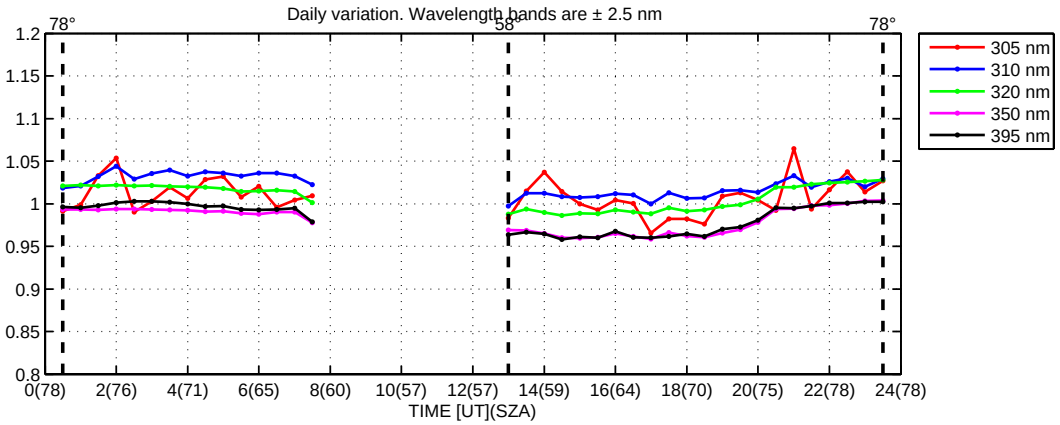
78°
56°
78°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:05−Jun−2009(156)
wl [nm]
UVIndex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78°
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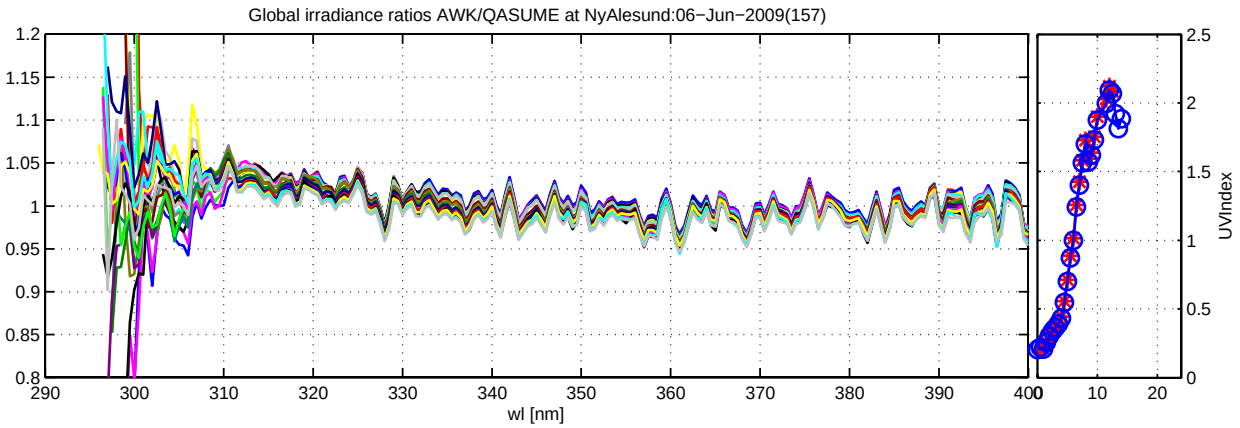
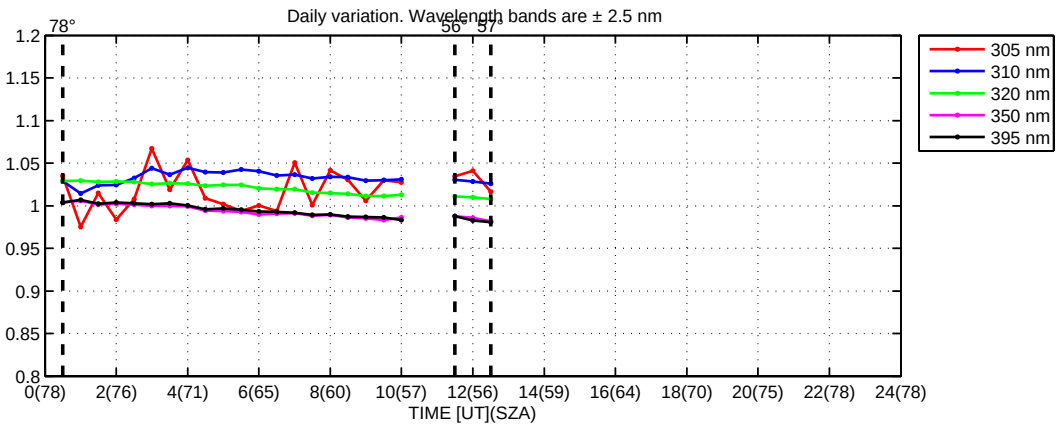
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)


Global irradiance ratios AWK/QASUME at NyAlesund:06−Jun−2009(157)
wl [nm]
UVIndex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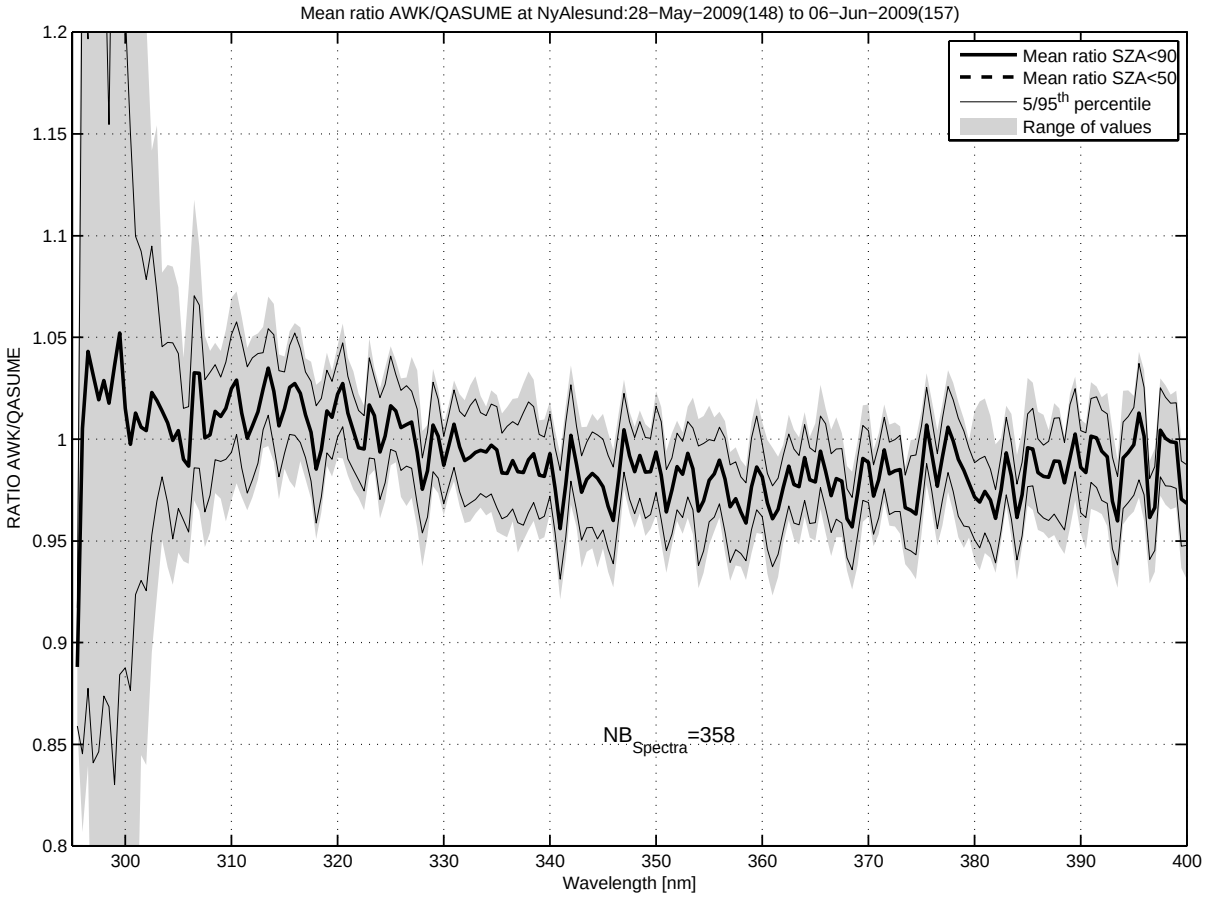
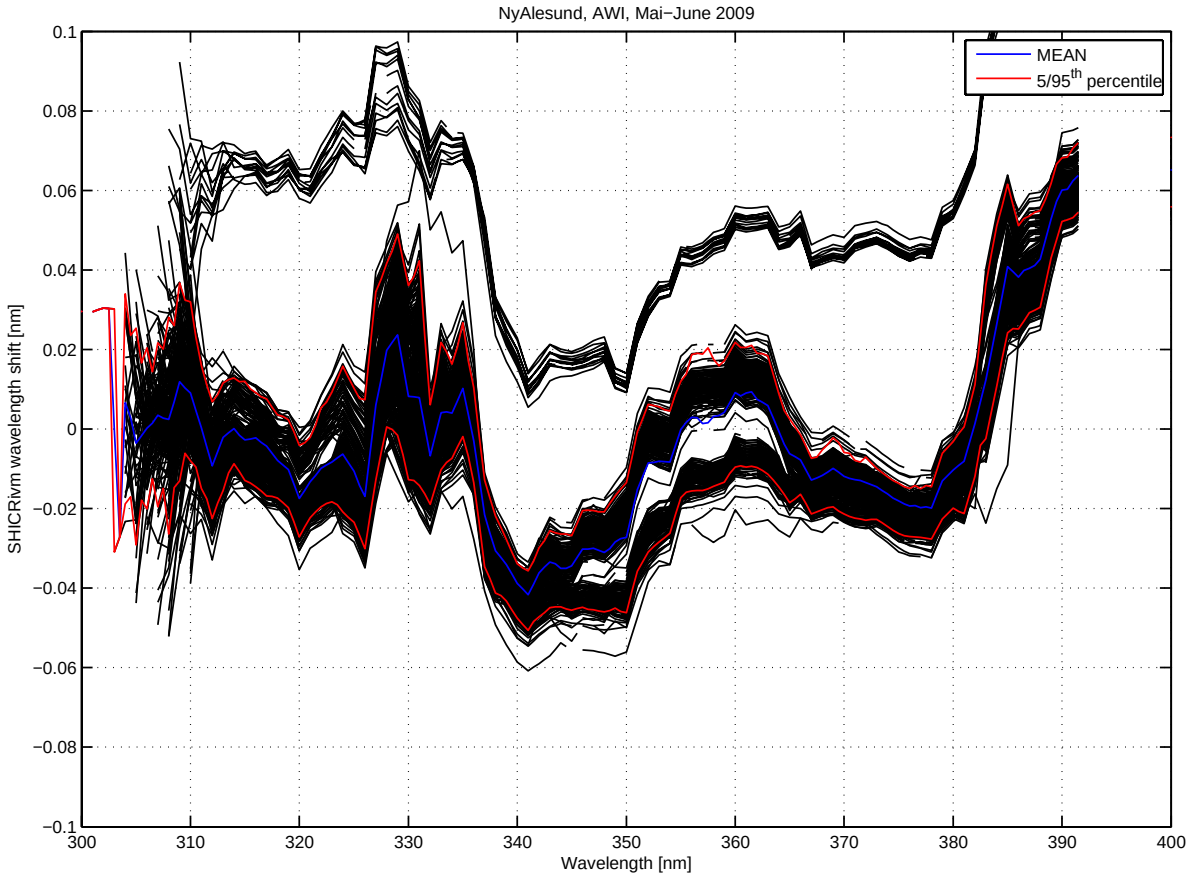
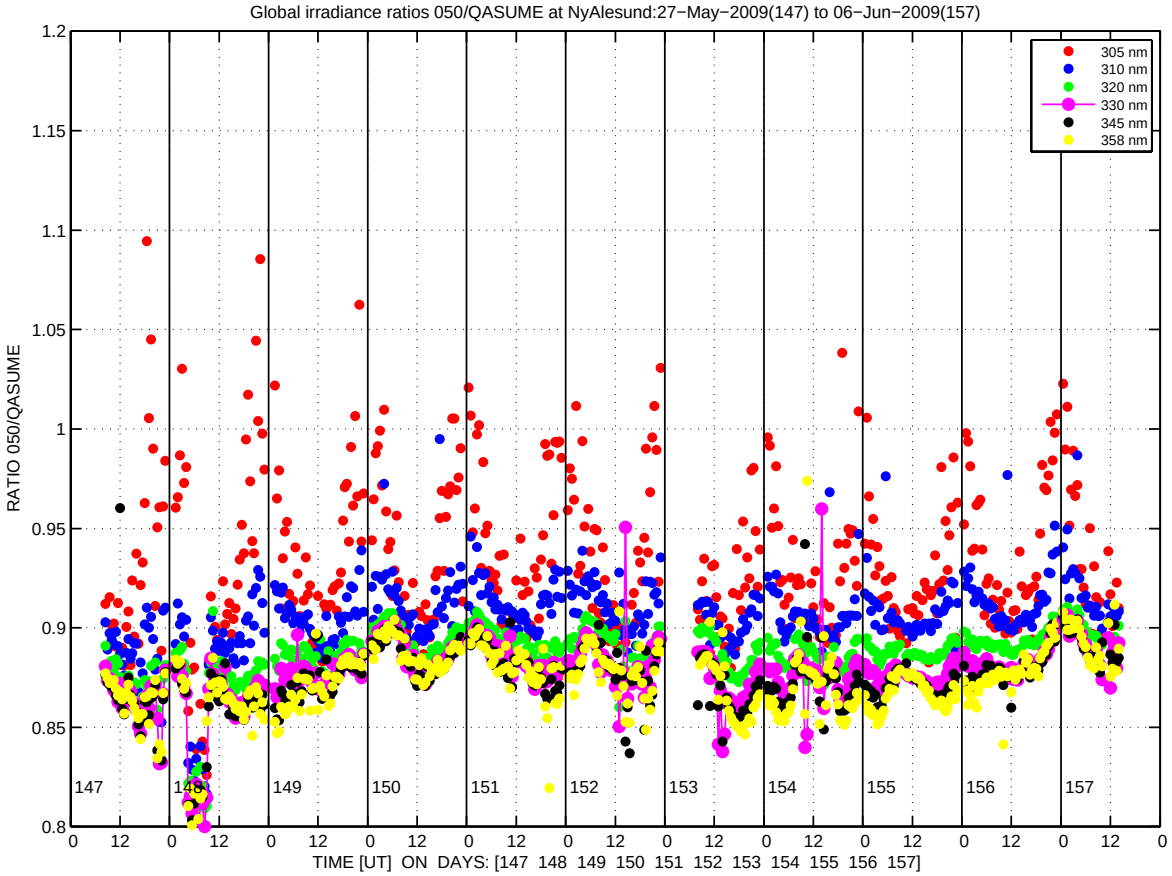
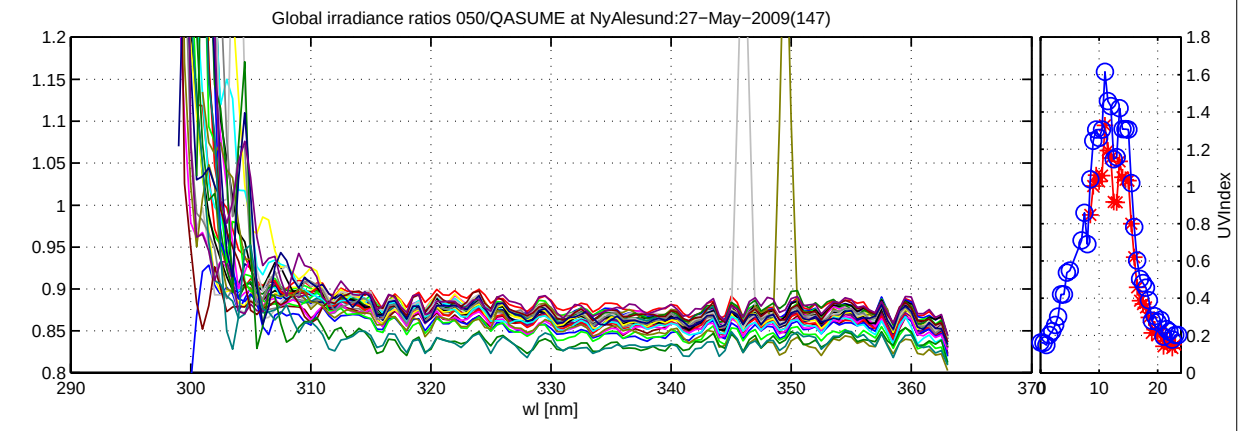
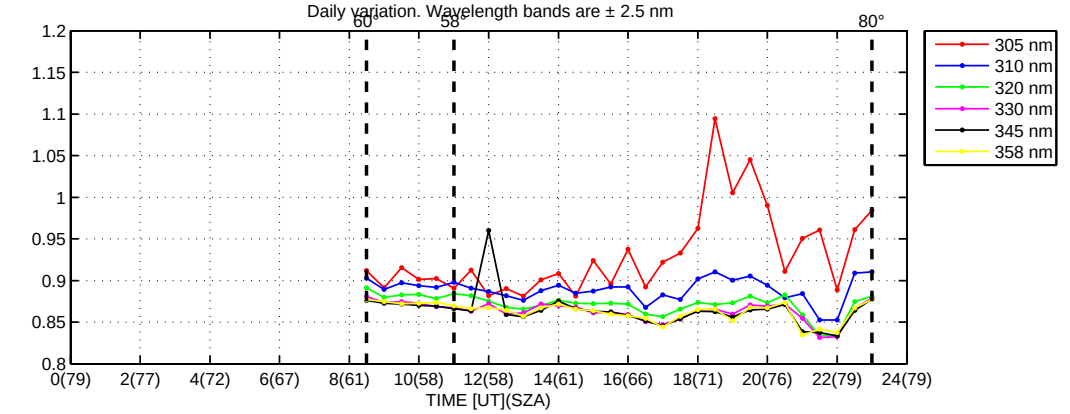
78°
56°
57°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

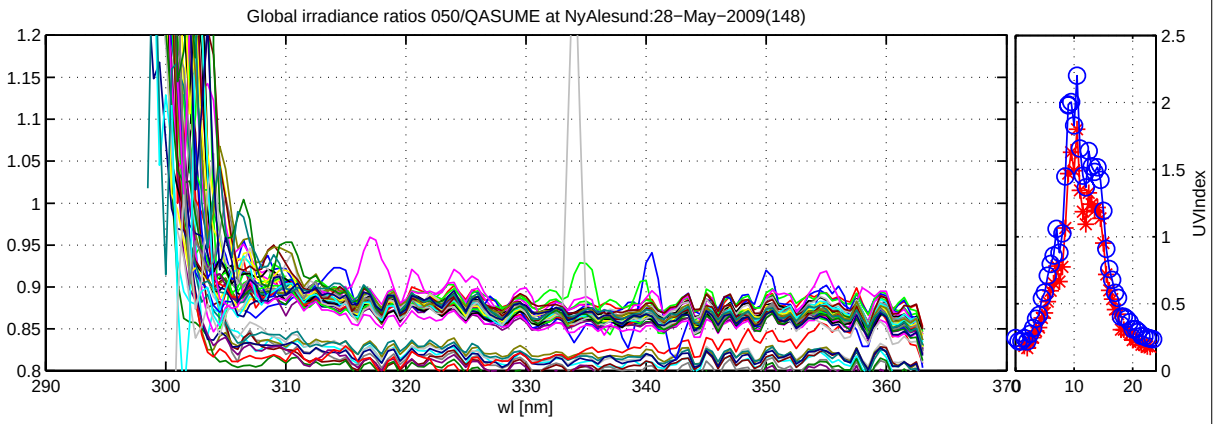

Mean ratio AWK/QASUME at NyAlesund:28−May−2009(148) to 06−Jun−2009(157)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO AWK/QASUME
NBSpectra=358
Wavelength [nm]

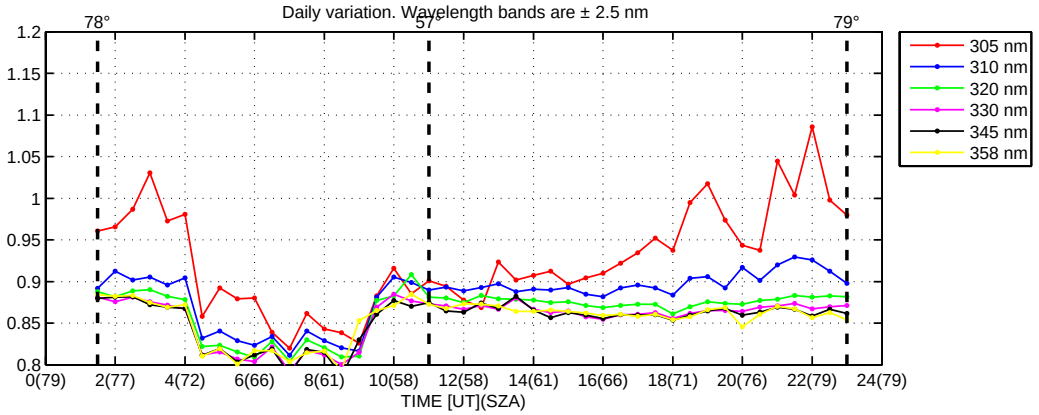

NyAlesund, AWI, Mai−June 2009
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]

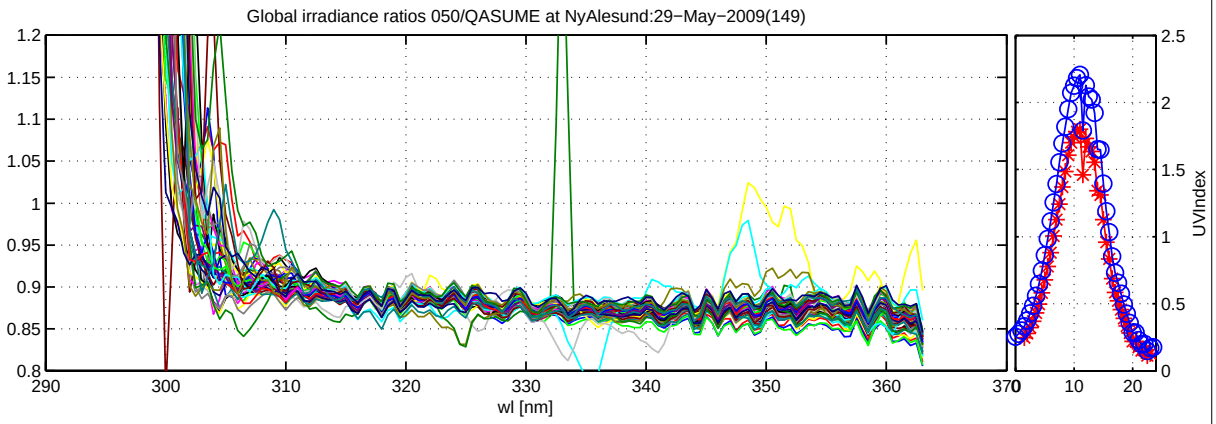

Global irradiance ratios 050/QASUME at NyAlesund:27−May−2009(147) to 06−Jun−2009(157)
RATIO 050/QASUME
TIME [UT] ON DAYS: [147 148 149 150 151 152 153 154 155 156 157]
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

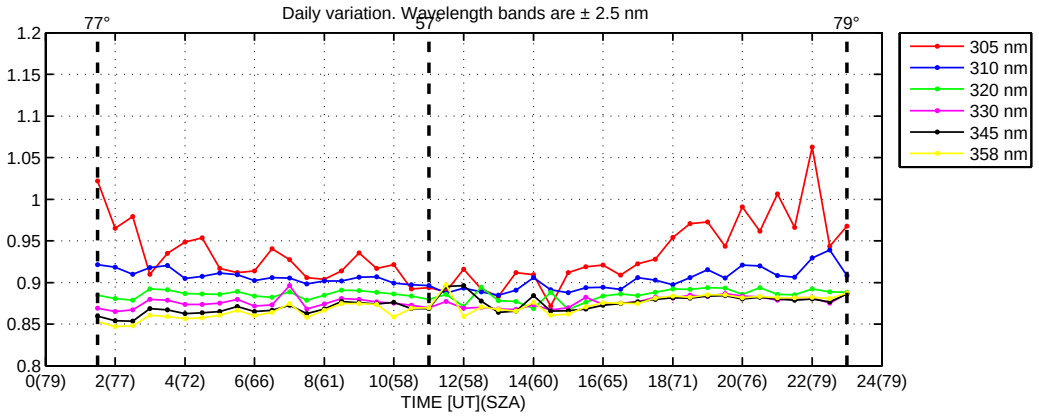

Global irradiance ratios 050/QASUME at NyAlesund:27−May−2009(147)
wl [nm]
UVIndex

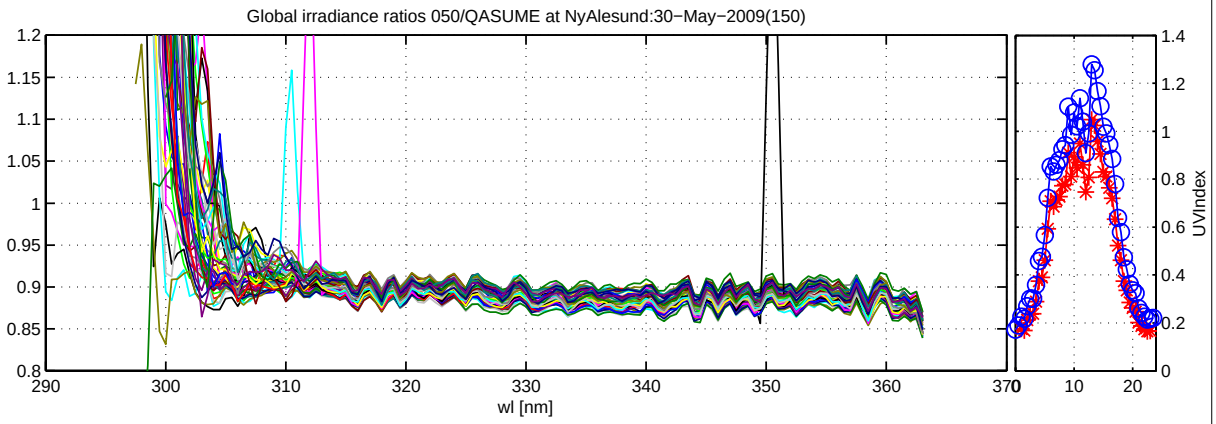

Daily variation. Wavelength bands are ± 2.5 nm
60°
58°
80°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

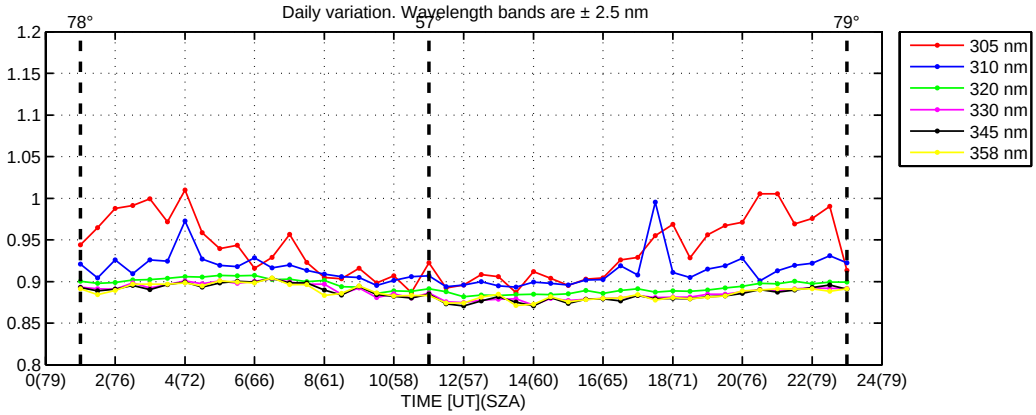

Global irradiance ratios 050/QASUME at NyAlesund:28−May−2009(148)
wl [nm]
UVIndex

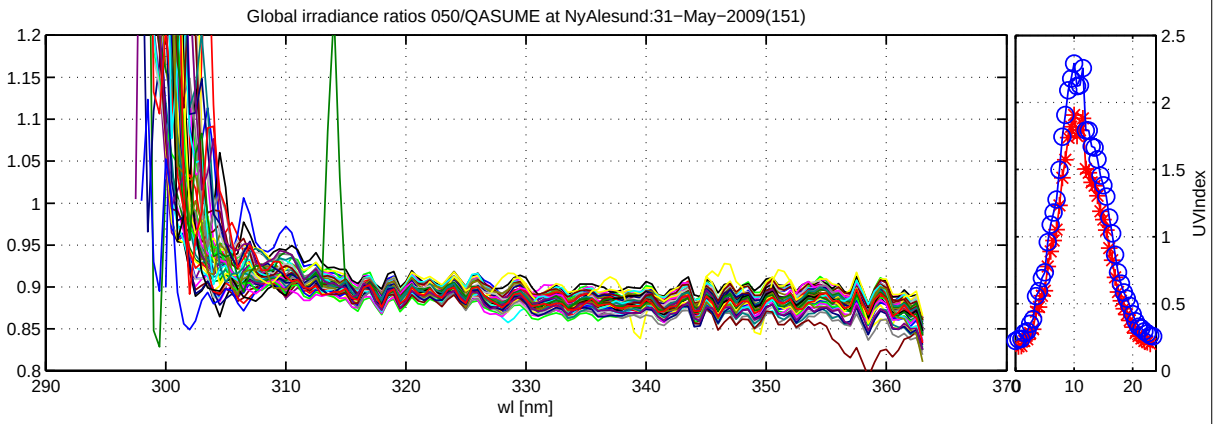

Daily variation. Wavelength bands are ± 2.5 nm
78°
79°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

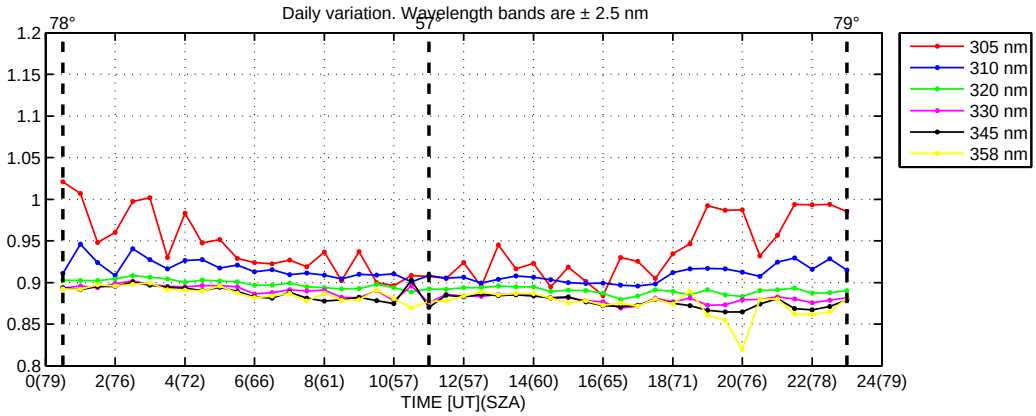

Global irradiance ratios 050/QASUME at NyAlesund:29−May−2009(149)
wl [nm]
UVIndex

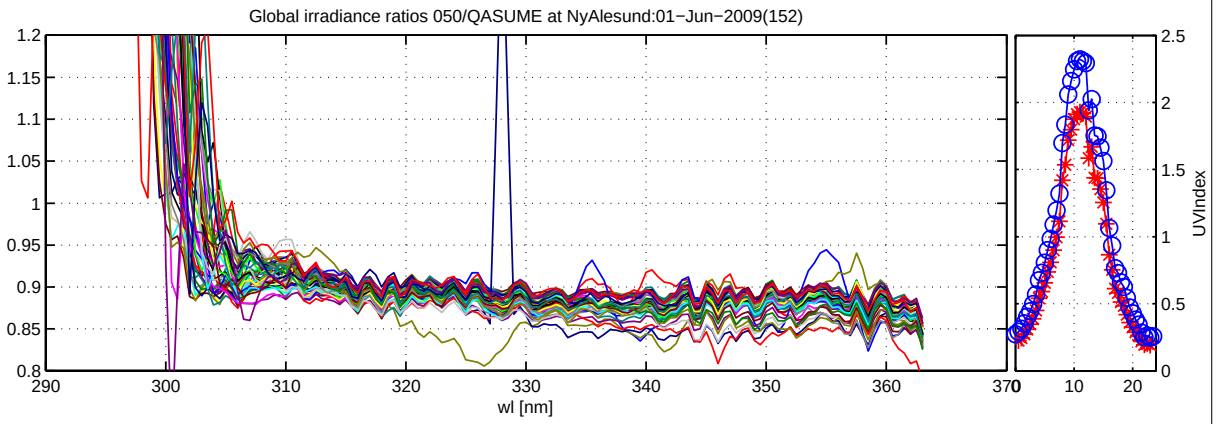

Daily variation. Wavelength bands are ± 2.5 nm
77°
79°
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm

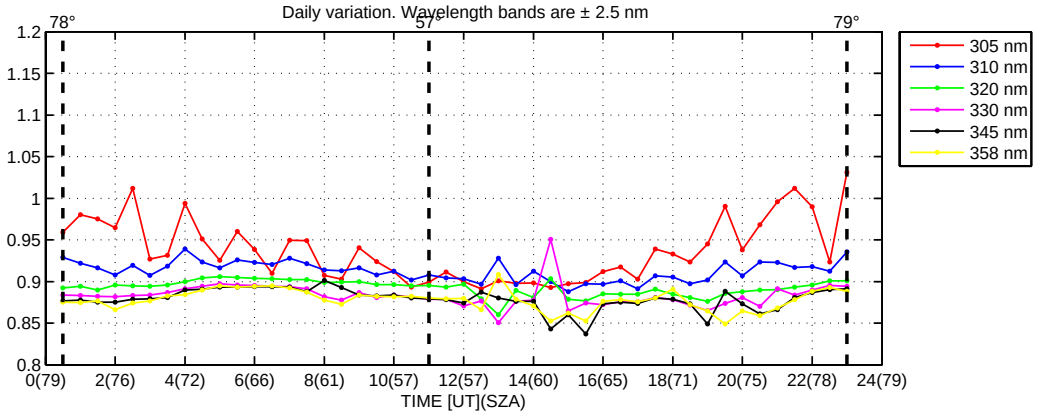

Global irradiance ratios 050/QASUME at NyAlesund:30−May−2009(150)
wl [nm]
UVIndex

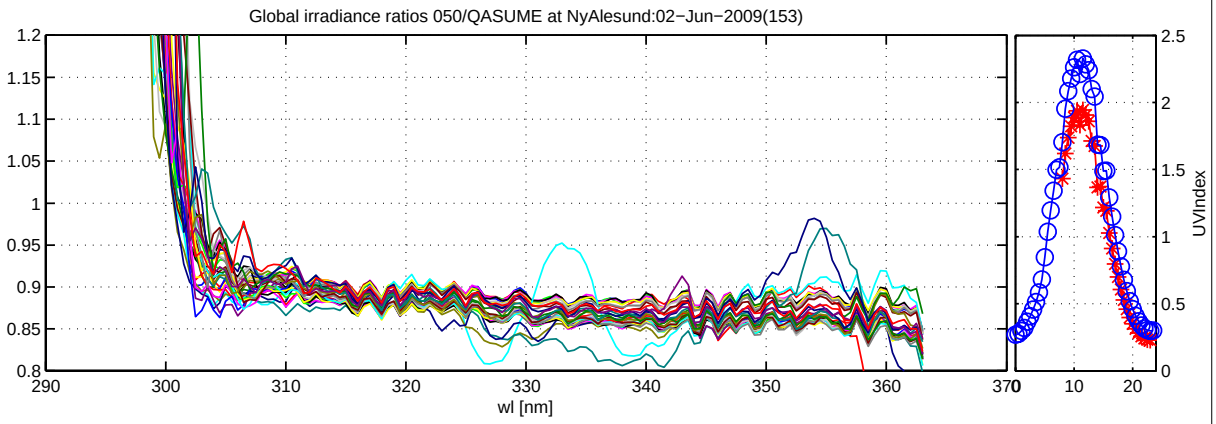

Daily variation. Wavelength bands are ± 2.5 nm
78°
79°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

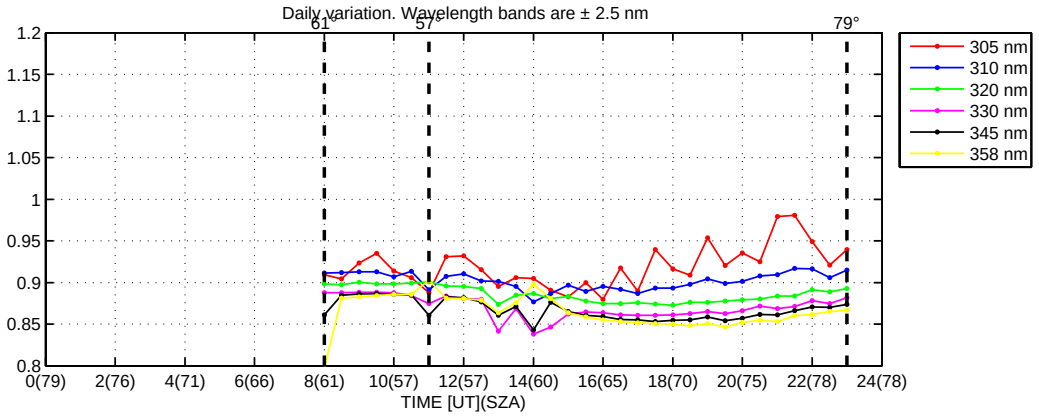

Global irradiance ratios 050/QASUME at NyAlesund:31−May−2009(151)
wl [nm]
UVIndex

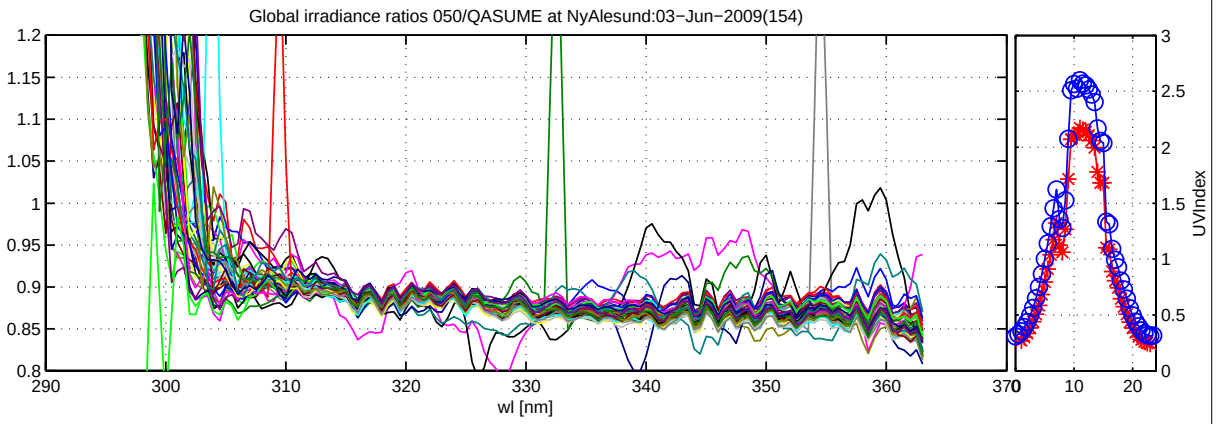

Daily variation. Wavelength bands are ± 2.5 nm
78°
79°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

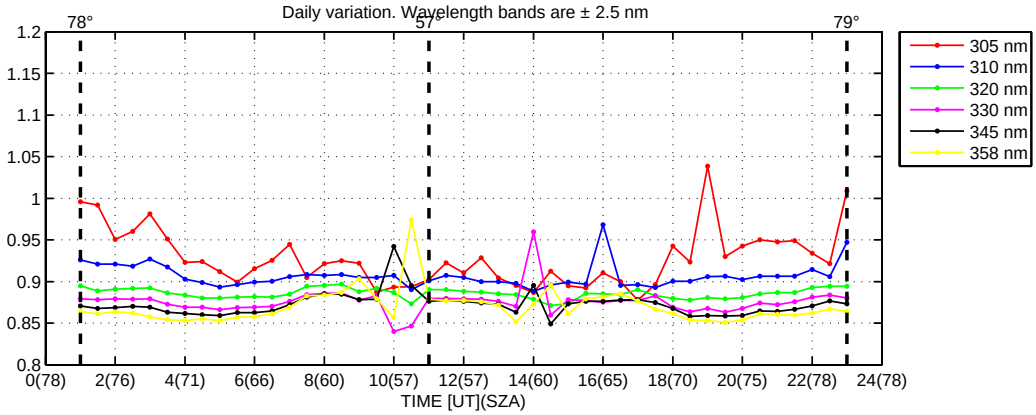

Global irradiance ratios 050/QASUME at NyAlesund:01−Jun−2009(152)
wl [nm]
UVIndex

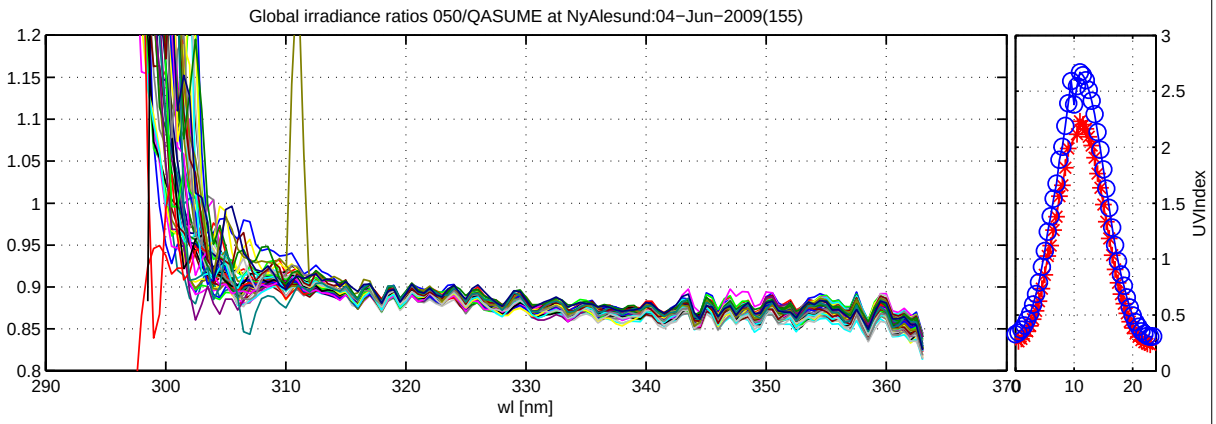

Daily variation. Wavelength bands are ± 2.5 nm
78°
57°
79°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

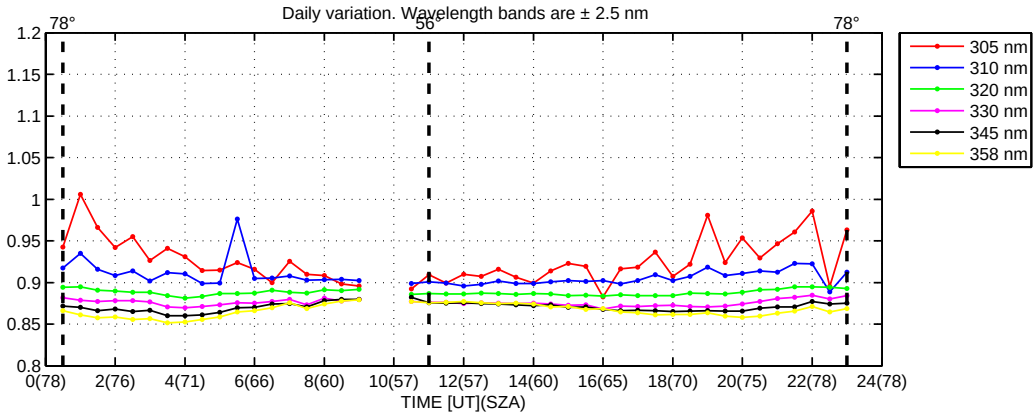

Global irradiance ratios 050/QASUME at NyAlesund:02−Jun−2009(153)
wl [nm]
UVIndex

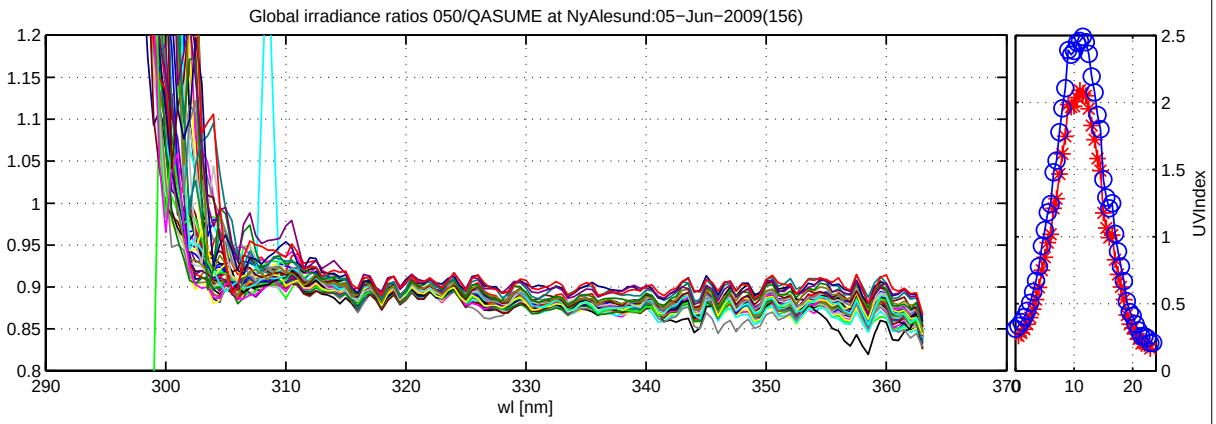

Daily variation. Wavelength bands are ± 2.5 nm
61°
57°
79°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

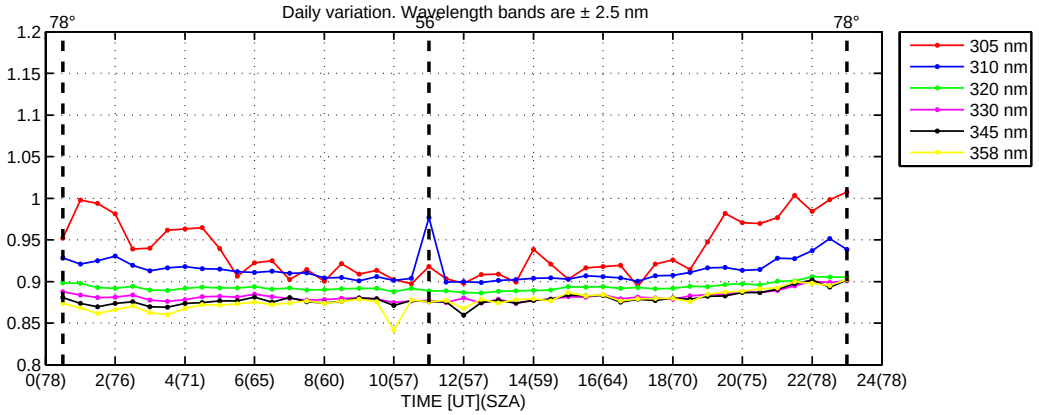

Global irradiance ratios 050/QASUME at NyAlesund:03−Jun−2009(154)
wl [nm]
UVIndex

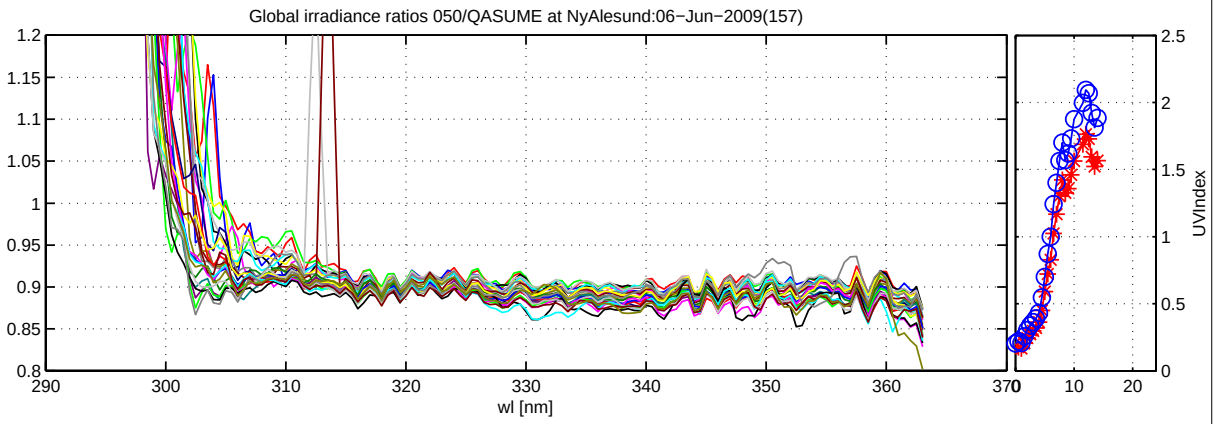

Daily variation. Wavelength bands are ± 2.5 nm
78°
57°
79°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

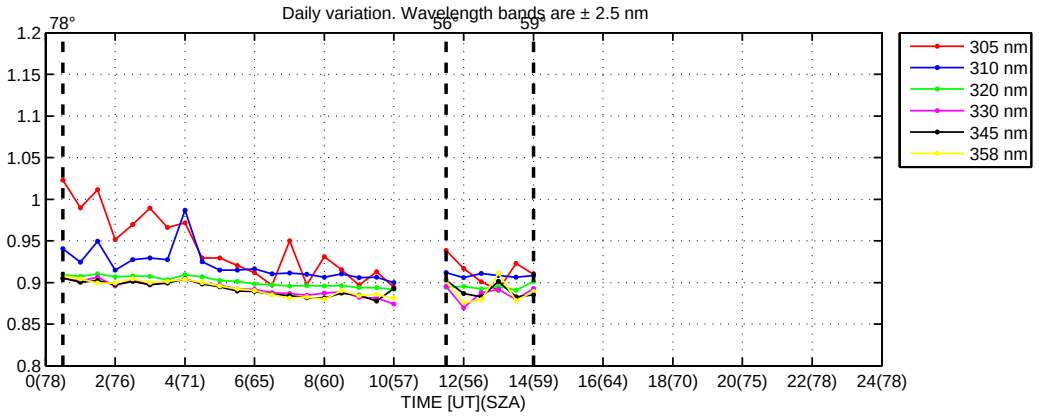

Global irradiance ratios 050/QASUME at NyAlesund:04−Jun−2009(155)
wl [nm]
UVIndex

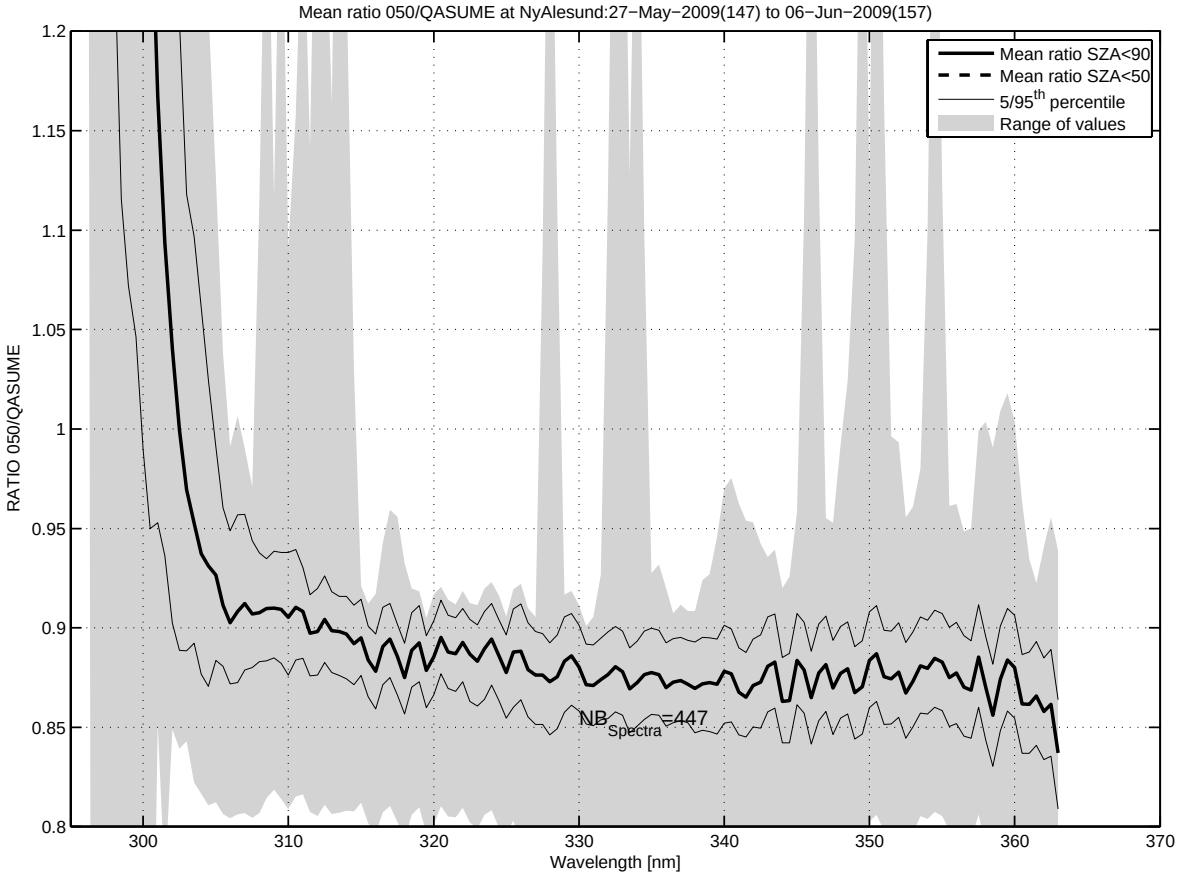

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
78°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

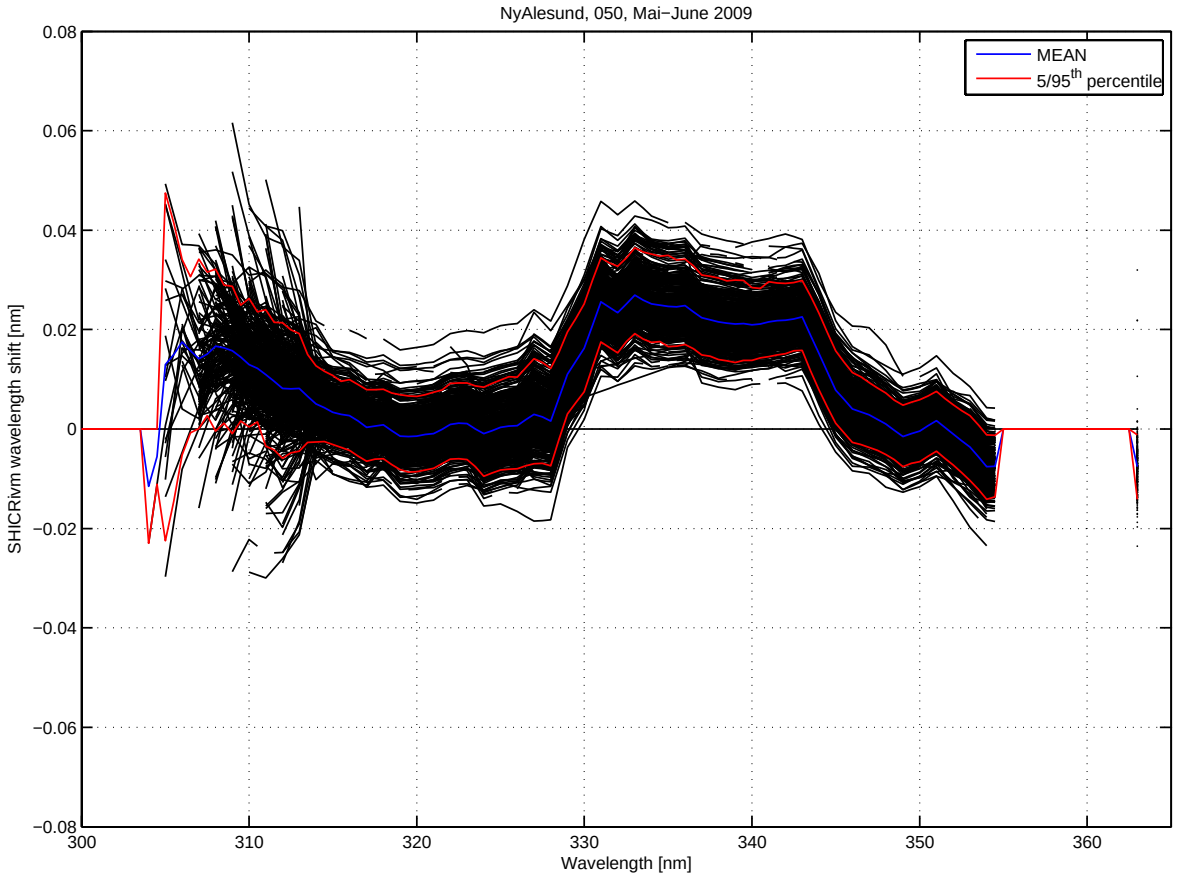

Global irradiance ratios 050/QASUME at NyAlesund:05−Jun−2009(156)
wl [nm]
UVIndex

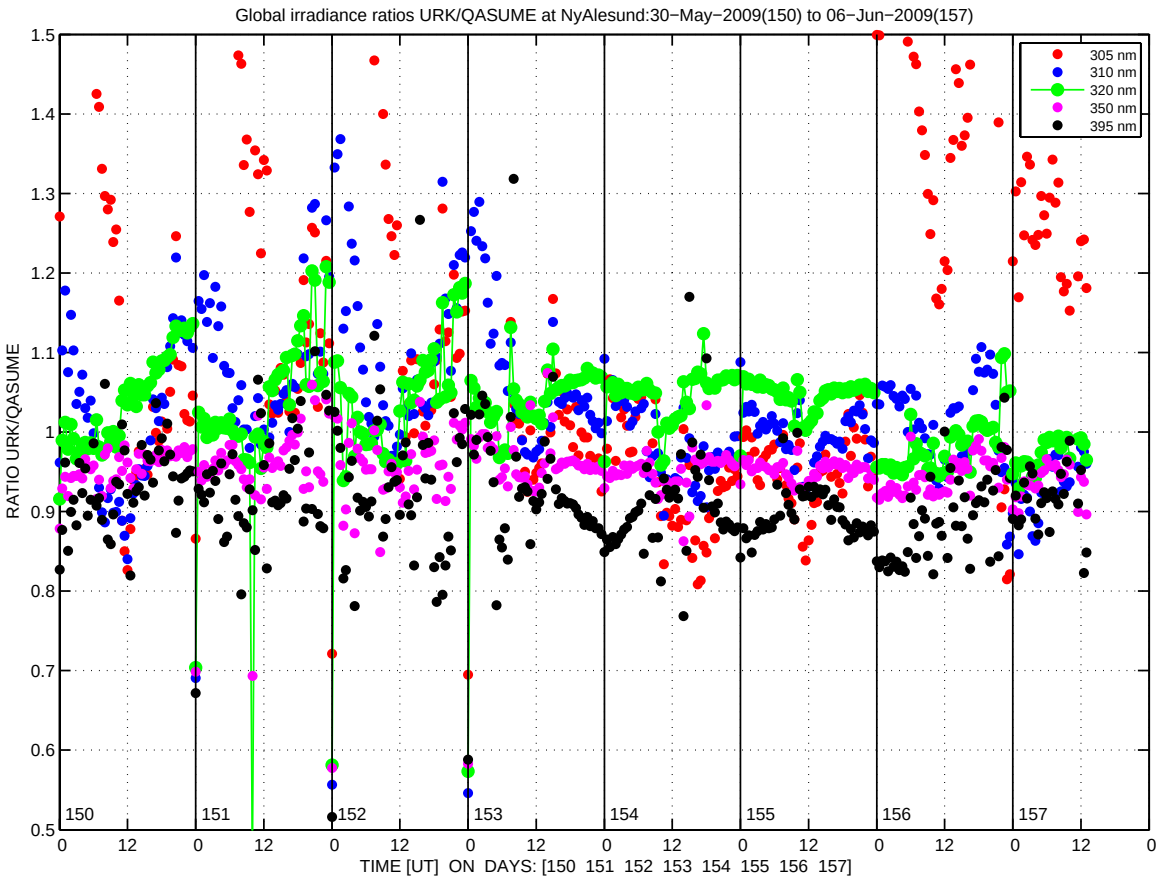

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
78°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

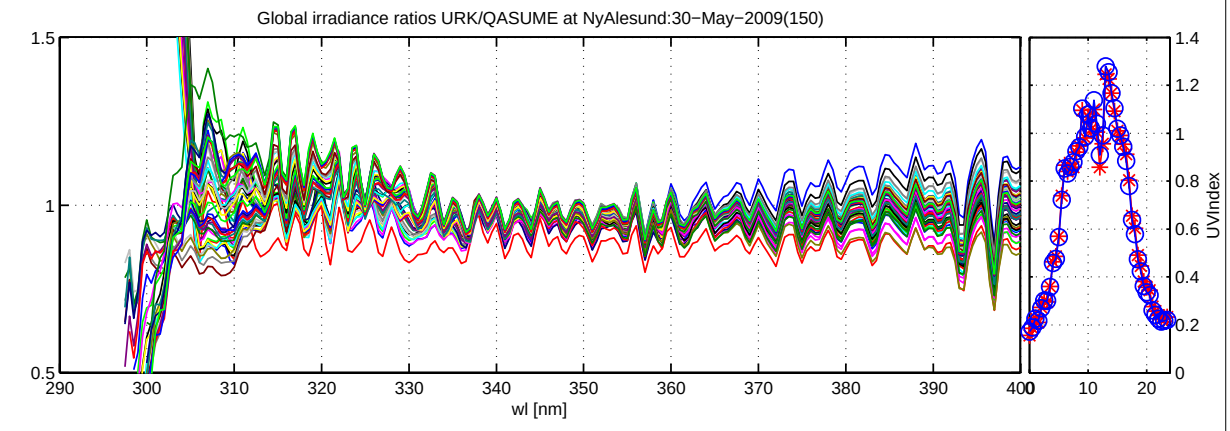

Global irradiance ratios 050/QASUME at NyAlesund:06−Jun−2009(157)
wl [nm]
UVIndex

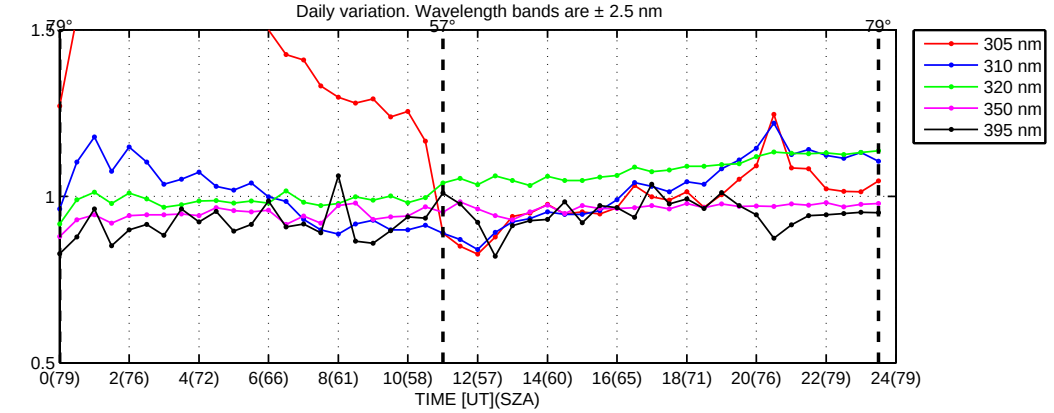

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
59°
305 nm
310 nm
320 nm
330 nm
345 nm
358 nm
TIME [UT](SZA)

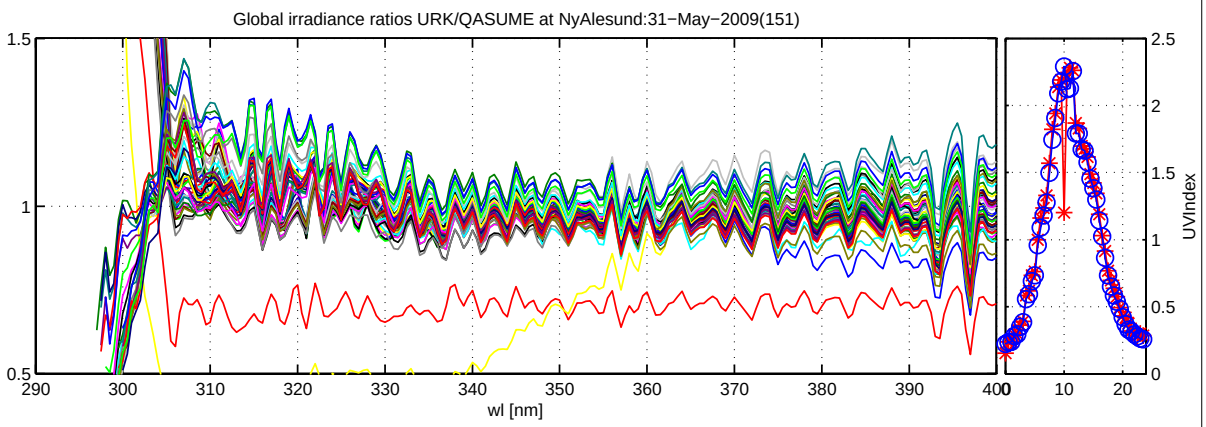

Mean ratio 050/QASUME at NyAlesund:27−May−2009(147) to 06−Jun−2009(157)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO 050/QASUME
Wavelength [nm]
NB Spectra =447
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370

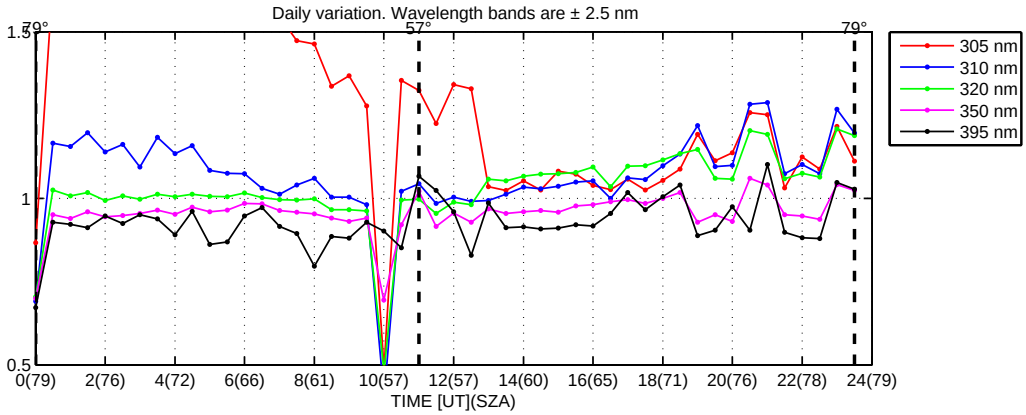

NyAlesund, 050, Mai−June 2009
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
300
310
320
330
340
350
360

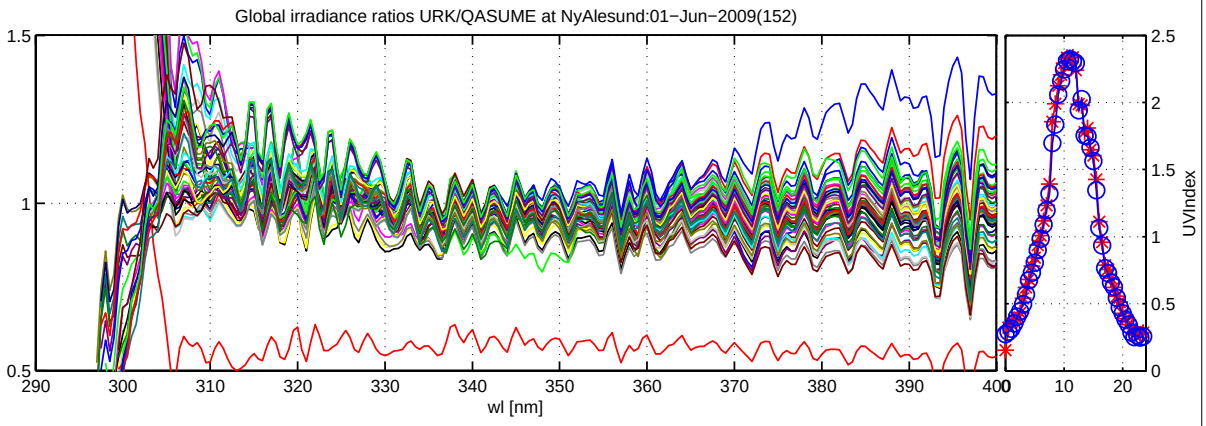

Global irradiance ratios URK/QASUME at NyAlesund:30−May−2009(150) to 06−Jun−2009(157)
RATIO URK/QASUME
TIME [UT] ON DAYS: [150 151 152 153 154 155 156 157]
305 nm
310 nm
320 nm
350 nm
395 nm

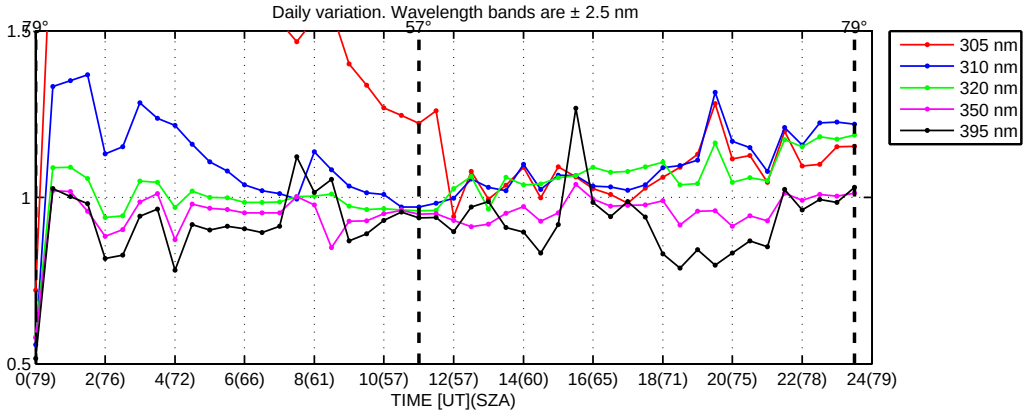

Global irradiance ratios URK/QASUME at NyAlesund:30−May−2009(150)
wl [nm]
UVIndex

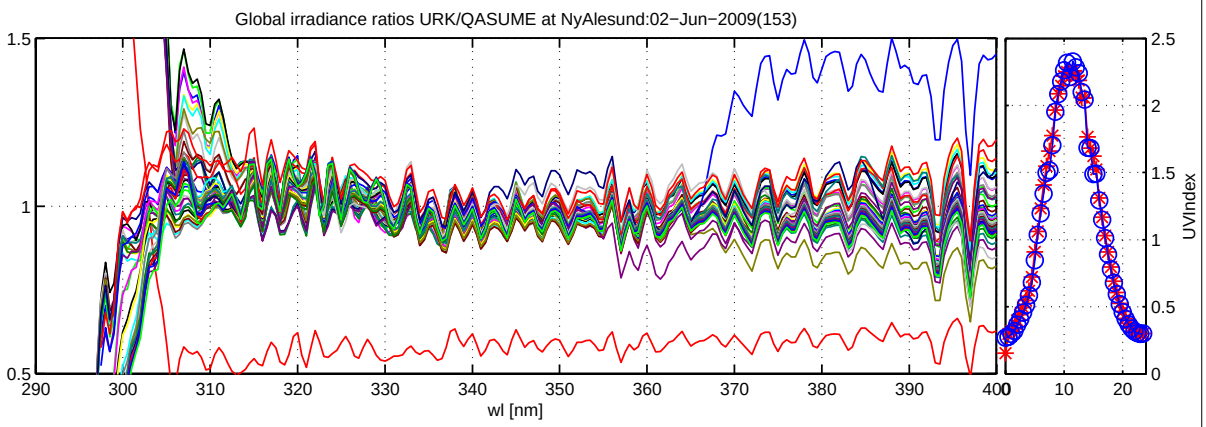

Daily variation. Wavelength bands are ± 2.5 nm
79°
57°
79°
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
395 nm

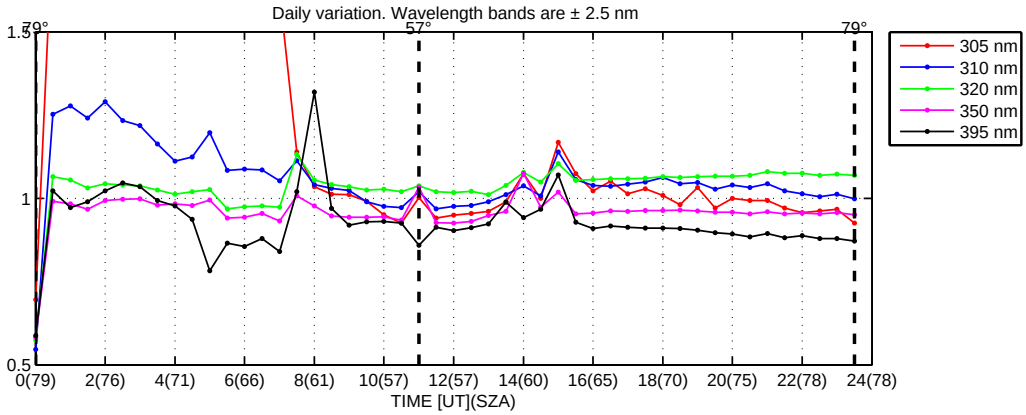

Global irradiance ratios URK/QASUME at NyAlesund:31−May−2009(151)
wl [nm]
UVIndex

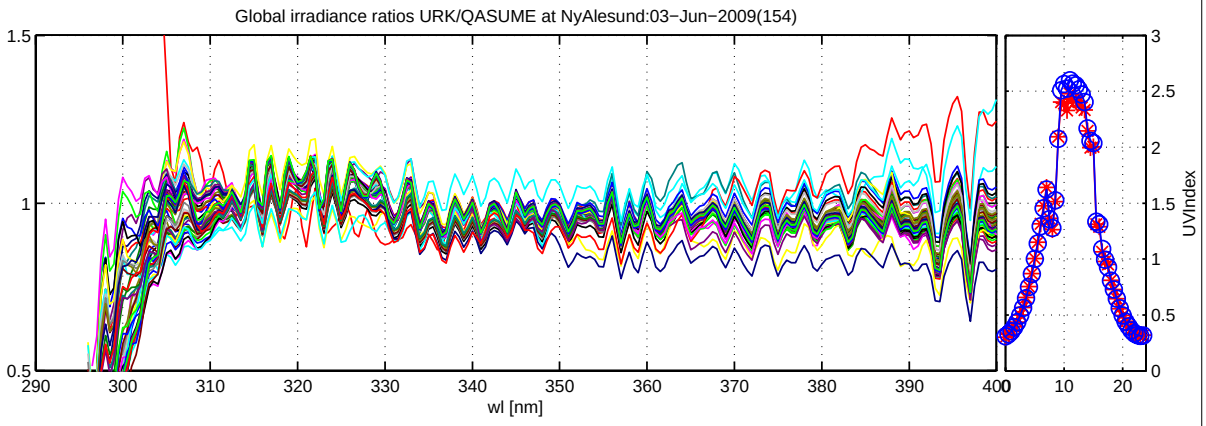

Daily variation. Wavelength bands are ± 2.5 nm
79°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

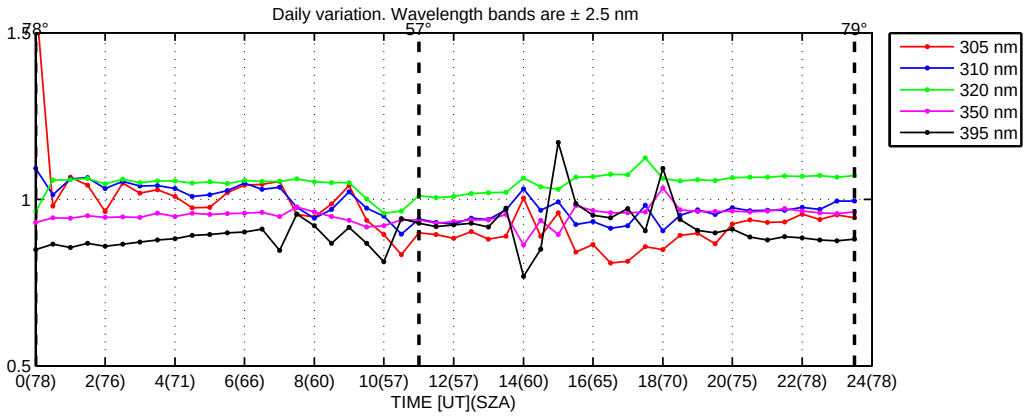

Global irradiance ratios URK/QASUME at NyAlesund:01−Jun−2009(152)
wl [nm]
UVIndex

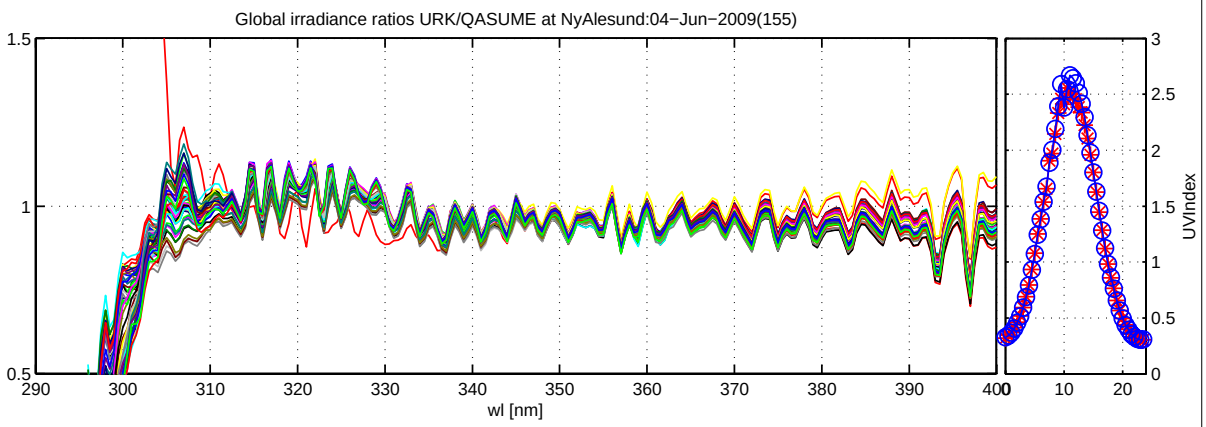

Daily variation. Wavelength bands are ± 2.5 nm
79°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

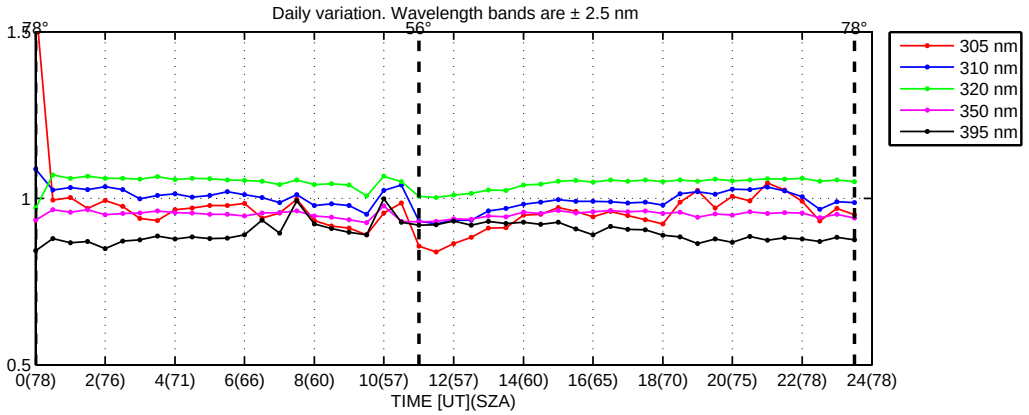

Global irradiance ratios URK/QASUME at NyAlesund:02−Jun−2009(153)
wl [nm]
UVIndex

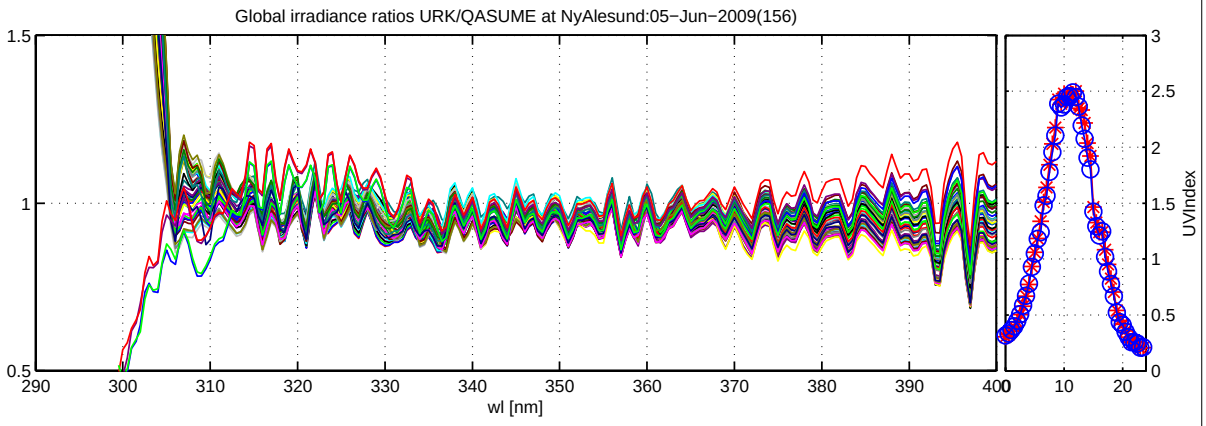

Daily variation. Wavelength bands are ± 2.5 nm
79°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

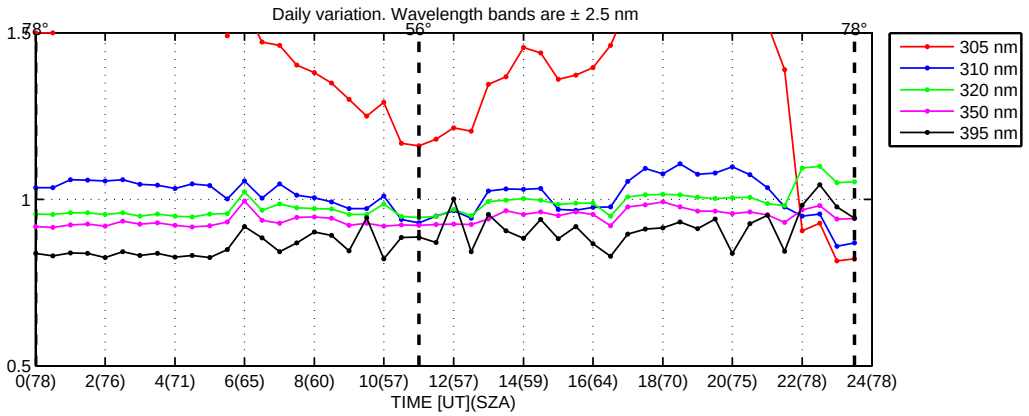

Global irradiance ratios URK/QASUME at NyAlesund:03−Jun−2009(154)
wl [nm]
UVIndex

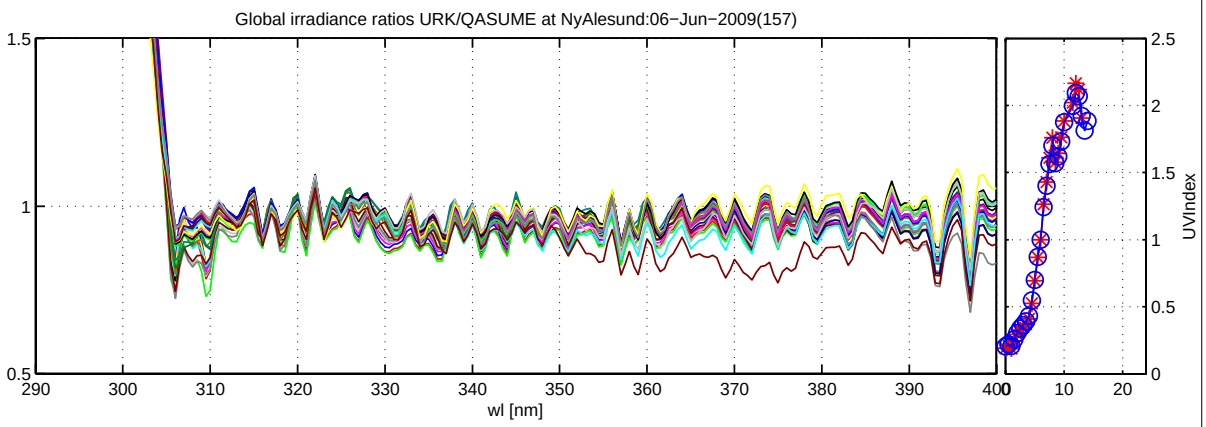

Daily variation. Wavelength bands are ± 2.5 nm
78°
57°
79°
305 nm
310 nm
320 nm
350 nm
395 nm
TIME [UT](SZA)

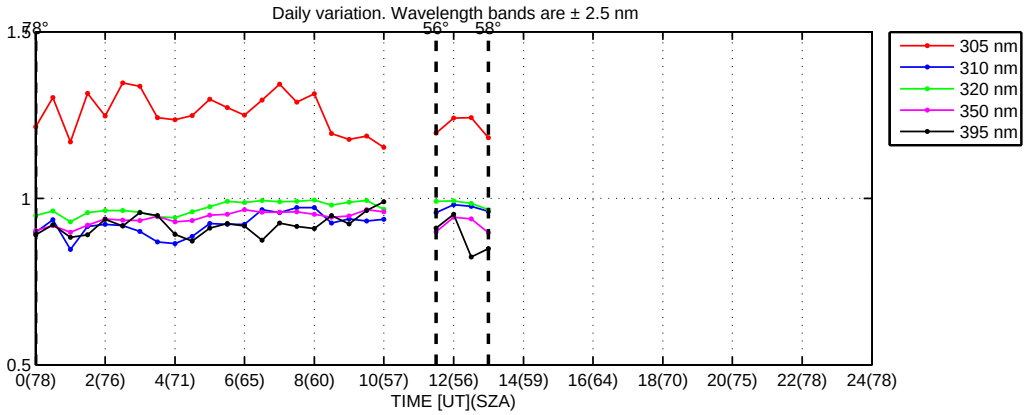

Global irradiance ratios URK/QASUME at NyAlesund:04−Jun−2009(155)
wl [nm]
UVIndex

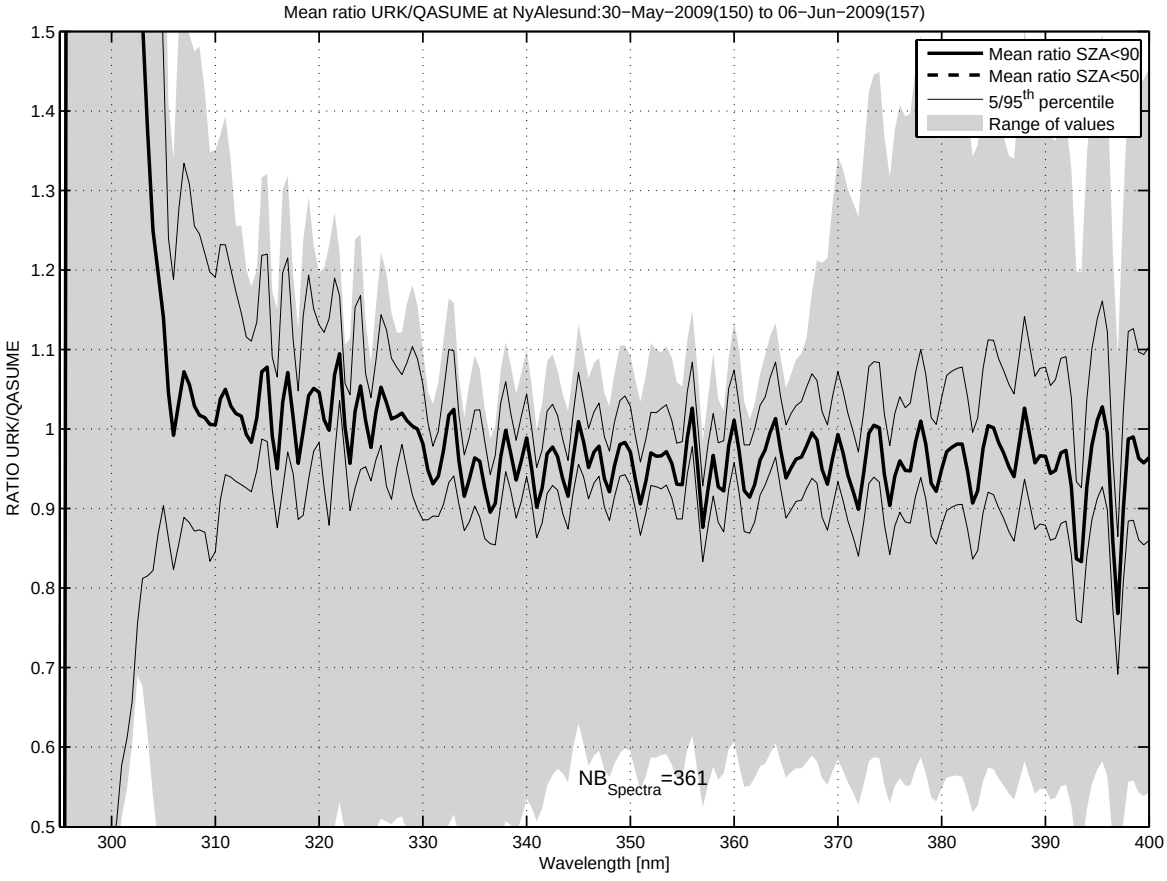

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
78°
305 nm
310 nm
320 nm
350 nm
395 nm
0(78) 2(76) 4(71) 6(66) 8(60) 10(57) 12(57) 14(60) 16(65) 18(70) 20(75) 22(78) 24(78)
TIME [UT](SZA)

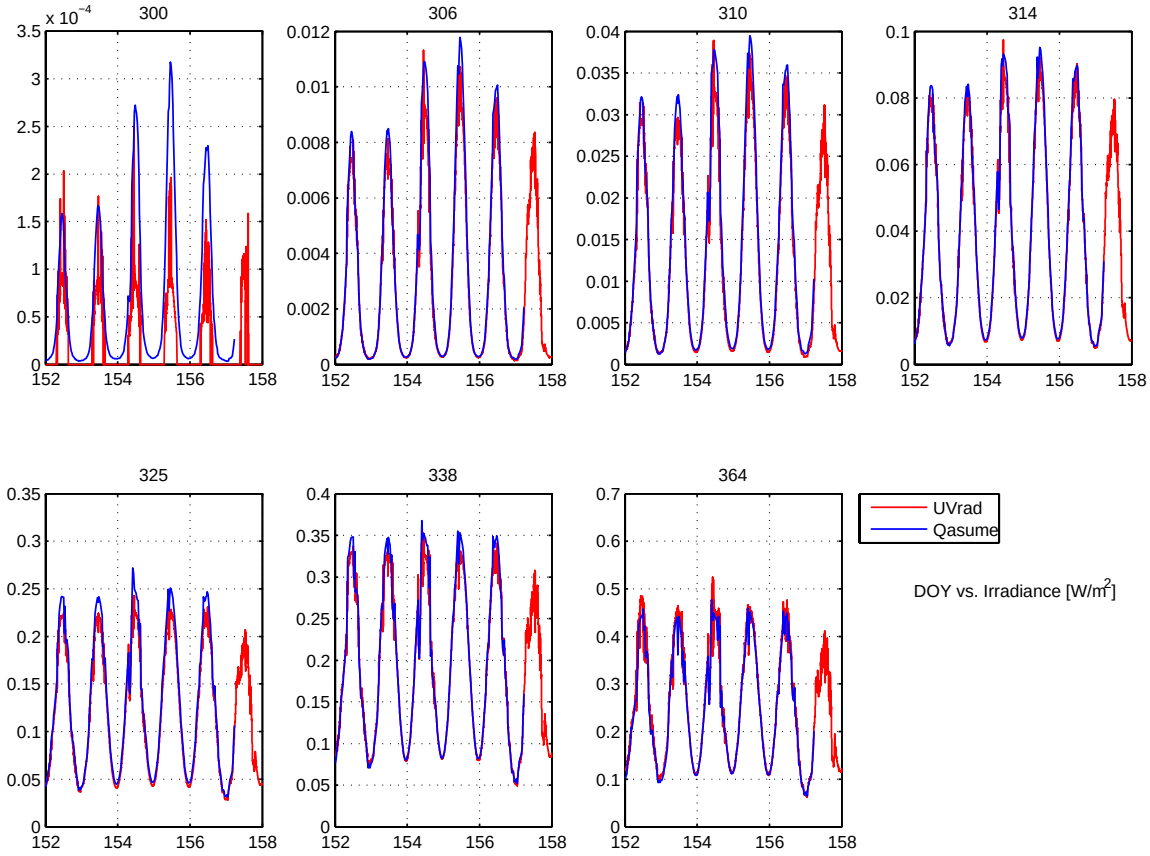

Global irradiance ratios URK/QASUME at NyAlesund:05−Jun−2009(156)
wl [nm]
UVIndex

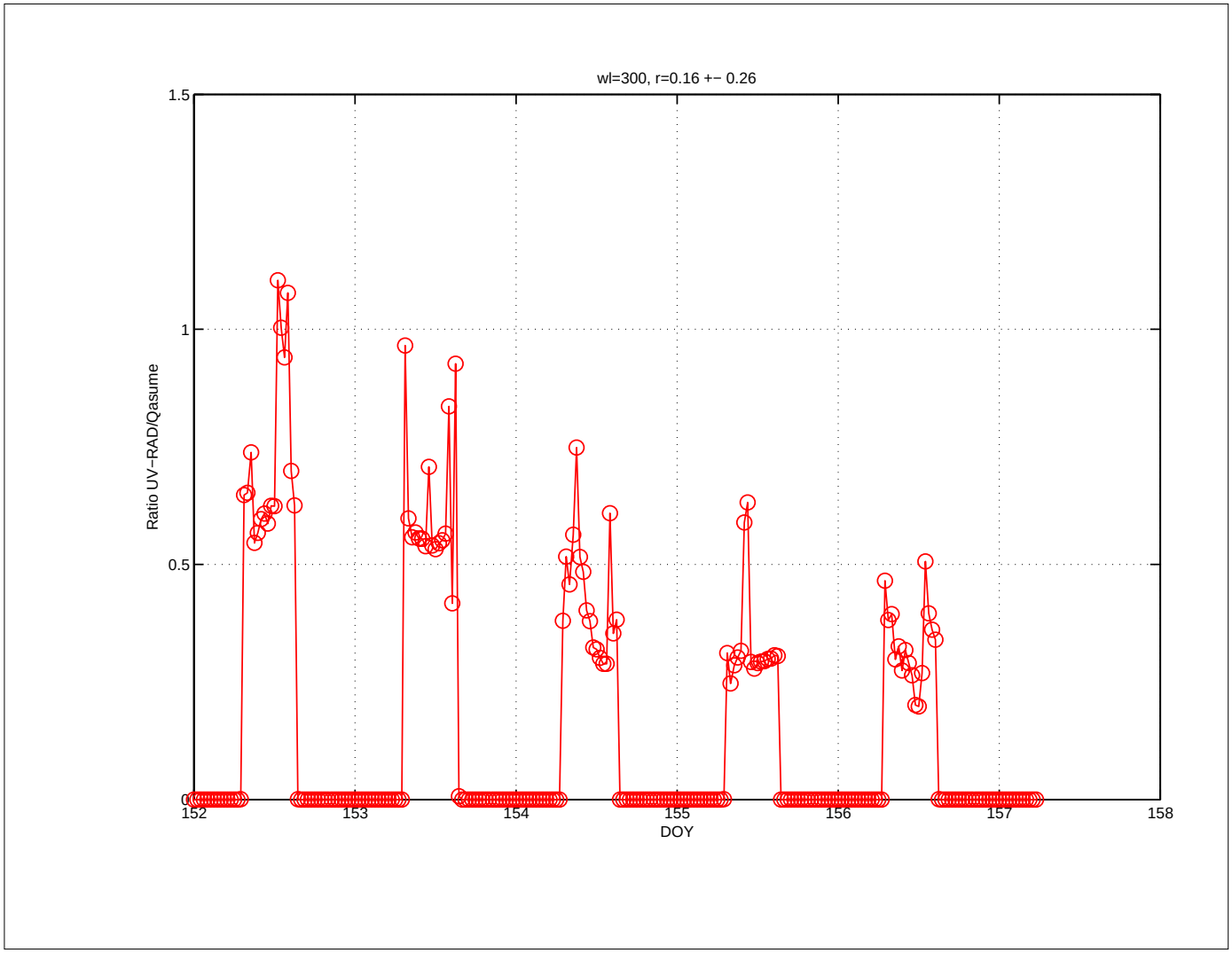

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
78°
305 nm
310 nm
320 nm
350 nm
395 nm
0(78) 2(76) 4(71) 6(65) 8(60) 10(57) 12(57) 14(59) 16(64) 18(70) 20(75) 22(78) 24(78)
TIME [UT](SZA)

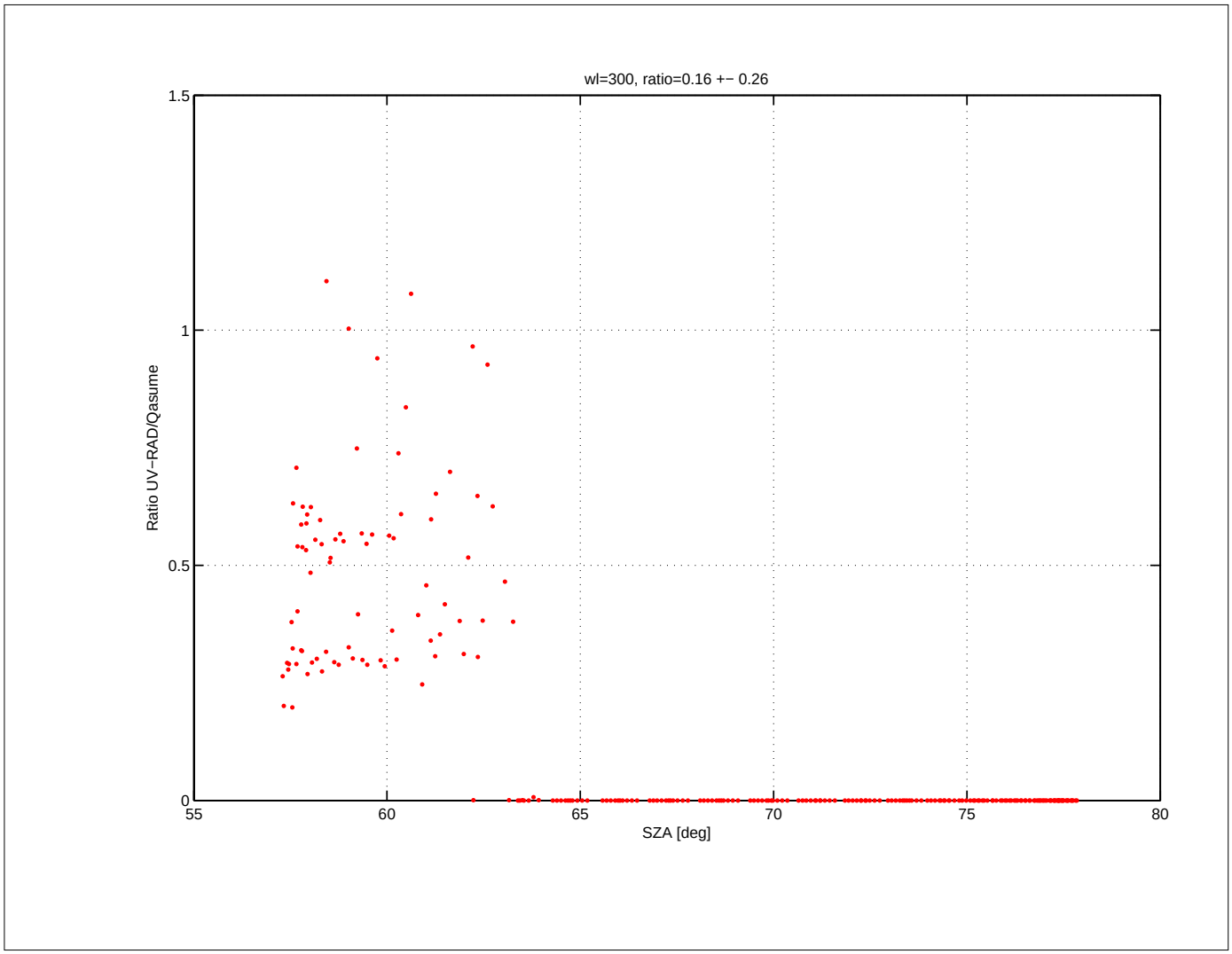

Global irradiance ratios URK/QASUME at NyAlesund:06−Jun−2009(157)
wl [nm]
UVIndex

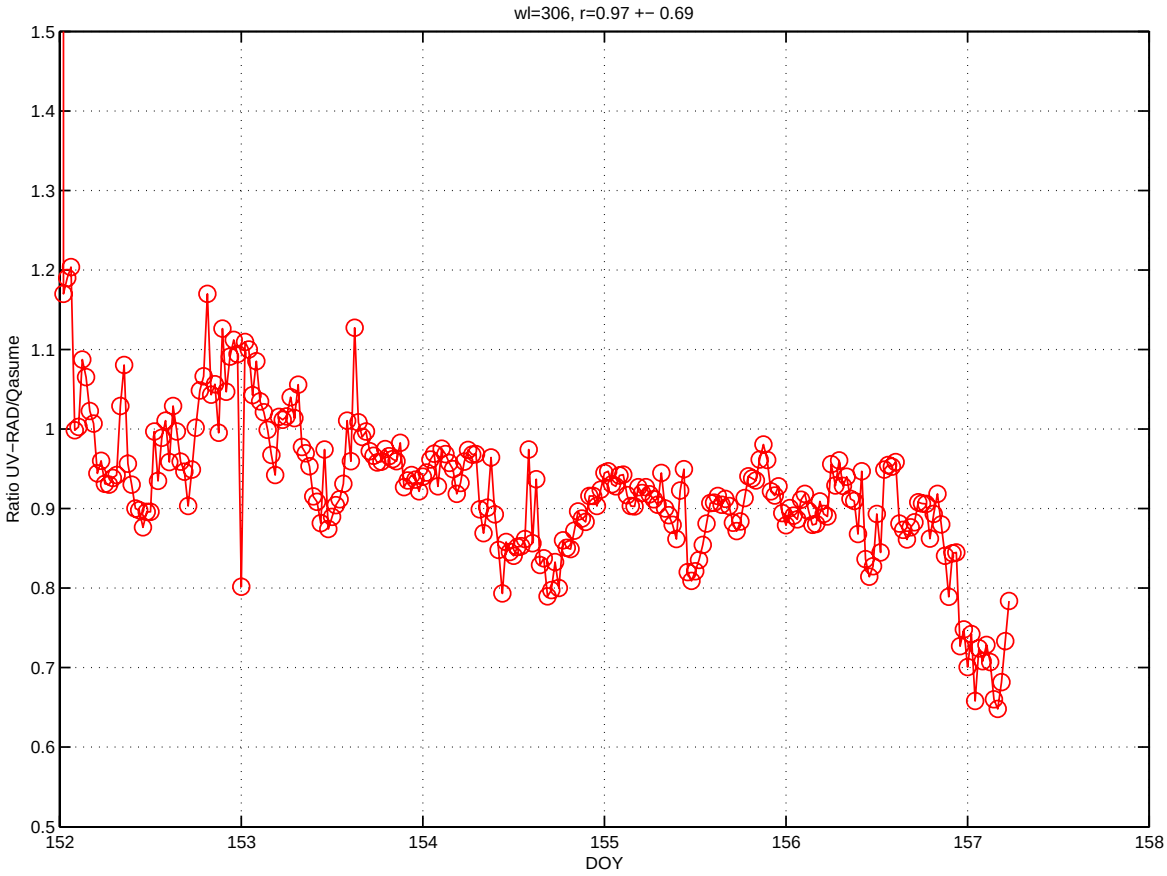

Daily variation. Wavelength bands are ± 2.5 nm
78°
56°
58°
305 nm
310 nm
320 nm
350 nm
395 nm
0(78)
2(76)
4(71)
6(65)
8(60)
10(57)
12(56)
14(59)
16(64)
18(70)
20(75)
22(78)
24(78)
TIME [UT](SZA)

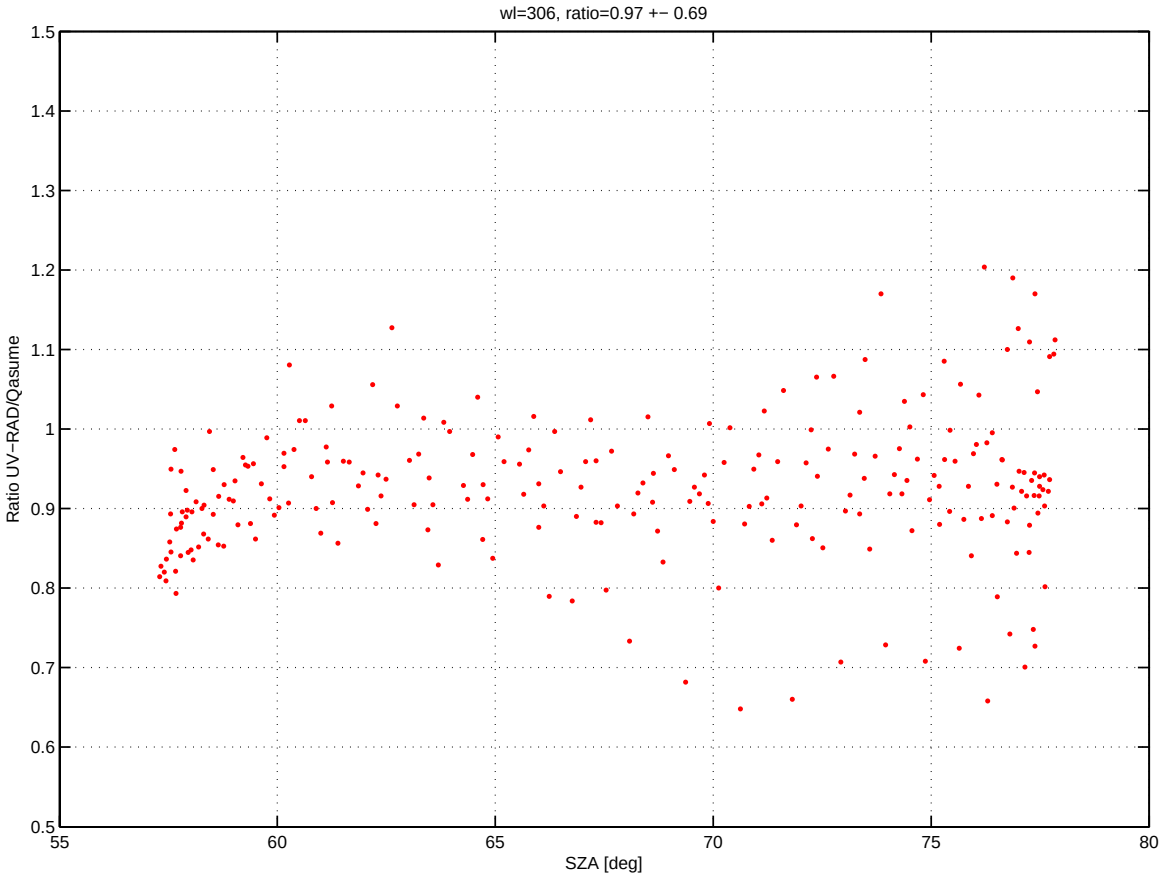

Mean ratio URK/QASUME at NyAlesund:30−May−2009(150) to 06−Jun−2009(157)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO URK/QASUME
NBSpectra=361
Wavelength [nm]

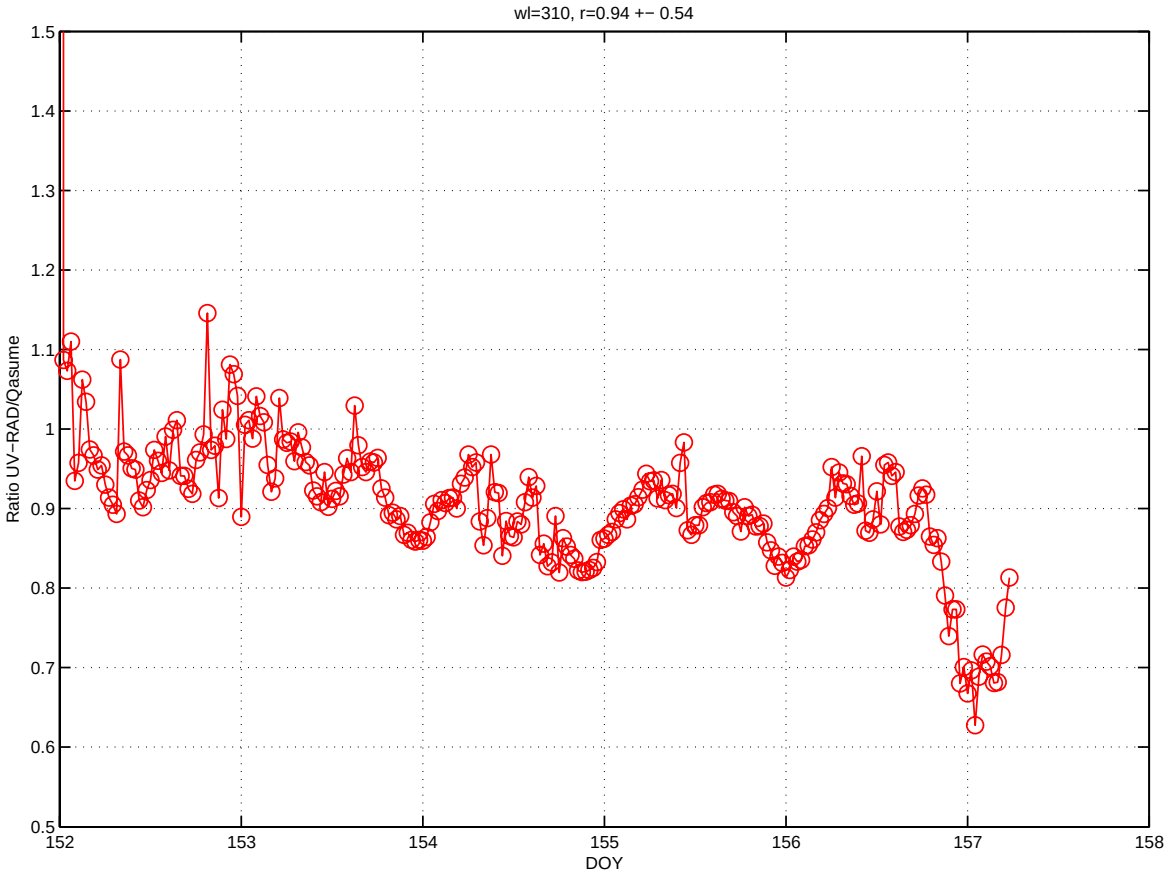

300
306
310
314
325
338
364
x 10^-4
UVrad
Qasume
DOY vs. Irradiance [W/m^2]

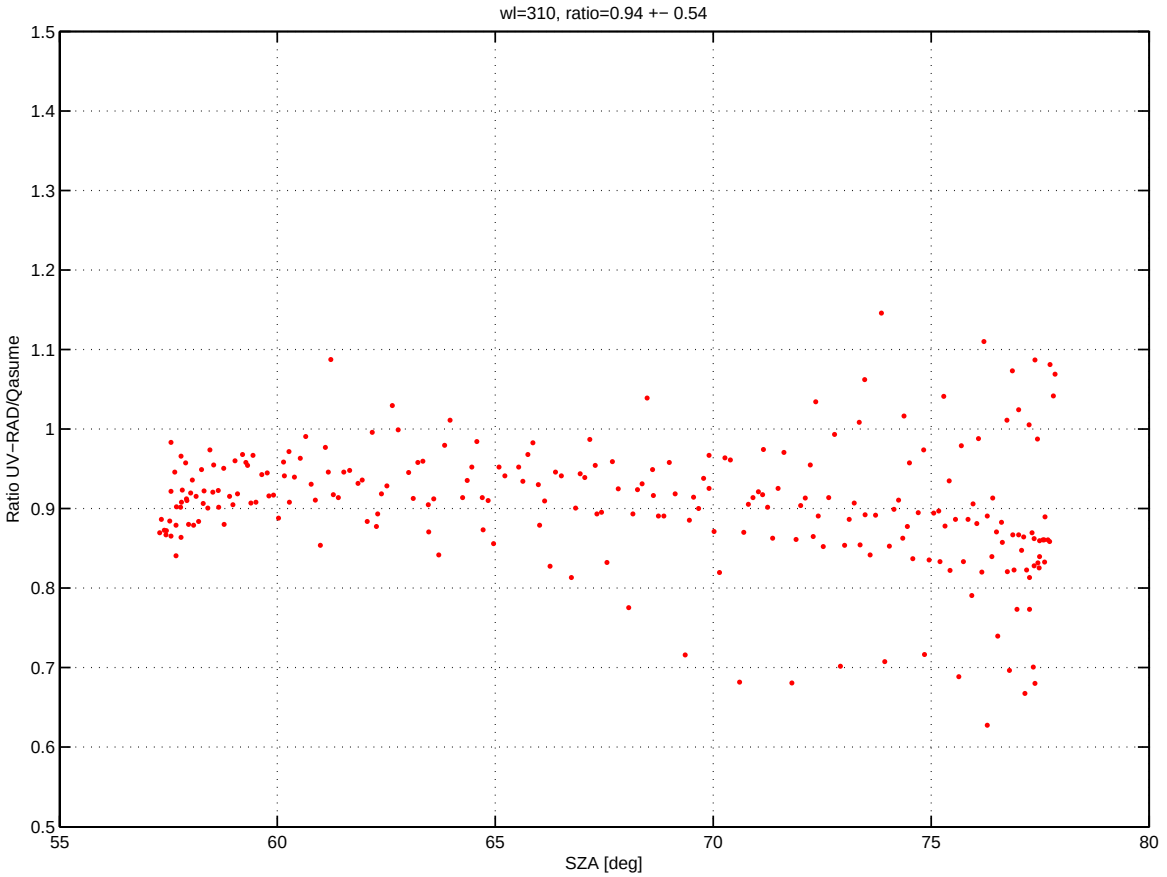

wl=300, r=0.16 +− 0.26
Ratio UV−RAD/Qasume
DOY
1.5
1
0.5
0
152
153
154
155
156
157
158

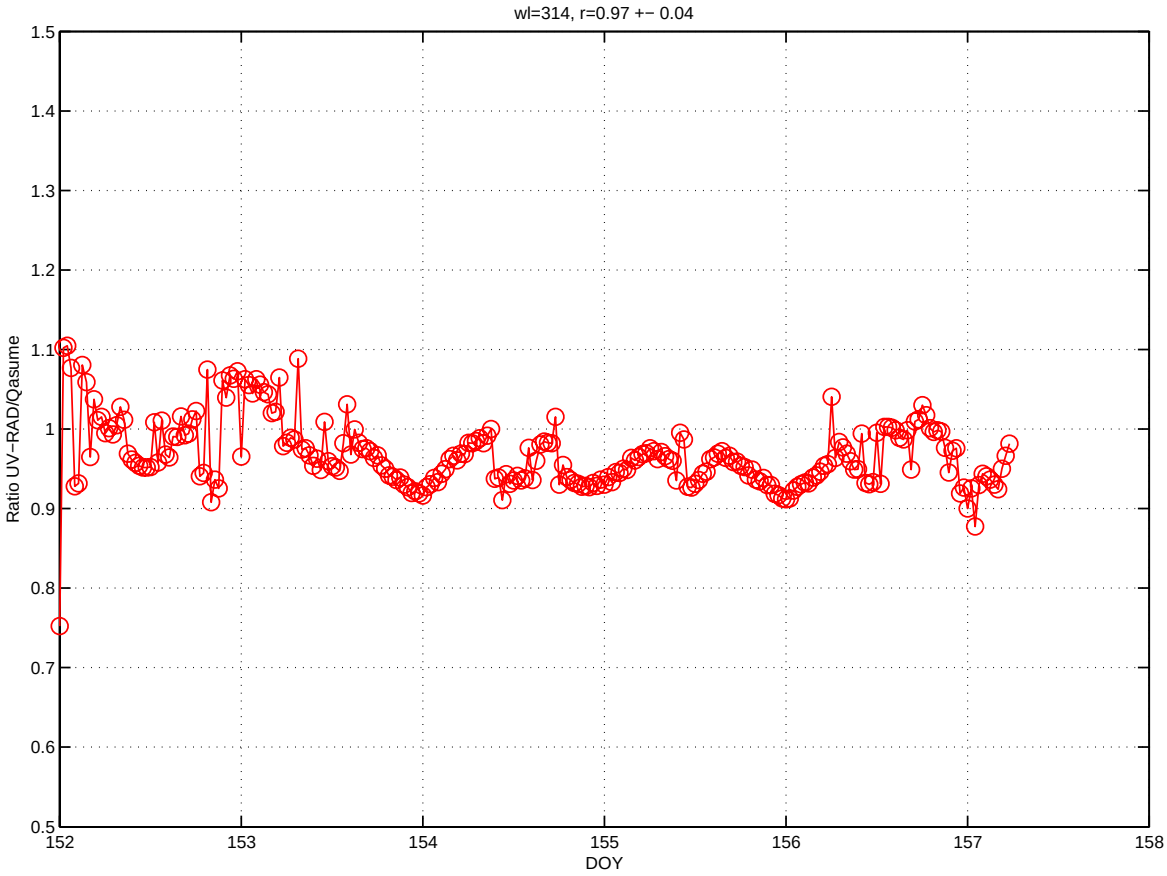

wl=300, ratio=0.16 +− 0.26
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1
0.5
0
55
60
65
70
75
80

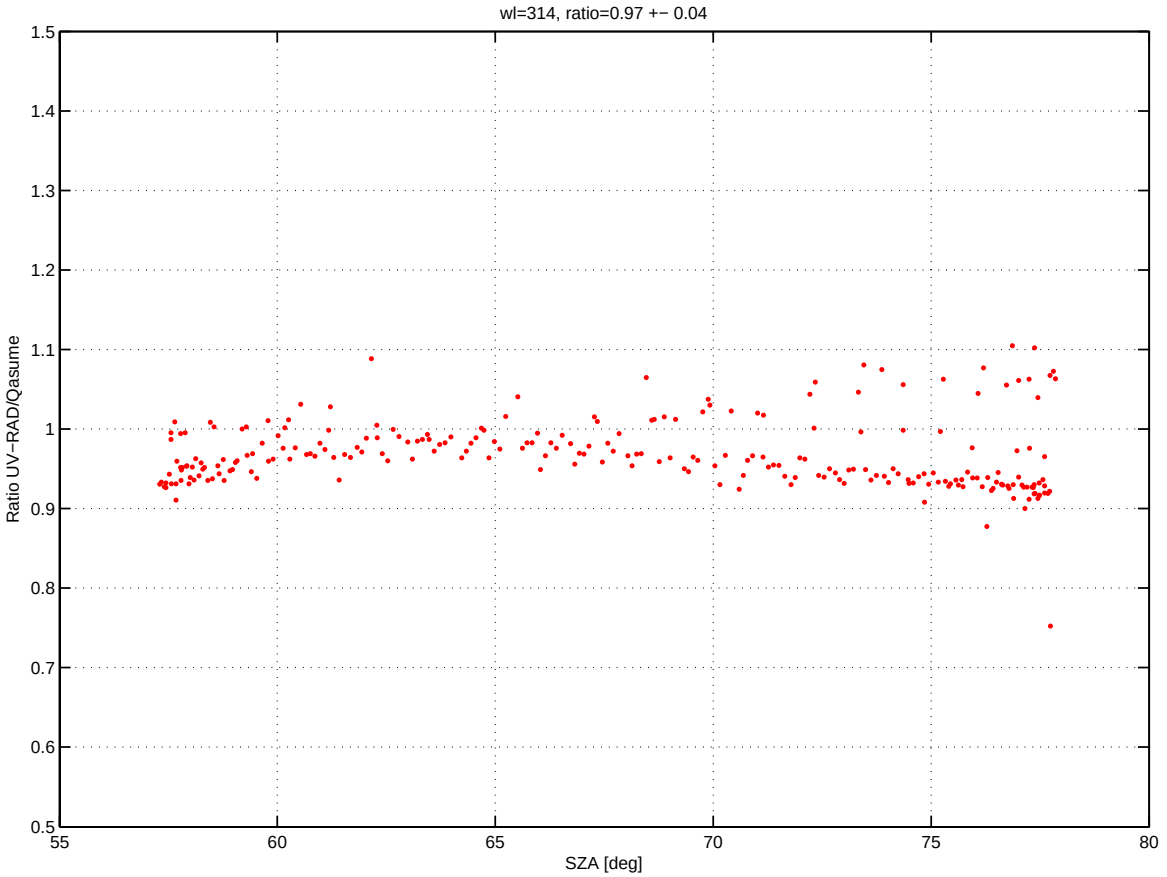

wl=306, r=0.97 +− 0.69
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

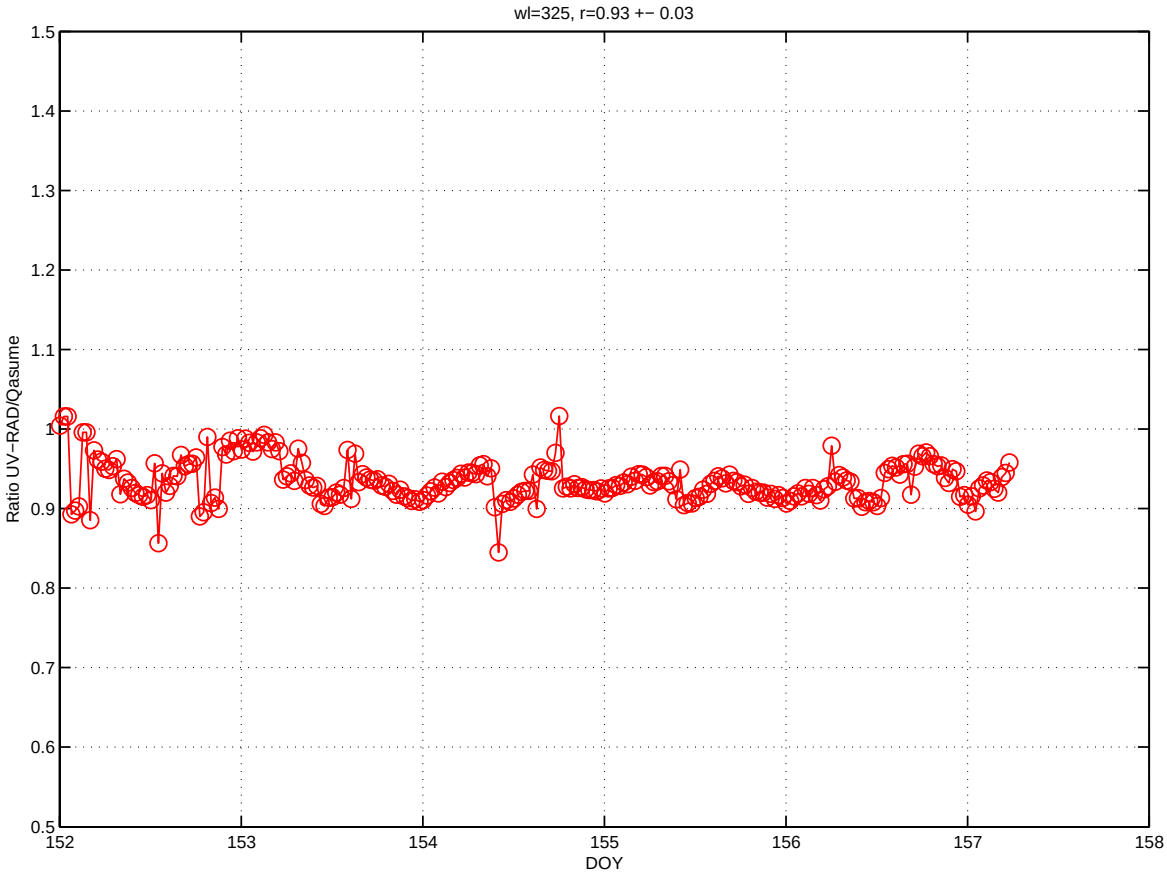

wl=306, ratio=0.97 +− 0.69
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

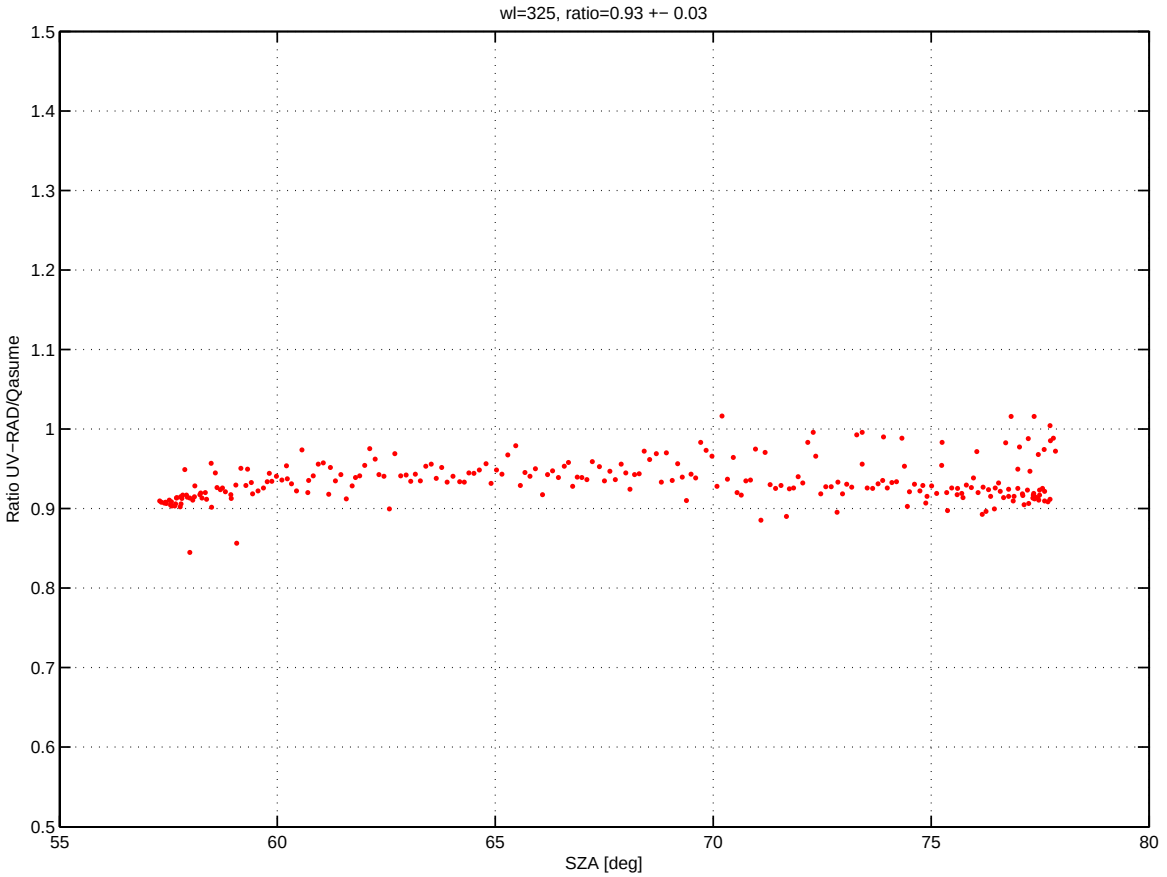

wl=310, r=0.94 +− 0.54
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

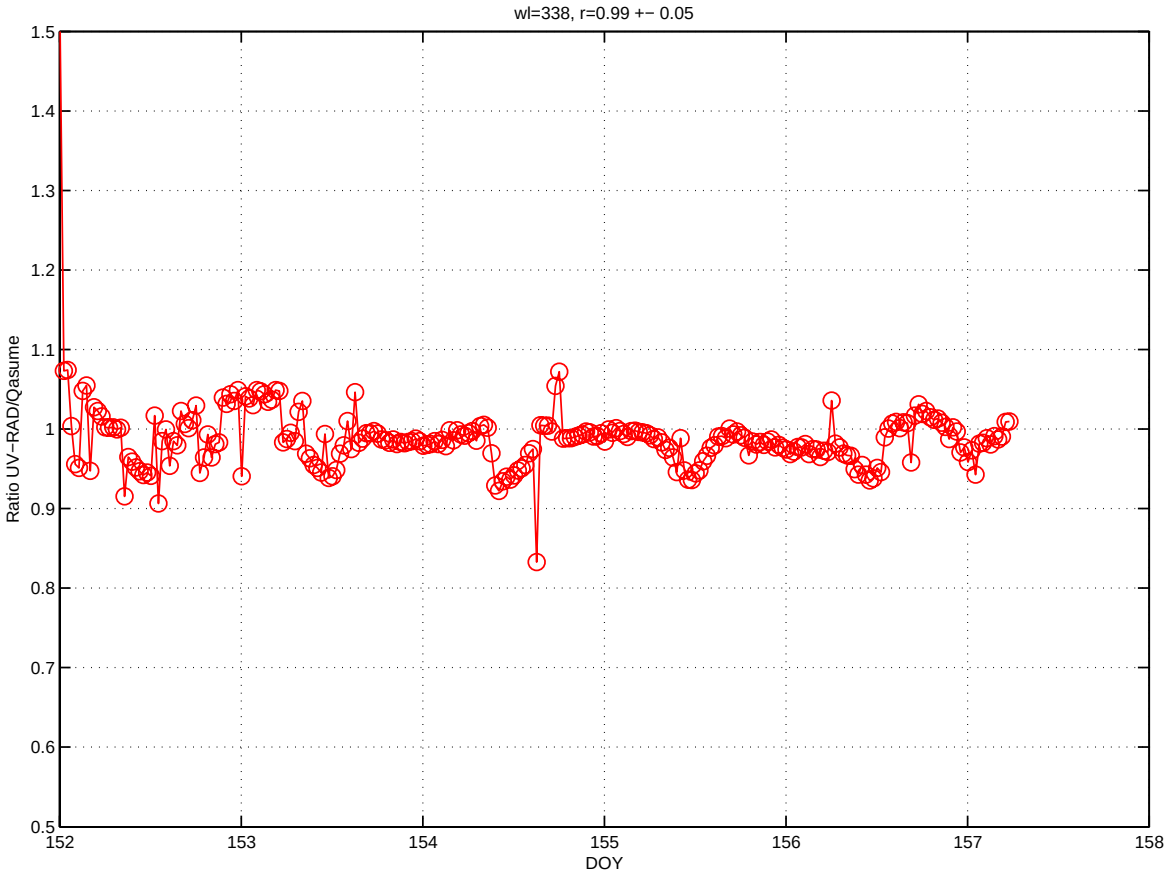

wl=310, ratio=0.94 +− 0.54
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

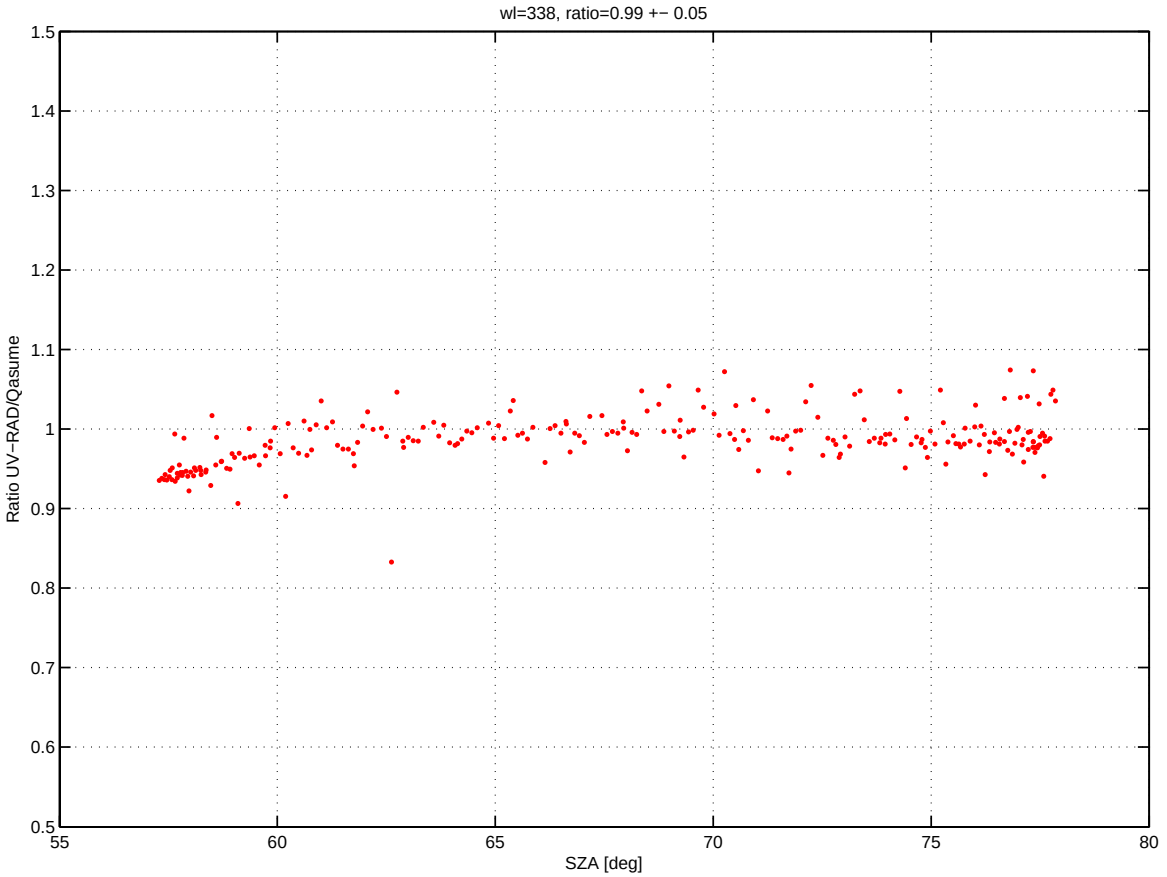

wl=314, r=0.97 +− 0.04
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

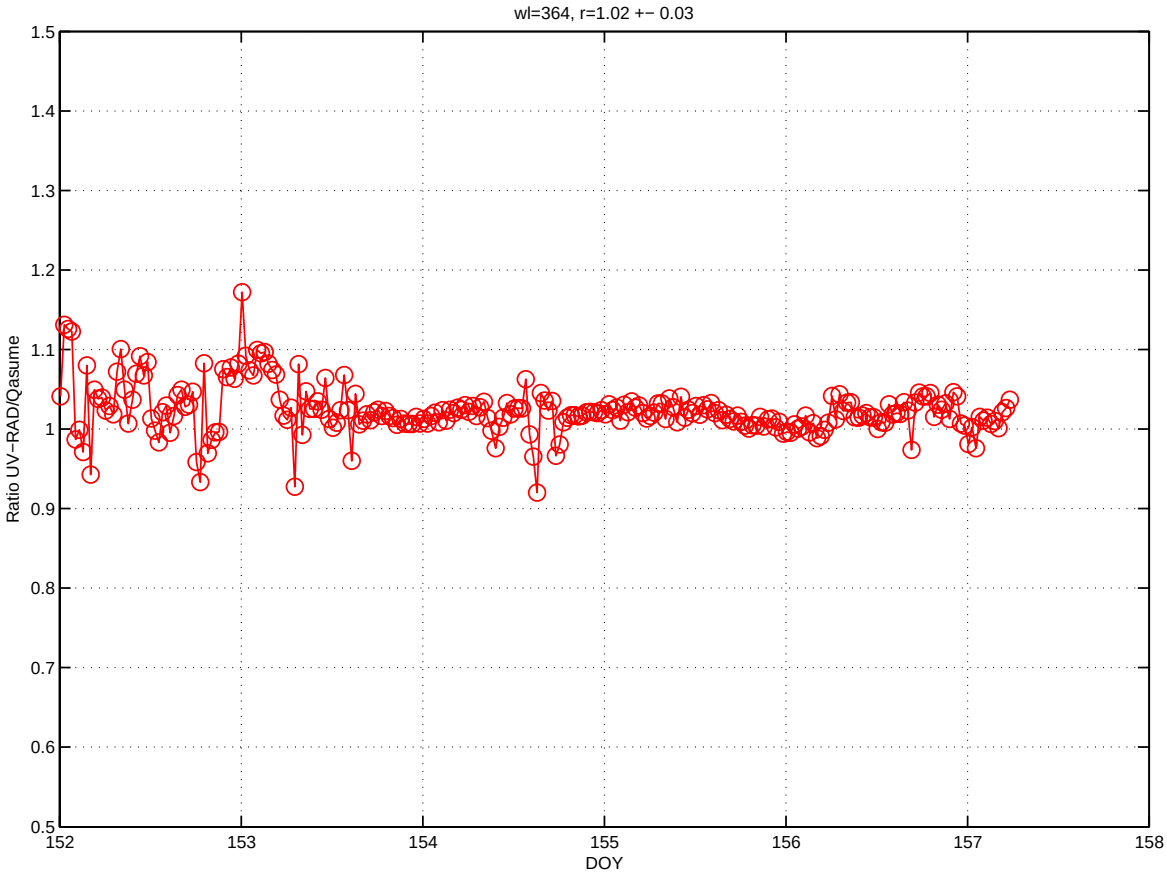

wl=314, ratio=0.97 +− 0.04
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

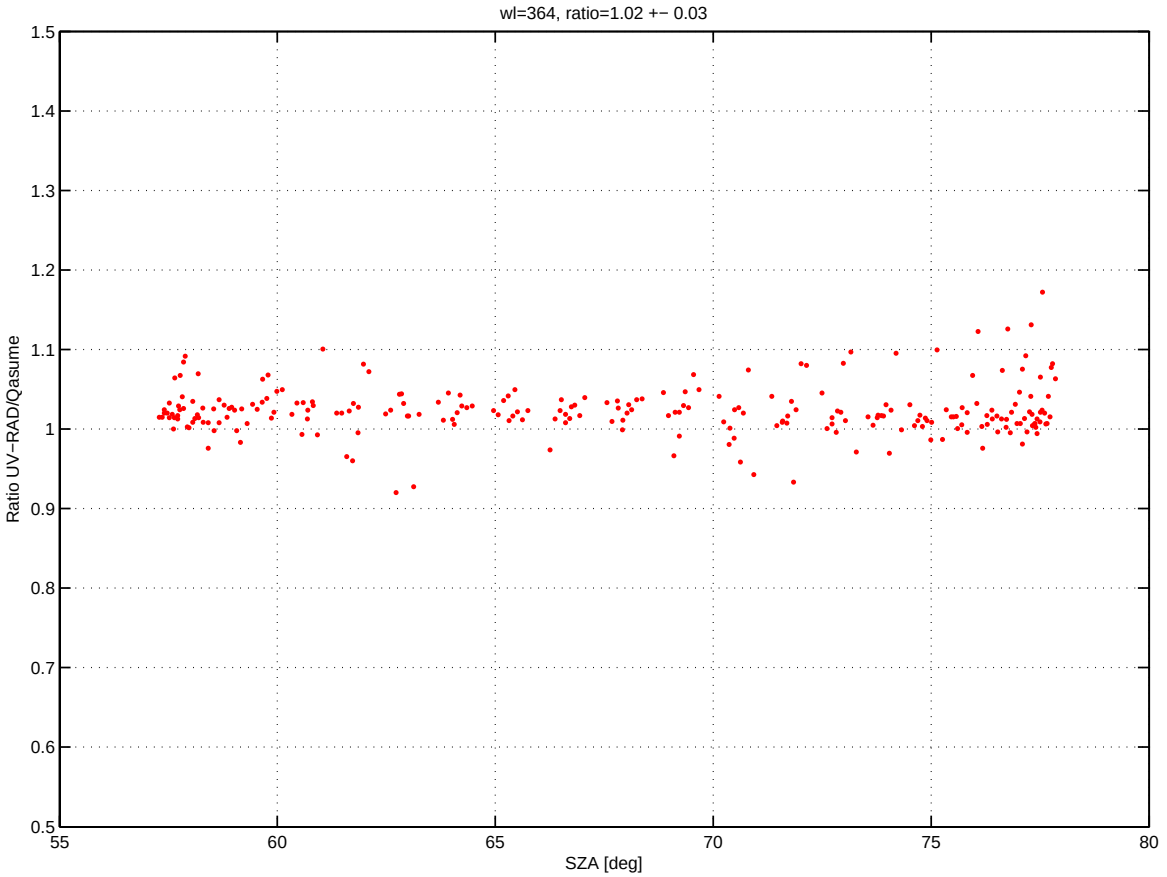

wl=325, r=0.93 +− 0.03
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

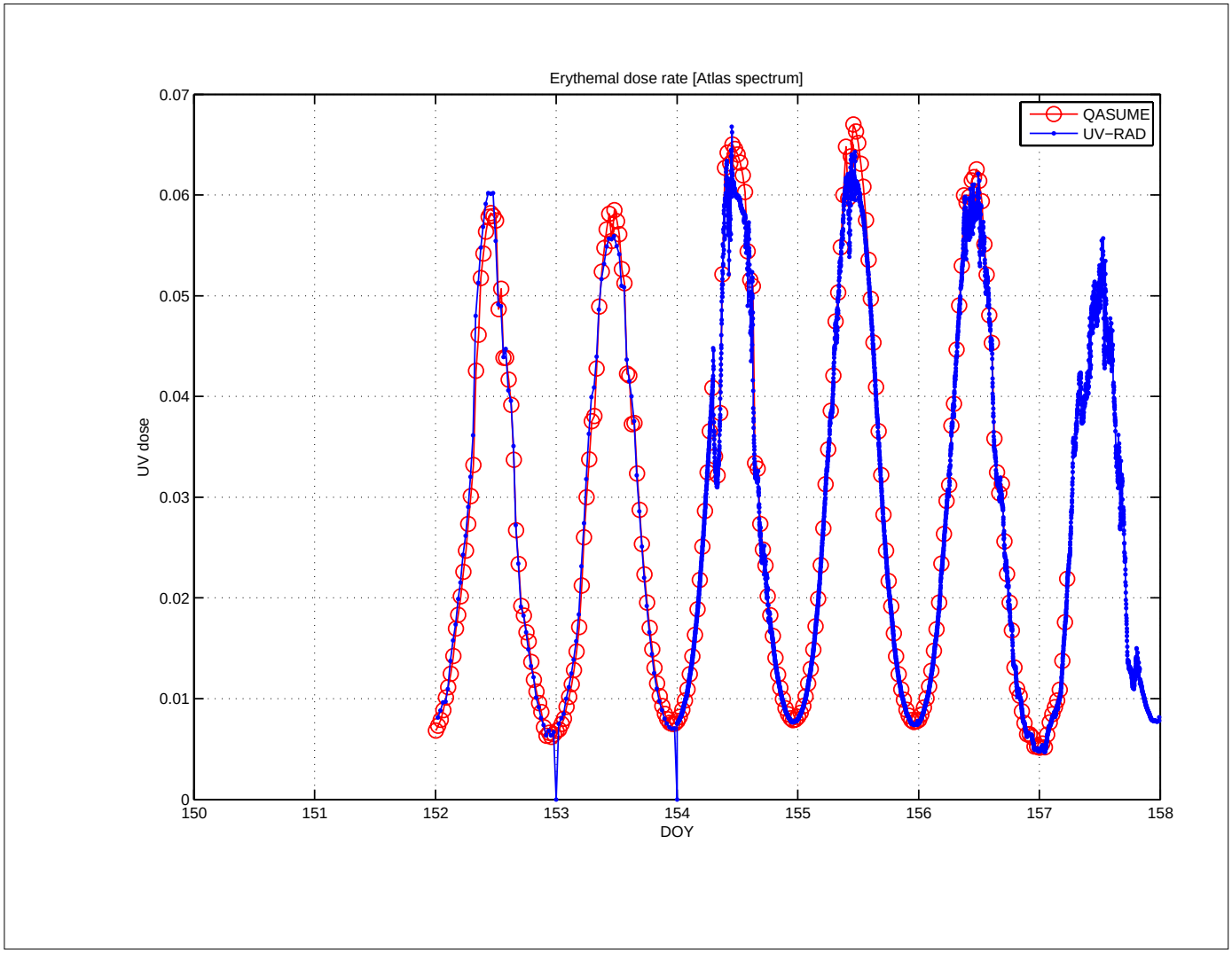

wl=325, ratio=0.93 +− 0.03
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

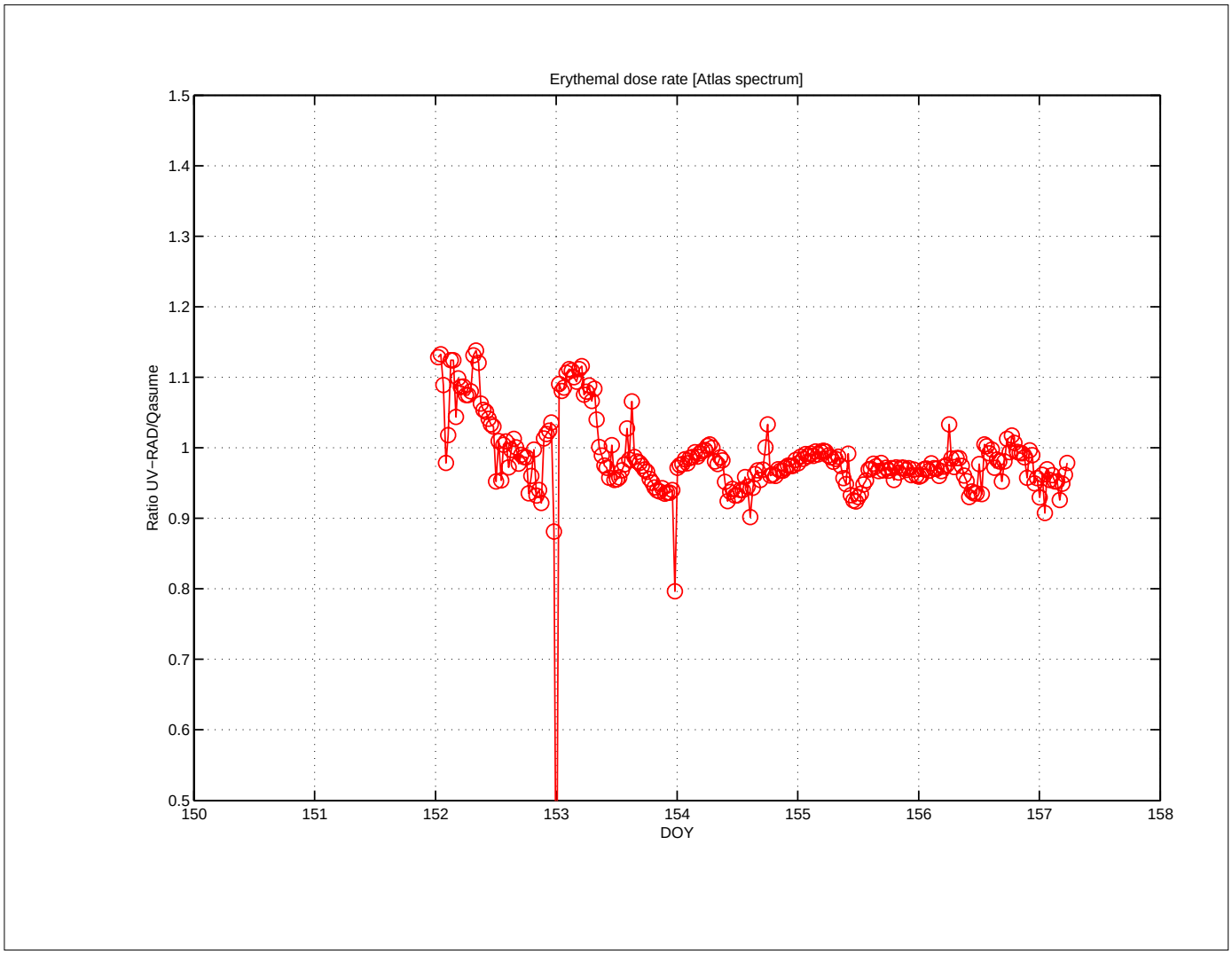

wl=338, r=0.99 +− 0.05
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

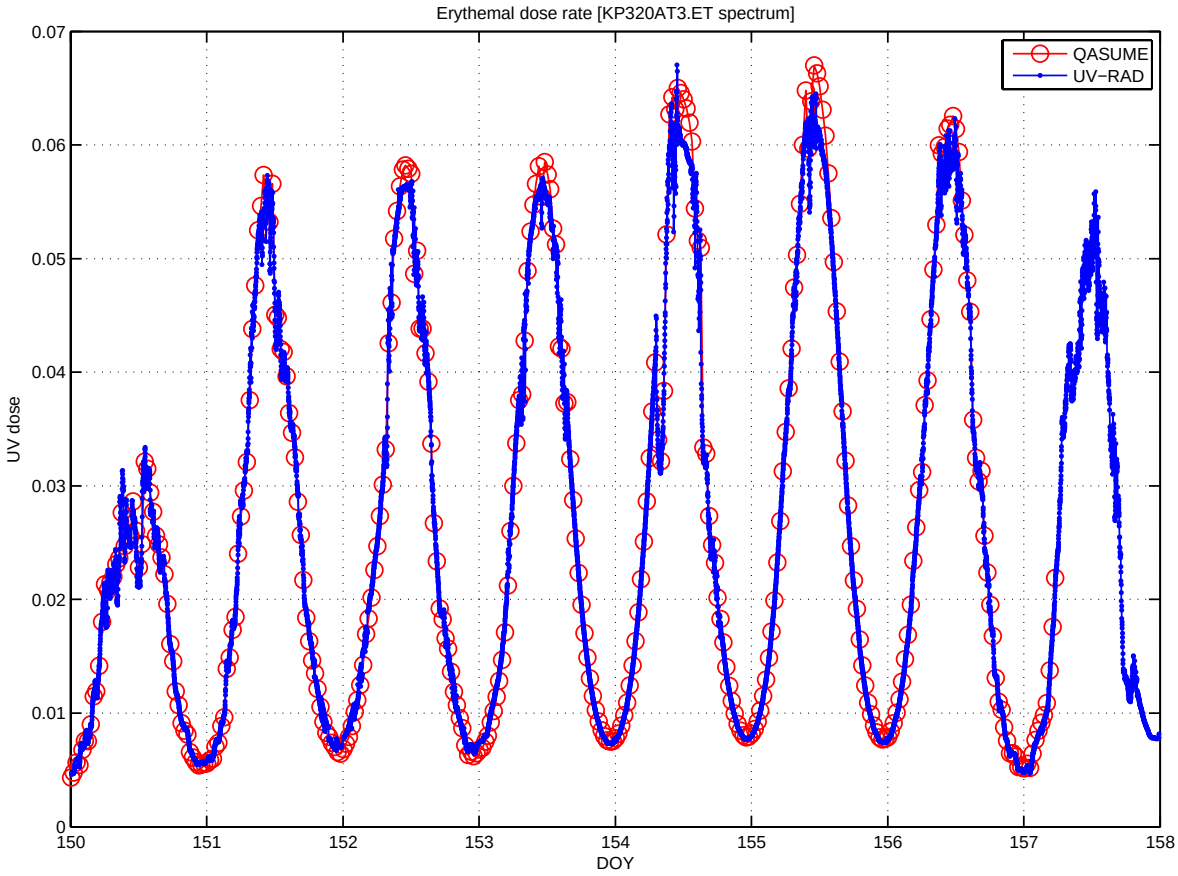

wl=338, ratio=0.99 +− 0.05
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

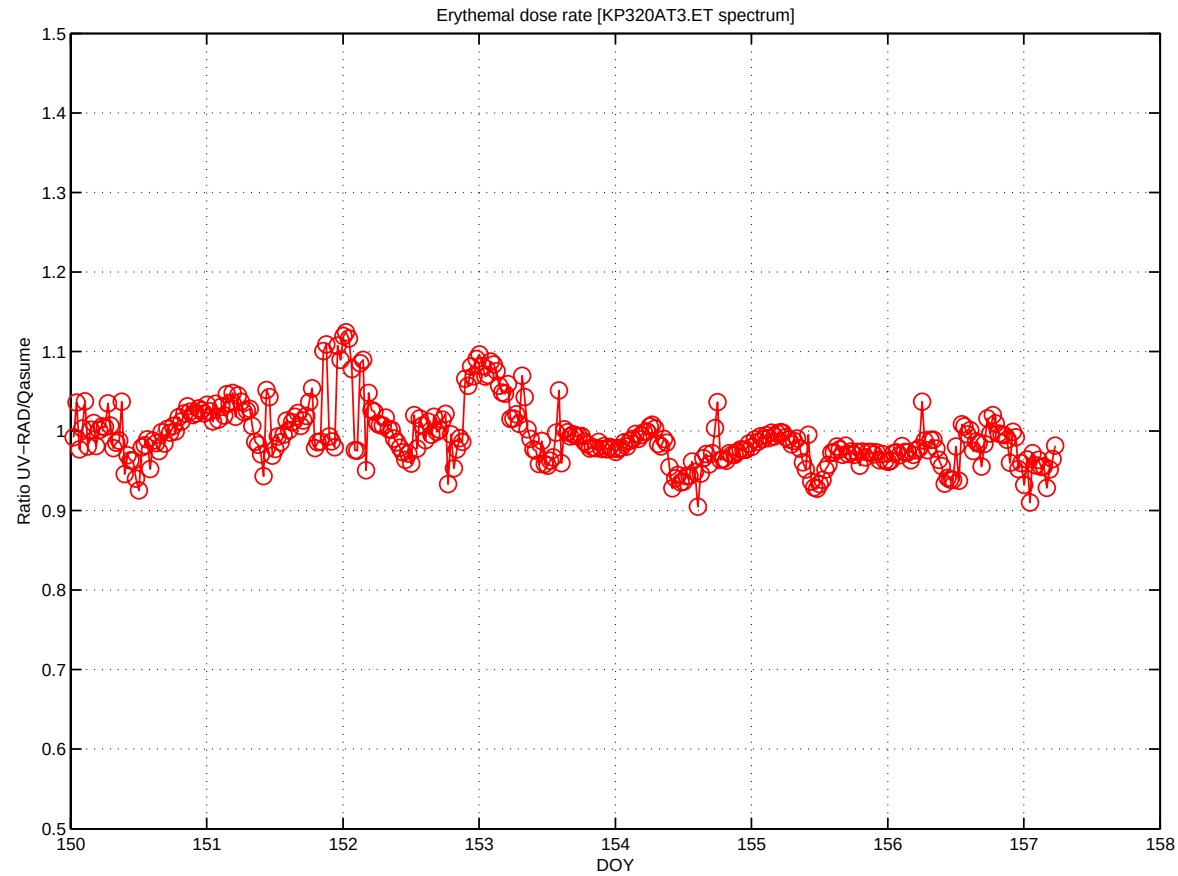

wl=364, r=1.02 +− 0.03
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
152
153
154
155
156
157
158

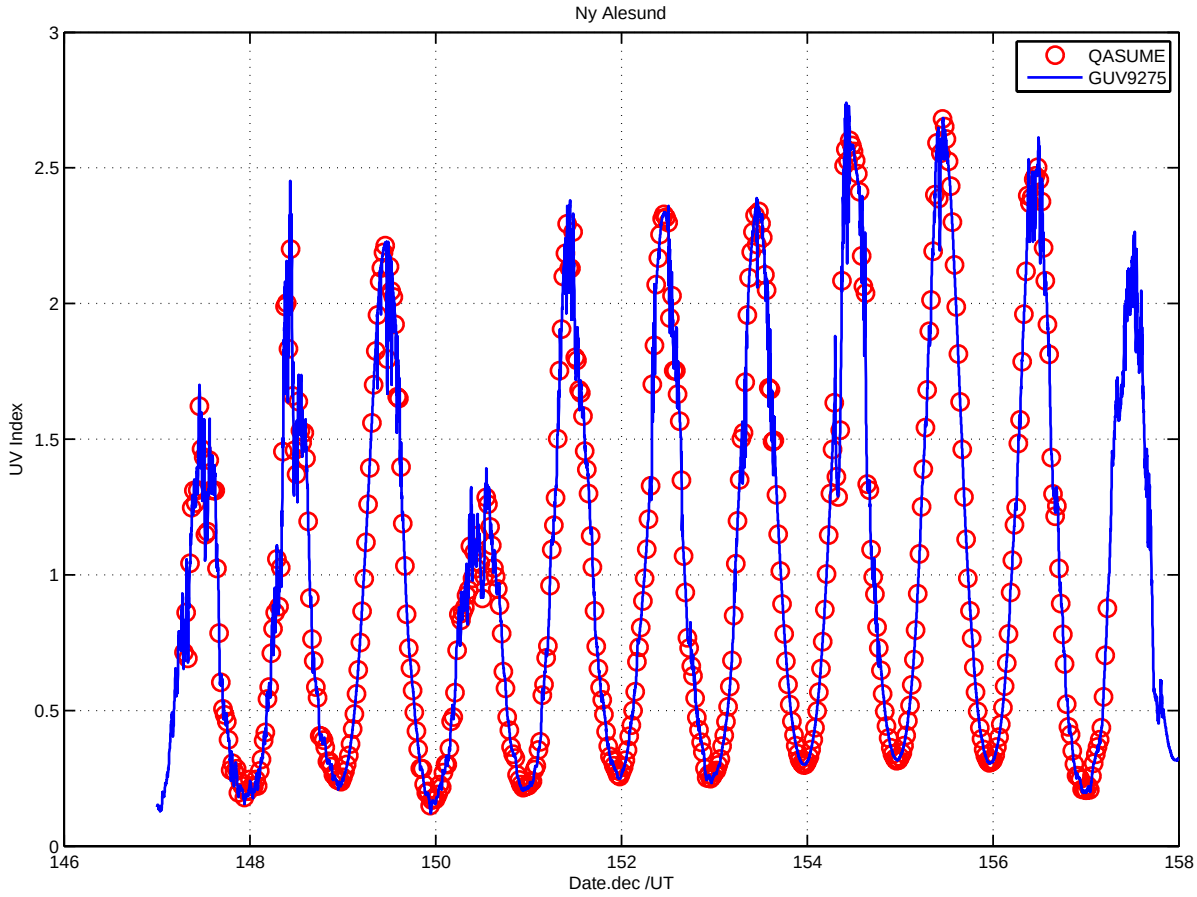

wl=364, ratio=1.02 +− 0.03
Ratio UV−RAD/Qasume
SZA [deg]
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
55
60
65
70
75
80

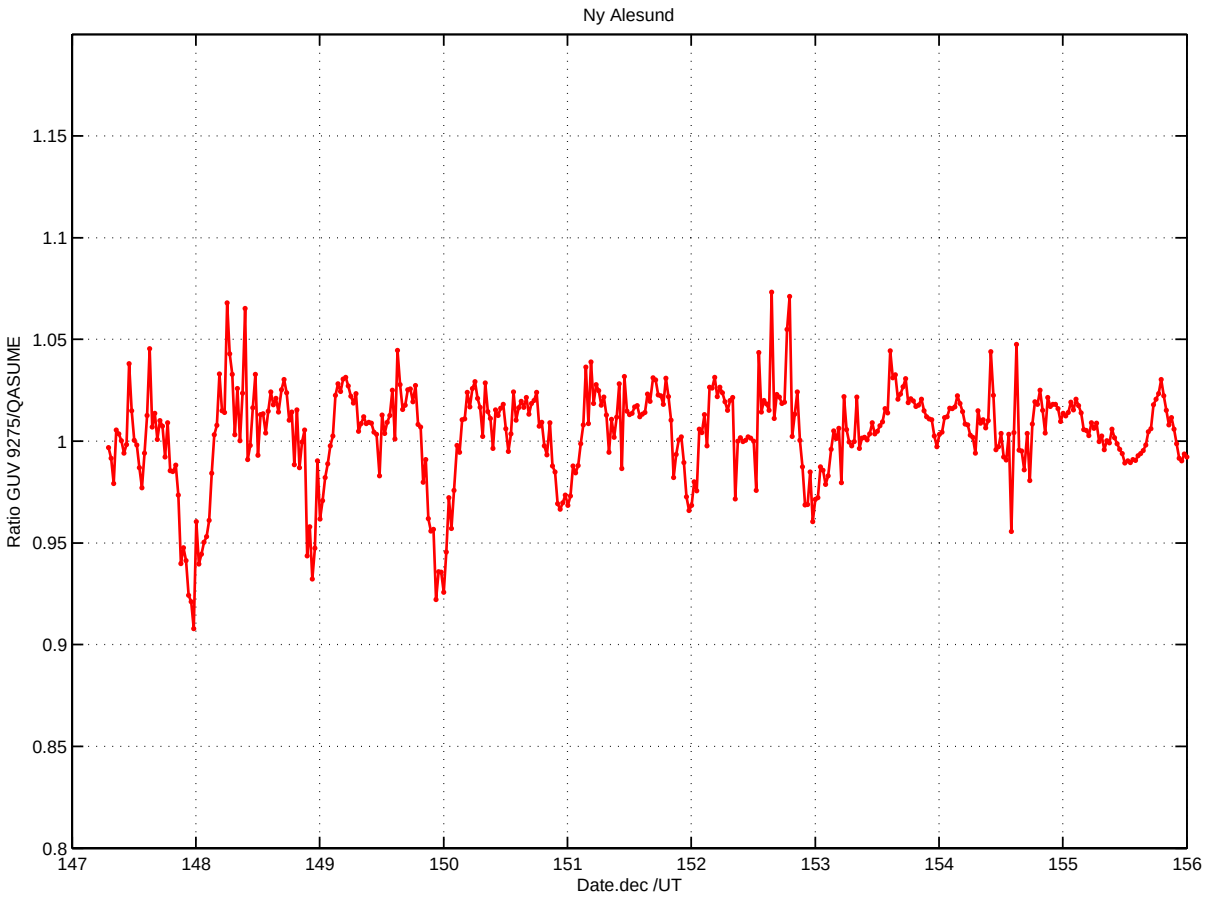

Erythemal dose rate [Atlas spectrum]
QASUME
UV−RAD
UV dose
DOY
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
150
151
152
153
154
155
156
157
158

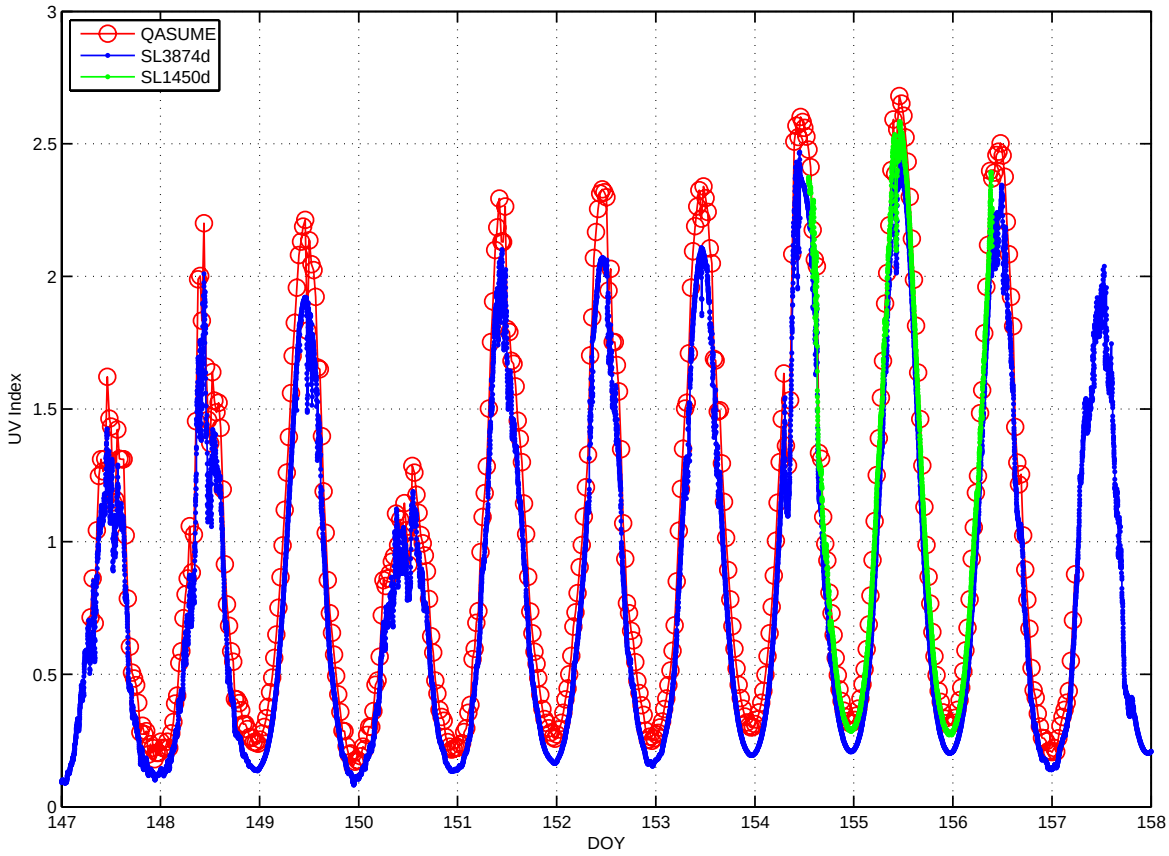

Erythemal dose rate [Atlas spectrum]
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
150
151
152
153
154
155
156
157
158

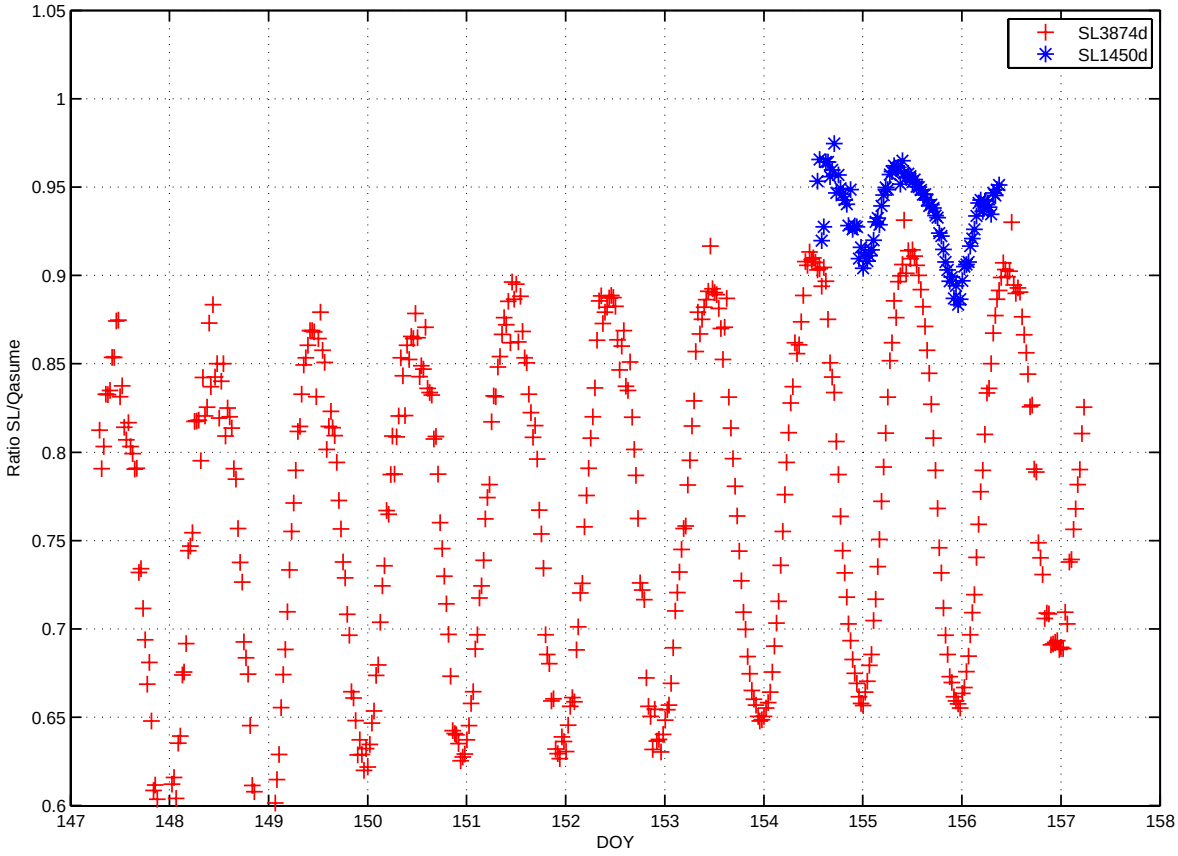

Erythemal dose rate [KP320AT3.ET spectrum]
QASUME
UV−RAD
UV dose
DOY
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
150
151
152
153
154
155
156
157
158

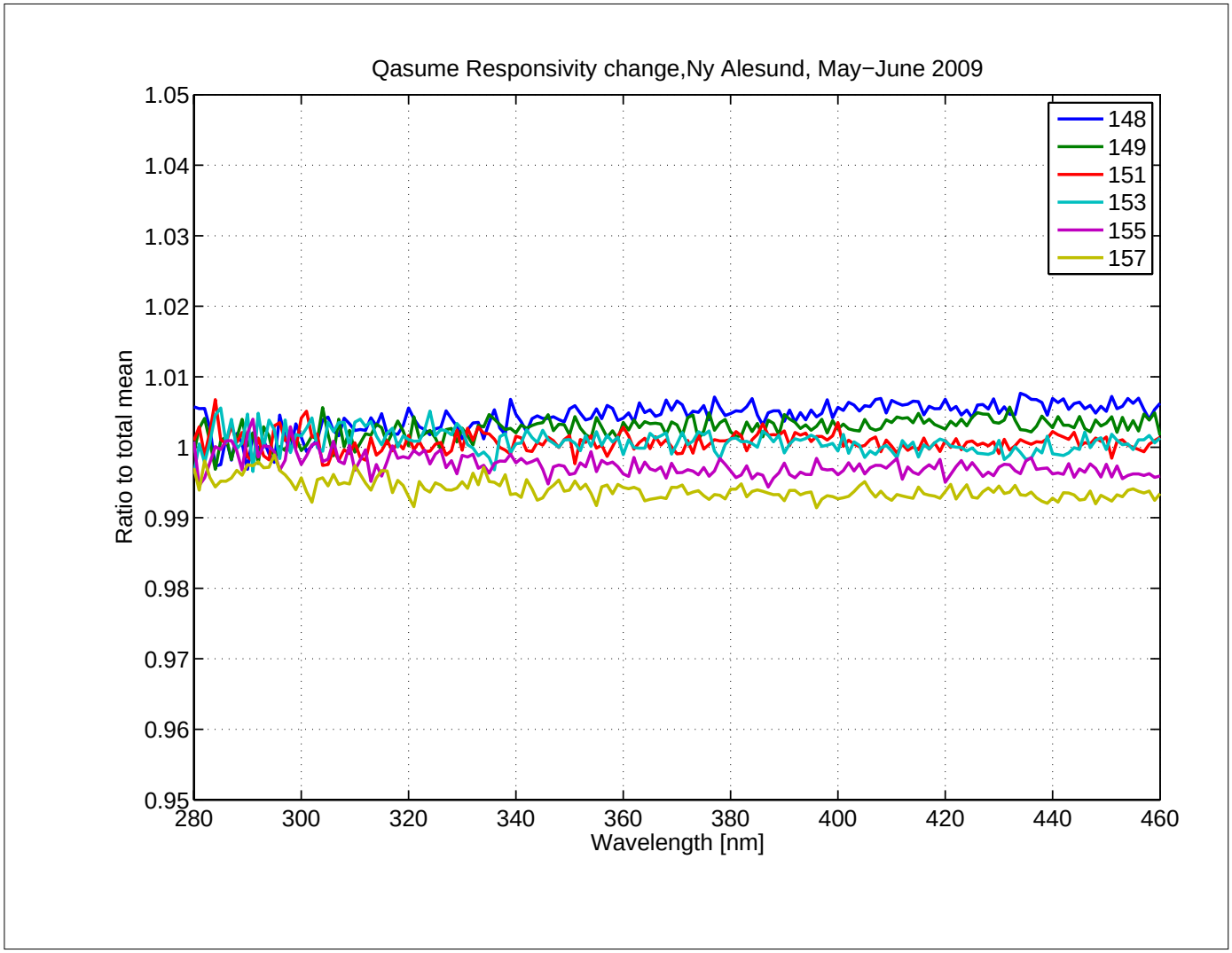

Erythemal dose rate [KP320AT3.ET spectrum]
Ratio UV−RAD/Qasume
DOY
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
150
151
152
153
154
155
156
157
158

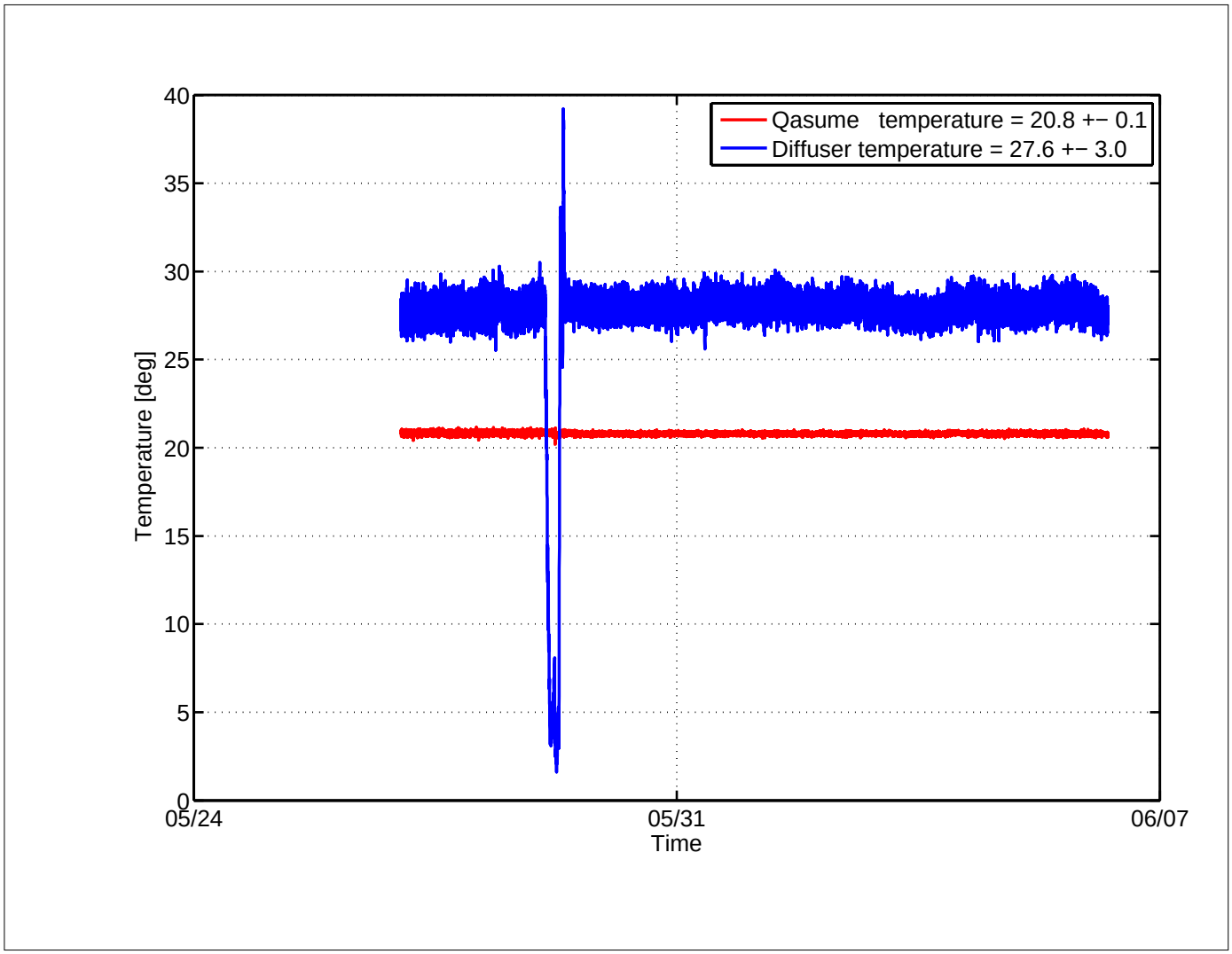

Ny Alesund
QASUME
GUV9275
UV Index
Date.dec /UT
0
0.5
1
1.5
2
2.5
3
146
148
150
152
154
156
158

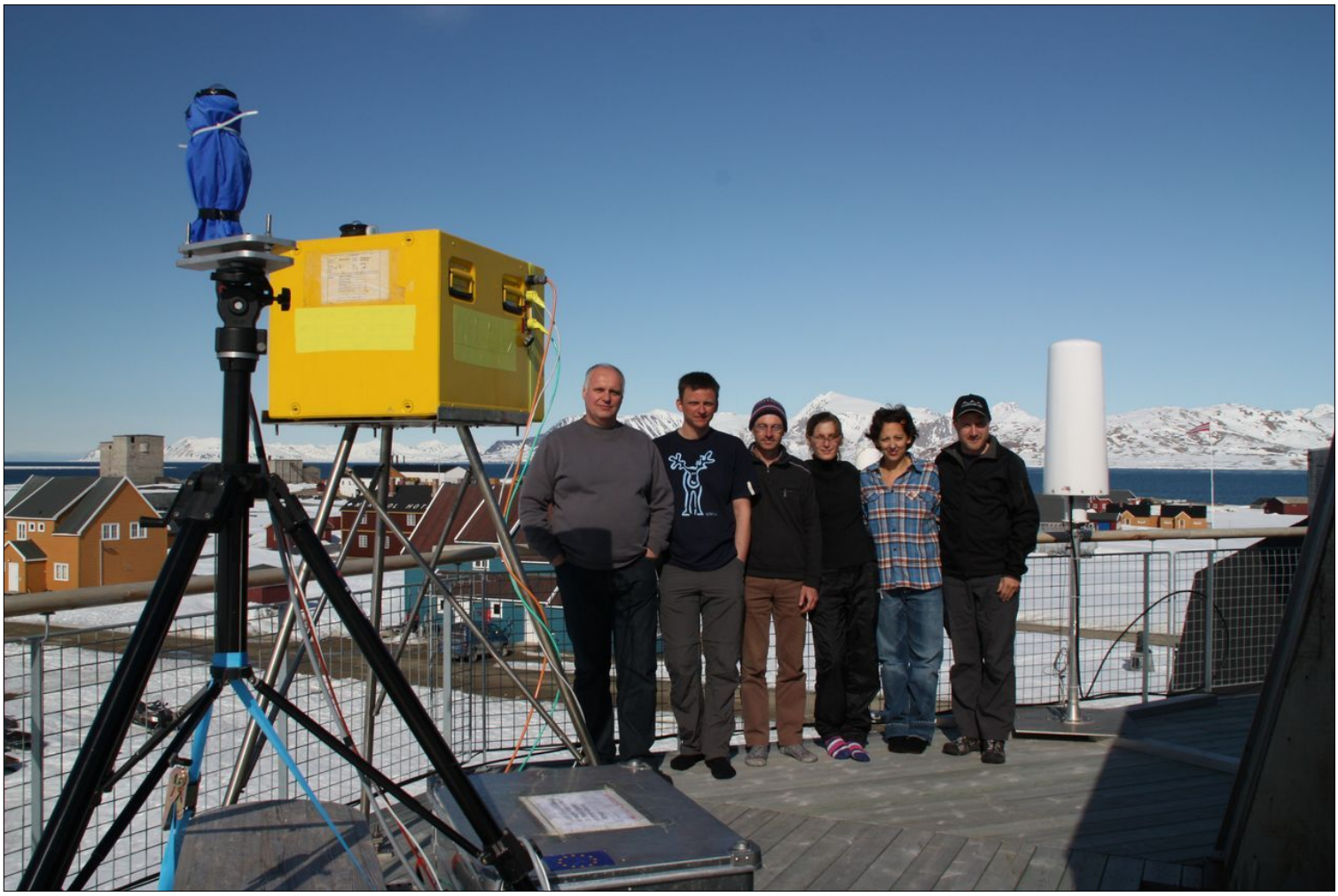

Ny Alesund
Ratio GUV 9275/QASUME
Date.dec /UT
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
147
148
149
150
151
152
153
154
155
156

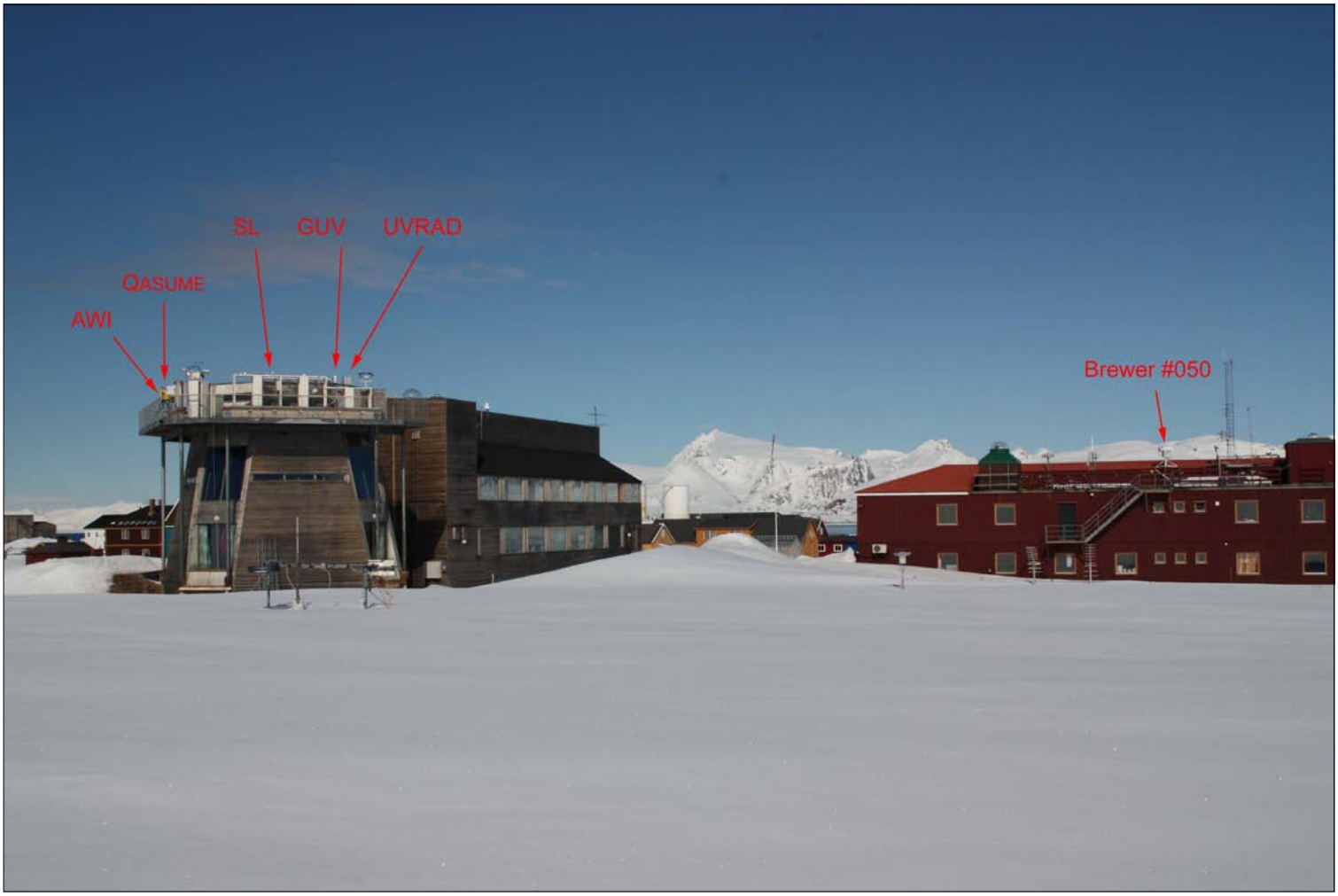

QASUME
SL3874d
SL1450d
UV Index
DOY
0
0.5
1
1.5
2
2.5
3
147
148
149
150
151
152
153
154
155
156
157
158


SL3874d
SL1450d
Ratio SL/Qasume
DOY
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
147
148
149
150
151
152
153
154
155
156
157
158


Qasume Responsivity change,Ny Alesund, May−June 2009
Ratio to total mean
Wavelength [nm]
148
149
151
153
155
157
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
420
440
460


Qasume temperature = 20.8 +− 0.1
Diffuser temperature = 27.6 +− 3.0
Temperature [deg]
Time
40
35
30
25
20
15
10
5
0
05/24
05/31
06/07




SL
GUV
UVRAD
QASUME
AWI
Brewer #050