Protocol of the intercomparison at University of Reading, Reading, England on June 27 to July 02, 2012 with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Gregor Hülsen

Operator: Gregor Hülsen, Luca Egli and Julian Gröbner

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer UKR operated and managed by the University of Manchester (hosted by the University of Reading) and the travel reference spectroradiometer QASUME. The measurement site is located in Reading; Latitude 51.44 N, Longitude 0.94 W and altitude 50 m.a.s.l.
The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 4:30 UT and 19:00 UT have been analysed.
The site was relocated recently to a temporary hutch. Therefore the situation at the measurement site was not representative of the normal working environment. Because of a joint campaign together with another site visit nearby a reschedule was not possible.

QASUME was installed at Reading at noon of June 27, 2012. The spectroradiometer was installed next to the UKR instrument with the entrance optic of QASUME within 2 m of UKR. The spectroradiometer in use at UKR is a Bentham DM150 double monochromator. The intercomparison between QASUME and the UKR spectroradiometer lasted six days, from the afternoon of June 27 to evening of July 2.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T68522, T68523 and T685240) 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 23.8±0.1 °C and the diffuser head was heated to a temperature of 28.1±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 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)
179	27. Jun	Wednesday	Mostly Overcasted Sky	Installed at 14:00
180	28. Jun	Thursday	Mix of Sun and Clouds Mostly Clear Sky in the afternoon (few rain drops)	8:22 calibration using T68522 (between solar scans
181	29. Jun	Friday	Mix of Sun and Clouds Strong Wind Light rain around noon	15:22 calibration using T68522 16:52 calibration using T68523 (between solar scans)
182	30. Jun	Saturday	Mix of Sun and Clouds Strong Wind Rain showers (morning)	8:56 calibration using T68522 and T685240 15:12 - 15:47 Slit Fct. Measurement
183	01. Jul	Sunday	Mix of Sun and Cloulds Rain showers	8:15 and 845 calibration using T68522 and T68523 21:15 - 22:30 ARF Measurement
184	02. Jul	Monday	Overcasted Sky with Rain	End of Campaign: 8:25

Results:

In total 34 synchronised simultaneous spectra from QASUME and UKR are available from the measurement period. Measurements between 4:30 and 19:00 UT have been analysed (SZA smaller than 90°).

Remarks:

1. The report is based on a **revised data set**. See comments of the operator for more details.
2. The ratios between UKR and QASUME have on average an offset of -7 %.
3. The diurnal variation of UKR to QASUME ratio is ±5%. Part of this variability can be addressed difficult weather conditions present throughout the campaign. Fast moving clouds prohibit a good synchronisation of the measurements between the two instruments.
4. The UKR instrument was calibrated several times during the campaign using 200 W DXW lamps traceable to one 1000 W NIST transfer standard. The calibration results are discussed in section “comments of the operator”.
5. The investigations of sensitivity changes at the beginning of the campaign revealed that the mounting of the fibre into the entrance optic was loose. The entrance optic was opened on June 30 and 3 screws were tightened.
6. The UKR Bentham Peltier Cooling System malfunctioned. It was restarted several times during the campaign. The temperature of the UKR DM150 monochromator carries therefore a high uncertainty to the nominal temperature of 22 °C.
7. The wavelength calibration of the UKR instrument was changed at the beginning of the campaign (29th June). An offset of 300pm was added to the calibration. On 30th June a restart of the control Software deleted this change and the original wavelength calibration was used for the rest of the campaign. For all solar scans the wavelength shifts of the UKR are therefore between -200pm till -350pm (original calibration, figure on page 9).

Additional Measurements

1. The slit function of UKR was measured using a HeCd Laser (325nm). This new function was used for the processing of the data.
2. The Angular Response Function of the entrance optic of UKR was measured on 1st July. The Diffuse Cosine Error of the D6-ENVIRO diffuser (Bentham) used by the UKR instrument is 0.994.

Conclusions:

The operation and reliability of the spectroradiometer has suffered from its temporary relocation in the hut. A fair and representative assessment of the quality of solar UV irradiance measurements from the UV monitoring site at Reading was therefore not possible. It is suggested to repeat the quality assurance site visit once the system has been installed at its permanent position.

Suggestions:

The following suggestions are aimed at improving the quality of spectral solar UV after the installation of the system to its new permanent location.

1. Reparation of the Peltier Cooling System
2. Further investigation of the input optics system (mounting of the fibre and the fibre itself)
3. Check of all the DM150 monochromator (slits, gratings, PMT)
4. Inspection of the irradiance calibration setup
5. Recalibration of the NIST transfer standard
6. Recalibration of the dispersion relation
7. Installation of a temperature monitoring system inside the Bentham Box.
8. **Follow up site audit with the reference spectroradiometer Qasume within the next years.**

Comments from the local operator

Our instrument is sited on the University of Reading Dept of Meteorology Atmospheric Observatory. During 2012, a major refurbishment had been planned which involved moving into a temporary hut whist work was in progress. Although the original schedule was for the work to be completed before the QASUME visit, numerous delays and disruptions resulted in the instrument still occupying the temporary hut during the intercomparison, with construction work affecting the power supply, causing severe problems with our temperature controller. In our opinion, this intercomparison was conducted at an unfortunate time given the temporary accommodations and ongoing construction site work which should have been completed weeks before but was beyond our control. We were unable to re-schedule as we were locked in to a joint visit with HPA. We do not accept that the results of this intercomparison are typical of our normal operating standard.

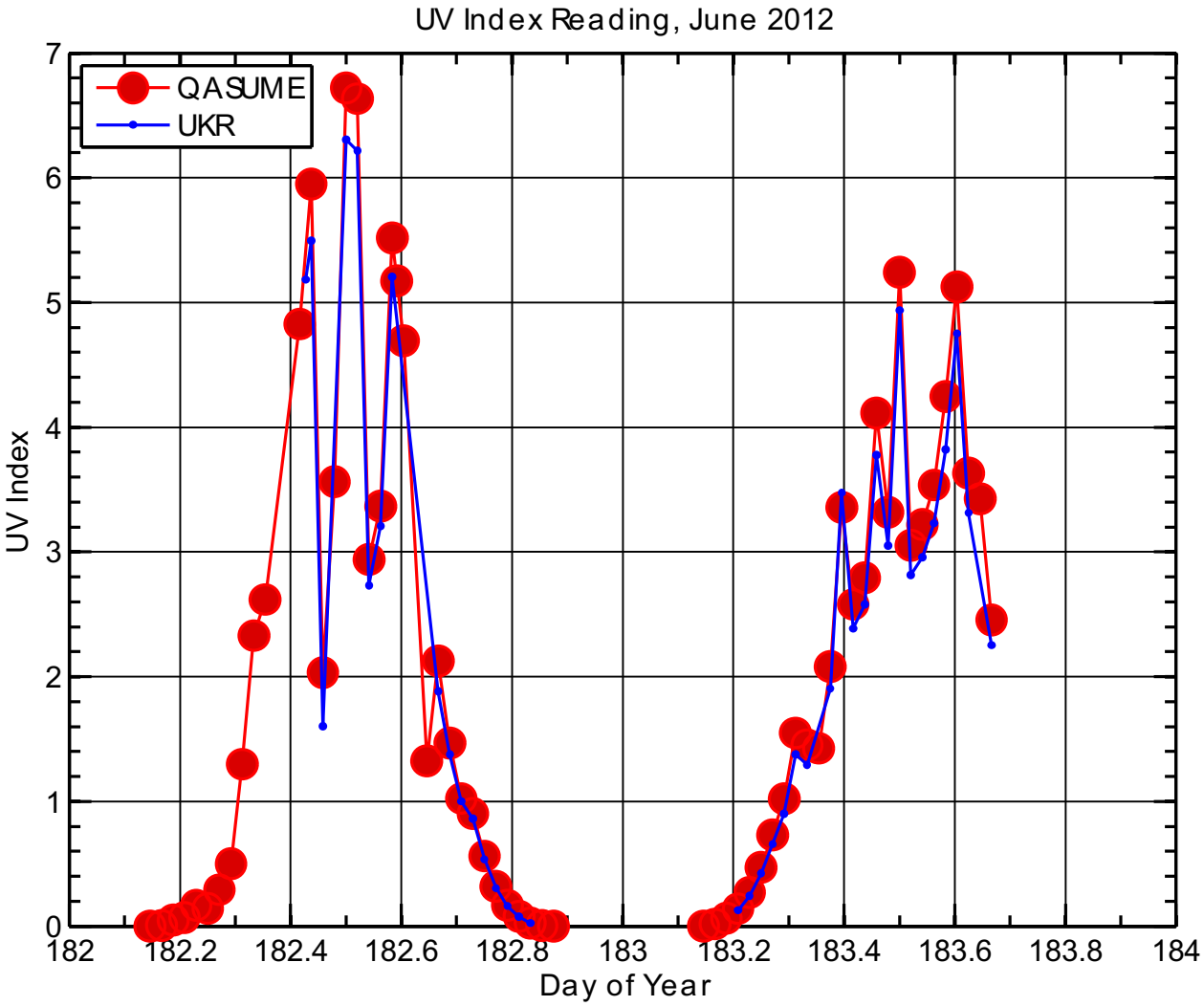
The data set was revised since it was discovered that the fibre coupling had become loose during the move and had to be retightened. We could not therefore be confident of the data taken from 27th to 29th June.

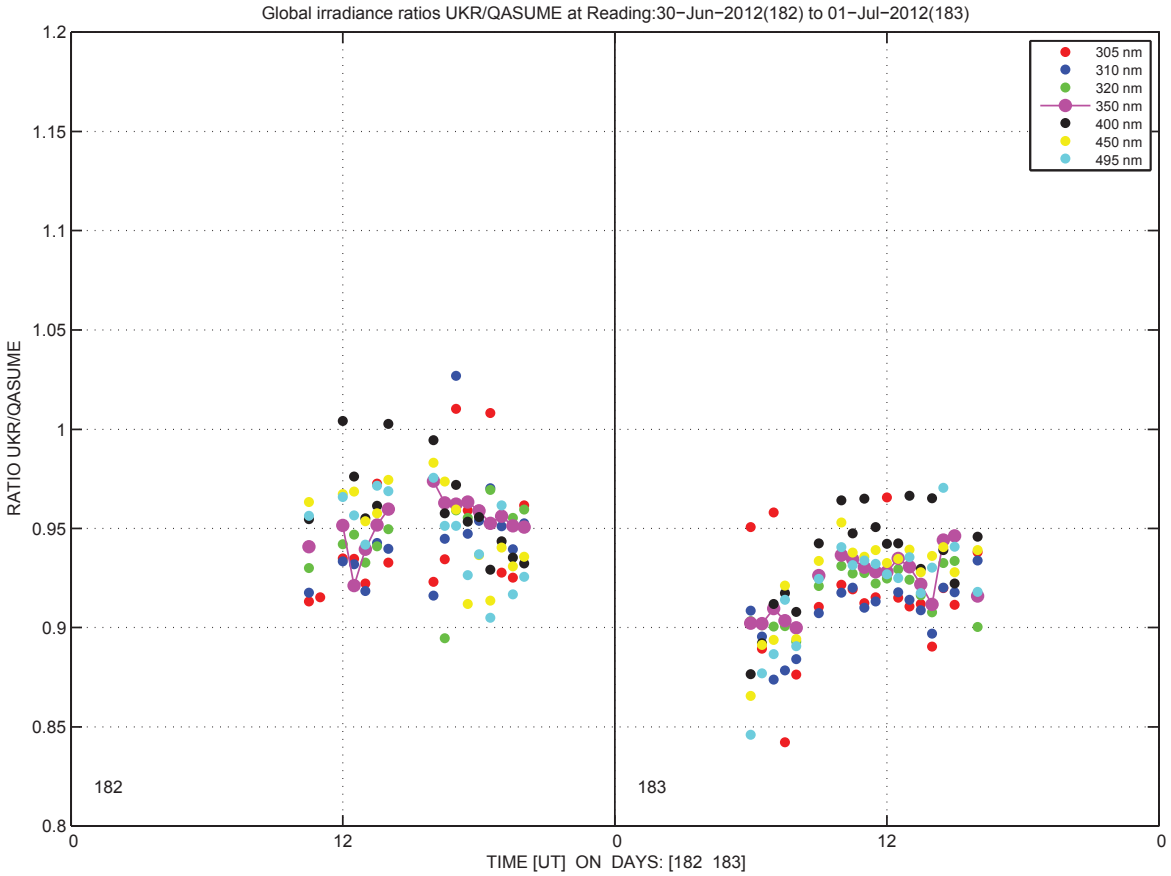
The data on the 30th June was reasonable given that we calibrate against the NIST standard but the data from 1st July had changed by about 3%. Significantly, there had been one of the numerous temperature controller interruptions and after checking the calibration that morning that too was changed by ~ 3% which could be the cause of the change in the data.

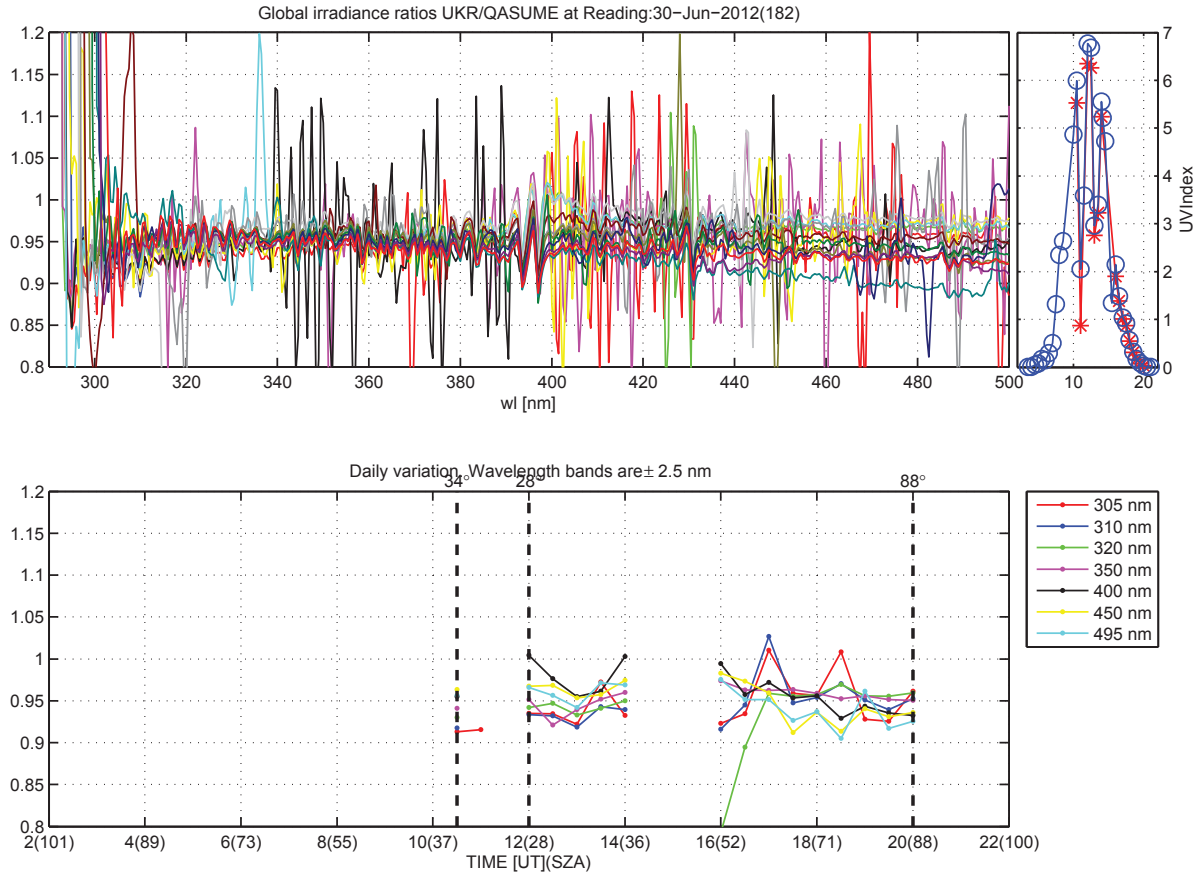
We therefore cannot accept that the absolute comparison has been in any way conclusive and hope to arrange a further visit in the near future. However, since moving the instrument into the new permanent accommodation and the absence of building contractors, 3 out of four calibrations have been stable within 1% and the 4th within 2%.

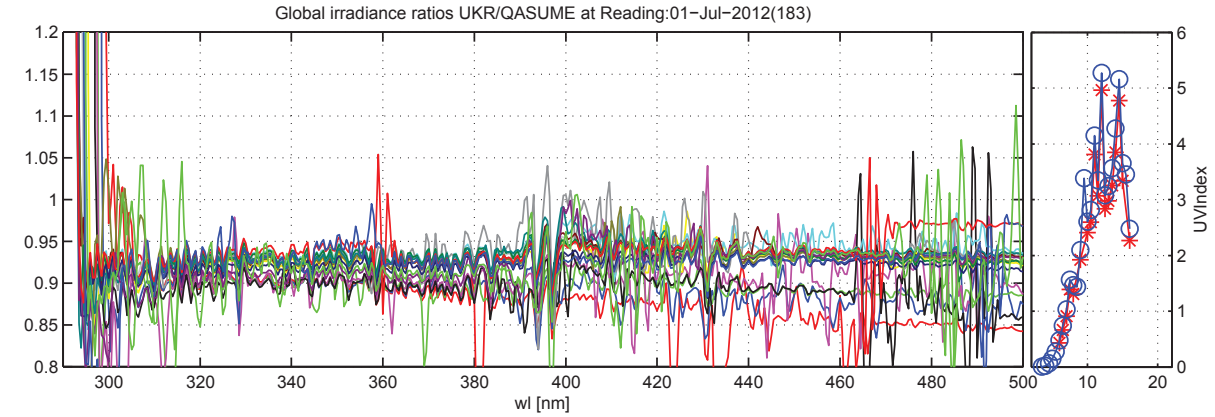
We agree that the dispersion relationship can be improved by re-writing the software; however the wavelength calibration is still well within the correctional abilities of the ShicRIVM processing software.

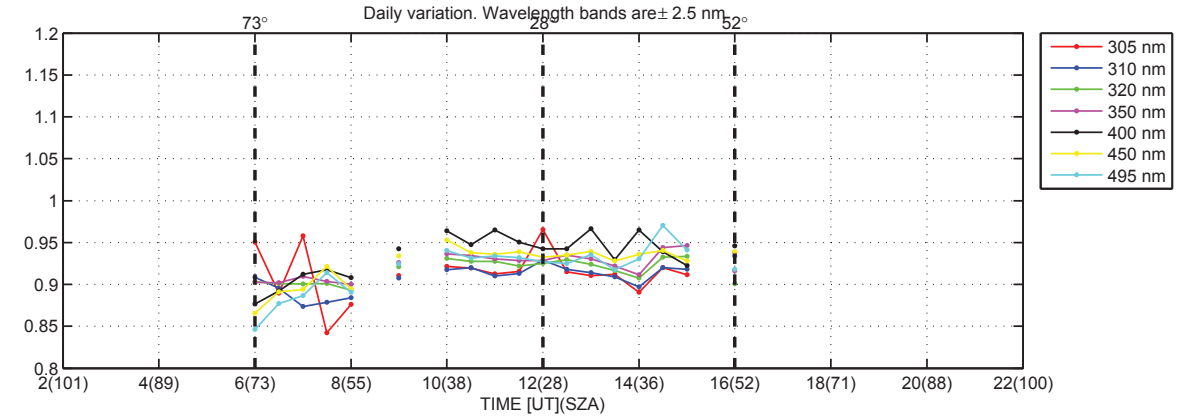
The instrument will be checked and serviced if necessary in an effort to determine the cause of the diurnal variation.

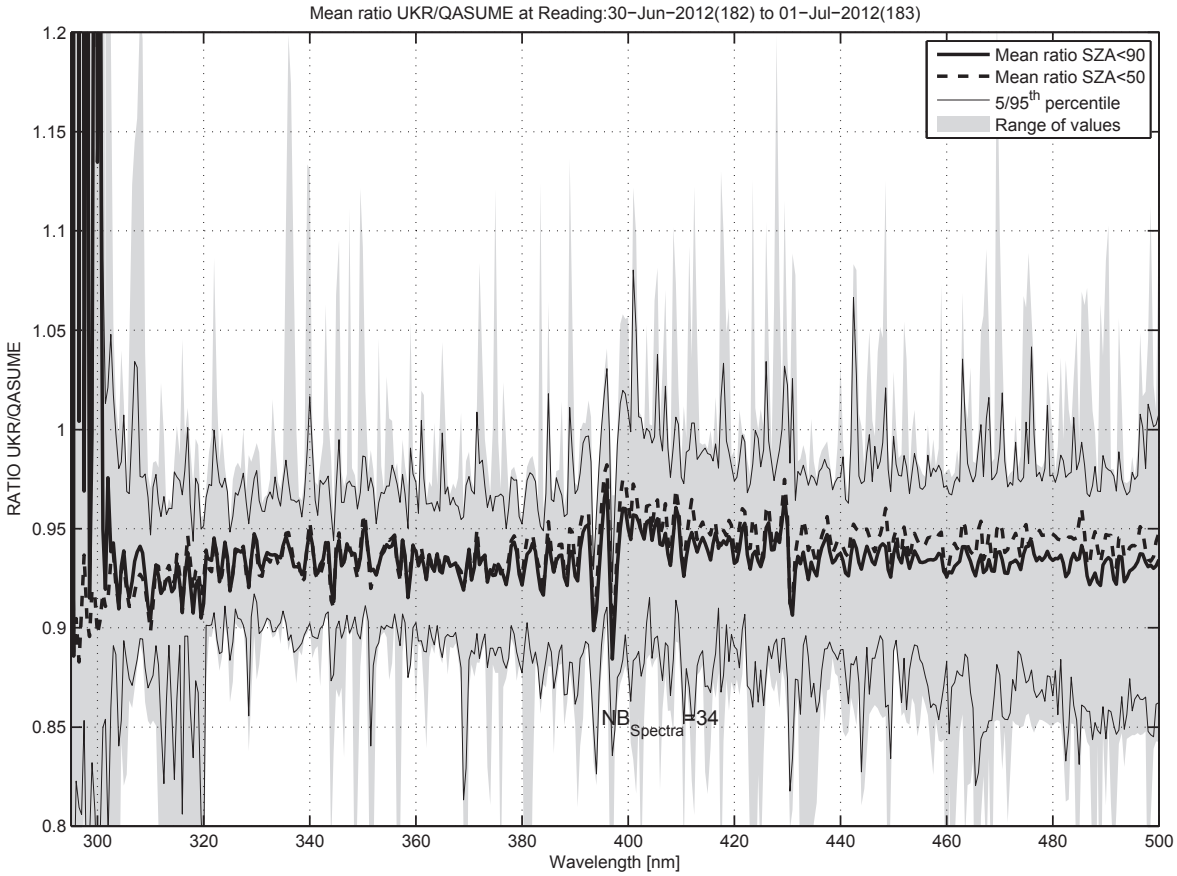

UV Index Reading, June 2012
QASUME
UKR
UV Index
Day of Year
0
1
2
3
4
5
6
7
182
182.2
182.4
182.6
182.8
183
183.2
183.4
183.6
183.8
184

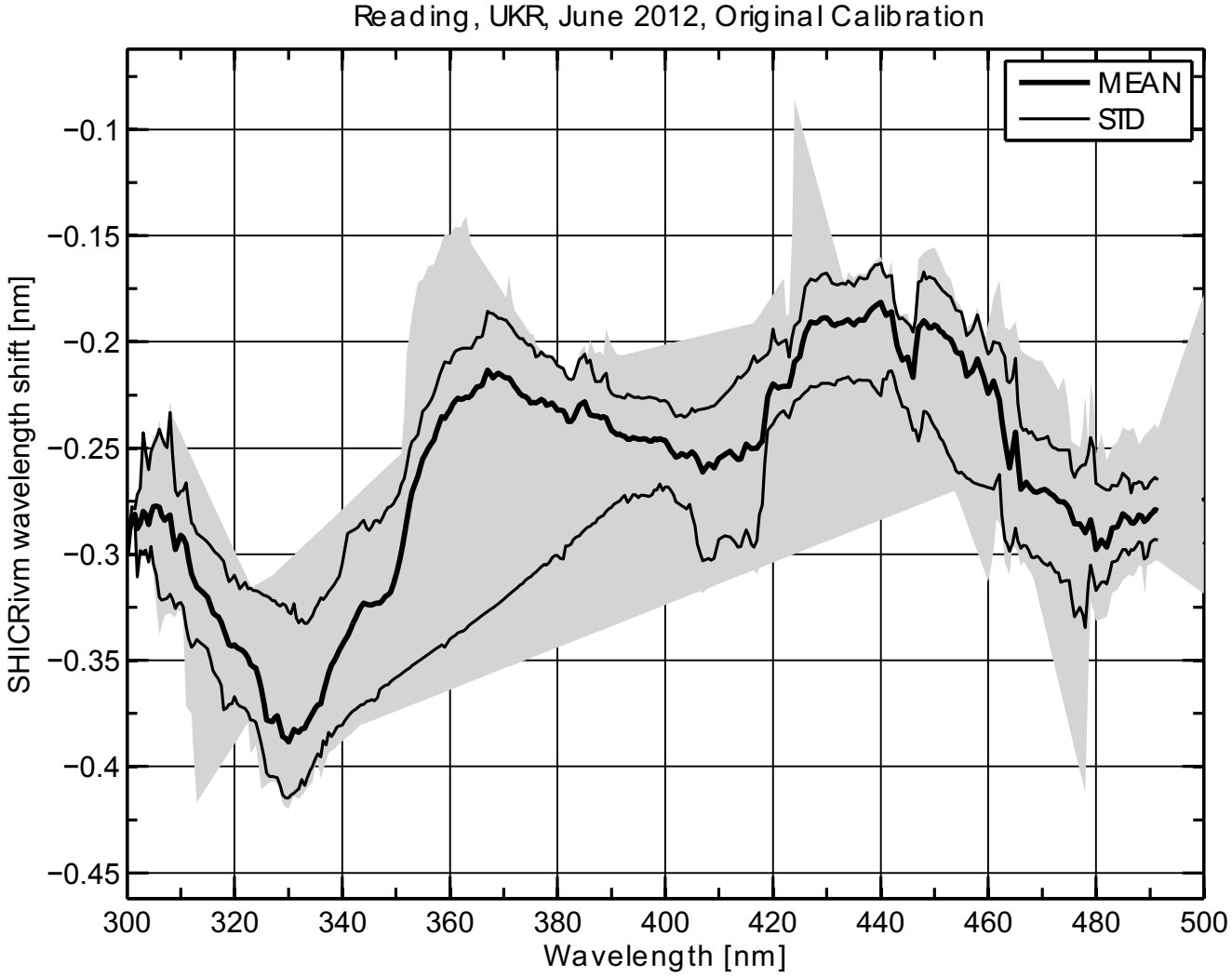

Global irradiance ratios UKR/QASUME at Reading:30−Jun−2012(182) to 01−Jul−2012(183)
RATIO UKR/QASUME
TIME [UT] ON DAYS: [182 183]
182
183
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm

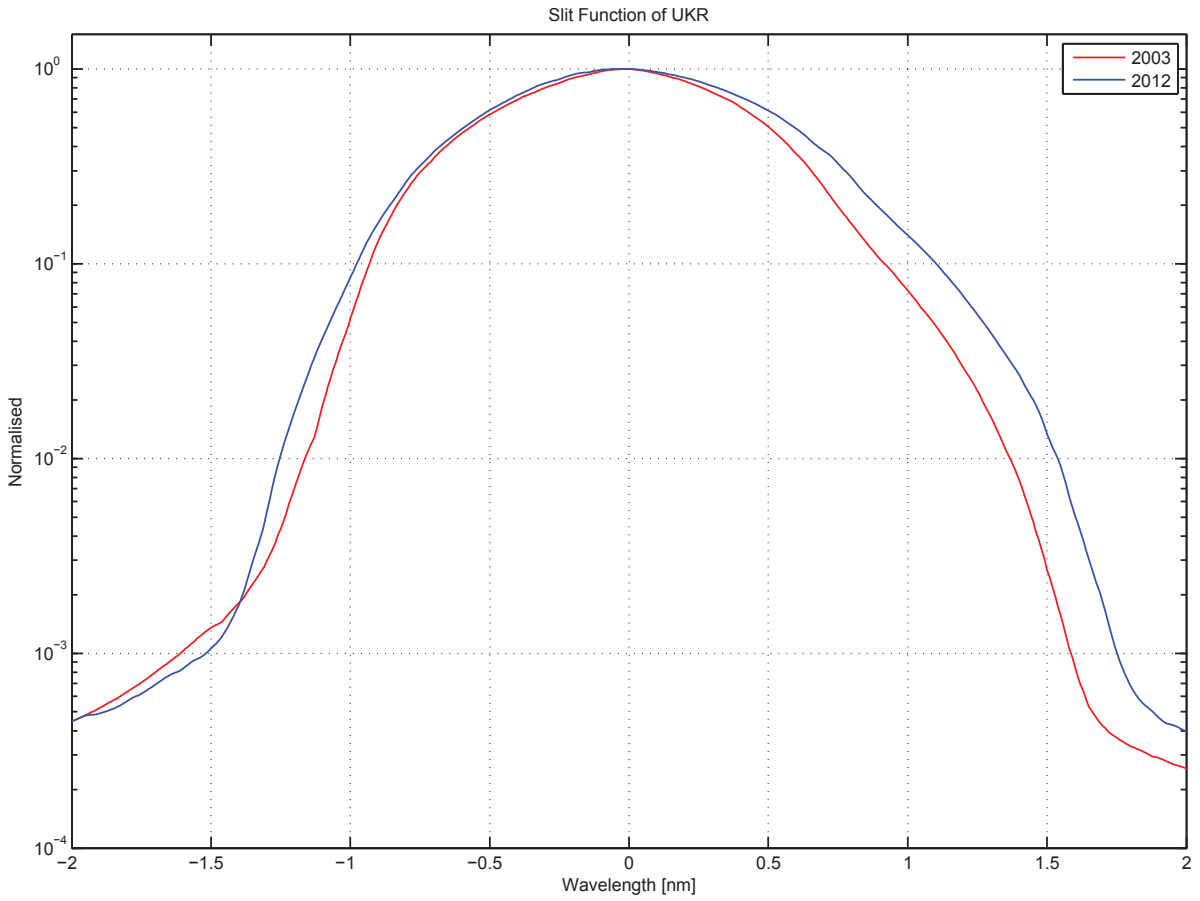

Global irradiance ratios UKR/QASUME at Reading:30−Jun−2012(182)
wl [nm]
UVIndex
Daily variation, Wavelength bands are± 2.5 nm
34°
28°
88°
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm

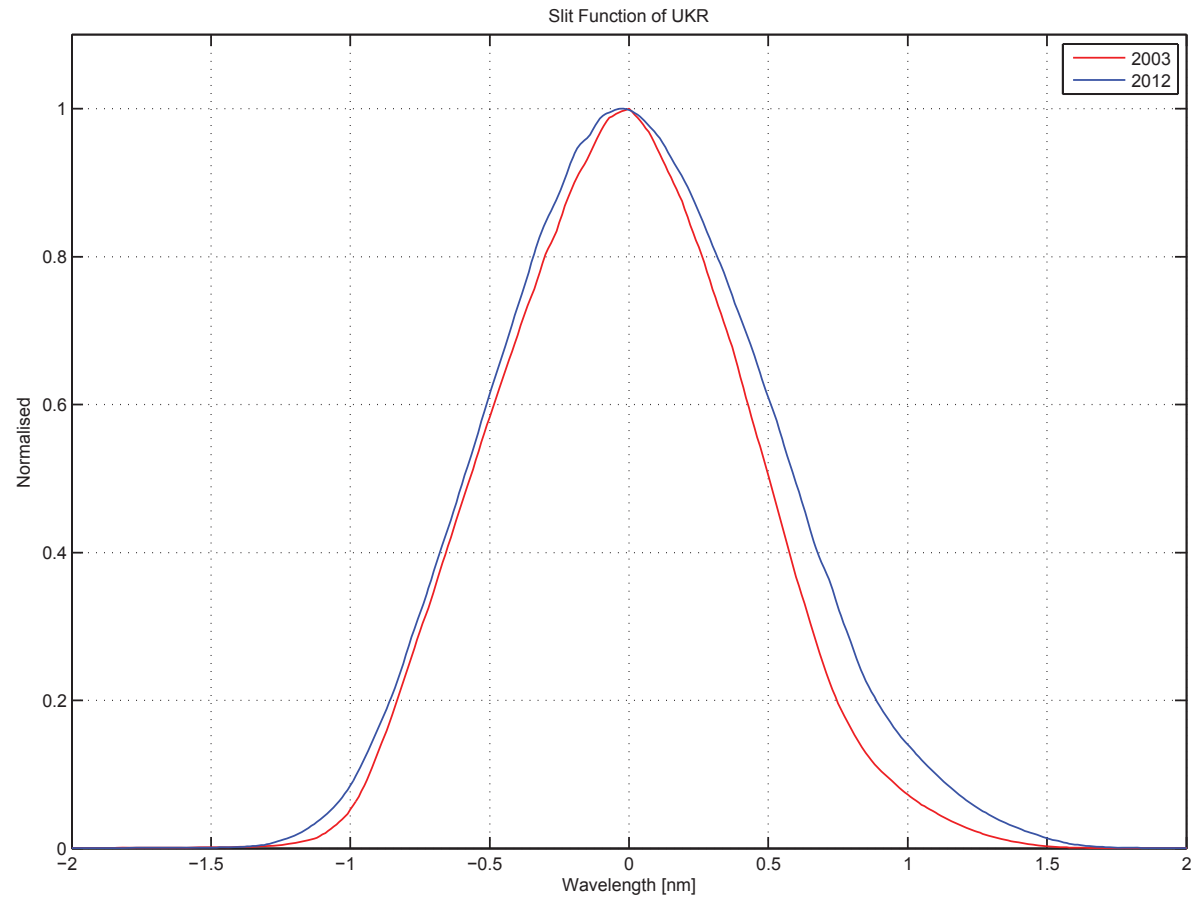

Global irradiance ratios UKR/QASUME at Reading:01−Jul−2012(183)
wl [nm]
UVIndex

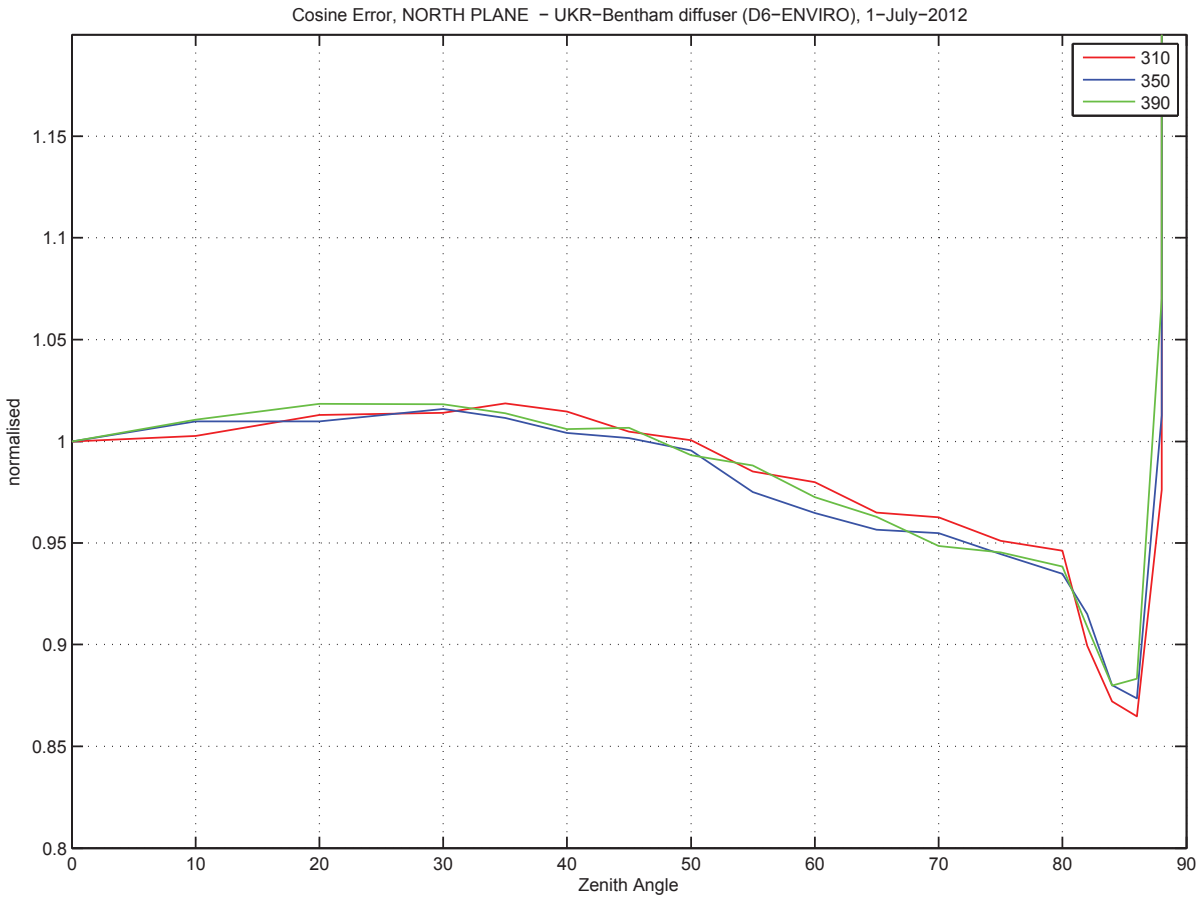

Daily variation. Wavelength bands are± 2.5 nm
73°
28°
52°
305 nm
310 nm
320 nm
350 nm
400 nm
450 nm
495 nm
TIME [UT](SZA)

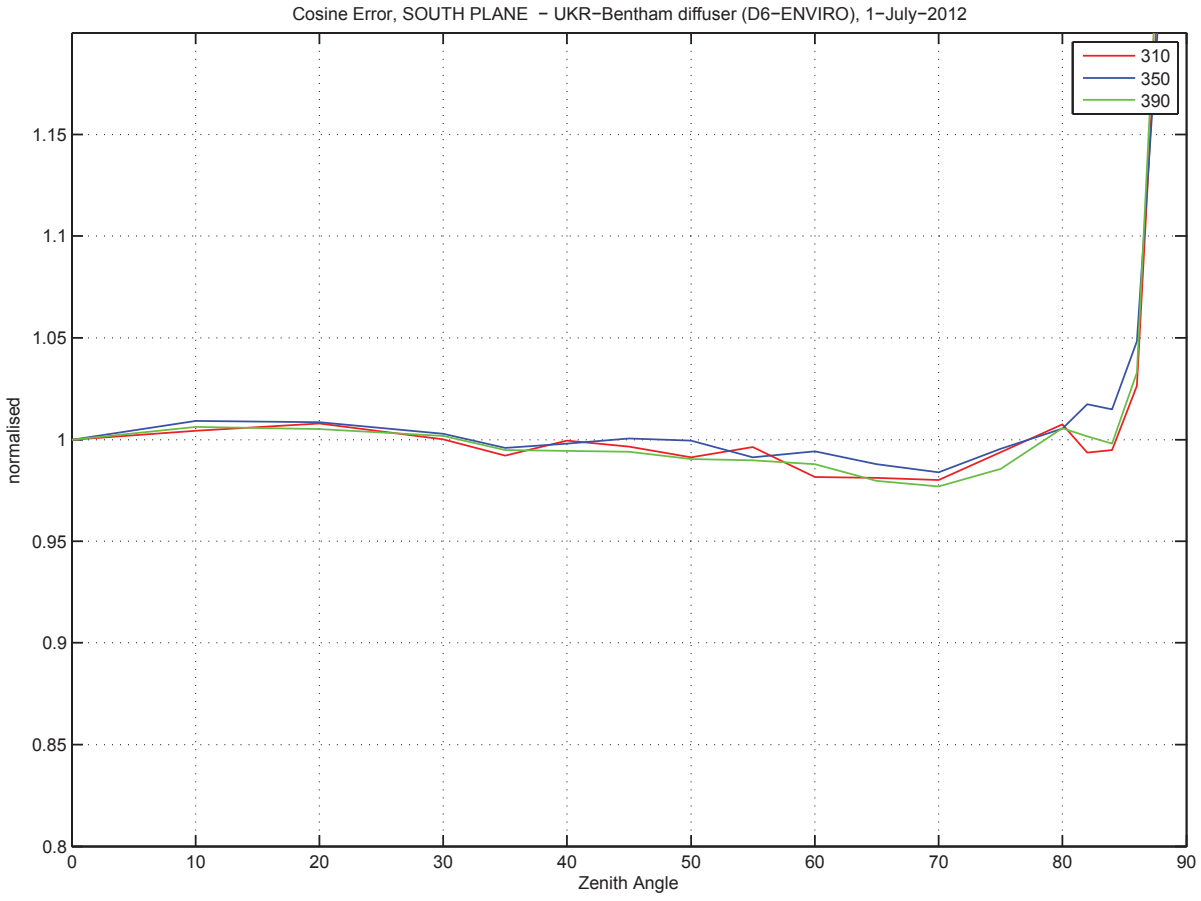

Mean ratio UKR/QASUME at Reading:30−Jun−2012(182) to 01−Jul−2012(183)
Mean ratio SZA<90
Mean ratio SZA<50
5/95th percentile
Range of values
RATIO UKR/QASUME
NBSpectra=34
Wavelength [nm]

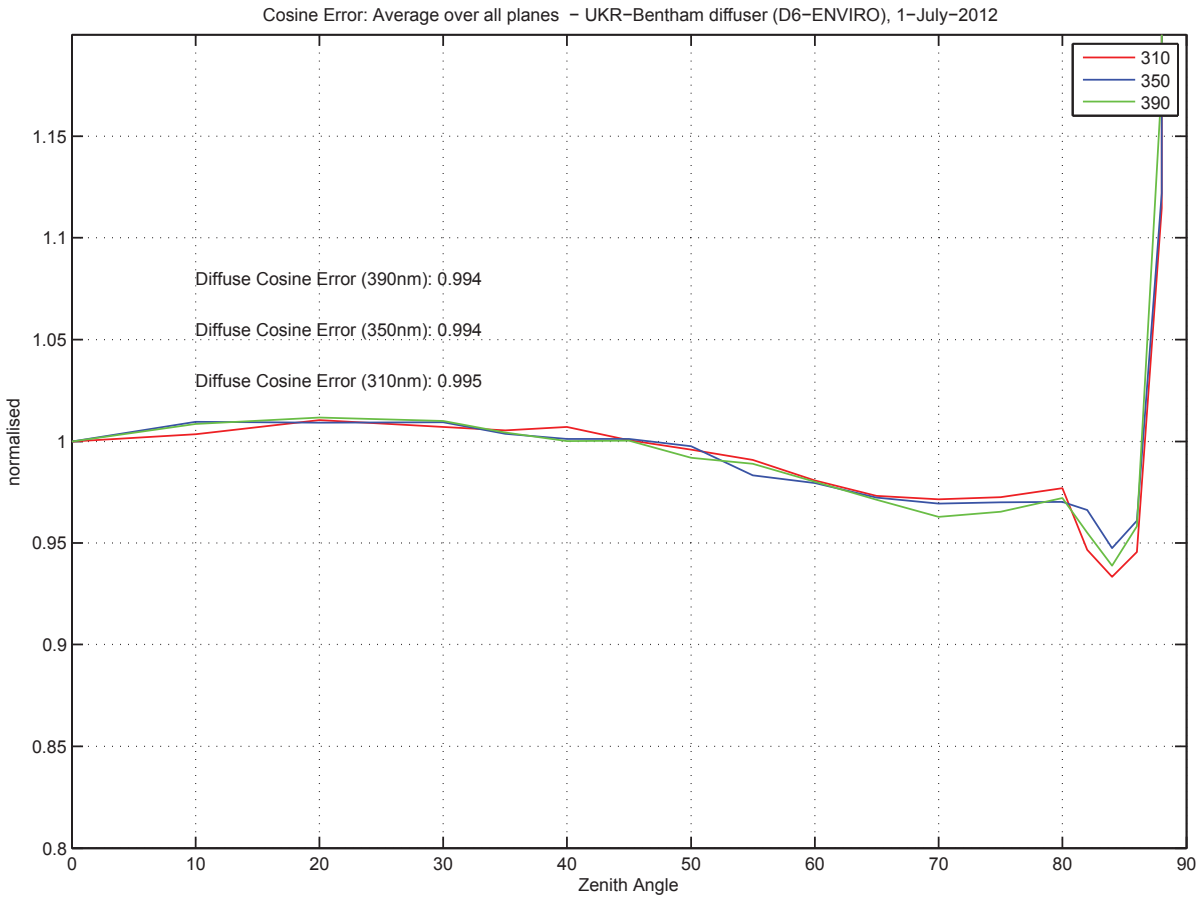

Reading, UKR, June 2012, Original Calibration
MEAN
STD
SHICRivm wavelength shift [nm]
−0.1
−0.15
−0.2
−0.25
−0.3
−0.35
−0.4
−0.45
300
320
340
360
380
400
420
440
460
480
500
Wavelength [nm]

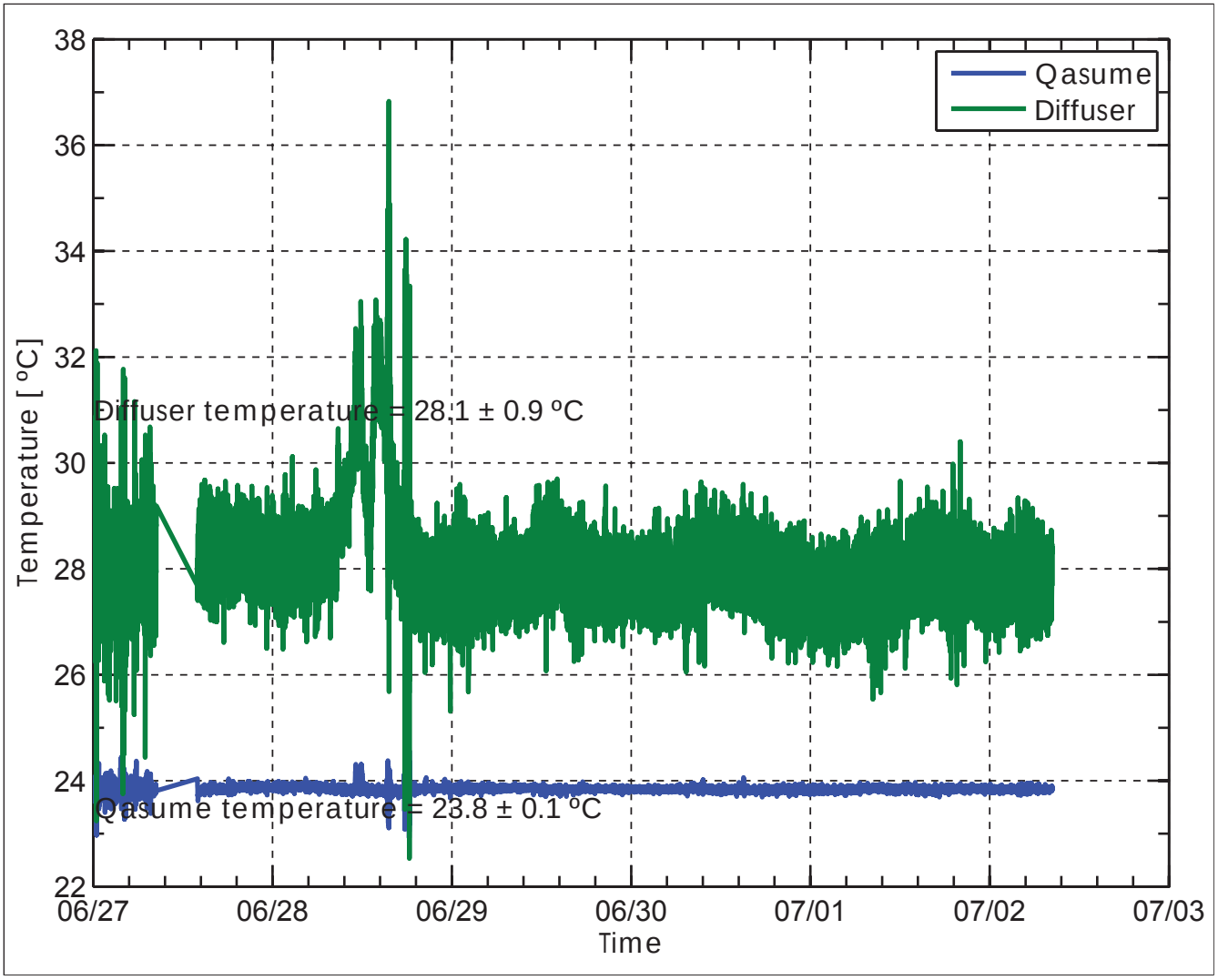

Slit Function of UKR
2003
2012
Normalised
Wavelength [nm]
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2

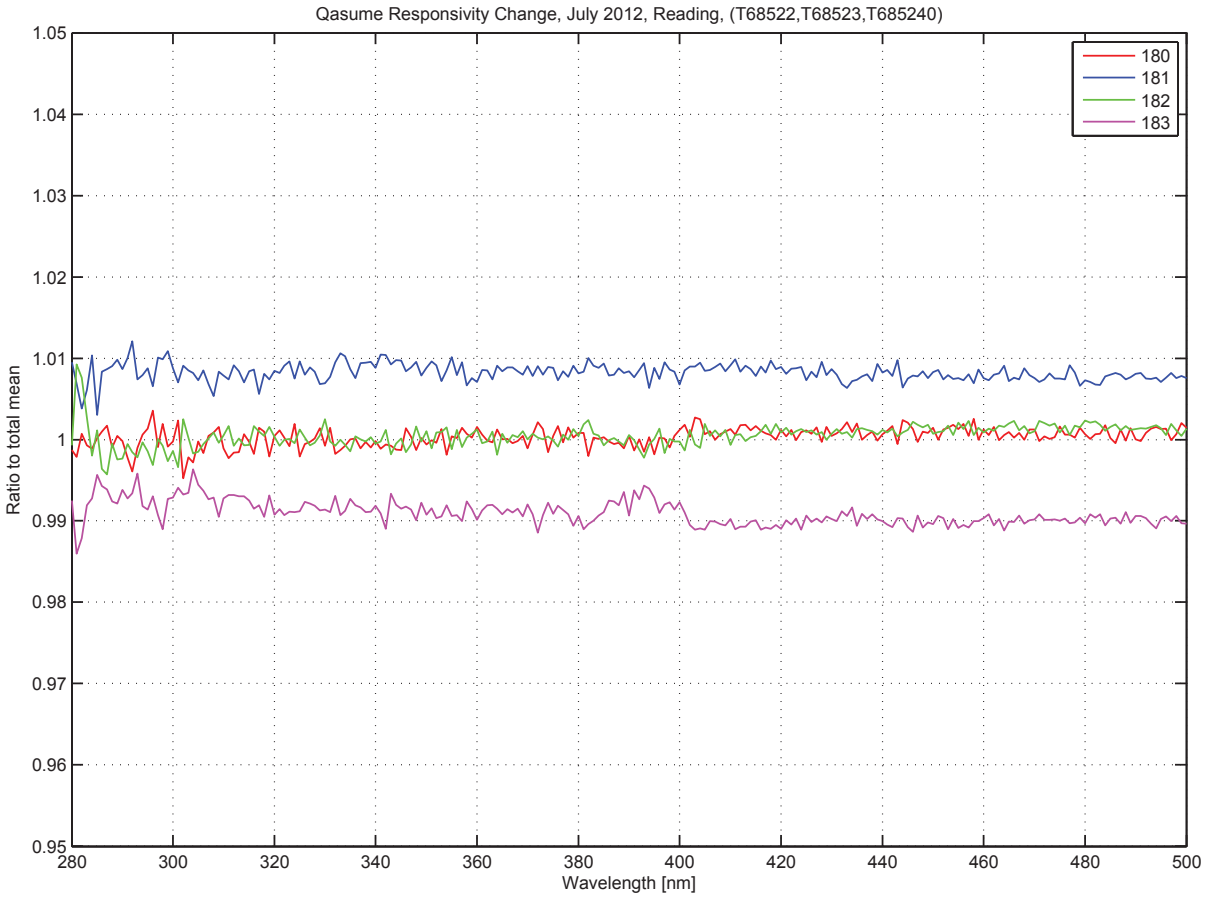

Slit Function of UKR
2003
2012
Normalised
Wavelength [nm]
1
0.8
0.6
0.4
0.2
0
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2


Cosine Error, NORTH PLANE − UKR−Bentham diffuser (D6−ENVIRO), 1−July−2012
310
350
390
normalised
Zenith Angle
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
0
10
20
30
40
50
60
70
80
90


Cosine Error, SOUTH PLANE − UKR−Bentham diffuser (D6−ENVIRO), 1−July−2012
310
350
390
normalised
Zenith Angle
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
0
10
20
30
40
50
60
70
80
90


Cosine Error: Average over all planes − UKR−Bentham diffuser (D6−ENVIRO), 1−July−2012
310
350
390
Diffuse Cosine Error (390nm): 0.994
Diffuse Cosine Error (350nm): 0.994
Diffuse Cosine Error (310nm): 0.995
normalised
Zenith Angle
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
10
20
30
40
50
60
70
80
90


Qasume
Diffuser
Diffuser temperature = 28.1 ± 0.9 ºC
Qasume temperature = 23.8 ± 0.1 ºC
Temperature [ºC]
Time
38
36
34
32
30
28
26
24
22
06/27
06/28
06/29
06/30
07/01
07/02
07/03


Qasume Responsivity Change, July 2012, Reading, (T68522,T68523,T685240)
180
181
182
183
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
420
440
460
480
500


UKR
QASUME
MORSTEINER BIER
pmod wrc