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GAW Report No. 216

Seventh Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E)

(Lichtklimatisches Observatorium, Arosa, Switzerland, 16-27 July 2012)

GLOBAL ATMOSPHERE WATCH

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Seventh Intercomparison Campaign of the
Regional Brewer Calibration Center Europe (RBCC-E)
Lichtklimatisches Observatorium, Arosa, Switzerland, 16-27 July 2012

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1. SUMMARY

This seventh intercomparison campaign was a joint exercise of the Regional Dobson Calibration Center for Europe (RDCC–E), the Regional Brewer Calibration Center for Europe (RBCC–E) and the Physikalisch-Meteorologisches Observatorium Davos - World Radiation Center (PMOD-WRC) in collaboration with the Arosa Lichtklimatisches Observatorium (LKO) of MeteoSwiss during the period from 16 to 27 July 2012. Nine Brewer spectroradiometers together with four Dobson instruments and the QASUME unit, managed by 18 experts from six countries participated in the campaign (Table 1).

The Brewer instruments were compared with the RBCC-E travelling reference Brewer #185 for ozone and with the QASUME unit for UV, European UV reference from the World Radiation Center (WRC). The Dobson Instruments located at Arosa were compared with the RDCC-E travelling reference D064 and finally a Brewer-Dobson comparison of the reference instruments were performed.

Table 1. Participant list at AROSA 2012 campaign

Institution	*Name*	*Brewer*	*Country*
		Brewer	
IOS	Martin Stanek Volodya Savastiouk	#017-MKII	Canada
LKO	René Stübi Herbert Schill Werner Siegrist	#040-MKII #072-MKII #156-MKIII	Switzerland
AAB	Henri Diemoz	#066-MKIV	Italy
URO. University of Rome	Giuseppe R. Casale	#067-MKIV	Italy
K&Z	Wim Roeterdink	#158-MKIII	Netherland
WRC	Julian Gröbner Gregor Huelsen	#163-MKIII	Switzerland
AEMET-IARC	Alberto Redondas Juan J. Rodríguez Virgilio Carreño Marta Sierra	#185-MKIII	Spain
		Dobson	
MOHp	Ulf Köhler Herbert Munier	D064	Germany
LKO	René Stübi Herbert Schill Werner Siegrist	D051	Switzerland
LKO	René Stübi Herbert Schill Werner Siegrist	D062	Switzerland
LKO	René Stübi Herbert Schill Werner Siegrist	D101	Switzerland

The Arosa campaign was the first campaign where RBCC-E transferred its own absolute ozone calibration obtained by the Langley method at the Izaña Observatory (IZO). The calibration of the reference instrument, as well as the link to the world triad, is discussed in Section 2**.** This campaign was processed in real time. All the participating instruments were provided with a provisional calibration at the end of the campaign, which can be considered final for most of them. The individual calibration reports are also available online. A calibration history was introduced for the instruments present at previous campaigns, allowing an easy recalculation of the past ozone data.The Brewer ozone comparison, using the instruments' original calibration constants, showed a good agreement with the reference, with most of the instruments within the

1% ozone deviation range (6 of 8 instruments). The agreement was very good for all the instruments after the maintenance was done, within the 0.5% level, on average (Figure 1). The comparison results are discussed in Section 2. A summary of individual calibration reports can be found in the same section.

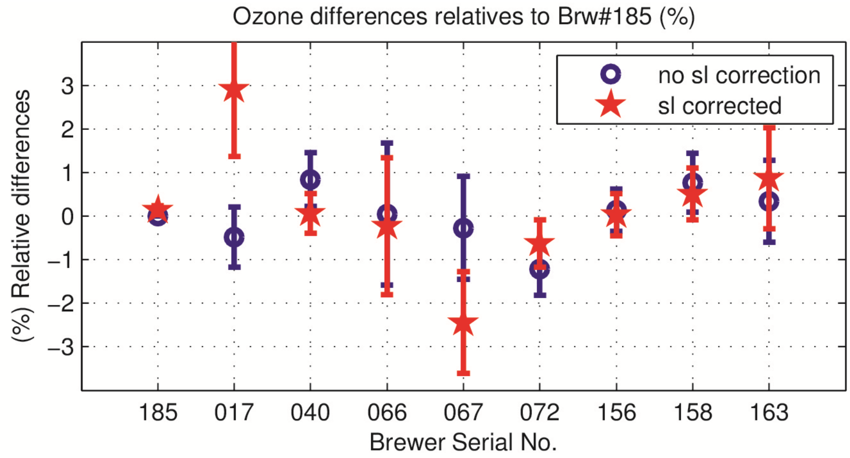


Figure 1. Ozone relative percentage differences of all Arosa 2012 participating instruments to RBCC-E travelling standard #185. Ozone measurements collected during the blind period are reprocessed using the original calibration constants, with (red plots) and without (blue plots) SL correction. Error bars represent the standard deviation.

The comparison with the QASUME unit shows that most of the instruments show a consistent mean underestimation of 5% (with the exception of Brewer AAB#066 who shows +5%) (Table 2, Figure 2). During this campaign the known temperature dependence of the instruments were determined by comparison of the QASUME unit (Table 3). A detailed report is shown on Section 3.

The combined Dobson-Brewer comparison campaign in Arosa in July 2012 had two Dobson-relevant objectives:

- Calibration service for the three Swiss Dobsons (regular RDCC-E task)
- Comparison between standard Dobson and standard Brewer (work package of the ESA-project)

Table 2. Mean values of the ratio Brewer/QASUME (305 – 320 nm), the diurnal variability and the wavelength shifts

Instrument ID	*Brewer to QASUME [%]*	*Diurnal variability [%]*	*Wavelength shift [pm]*	*Temperature Dependence [%/K]*
#017	-	-	-	-
#040	-5	±3	-20 .. +40	-0.11
#072	-6	±4	-20 .. +40	n.a.
#156	-4	±5	-50 .. +50	-0.45
#066_AAB	-3	±2	-20 .. +50	~0
#067	5	±2	-50 .. +50	
#158	-5	±4	-70 .. +50	
#163_ISQ	-	-	-	~0
#185_IZ3	-4	±3	-30 .. +30	~0

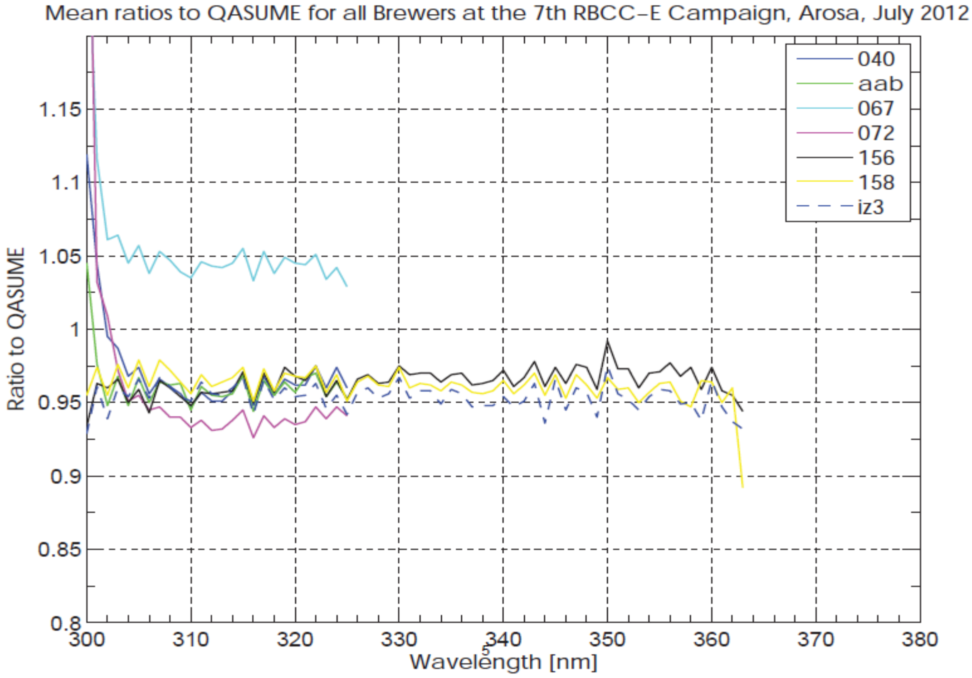
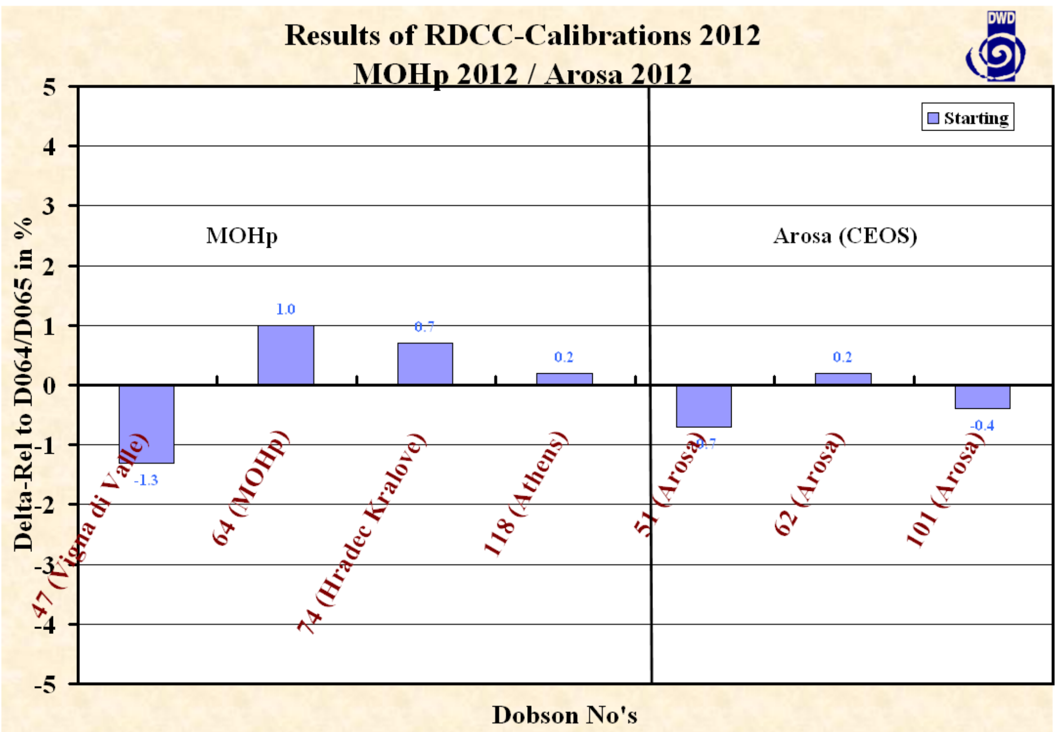


Figure 2. Average ratios between all participating Brewer spectrophotometers and the QASUME reference spectroradiometer

Figure 3 summarizes the results of Arosa 2012 for the Dobsons in the European ozone monitoring network, compared with Dobson No. 064. The Dobsons from Arosa are in good agreement with mean deviations of -0.7 %, 0.2%, and -0.4 for the Dobson 51, 62 and 101 respectively. The maximum differences after the final calibration are less than 0.2%. The detailed report can be found in Section 5.



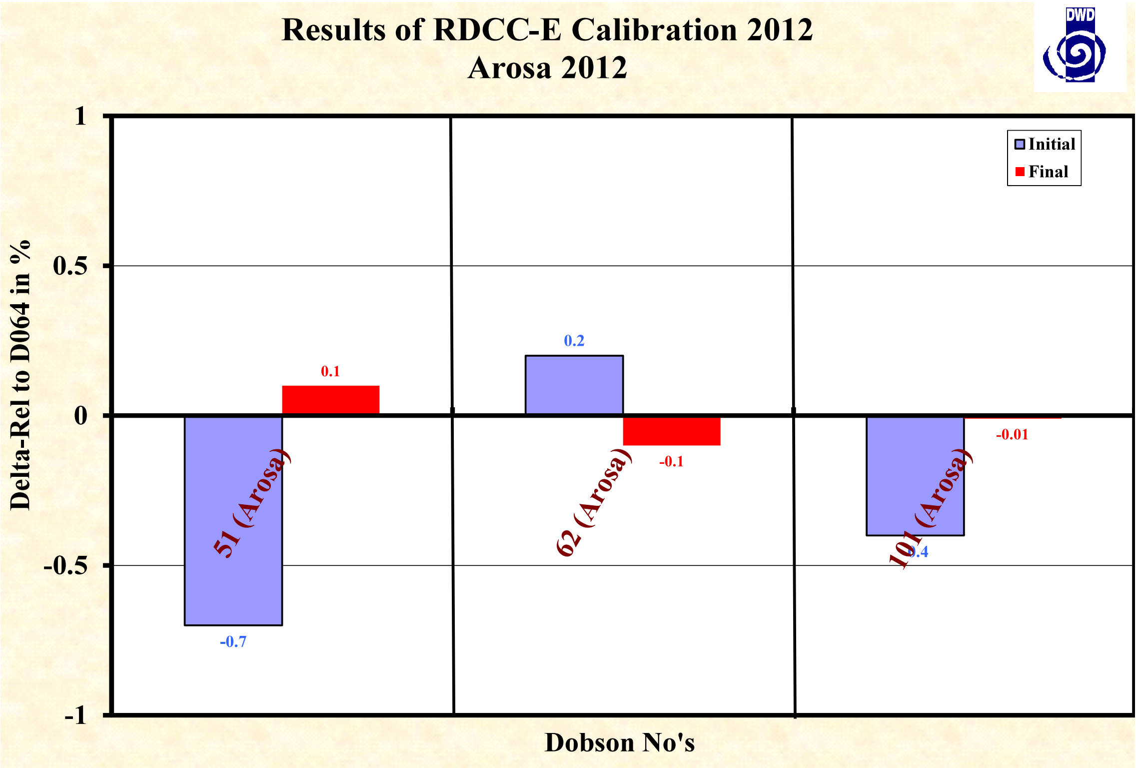


Figure 3. Results of the regular European Dobson campaigns in 2012. Relative difference between field and standard Dobson at the beginning of a campaign (initial calibration).

The results of the second goal, the comparison between standard Dobson No. 064 and standard Brewer No. 185, is shown in Figure 4, which confirms the findings of the ESA campaigns in the previous years. A principal mean difference of approx. 1% (Dobson lower than Brewer) can be seen in almost all comparisons of the RDCC-E and RBCC-E standard instruments.

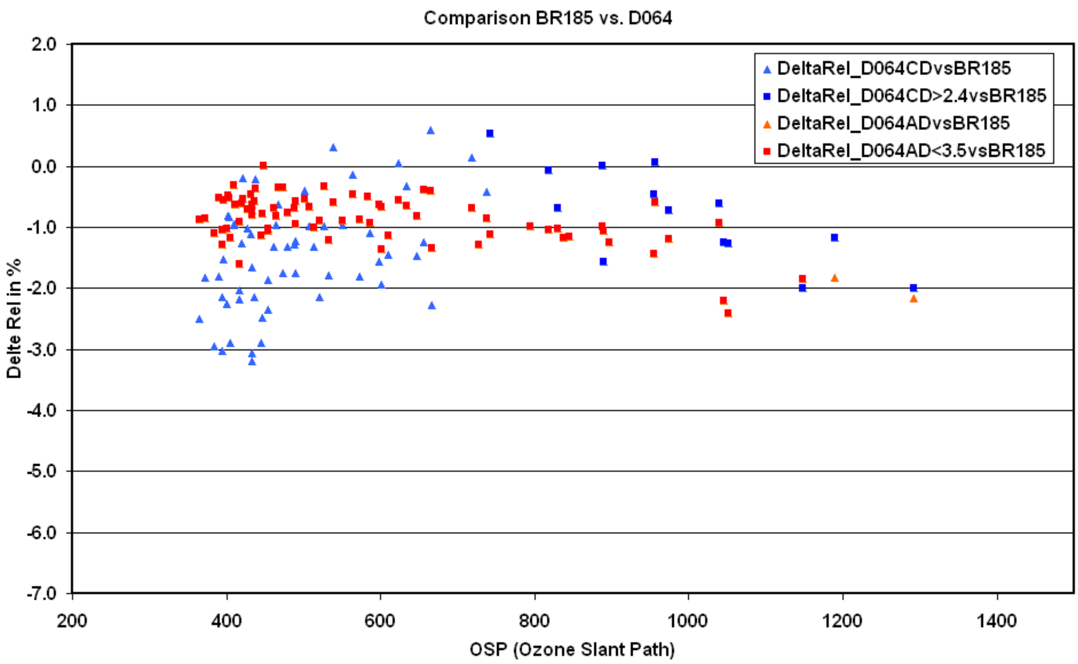


Figure 4. Comparison of D064 (combined AD- and CD-wavelength pairs in different Mu-ranges) and BR185 during Arosa 2012, relative difference in % related to the Brewer values

Figure 5. Overview of the measurement platform at LKO Arosa with the participating Brewer spectrophotometers

1.1 Weather conditions and campaign schedule

The ozone calibration for Dobson and Brewer requires clear skies; this condition is also desirable for the UV calibration. The weather conditions during the campaign at Arosa Observatory (1860 m.a.s.l) were not the best, with four rainy days, but allowed enough direct sun ozone measurements so as to perform a reliable calibration for all instruments. Rainy days were used for instrument characterization and maintenance works (Table 3). The maintenance of the Brewer instruments was performed by IOS (International Ozone Services but the world travelling standard Brewer #017 finally could not participate in this intercomparison. Data labelled as #017 on this report were obtained using its optics on the Brewer #072.

As regards the UV comparisons, 35 to 82 synchronized simultaneous spectra from the QASUME unit and the Brewer spectrophotometers were collected during the campaign days. Measurements from 4:00 to 19:00 UT have been analysed (corresponding to solar zenith angle (SZA) smaller than 90°). The UV index recorded ranges from 0 to 9.

Table 3. Weather conditions during the campaign

DOY	*Date*	*Day*	*Action*	*Weather*
198	16-jul	Monday	Installation	Mostly clear sky with few cirrus clouds
199	17-jul	Tuesday	O3 Blind Days	Mix of sun & clouds
200	18-jul	Wednesday	O3 Blind Days	Mostly clear sky with few cirrus clouds
201	19-jul	Thursday	Maintenance	Mix of sun & clouds Rain shower (afternoon)
202	20-jul	Friday	Maintenance	Mix of sun & clouds Fog in the morning
203	21-jul	Saturday	Maintenance	Mix of sun & clouds Rain during the day
204	22-jul	Sunday	Maintenance	Mix of sun & clouds Rain during the day
205	23-jul	Monday	O3 Final days UV intercomparison	Mostly clear sky
206	24-jul	Tuesday	O3 Final days UV intercomparison	Clear sky (Morning) Mix of sun & clouds
207	25-jul	Wednesday	O3 Final days UV intercomparison	Clear sky (Morning) Mix of sun & clouds Rain started 9:30
208	26-jul	Thursday	Brewer-Dobson	Clear sky (Morning)
209	25-jul	Friday	Packing	Clear sky

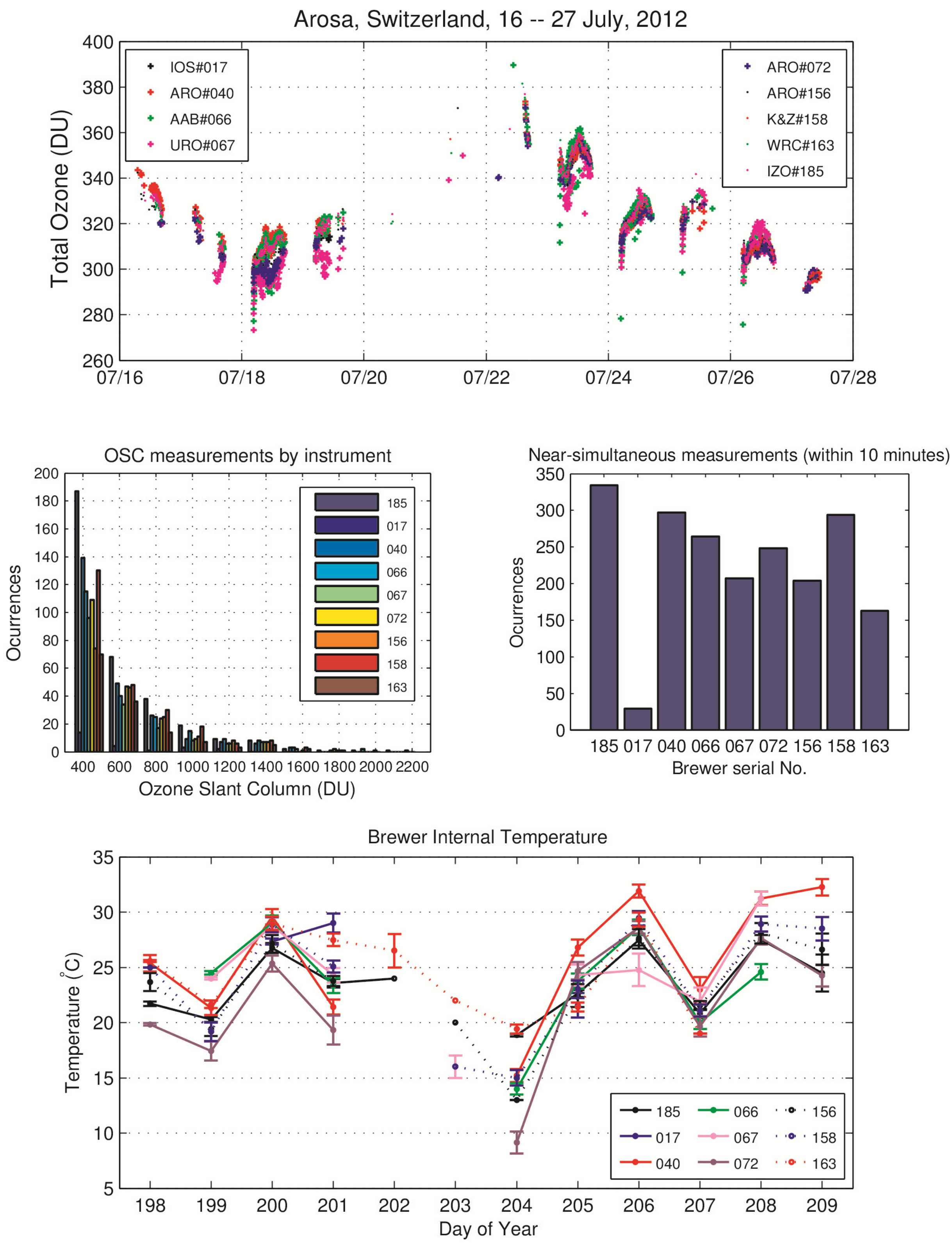


Figure 6. Statistics of the intercomparison conditions. Overview of the intercomparison, ozone (top), number of near-simultaneous ozone measurements (middle panel, right) and frequency distribution of ozone slant column ranges (middle panel, left), and internal temperature variability for all the participant instruments (bottom).

2. RBCC-E BREWER SPECTROMETER REPORT

This seventh intercomparison campaign was a joint exercise of the Regional Dobson Calibration Center for Europe (RDCC-E) and the Regional Brewer Calibration Center for Europe (RBCC-E) in collaboration with the Arosa Lichtklimatisches Observatorium (LKO) of Meteo Swiss during the period July 16 to 27, 2012.

During this campaign we introduced several improvements.

- The Arosa campaign was the first campaign processed in real time, a provisional calibration was provided to the instruments at the end of the campaign, this calibration can be considered final for most of the instruments. The calibration reports are available online.

- A calibration history of the instruments was introduced, for the instruments present on previous campaigns. This allows an easy recalculation of the previous observations.

- The measurement schedule of the campaign was optimized and even with not ideal conditions we obtained 340 observations with the reference with many instruments reaching 80% of the potential measurements.

The Brewer calibration, was performed using 340 near-simultaneous direct sun ozone measurements with the reference instrument Brewer #185. The measurement schedules, designed to maximize the simultaneous ozone measurements during the campaign, worked properly reaching, for some instruments, 80% of the potential near-simultaneous ozone measurements. The conditions during the campaign are summarized in Figure 6. Total ozone content at Arosa during the campaign ranged between 280 and 380 DU. The ozone slant column measured was comprised within the 300-2000 DU range, but most of the measurements (≈ 60%) were within 300-600 DU. The instruments' internal temperature varied between 19ºC to 35°*C* for thermally stabilized instruments, and from 5ºC to 35º*C* for non-thermally stabilized instruments.

2.1 Reference calibration and checklist

The RBCC-E was established at the Izaña Atmospheric Research Centre in 2003. It comprises of three MkIII type Brewer spectrophotometers: a Regional Primary Reference (Brewer#157), a Regional Secondary Reference (Brewer#183) and a Regional Travelling Standard (Brewer#185). The calibration of the RBCC-E triad against the World Brewer Triad (WBT) has been established by yearly comparison with the IOS travelling standard Brewer #017 and checked at the station by means of the Langley extrapolation method. In addition, during the RBCC-E Brewer intercomparison campaigns the travelling standard #185 is compared with other reference instruments, when possible. These reference instruments are: IOS travelling reference #017, the Brewer #145, operated by Environment Canada (EC), and the Kipp & Zonen travelling reference #158. The first two instruments provide a direct link to the world triad. The last world travelling reference triad to European reference triad calibration transfers was performed in July 2011. Since the beginning of 2012, due to internal reorganization of the Spanish Meteorological Service (AEMET), the technical maintenance of the RBCC-E Brewer triad is performed by Kipp & Zonen, Brewer manufacturer, and the link to the WBT will be conducted directly in Toronto or by common Langley campaigns at Mauna Loa or IZO stations. Due to the EC situation and the lack of funds of AEMET, these options were not possible this year (2012). As well, and because of the doubts about the maintenance of the WBT, the WMO scientific advisory group (WMO-SAG) authorized the RBCC-E to transfer its own ozone absolute calibration. The methodology used is described in *Redondas* 2003, *WMO* 2008a, *WMO* 2008b and *Ito et al.*, 2011.

During the Arosa 2012 campaign we transferred the ozone absolute calibration obtained at IZO. Unfortunately the Brewer #017 was inoperative during the campaign days, and it was not possible to compare our Langley calibration with the WBT. We show in Figure 7 the long-term comparison of the calibration transferred by IOS with instrument #017 at Izaña, with the calibration obtained by Langley for instrument #157. The observed agreement is good, with ozone deviations always below 1% and usually less than 0.5% and with no systematic differences (Figure 8). It is important to note that there isn't any change in the IOS transferred calibration constant since 2005.

To assure the calibration of the RBCC-E Brewer triad, a weekly calibration is performed at IZO and the frequency of instrumental tests has been increased from a yearly to a monthly basis. Further, the measurement schedules have been adapted to maximize the Langley observations, reducing the spectral UV and Umkehr measurements. These routine calibrations are reported on the internal web showing the evolution of the instrumental performance of the RBCC-E triad. The status of the Brewer triad is also summarized on a public RBCC-E Checklist. As a result of this maintenance and continuous calibration work we have achieved a quite good long-term agreement between the instruments of the triad, with ozone deviation less than 0.25% (see Figure 9).

Table 4. RBCC-E Travelling Standard Checklist

Travelling standard Check list: Brewer#185	*Description*	*Y*	*N*	*Value*	*Comment*
Calibration Data	170-190. 2012	Y			
Reference of the travelling (Triad, RBCC-E,...)	RBCC-E reference #185				IOS#0172011, 07/2011
Is travelling standard calibrated?		Y			
%diff. before travel				-0.2 ± 0.3	620 obs
%diff. after travel				-0.08 ±-0.3	966 obs
Instrument operation:					
HP/HG	Hp/Hg tests repeatable within 0.2 steps	Y			
SH	SH shutter delay is correct				NaN
RS	Run/Stop test within ±0.003 from unity for illuminated slits and between 0.5 and 2 for the dark count	Y			
DT	Dead time is between 28 ns and 45 ns for multiple-board Brewers and between 16 ns and 25 ns for single-board Brewers		N		DT on cfg 33 ns
SL R6	SL ratio R6 is within 5 units from calibration	Y		213/215	
SL R5	SL ratio R5 is within 10 units from calibration	Y			

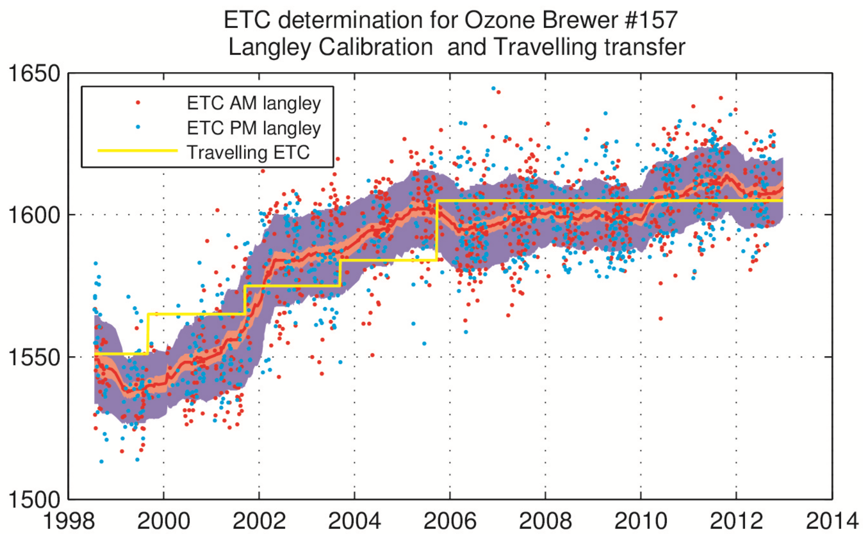


Figure 7. Calibration of the Brewer #157 performed by Langley and from the calibration transferred by IOS Brewer #017 (in yellow) since 1998. The Langley events are averaged by ±1 month, (red line) the red shaded area indicates the 95% confidence interval of the mean and the blue area indicates one standard deviation.

Table 5. Relative differences (%) to IZO#157 (3123 near-simultaneous observations)

	IZO#183	IZO#185
Mean	0.18	-0.25
Dev. Std.	0.63	0.45

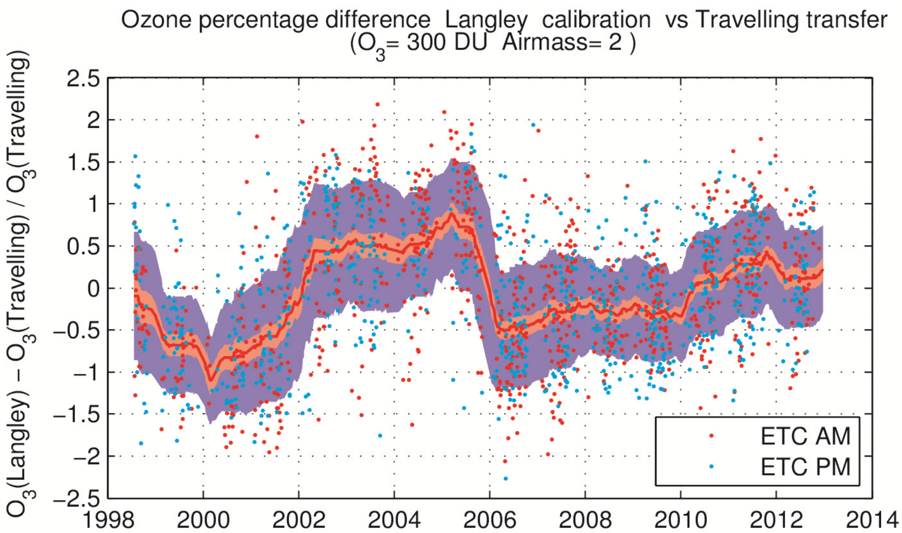


Figure 8. Percentage difference in measured ozone from the ozone calculated by Langley calibration and the derived if the travelling calibration is used. The plot is the same as in Figure 7 where the ETC differences are translated to the ozone calculation assuming ozone equal to 300 DU and airmass=2.

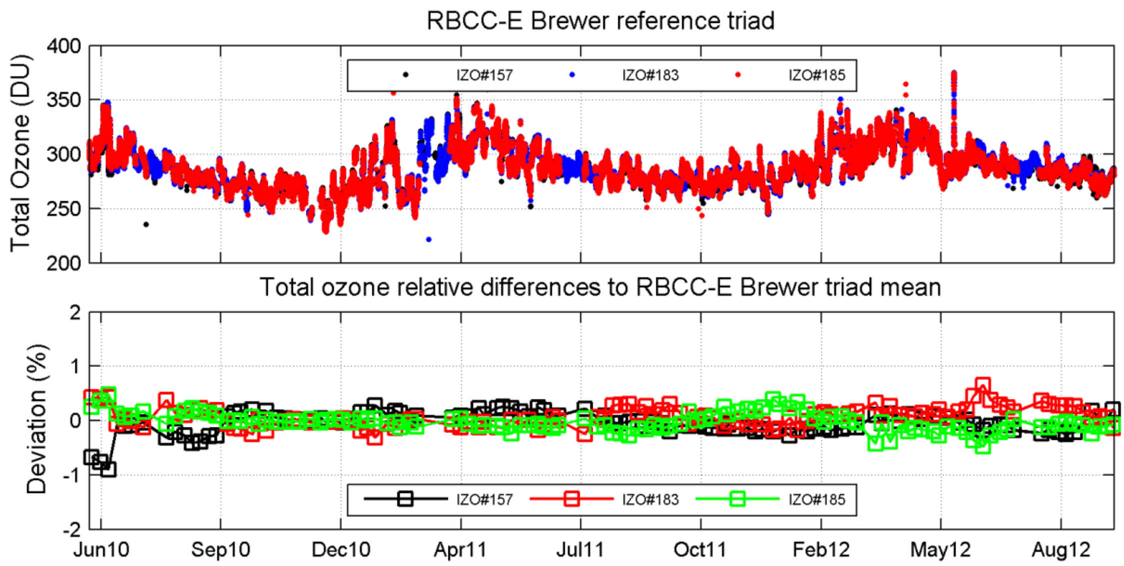


Figure 9. Long-term weekly comparison of the RBCC-E triad during the period from June 2010 to September 2012

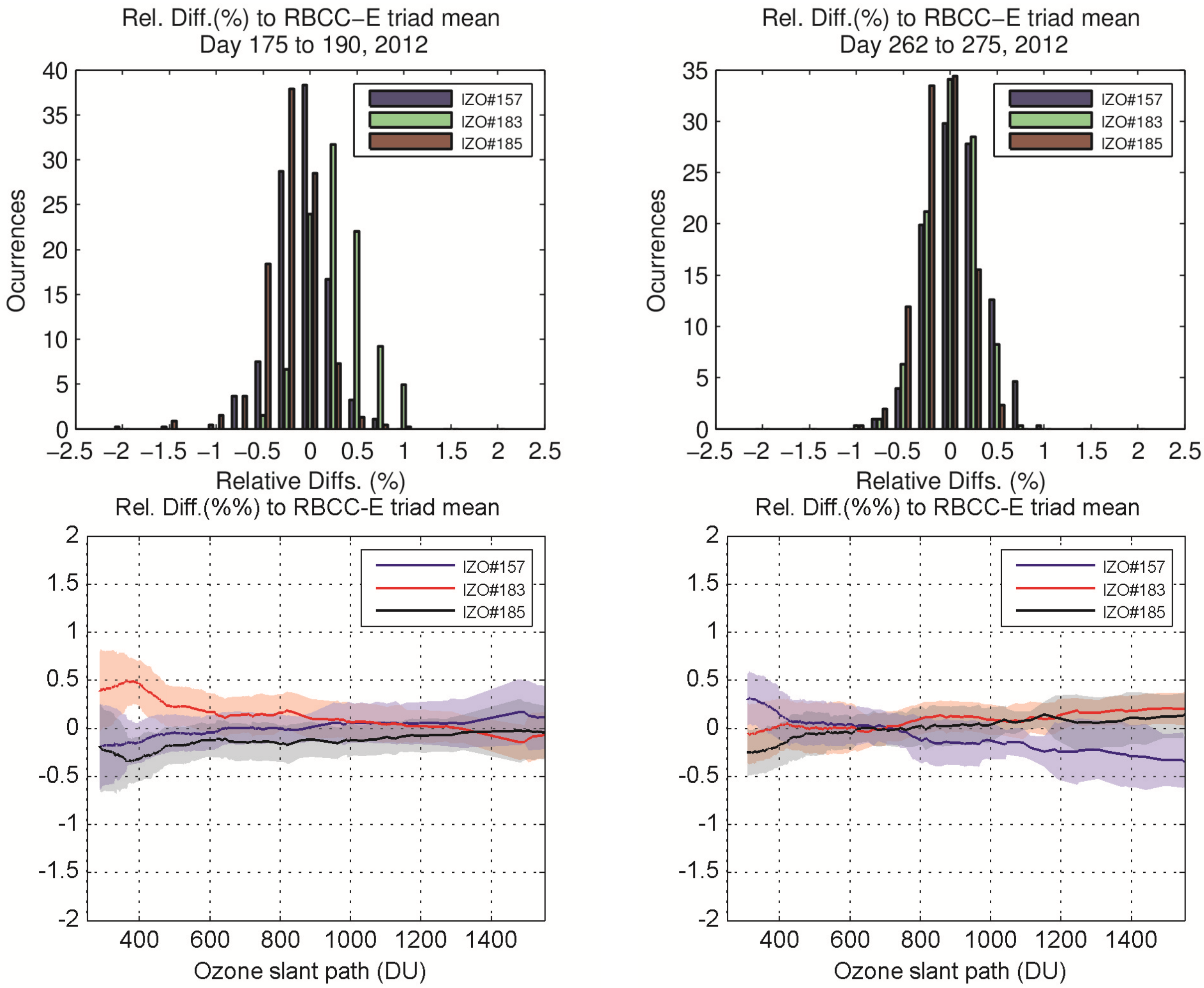


Figure 10. Ratio of near-simultaneous measurements of RBCC-E standard Brewer (serial no. #157, #183 and #185) to the triad mean.
Before (left) and after (right) the Arosa 2012 intercomparison campaign.

2.2 Blind Comparison

The blind comparison gives us an idea of the initial status of the instrument, i.e. how well the instrument performed using the original calibration constants (those operational at the instrument's station). Possible changes of the instrument response due to the travel can be detected through the analysis of internal tests performed before and after the travel.

During the blind comparison period the instruments are working with their home calibration and the ozone is calculated using these calibration constants. The Standard Lamp test is an ozone measurement using the internal halogen lamp as a source. This test is used routinely during the operation of the instrument to track the spectral response of the instrument and therefore the ozone calibration. During the calibration of the instrument a reference value of the test is provided. The ozone is routinely corrected assuming that the change of the value of the test from the reference is the same as the change in the Extraterrestrial constant (ETC). This is the so called Standard Lamp correction. Hence, it is reasonable to investigate if the observed R6 changes are related with similar changes in the calibration constant. If this would be the case, then the ETC constant should be corrected by the same change in SL R6 ratio as $ETC_{new} = ETC_{old} - (SL_{ref} - SL_{measured})$.

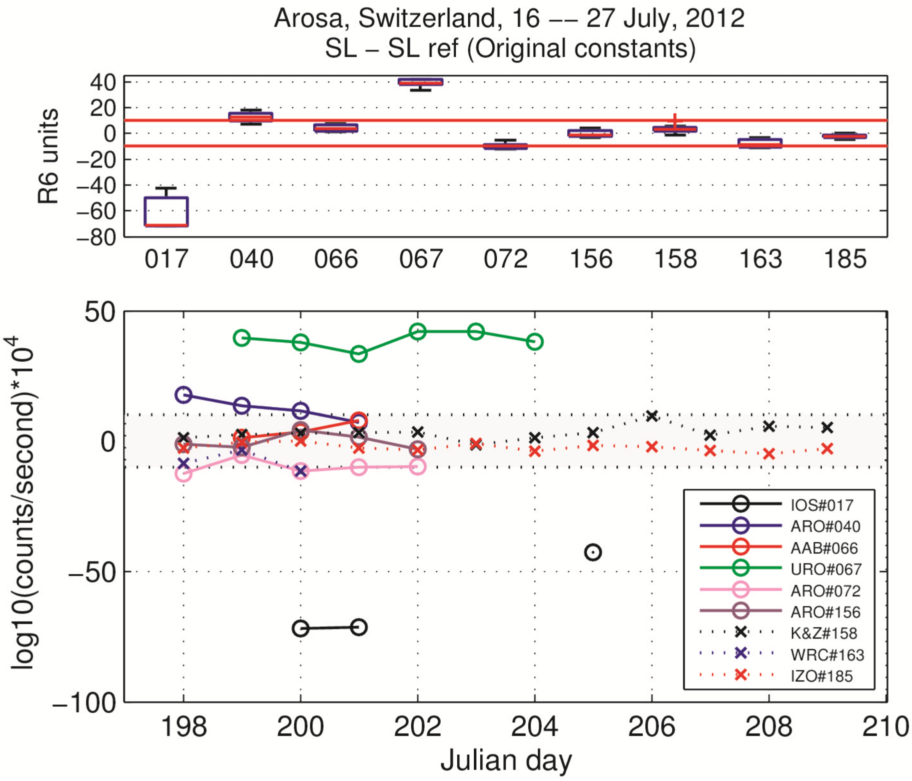


Figure 11. Standard lamp R6 difference to R6 reference value from last calibration during the blind days, before the maintenance. Variations within the ± 10 range (≈1% in ozone) are considered normal, whereas larger changes would require further analysis of the instrument performance.

During the Arosa 2012 intercomparison campaign all the instruments agreed (on average) with the corresponding R6 reference value within ±10 units, which is about 1% in ozone, with the exception of Brewer URO#067 (ARO#040 is just on the limit). The comparison with a reference standard instrument is the only tool to assess whether the SL measurements properly track changes in the calibration constants or if the change observed is due to changes in the spectral emission of the lamp. For example, in the case of URO#067 we found that the correction to the ETC due to the change in R6 ($R6_{ref}$ - $R6_{measured}$ ≈ 40 units) is not real, and thus it is not related to changes in the instrument's response. On the contrary, in the case of Brewer#040 the correction improves the comparison and so changes in the Standard Lamp reflect changes in the calibration of the instrument.

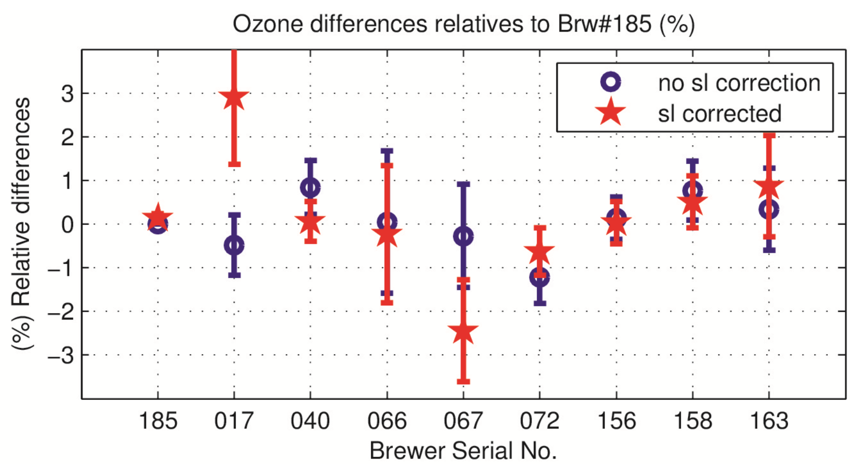


Figure 12. Ozone relative percentage differences of all Arosa 2012 participating instruments to RBCC-E travelling standard #185. Ozone measurements collected during the blind period are reprocessed using the original calibration constants, with (red plots) and without (blue plots) SL correction. Error bars represent the standard deviation.

The comparison with the reference instrument Brewer #185 during the blind days shows a good agreement. After the Standard Lamp correction, when applicable, all the participating instruments were within ±1% on average (Figure 12). As we mentioned before, the SL correction improved the comparison for all the instruments with the exception of Brewer #067. The stray light rejection appears evident for single Brewers (single monochromator) as can be deduced from the larger error bars in Figure 12. As a consequence of this stray light rejection, marked ozone slant column dependence in ozone measurements is expected for these Brewers. We analyse individual instruments in the following section.

2.3 Final Calibration

We defined the final days as those available after the maintenance work was finished for each participating instrument. These days are used to perform the ozone final calibration, so we tried to not manipulate the instruments during this period. As well, the standard lamp R6 value recorded during the final days is normally adopted as the new SL reference value. It is also expected that this parameter will not vary more than 5 units during the same period.

We show in Figure 13 the differences between the daily standard lamp R6 ratio and the proposed R6 reference value during the final days. As expected, the recorded SL values did not vary more than 5 units during this period, with the exception of Brewer #163.

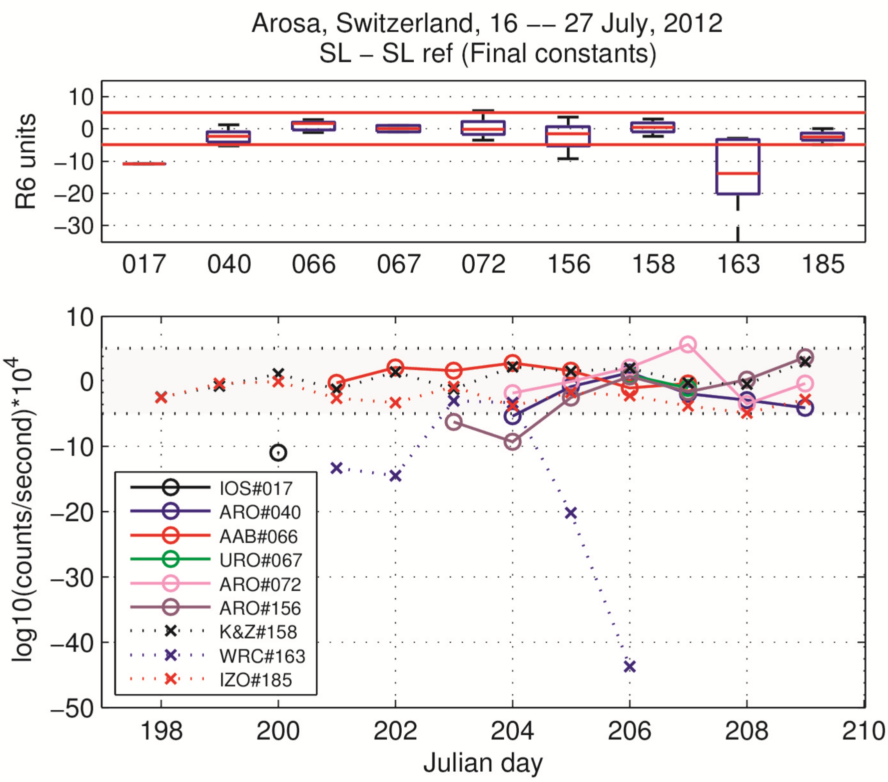


Figure 13. Standard lamp R6 ratio to R6 reference from last calibration differences during the blind days grouped by Brewer serial number (above) and as a function of time (below). The shadow area represents the tolerance range (±5 R6 units).

Ozone column percentage differences for all the participating instruments, using as a reference the RBCC-E travelling standard Brewer#185, are shown in Figure 14. We have recalculated the ozone measurements using the final calibration constants, with and without SL correction. All Brewers were calibrated using the one parameter ETC transfer method: the ozone absorption coefficient was derived from the wavelength calibration (dispersion test) and only the ETC is transferred from the reference instrument. The two parameters calibration method is also used as a quality indicator. For all the instruments both one parameter and two parameters ETC transfer methods agreed with each other within the limits of ±5 units for ETC constants and ±0.3% (one micrometer step) for ozone absorption coefficients, which is a very good indication of the quality of the calibration provided.

Overall, we found a quite good agreement with the reference instrument, within the range ±0.5%. Note that anomalous low total ozone deviations are frequent in the case of single monochromator Brewers, corresponding to high ozone slant values where the stray light effect is large. Correcting for the standard lamp R6 ratio change leads to notably worse results in the case of Brewer #163 (the abrupt change in R6 during the last days of the campaign is not reflected in the ozone measurements).

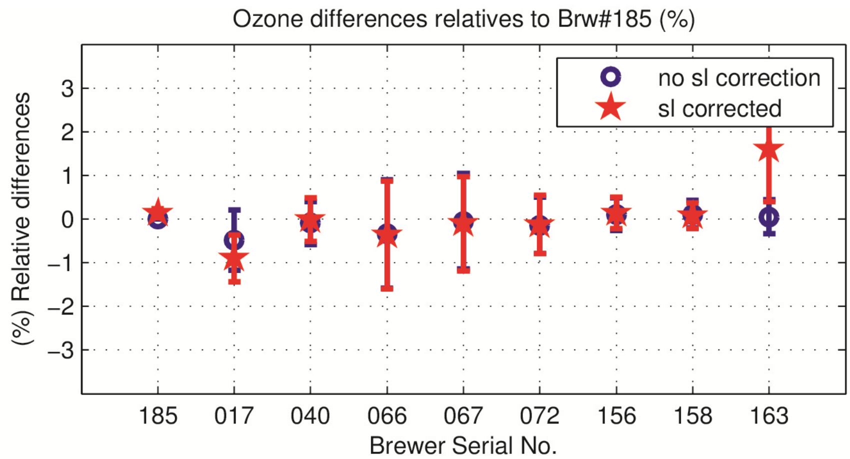


Figure 14. Ozone relative percentage differences of all Arosa 2012 participating instruments to RBCC-E travelling standard Brewer #185. Ozone measurements collected during the final period are reprocessed using the final proposed calibration constants, with (red plots) and without (blue plots) SL correction. Error bars represent the standard deviation

Finally, the sparkline plot shown in Figure 15 summarizes the ratio to the reference as a function of ozone slant column (OSC) for every instrument, with final calibration constants used. The plots are the percentage ratios from 0.3 to 1.6 OSC (cm), the gray area indicates the ±0.5% range and in red the percentage ratios evaluated at 0.3 and 1.6 OSC. The mean values are indicated in blue for the full OSC range and for OSC < 0.7 DU. These last values are representative for single instruments (excluding the stray light affected range).

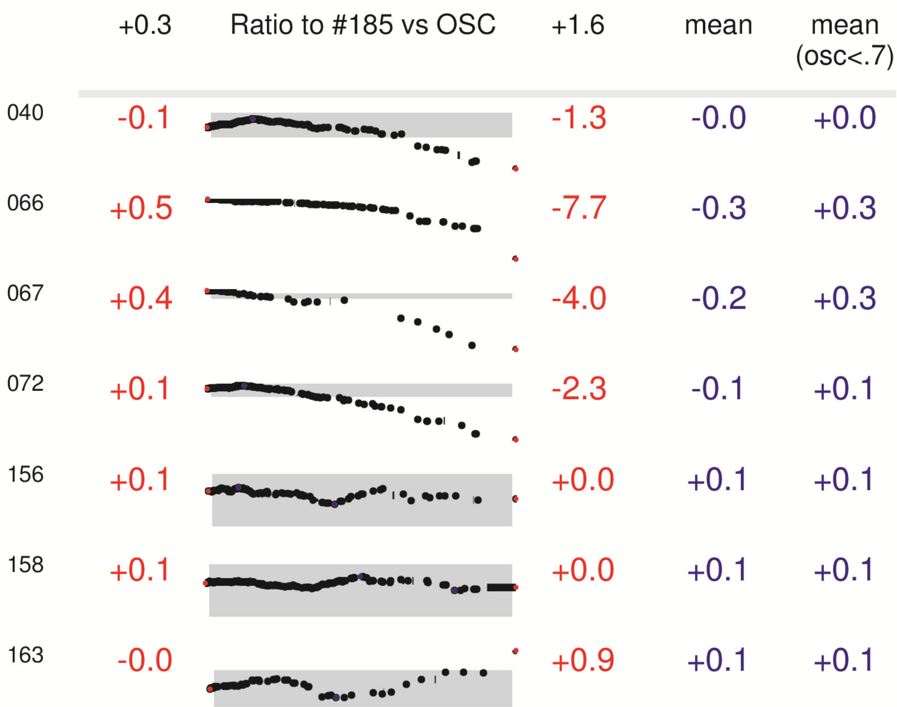


Figure 15. Sparkline plot showing ozone relative percentage difference of every instrument to RBCC-E reference against OSC during the final days (using final calibration constants). The red labels represent the values at 0.3 and 1.6 OSC. The grey area of individual plots represents the ± 0.5%.

2.4 Ozone Brewer Reports

2.4.1 Brewer ARO#040, Station: Arosa, Switzerland

Brewer ARO#040 participated in the campaign during the period from 16-27 July 2012. The days from July 17 to 21, before the maintenance work, were used for the evaluation of the initial status (128 near -simultaneous direct sun ozone measurements). Days July 22 to 27 were used for final calibration purposes (248 near-simultaneous direct sun ozone measurements).

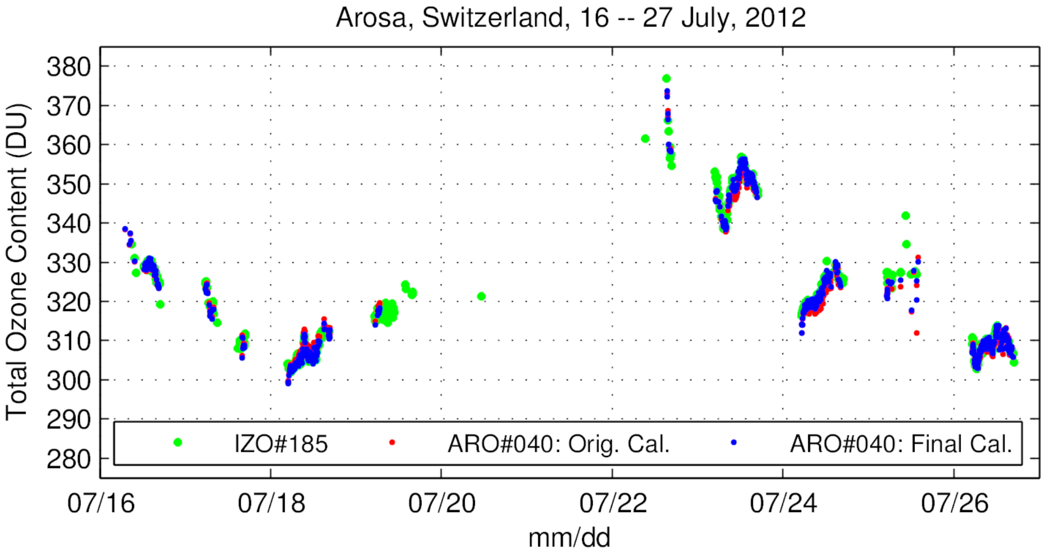


Figure 16. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf21010.040 and reference value 1745 for the standard lamp R6 ratio. These calibration constants were obtained after the 2010 intercomparison at Arosa, Switzerland, using the RBCC-E travelling standard Brewer IZO#185 as the reference instrument.

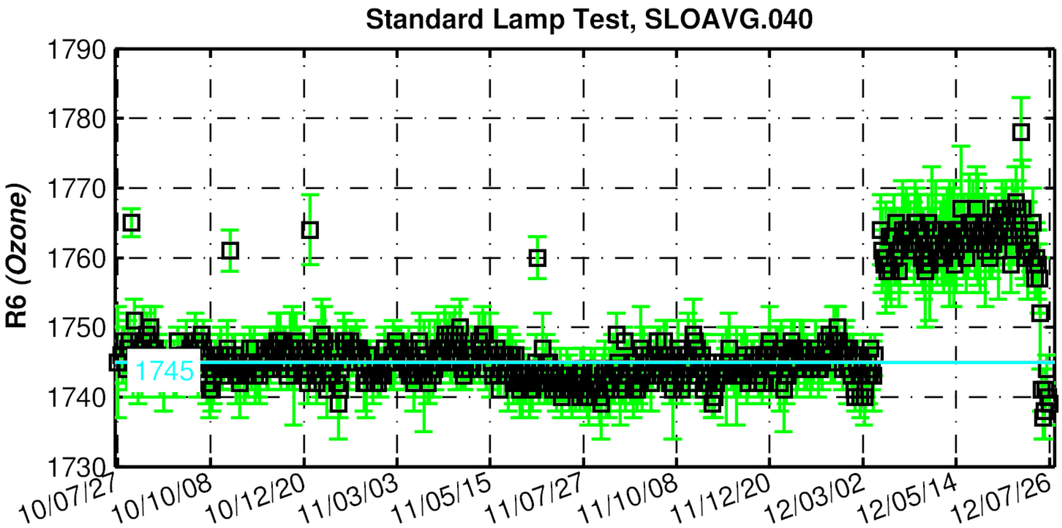


Figure 17. Standard Lamp test R6 (Ozone) ratio

Historical Analysis

ARO#040 has shown very good stability based on its SL ratios during the last two years, with the exception of some noticeable change (~20 units, ~2% in ozone) in March 2012, due to electrical problems. DT tests were noisy and resulted in DT constant around 5 ns lower than the reference value due to the same reason. Before this event, the recorded SL ratios matched quite well the reference values provided during the last intercomparison.

Initial comparison

ARO#040 shows a good agreement with the reference instrument (ozone deviations lower than 0.5%) when the proper SL correction is applied. Note that the R6 reference value provided by the operator (1760) was not correct. The ozone data from the last 2 years should be reprocessed using the Arosa 2010 calibration constants, SL corrected. The noisy DT results before the power supply replacement do not affect the ozone measurements.

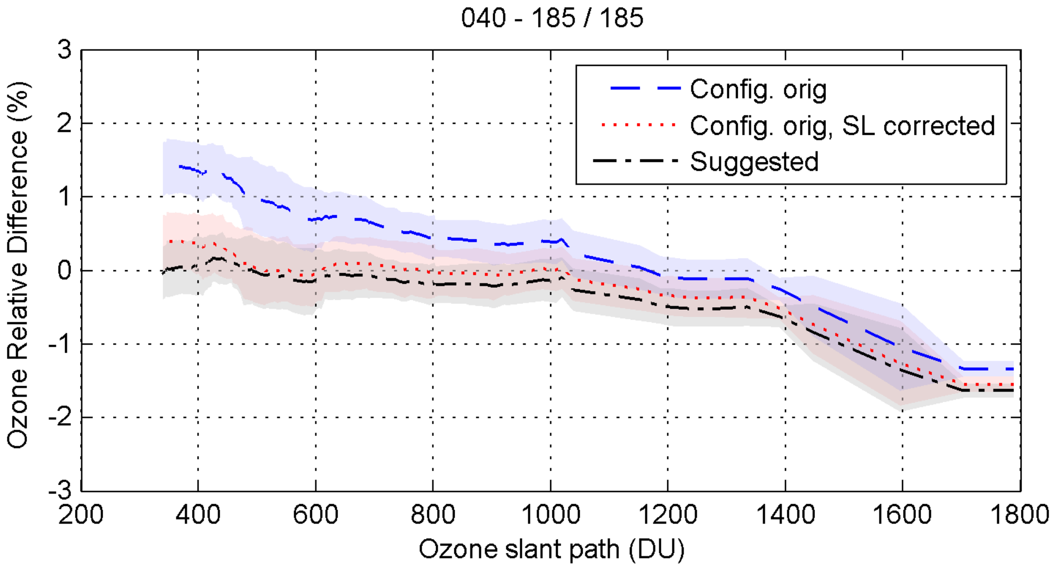


Figure 18. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

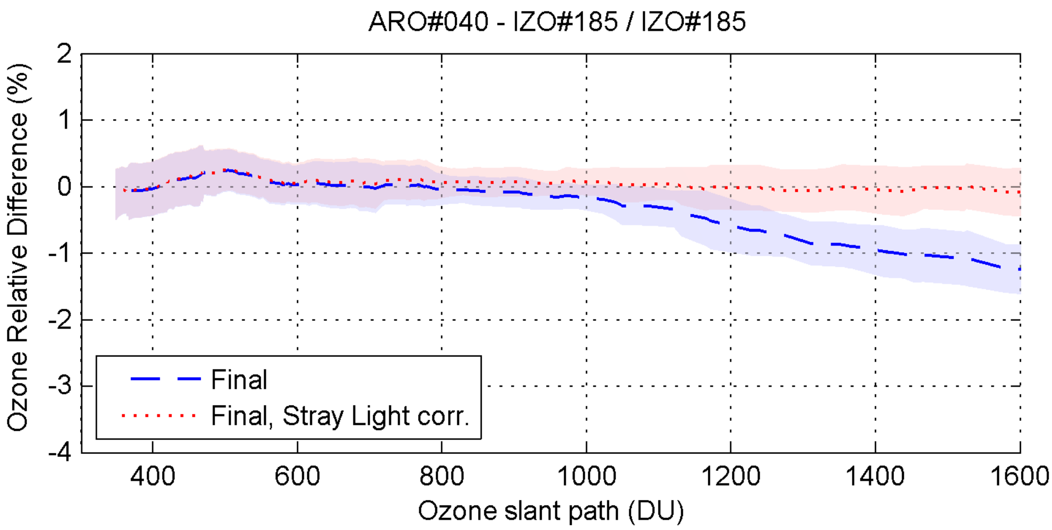


Figure 19. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Final calibration

We have updated the DT constant on the final calibration, improving the ND filter#3 performance. All the other calibration constants have been kept the same as the original. We observed poor wavelength accuracy on slit#1, with -0.03 nm displacement on the mercury line (the accepted tolerance range is 0.01 nm). Although this does not affect the ozone retrievals, effects on UV measurements should be corrected using the SHICRIVM algorithm. We achieved a very good agreement against the RBCC-E travelling standard using this calibration set, with ozone deviations lower than 0.25% up to ozone slant paths of 1200 DU.

Straylight

This single Brewer shows a low stray light rejection, with 1% underestimated ozone at around an ozone slant path of 1400 DU.

Calibration constants Summary: ARO#040

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	2985		2985
SL R6 reference value	1745	1745	1745
change SL R6 ratio /ETC		15 / 15	3 / 0
DT Constant (ns)	38	38	41
Temp. Coeffs.		No change	No change
Cal Step Number	943	943	943
Ozone Abs. Coeff.	0.3335	0.3335	0.3335
Stray Light factors (F0 / k / s)			2986 / -8.56 / 4.97
Calibration File recommended			icf20412.040

Recommendations and comments

- The high sun ozone measurements before correction were about 1.5% higher than the reference instrument. The standard lamp correction to the ETC improved the comparison.

- The standard lamp ratios increased notably (from ~1745 to ~1760 for R6) from March 2012, due to electrical problems. This new value was the reference R6 provided by the Brewer operator during the intercomparison, which is not valid. Using this wrong R6 gives an error up to 1.5% in ozone. It is recommended to reprocess ozone data from March 2012 using the calibration constants from the Arosa 2010 campaign, SL corrected.

- We analysed two final calibration sets: DT=38 ns, ETC=2975 (icf20412_DT38.040) or DT=41 ns, ETC=2985 (icf20412_DT41.040). We recommend for data recalculation the last alternative, based on neutral density filter#3 performance.

Calibration report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_040.pdf

2.4.2 Brewer AAB#066, Station: Rome, Italy

Brewer AAB#066 participated in the campaign during the period from 17-26 July 2012. The days from July 17 to 19, before the maintenance work, were used for the evaluation of the initial status (104 near-simultaneous direct sun ozone measurements). Days July 20 to 26 were used for final calibration purposes (260 near-simultaneous direct sun ozone measurements).

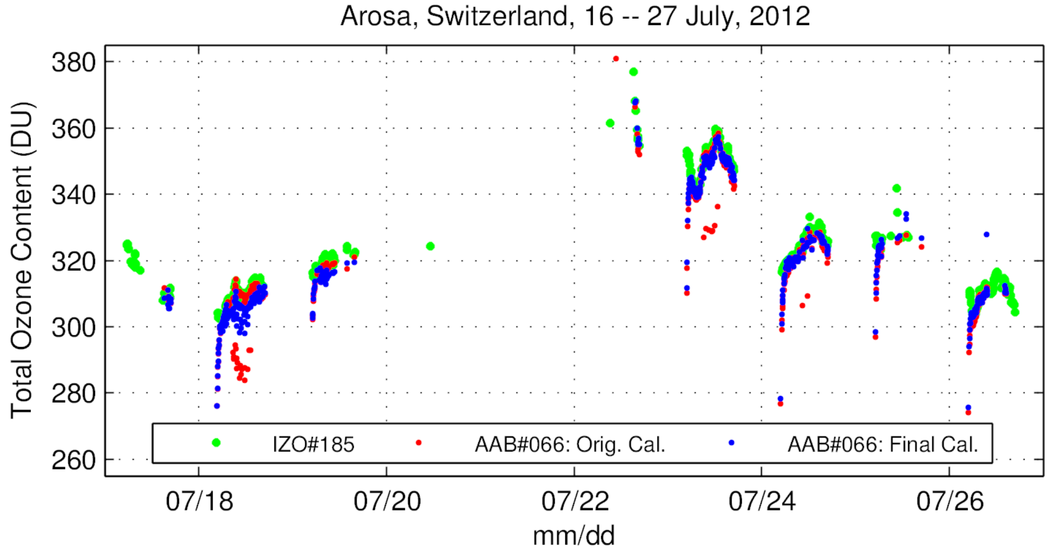


Figure 20. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf21511.066 and reference value 1840 for the standard lamp R6 ratio. These calibration constants were obtained after the August 2011 intercomparison against the IOS travelling standard IOS#017.

Historical analysis

AAB#066 has shown good stability based on its SL ratios during the last year, within the accepted tolerance range ±5 R6 units. The recorded SL ratios fitted well the reference values provided by the Brewer operator (1840 / 3405). DT tests resulted in DT constant around 3 ns lower than the reference value (34 ns). All the other parameters analysed are within the tolerance range.

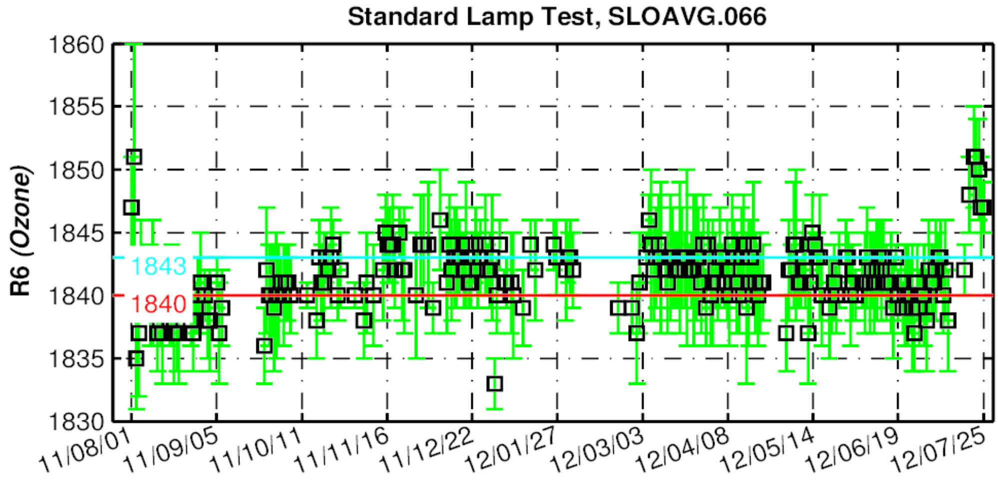


Figure 21. Standard Lamp test R6 (Ozone) ratio

Initial comparison

AAB#066 shows a good agreement with the reference instrument, with ozone deviations within 1% for ozone slant paths lower than 800 DU. Correcting for the standard lamp ratio slightly improved the comparison.

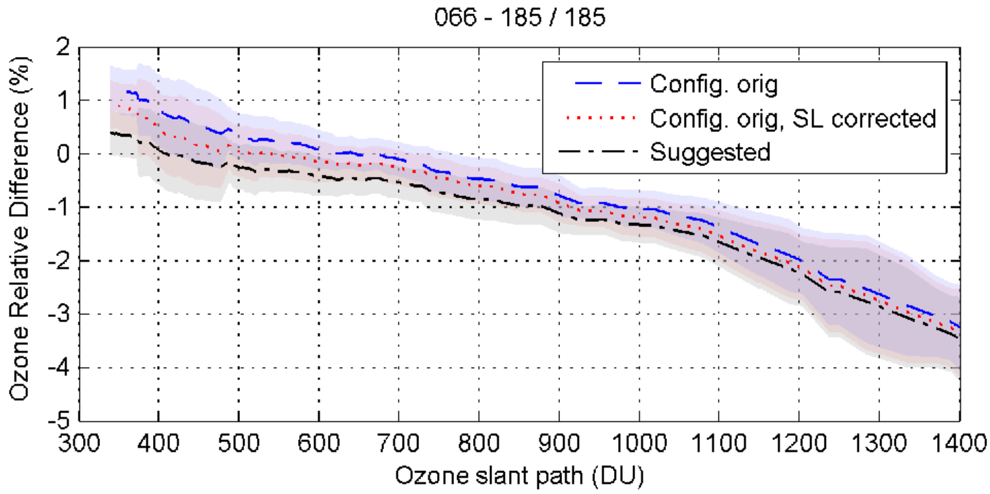


Figure 22. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Final calibration

We have updated the DT and ETC constants on final calibration, while keeping the same as the original the rest of calibration constants. We achieved a very good agreement against the RBCC-E travelling standard using this calibration set, with ozone deviations lower than 0.5% up to ozone slant paths of 900 DU.

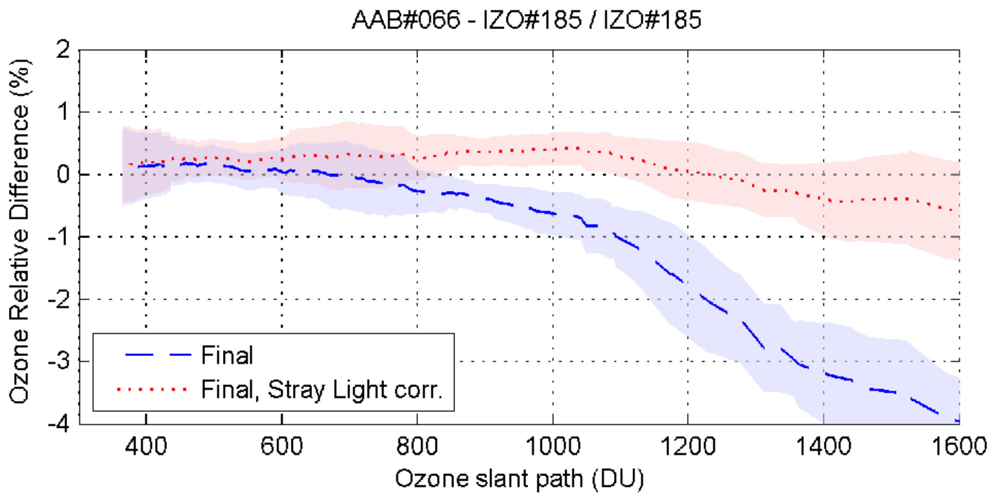


Figure 23. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation

Straylight

This single Brewer show a moderate stray light rejection, with ozone underestimated by 1% at ozone slant paths of 1100 DU. This is greatly improved after the stray light rejection has been applied (see Figure 23, red dotted line).

Calibration constants Summary: AAB#066

	Last Cal.	Initial (blind)	Final
O3 ETC constant	3065	3065	3043
SL R6 reference value	1840	1840	1843
change SL R6 ratio /ETC		<5 / <5	3 / 22
DT Constant (ns)	34	34	31
Temp. Coeffs.		No change	No change
Cal Step Number	932	932	932
Ozone Abs. Coeff.	0.3399	0.3399	0.3399
Stray Light factors (F0 / k / s)			3050 / -37.5 / 4.29
Calibration File recommended			icf20412.066

Recommendations and comments

- AAB#066 has shown good stability based on its SL ratios during the last year. The original constants SL corrected should perform fine. However, you should discard neutral density filter #4 ozone measurements.

- We have updated the DT constant to a new reference value of 31 ns. Using this new DT constant, we calculate 1843 as a reference value to be used for R6 ratio.

- As concerns to neutral density filters we have applied correction factors 18 and -50 to filters #3 and #4, respectively. Note that these factors are highly dependent on which value you use for the DT constant. We recommend replacing the neutral density filter #4.

Calibration report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_066.pdf

2.4.3 Brewer URO#067, Station: Rome, Italy

Brewer URO#067 participated in the campaign during the period from 17-26 July 2012. The days from July 17 to 22, before the maintenance work, were used for the evaluation of the initial status (133 near-simultaneous direct sun ozone measurements). Days July 23 to 26 were used for final calibration purposes (85 near-simultaneous direct sun ozone measurements).

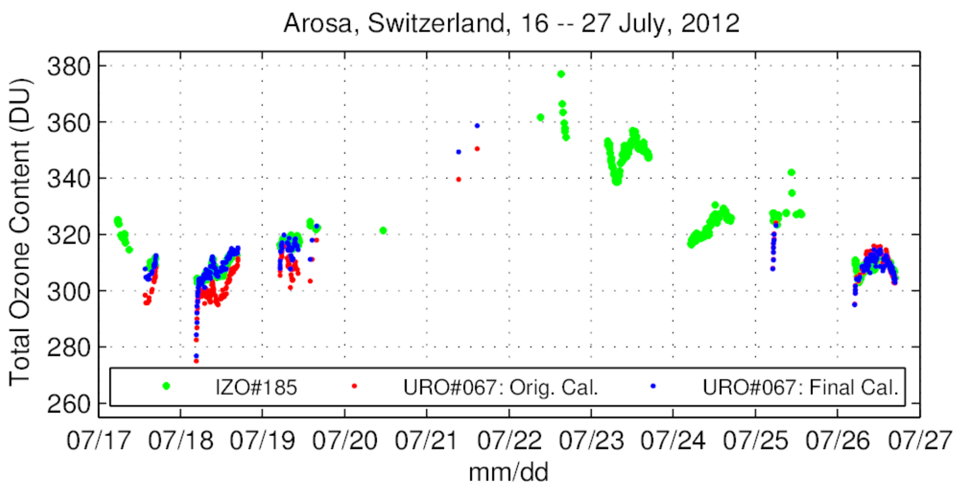


Figure 24. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf20911.067, and the reference value for the standard lamp R6 ratio is 2000. These calibration constants were obtained after the July 2011 intercomparison against the IOS travelling standard IOS#017.

Historical analysis

URO#067 has shown poor stability based on its SL ratios during the last year. The recorded SL ratios were, on average, around 35 units different as compared to the reference value provided by the Brewer operator (2000). DT tests resulted in DT constants around 5 ns lower than the reference value (44 ns). All the other parameters analysed were within the tolerance range.

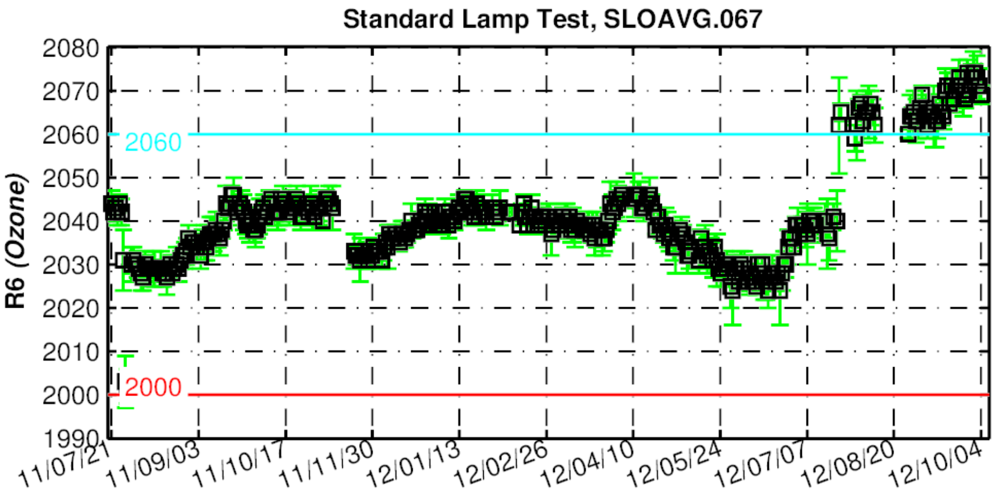


Figure 25. Standard Lamp test R6 (Ozone) ratio

Initial comparison

URO#067 shows a very good agreement with the reference instrument, with ozone deviations within 0.25% for ozone slant path lower than 1100 DU. The comparison with the reference got worse after correcting for the standard lamp ratio (Figure 26). We recommend using R6ref = 2030 to re-evaluate the ozone measurements back in time to the last 2011 calibration campaign, instead of the value provided by the Brewer operator (2000).

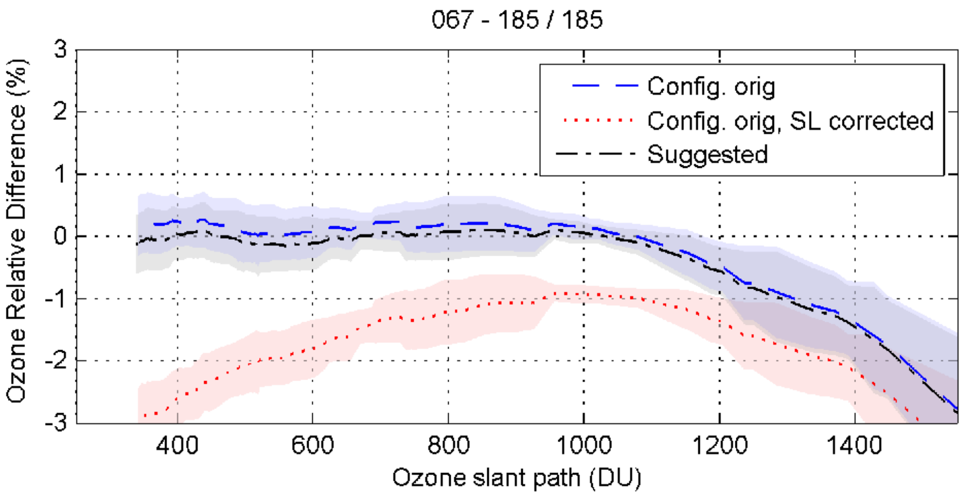


Figure 26. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation

Final calibration

We have updated the DT, A1, CSN and ETC constants on final calibration. The neutral density filters did not show nonlinearity in the attenuation spectral characteristics, except for filter #4. It is worth noting that it performed well before the maintenance, although we suspect that it was indeed the result of a wrong DT. We have applied a correction factor of 25 to this filter. After all, we achieved a good agreement against the RBCC-E travelling standard using this calibration set, with ozone deviation lower than 0.5% up to ozone slant path around 900 DU.

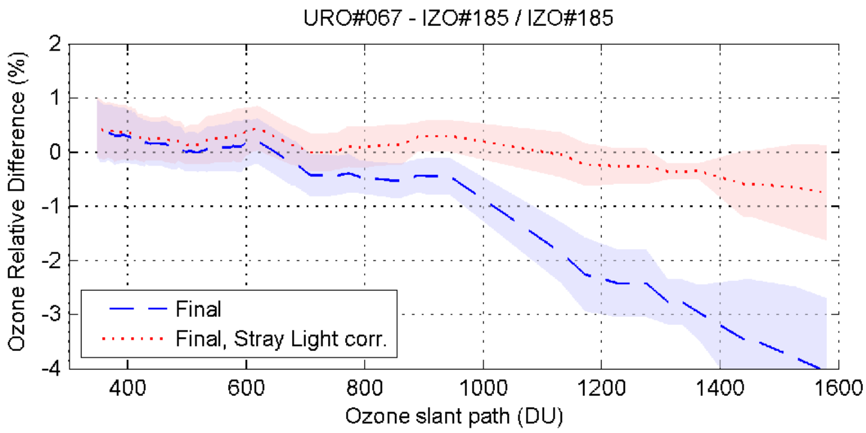


Figure 27. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation

Straylight

This single Brewer shows a moderate stray light rejection, with ozone underestimated by 1% at ozone slant path 1000 DU. This is greatly improved after the stray light rejection has been applied (see Figure 27, red dotted line).

Calibration constants Summary: URO#067

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	3140	3140	3170
SL R6 reference value	2000	2030	2060
change SL R6 ratio / ETC		40 / <5	<5 / <5
DT Constant (ns)	44	44	39
Temp. Coeffs.		No change	No change
Cal Step Number	158	158	159
Ozone Abs. Coeff.	0.3405	0.3405	0.3430
Stray Light factors (F0 / k / s)			3175 / -38.1 / 4.07
Calibration File recommended			icf20612.067

Recommendations and comments

- URO#067 has shown poor stability based on its SL ratios during the last year. However, the original constants performed fine. The comparison with the reference instrument got worse after the ETC was corrected by the SL R6 ratio change. We recommend using $R6_{REF}$= 2030, instead of the provided value, 2000, to re-evaluate Brewer ozone measurements during the last year.

- We have updated the DT constant to a new reference value 39 ns, improving performance for the neutral density filter #4. As well, we have applied a correction factor 25 to this filter. Using this DT constant we proposed R6 = 2060 as a new reference value.

- Both the CSN and the A1 constants have been updated in the final configuration.

- We achieved a good agreement with the standard using the final calibration constants set, with ozone deviations lower than 0.5% up to ozone slant path of 900 DU. This instrument shows a moderate stray light rejection, 1% over 1000 DU.

Calibration report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_067.pdf

2.4.4 Brewer ARO#072, Station: Arosa, Switzerland

Brewer ARO#072 participated in the campaign during the period from 16-27 July 2012. The days from July 16 to 20, before the maintenance work, were used for the evaluation of the initial status (127 near-simultaneous direct sun ozone measurements). Days July 22 to 27 were used for final calibration purposes (253 near-simultaneous direct sun ozone measurements).

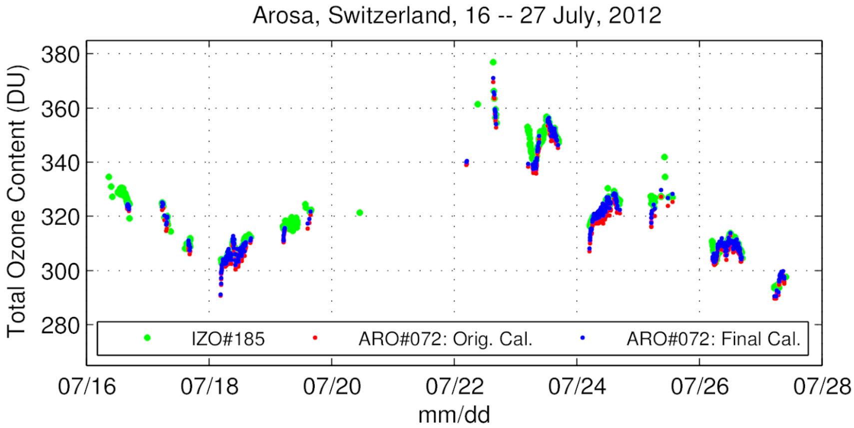


Figure 28. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf21010.072 and the reference value for the standard lamp R6 ratio is 1905. These calibration constants were obtained after the last RBCC-E intercomparison campaign (July 2010).

Historical Analysis

ARO#072 has shown good stability based on its SL ratios during the two last years. The recorded SL ratios were, on average, in good agreement with the Arosa 2010 reference value proposed (1905 +/- 5 units). After the power supply was replaced, the DT constant increased to the value adopted in the final configuration, 39 ns. All the other parameters analysed were within the tolerance range.

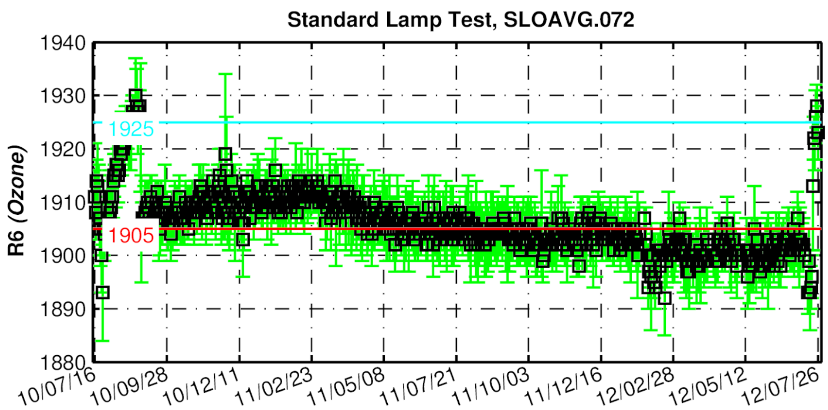


Figure 29. Standard Lamp test R6 (Ozone) ratio

Initial Comparison

The initial comparison with reference IZO#185 was found to be poor, showing an average ozone deviation of -1%. An improvement in Brewer ozone retrievals was achieved after correcting the ETC by the standard lamp ratio change (Figure 30). We recommend the calibration constants ETC = 3150 and $R6_{REF}$ = 1900 to be applied from February 03, 2012. On the other hand, the original constants should perform well before that date.

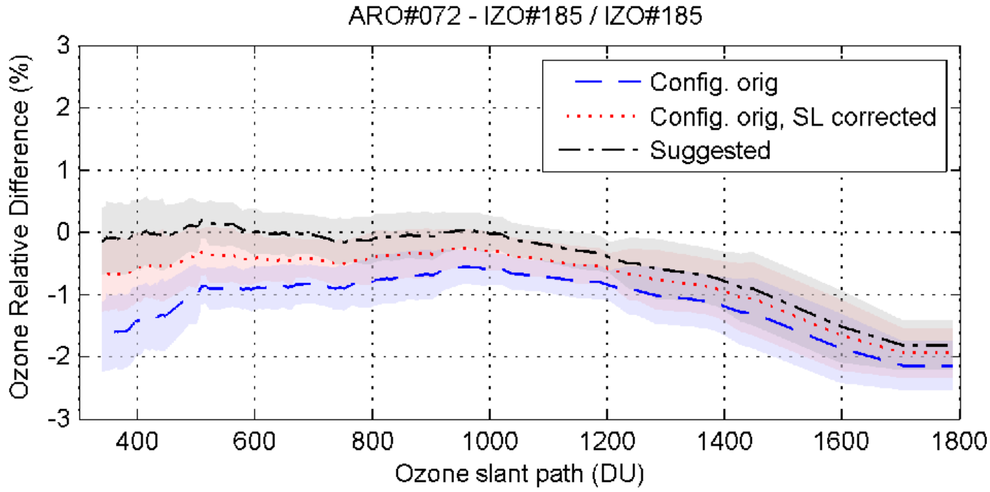


Figure 30. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Final Calibration

A notable change in the instrument's response resulted from maintenance activities during the campaign. We have used updated the DT and A1 constants for the final calibration. As well, the CSN was updated to a new value of 915. We achieved a good agreement against the RBCC-E travelling standard using this calibration set, with ozone deviation lower than 0.5% up to ozone slant paths around 900 DU.

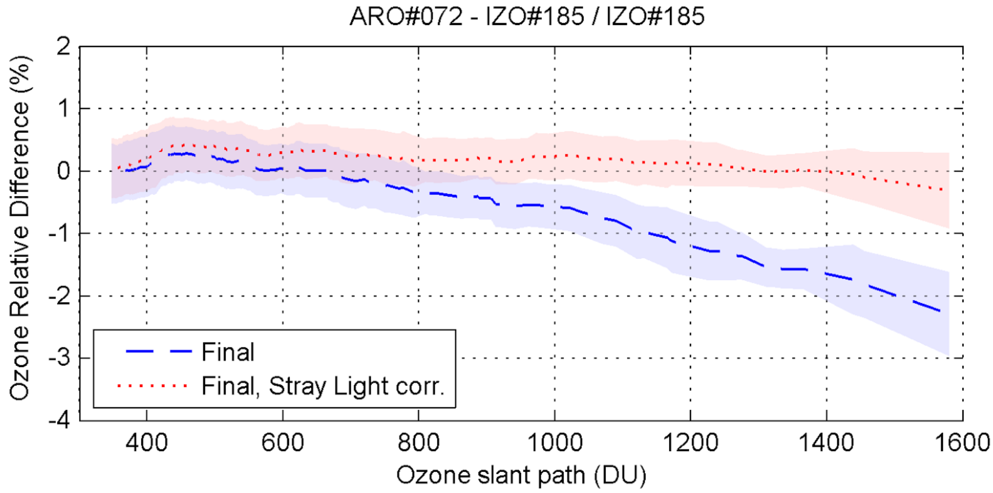


Figure 31. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Straylight

This single Brewer shows a moderate stray light rejection, with ozone underestimated by 1% at an ozone slant path of 1100 DU. This has been greatly improved after applying the power-law correction to the ETC (see Figure 31, red dotted line).

Calibration Constants Summary: ARO#072

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	3168	3150	3187
SL R6 reference value	1905	1905	1925
change SL R6 ratio / ETC		-10 / -18	15 / 37
DT Constant (ns)	38	38	39
Temp. Coeffs.		No change	No change
Cal Step Number	911	911	915
Ozone Abs. Coeff.	0.3397	0.3397	0.3386
Stray Light factors (F0 / k / s)			3192 / -29.4 / 3.27
Calibration File recommended			icf20312.072

Recommendations and Comments

- ARO#072 has shown good stability based on its SL ratios during the two last years. However, it is worth noting two main events related to R6 ratio performance: just after the Arosa 2010 intercomparison and around February 03, 2012.

- The original constants corrected for the SL change resulted in an averaged ozone deviation of -1%. We recommend the calibration constants ETC = 3150 and $R6_{REF}$ = 1900 to re-evaluate Brewer ozone measurements after 03 February 2012. The original constants should perform well before that date.

- We have updated the DT constant to a new reference value of 39 ns. Using this DT constant we proposed 1925 as the new R6 reference value. Both the CSN and the A1 constants have been also updated in the final configuration.

- We achieved a good agreement with the standard instrument using the final calibration constants set, with ozone deviations lower than 0.5% up to ozone slant paths of 900 DU. This instrument shows a moderate stray light rejection, 1% over 1100 DU.

Calibration Report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_072.pd

2.4.5 Brewer ARO#156, Station: Arosa, Switzerland

Brewer ARO#156 participated in the campaign during the period from 16-27 July 2012. The days from July 16 to 20, before the maintenance work, were used for the evaluation of the initial status (116 near-simultaneous direct sun ozone measurements). Days July 21 to 27 were used for final calibration purposes (162 near-simultaneous direct sun ozone measurements).

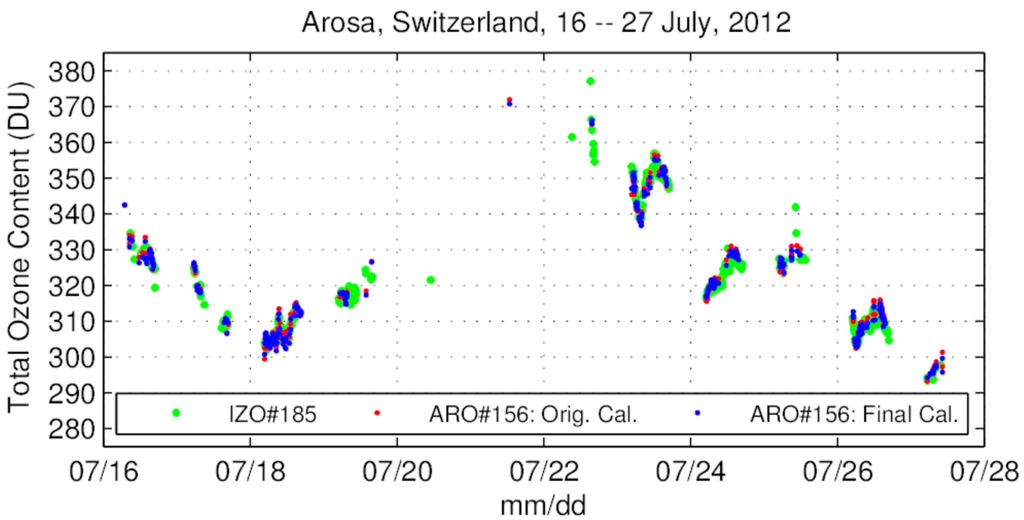


Figure 32. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf21010.156 and the reference value for the standard lamp R6 ratio is 458. These calibration constants (except for the R6 reference value, see below) were obtained after the last RBCC-E intercomparison campaign (July 2010).

Historical Analysis

ARO#156 has shown good stability based on its SL ratios during the two last years, except for some notable change (around 20 units) in SL ratios occurring in October 2010. Accordingly to this change, a different reference R6 value (458) to the one stated at the Arosa 2010 intercomparison (445) was provided by the Brewer operator. All the other parameters analysed were within the tolerance range.

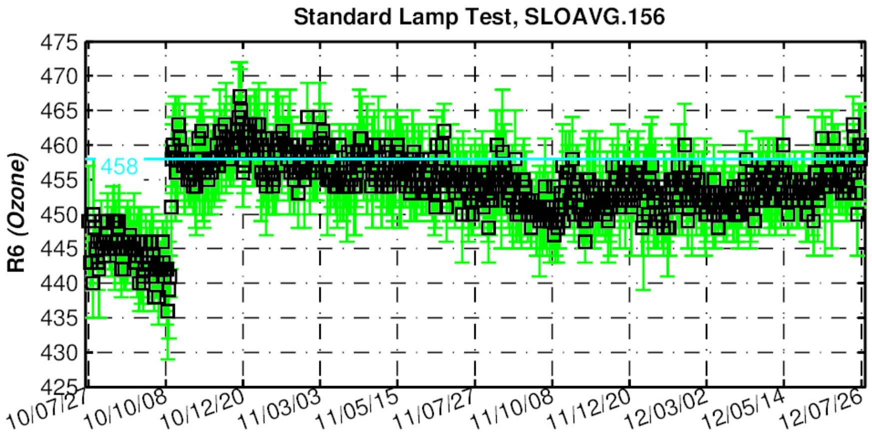


Figure 33. Standard Lamp test R6 (Ozone) ratio

Initial Comparison

The initial comparison with reference IZO#185 was found to be quite good, with an ozone deviation less than 0.5% for an ozone slant path in the range from 300 DU to 1500 DU. Although the SL R6 ratio was updated from the value 445 to 458 in October, the ETC constant was kept the same as the one provided during the last Arosa 2010 intercomparison. From this, and from the good agreement observed during the initial campaign days, we conclude that SL R6 ratio changes seemed not to be related to changes in the instrument's response. Accordingly, we recommend to not apply the standard lamp correction to this instrument.

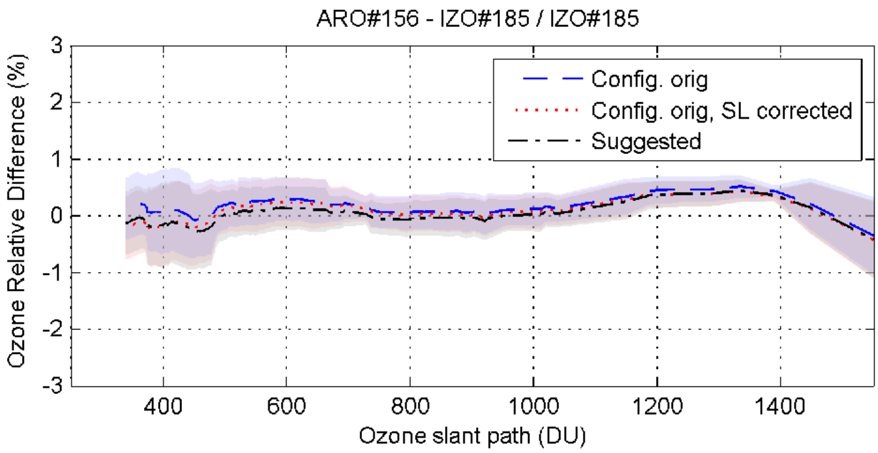


Figure 34. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Final Calibration

We have used updated A1 and CSN constants for the final calibration. All other instrumental calibration constants remained the same. We achieved a very good agreement against the RBCC-E travelling standard using this calibration set, with an ozone deviation lower than 0.25% up to ozone slant paths of 1600 DU.

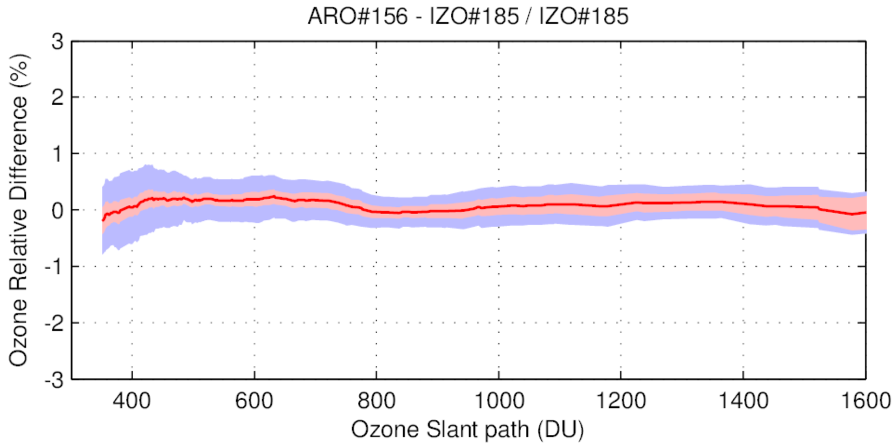


Figure 35. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation.

Straylight

No stray light rejection (double monochromator).

Calibration Constants Summary: ARO#156

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	1750	1750	1765
SL R6 reference value	445	458	458
change SL R6 ratio / ETC		<5 / <5	<5 / 15
DT Constant (ns)	24	24	24
Temp. Coeffs.		No change	No change
Cal Step Number	1020	1020	1022
Ozone Abs. Coeff.	0.3426	0.3426	0.3402
Stray Light factors (F0 / k / s)			Double Monochr.
Calibration File recommended			icf20312.156

Recommendations and Comments

- ARO#156 has shown good stability based in its SL ratios during the last two years, with the exception of some significant change (20 units) in October 2010. As a consequence of this change, a different reference value for the SL R6 ratio to the one stated during the last Arosa 2010 intercomparison (445) has been provided by the Brewer operator (458).

- The original constants performed well with ozone deviations on the order of 0.5% for a wide ozone slant path range. Since the SL R6 ratio but not the ETC constants were updated in October 2010 (the ETC remained the same as the one provided during the Arosa 2010 campaign, 1750), we concluded that changes in the SL ratios are not related to changes in the instrument's response. We do not recommend applying the standard lamp correction to this instrument.

- Both the CSN and the A1 constants have been also updated in the final configuration.

- We achieved a good agreement with the standard instrument using the final calibration constants set, with ozone deviations lower than 0.25% up to ozone slant paths of 1600 DU.

Calibration Report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_156.pdf

2.4.6 Brewer K&Z#158, Station: Delft, Netherlands

Brewer K&Z#158 participated in the campaign during the period from 16-27 July 2012. No maintenance work was done to the instrument, so we used the same dataset to evaluate the initial status of the instrument as well as for final calibration purposes (427 near-simultaneous direct sun ozone measurements).

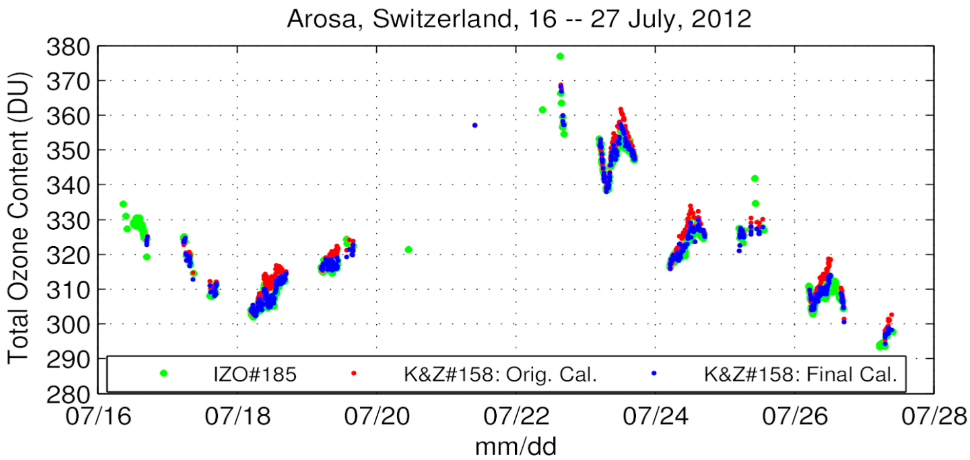


Figure 36. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf11010.158 and reference value for the standard lamp R6 ratio 476.

Historical Analysis

K&Z#158 has shown good stability based on its SL ratios during the last year until June. The photomultiplier tube was replaced just before the campaign days (late June 2012). As a result, a moderate change in the standard lamp R6 ratio is observed (from 460 to 480) as well as in DT values (from 30 to 22 ns). The reference value for SL R6 ratio provided (476) referred to this last period. It is advised to carefully check the instrument performance during the following months. All the other parameters analysed were within the tolerance range.

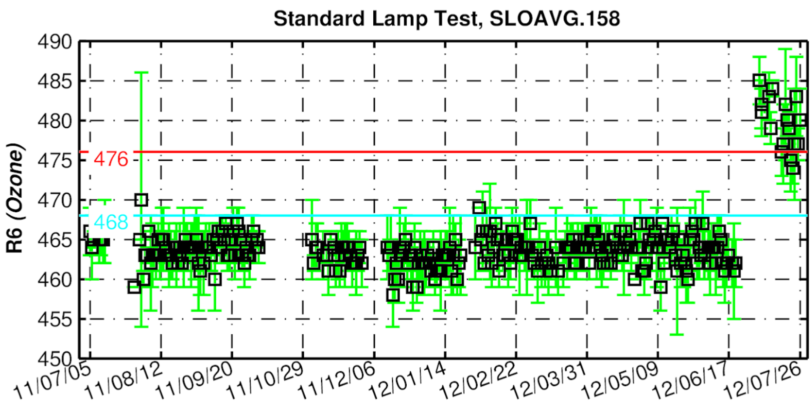


Figure 37. Standard Lamp test R6 (Ozone) ratio

Initial Comparison

We used the same data set to evaluate the initial status of the instrument as well as for the final calibration purposes.

Final Calibration

The initial comparison with reference IZO#185 was found to be poor, showing an average ozone deviation of 1% for low ozone slant path (<500 DU). Correcting the ETC by the standard lamp ratio change did not improve significantly the comparison. We have used updated DT constant and temperature coefficients for the final calibration. Note that, and because we have reprocessed the SL ratios using these new constants, the suggested reference value for R6 (468) does not match the values plotted in Figure 37. We achieved a very good agreement against the RBCC-E travelling standard using this calibration set, with ozone deviation lower than 0.25% up to ozone slant path 1600 DU. This calibration is only valid after PMT tube replacement in June.

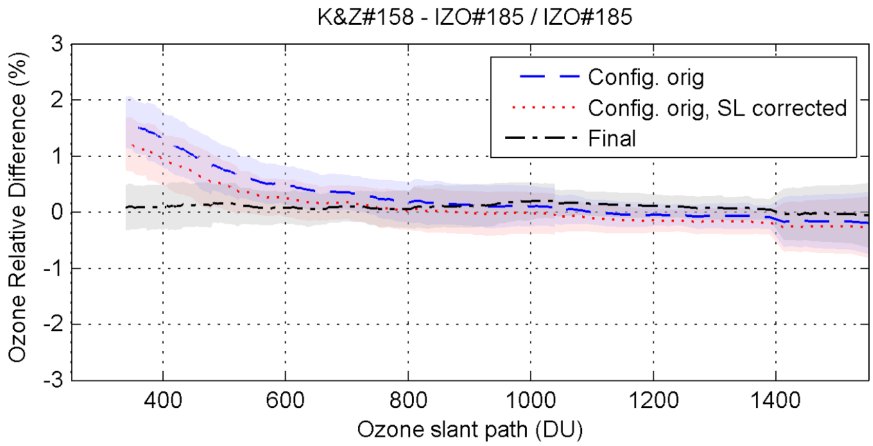


Figure 38. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation

Straylight

No stray light rejection (double monochromator).

Calibration Constants Summary: K&Z#158

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	1738		1731
SL R6 reference value	476		468
change SL R6 ratio / ETC			New DT & TC's
DT Constant (ns)	30		22
Temp. Coeffs.			New set
Cal Step Number	284		284
Ozone Abs. Coeff.	0.3432		0.3432
Stray Light factors (F0 / k / s)			Double Monochr.
Calibration File recommended			icf19812.158

Recommendations and Comments

- K&Z#158 has shown good stability based on its SL ratios during the last year until June, when the photomultiplier tube was replaced. The reference value for SL R6 ratio provided by the Brewer operator (476) referred to the period after this event.

- We achieved a good agreement with the standard instrument using the final calibration constants set, with ozone deviations lower than 0.25% up to ozone slant path to 1600 DU.

- The Standard Lamp do not track the PMT change and the new calibration is only valid after the PMT replacement with the updated DT and temperature coefficients.

- Due stability of the SL record the original calibration looks valid before the PMT.

Calibration Report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_158.pdf

2.4.7 Brewer ARO#163, Station: Davos, Switzerland

Brewer WRC#163 participated in the campaign during the period from 16-25 July 2012. We used the same dataset to evaluate the initial status of the instrument as well as for final calibration purposes (227 near-simultaneous direct sun ozone measurements).

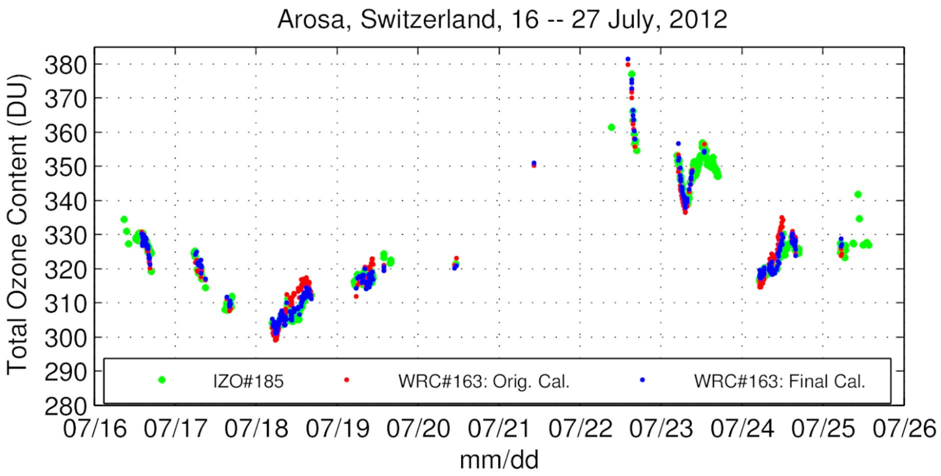


Figure 39. Brewer Intercomparison Arosa 2012

Original Calibration

The instrument operates with the configuration file icf04112.163 and reference value for the standard lamp R6 ratio 240. These calibration constants (except for the R6 reference value, which corresponds to the provided value at El Arenosillo 2011 campaign) were obtained after the Arosa 2010 intercomparison.

Historical Analysis

From reprocessed SL R6 ratio (using the provided configuration file) we concluded a rather poor instrument's performance since the last intercomparison, El Arenosillo 2011, with R6 deviations to the reference value (240) greater than 10 units. Because of frequent instrumental constants changes, we couldn't use the historical SL records for this same purpose. All the other parameters analysed were acceptable, except for the noisy DT and RS tests, mainly due to the very low standard lamp intensity (fixed after the internal halogen lamp was replaced).

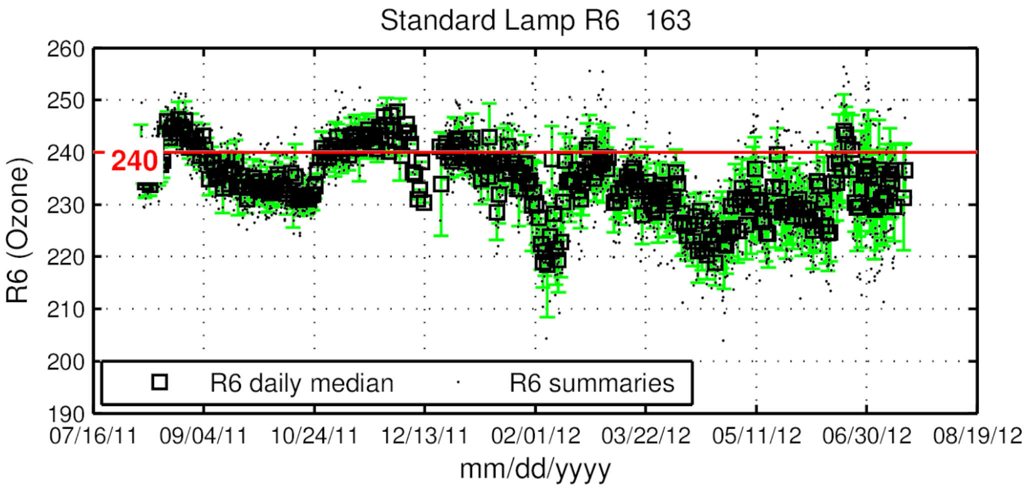


Figure 40. Standard Lamp test R6 (Ozone) ratio

Initial Comparison

Despite internal halogen and mercury lamps replacement, we did not detect any change in the instrument's performance during the campaign days; thus, we used the same data set to evaluate the initial status of the instrument as well as for final calibration purposes. Instrument's normal operation was difficult during the last days due to power supply failure (no HP tests were possible). As a result, scanning measurements like UV, CI or CZ were not possible.

Final Calibration

We have used updated temperature coefficients and A1 constant for the final calibration. Standard lamp ratios were rather unstable during the campaign days. We finally adopted as the reference R6 ratio the mean value calculated after the internal halogen lamp replacement (178). Changes in R6 ratio were not related with changes in the instrument's response, so we advise to be careful when applying the SL correction to ozone measurements. A good agreement against the RBCC-E standard IZO#185 is observed after using these calibration constants, with ozone deviation around 0.25% up to ozone slant path 1400 DU.

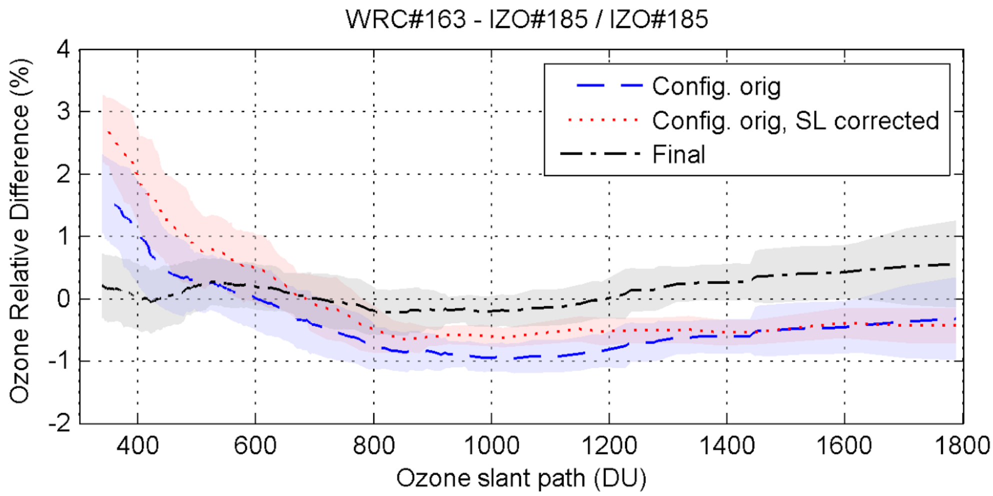


Figure 41. Ozone deviation to the reference instrument as a function of ozone slant path. The shadow areas represent standard deviation

Straylight
No stray light rejection (double monochromator).

Calibration Constants Summary: WRC#163

	Last Cal.	*Initial (blind)*	*Final*
O3 ETC constant	1450		1426
SL R6 reference value	240		178
change SL R6 ratio / ETC			62 / 24
DT Constant (ns)	24		24
Temp. Coeffs.			New TC's
Cal Step Number	1024		1024
Ozone Abs. Coeff.	0.3414		0.3388
Stray Light factors (F0 / k / s)			Double Monochr.
Calibration File recommended			icf19812.163

Recommendations and Comments

- Because of frequent instrumental constants changes, we couldn't use the historical SL records for assessing the instrument's performance since the last El Arenosillo 2011 intercomparison. In any case, from reprocessed SL R6 ratio (using the provided configuration file) we concluded a rather poor instrument's performance in this period.

- Very noisy DT and RS tests were fixed after the internal halogen lamp was replaced. Using updated temperature coefficients we calculated a new reference value (178) for the SL R6 ratio.

- The initial comparison with reference IZO#185 was found to be poor, with ozone deviation greater than 1% for low ozone slant path (below 600 DU) and on the order of -1% for high ozone slant path. Correcting by the SL change made the comparison even worse. We do not recommend applying the standard lamp correction to this instrument.

- We used updated DT constant and temperature coefficients for the final calibration. A good agreement with the standard instrument is observed using the final calibration constants, with ozone deviations lower than 0.25% up to ozone slant path to 1400 DU. These constants should be valid at least since February 2012.

Calibration Report

http://www.iberonesia.net/archives/reports/Aro2012/CALIBRATION_163.pdf

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3. PROTOCOL OF THE INTERCOMPARISON AT LKO WITH THE TRAVELLING REFERENCE SPECTRORADIOMETER QASUME FROM PMOD/WRC

Report prepared by Gregor Hülsen and Julian Gröbner

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The purpose of the visit was the intercomparison of spectral global solar ultraviolet irradiance measurements from 9 Brewer spectrophotometers participating in the 7th Regional Brewer Calibration Center – Europe (RBCC-E) Campaign (see Table 1) and the travel reference spectroradiometer QASUME at the Lichtklimatische Observatorium (LKO) in Arosa; Latitude 46.78 N, Longitude 9.68 E and altitude 1846 m.a.s.l..

Measurements between 4:00 UT and 19:00 UT have been analysed.

QASUME arrived at LKO in the morning of July 16, 2012. The spectroradiometer was installed in line to the Brewer spectrophotometers with the entrance optic of QASUME between 2 and 10 m away from the other instruments. The measurement campaign was from July 16 to the morning of July 25; the core UV comparison days were from 22-24 July.

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 23.9±0.3 °C. The diffuser head was heated to a temperature of 28.5±1.6°C.

The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm analysis were between ±50 pm in the spectral range from 290 to 400nm.

Table 1. Mean values of the ratio Brewer/QASUME (305 – 320 nm), the diurnal variability and the wavelength shifts

Instrument ID	*Brewer to QASUME [%]*	*Diurnal variability [%]*	*Wavelength shift [pm]*	*Temperature Dependence [%/K]*
#017	-	-	-	-
#040	-5	±3	-20 .. +40	-0.11
#072	-6	±4	-20 .. +40	-
#156	-4	±5	-50 .. +50	-0.45
#066_AAB	-3	±2	-20 .. +50	~0
#067	5	±2	-50 .. +50	-
#158	-5	±4	-70 .. +50	-
#163_ISQ	-	-	-	~0
#185_IZ3	-4	±3	-30 .. +30	~0

Protocol

The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 to 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

DOY	*Date*	*Day*	*Weather*	*Comment*
198	16-Jul	Monday	Mostly clear sky with few cirrus clouds	Installed at 11:00 UT
199	17-Jul	Tuesday	Mix of sun & clouds	Calibrated: 10:28 (T68523) Calibrated: 10:48 (T68522)
200	18-Jul	Wednesday	Mostly clear sky with few cirrus clouds	12-16 UT: Cooling Problem
201	19-Jul	Thursday	Mix of sun & clouds Rain shower (afternoon)	
202	20-Jul	Friday	Mix of sun & clouds Foog in the morning	Calibrated: 9:32 (T68523)
203	21-Jul	Saturday	Mix of sun & clouds Rain during the day	(No Qasume Operator) Qasume Com.Error
204	22-Jul	Sunday	Mix of sun & clouds Rain during the day	UV Days Cooling Problem
205	23-Jul	Monday	Mostly clear sky	UV Days Calibrated: 6:11 (T68523)
206	24-Jul	Tuesday	Clear sky (Morning) Mix of sun & clouds	Calibrated: 9:12 (T68523)
207	25-Jul	Wednesday	Clear sky (Morning) Mix of sun & clouds Rain started 9:30	Calibrated: 5:45 (T68523) Calibrated: 6:13 (T68522) End of Campaign: 10:00 UT

Results

In total 35 to 82 synchronized simultaneous spectra from QASUME and the Brewer spectrophotometers are available from the measurement period. Measurements between 4:00 and 19:00 UT have been analysed (SZA smaller than 90°).

Remarks

1. The first day of the intercomparison was dedicated to the setup and training phase. The official “UV-days” were 22 and 24 July (204-206). However, synchronized UV scans are also available from the start of the campaign.

2. Although different calibrations and measurements were performed during the campaign, traffic on the roof could be limited. Therefore only a few scans are disturbed.

Specific Remarks for the individual Brewer spectrophotometer

1. Brewer #017 arrived at Arosa without electronic boards and case. The optical parts (front optics and spectrometer) of this reference instrument were used for ozone calibration but not for UV measurements.

2. Brewer #066 (AAB) and #158 show various spikes in the data during the campaign.

3. Brewer #156: The largest contribution to its measurement uncertainty arises from its exceptional large temperature dependence (see discussion on the next page). A temperature correction of the data is recommended.

4. Brewer #163 (ISQ) malfunctioned during the campaign. No reliable UV data could be recorded.

5. Brewer #185 (IZ3): On clear sky days (see for example DOY 205 and 206) the cosine error of the input optic of this instrument dominates its measurement uncertainty.

Brewer Temperature dependence

The standard Brewer global UV measurement procedure does not take into account the dependence of the Brewer spectral responsibility to ambient temperatures. However several studies have shown, that Brewer spectrophotometers have a temperature dependence which can be as large as 0.9%/K and which depends on wavelength (*see Cappellani, F. and C. Kochler* (2000) and *Weatherhead, E. et al.* (2001)).

At Arosa, due to the high diurnal temperature variations, the temperature dependence of the Brewer spectrophotometers has therefore a significant influence on the global UV measurements as can be seen in the respective ratios relative to the QASUME spectroradiometer which is temperature stabilized. An example can be seen with Brewer #156 on the clear sky day 205 and 206 (see also protocol of the 3rd RBBC-E, Arosa 2008).

Recommendations

The variability observed between individual Brewer spectrophotometers relative to the QASUME spectroradiometer are due to ambient temperature variations on the one hand (see above paragraph), and to angular response errors which were not accounted for (see *Gröbner, J*. (2003)) While a reliable correction of angular response errors requires the modification of the Brewer entrance optic, the temperature dependence can be corrected by applying a suitable spectral temperature correction to global UV measurements. This function should be determined individually for every Brewer using a measurement procedure as described in the refereed literature (see references above).

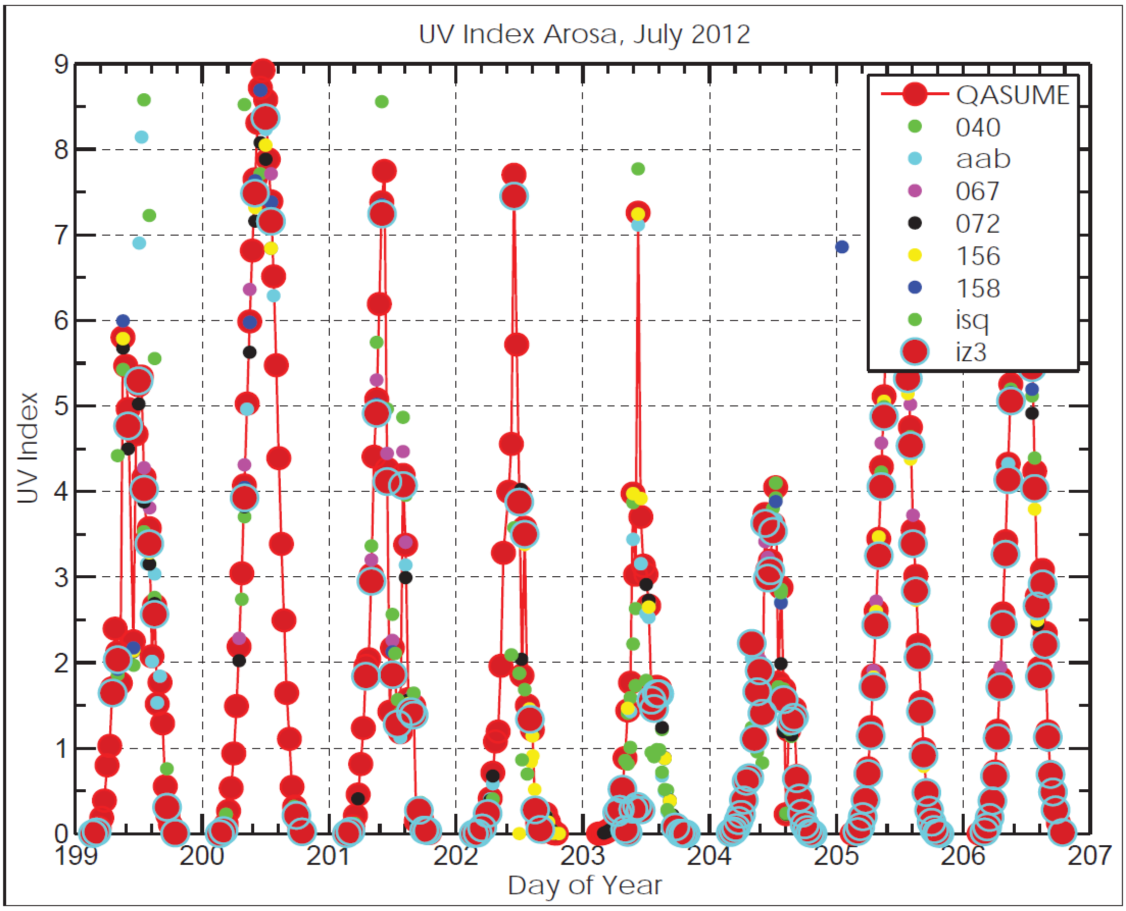


Figure 1. Overview of UV measurements during the intercomparison period

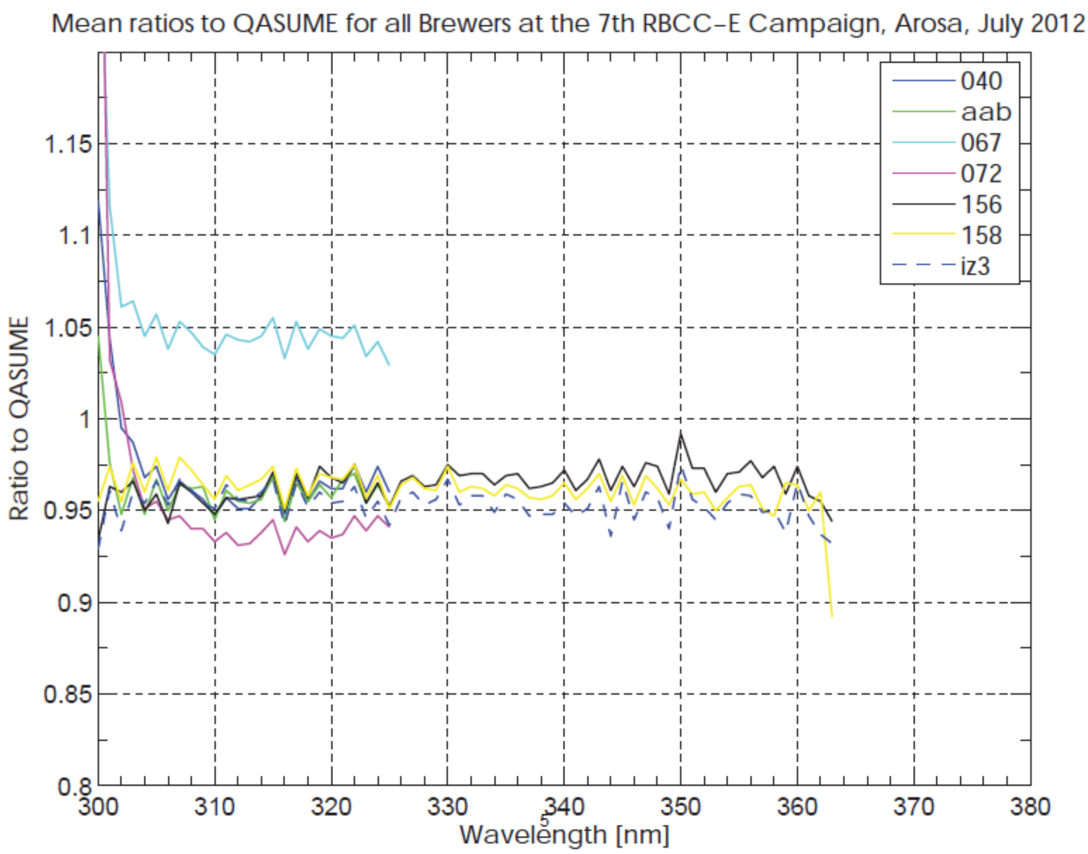


Figure 2. Average ratios between all participating Brewer spectrophotometers and the QASUME reference spectroradiometer

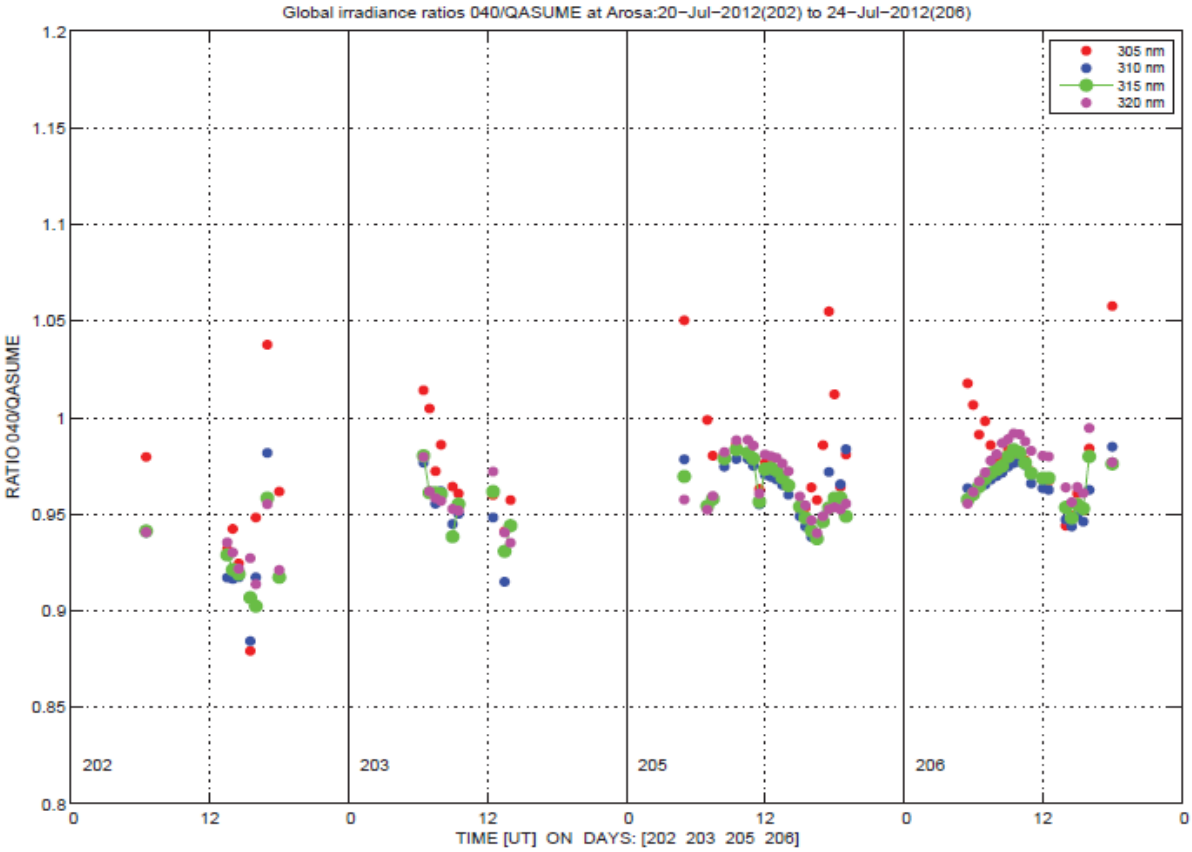


Figure 3. Diurnal variation of the ratio between Brewer #40 and QASUME at selected wavelength bands for the whole measurement period

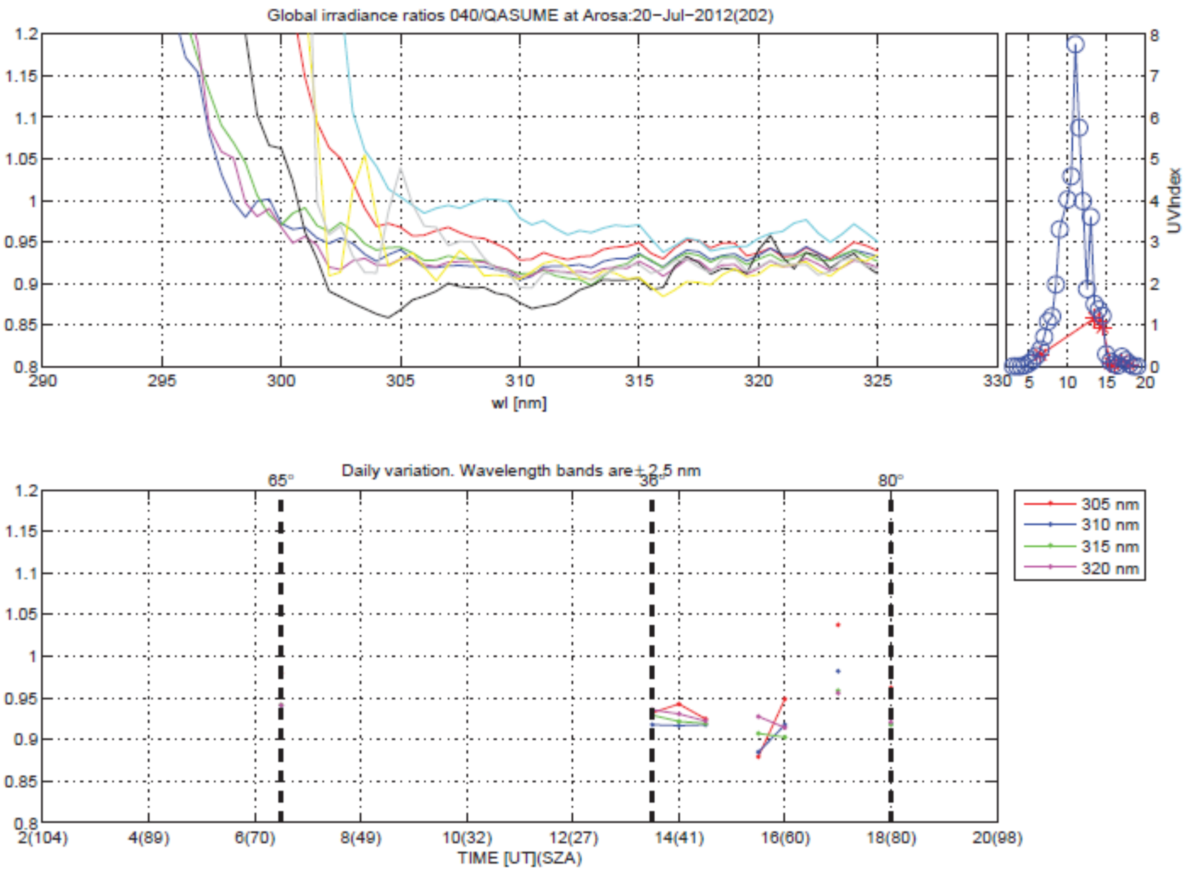


Figure 4. Upper figure: Spectral ratios between Brewer #40 and QASUME on 20 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #40 and QASUME at selected wavelength bands.

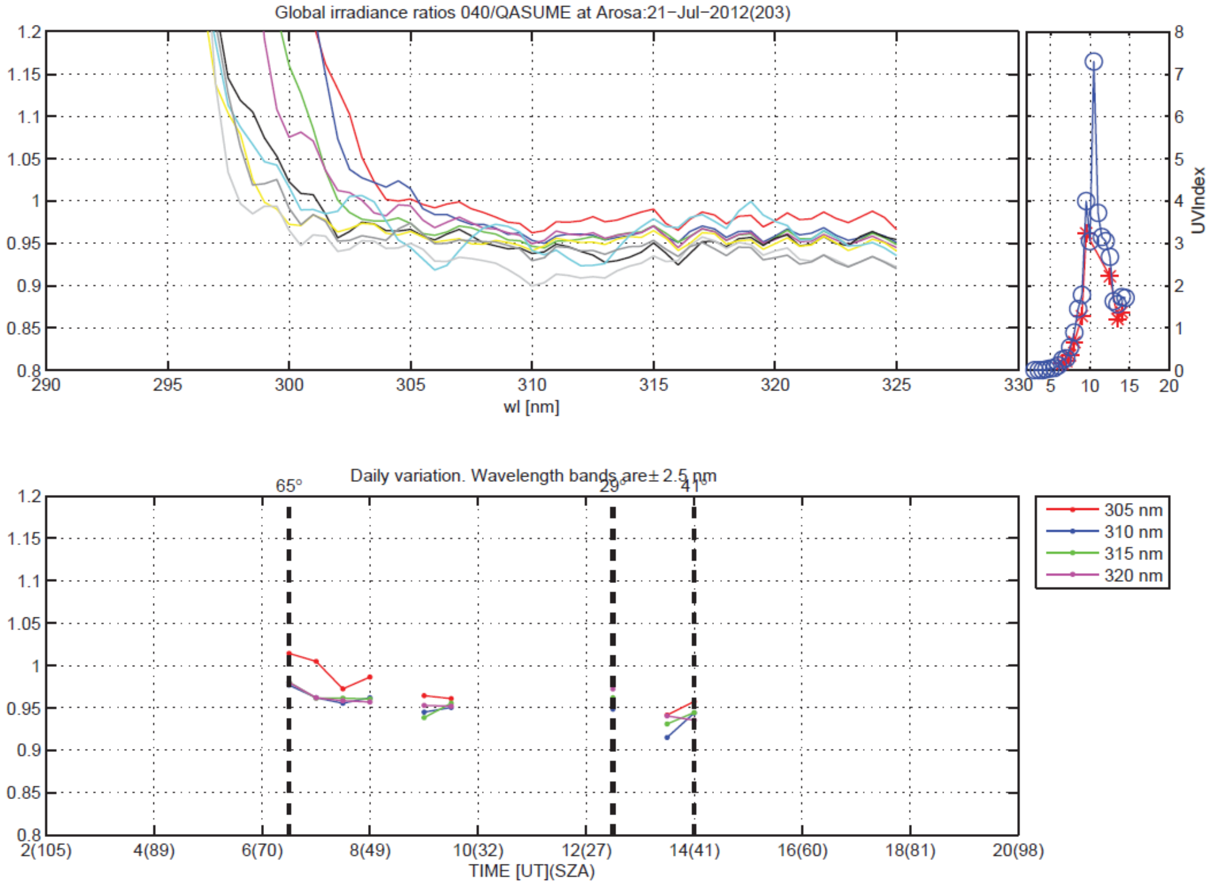


Figure 5. Idem to Figure 4 for 21 July 2012

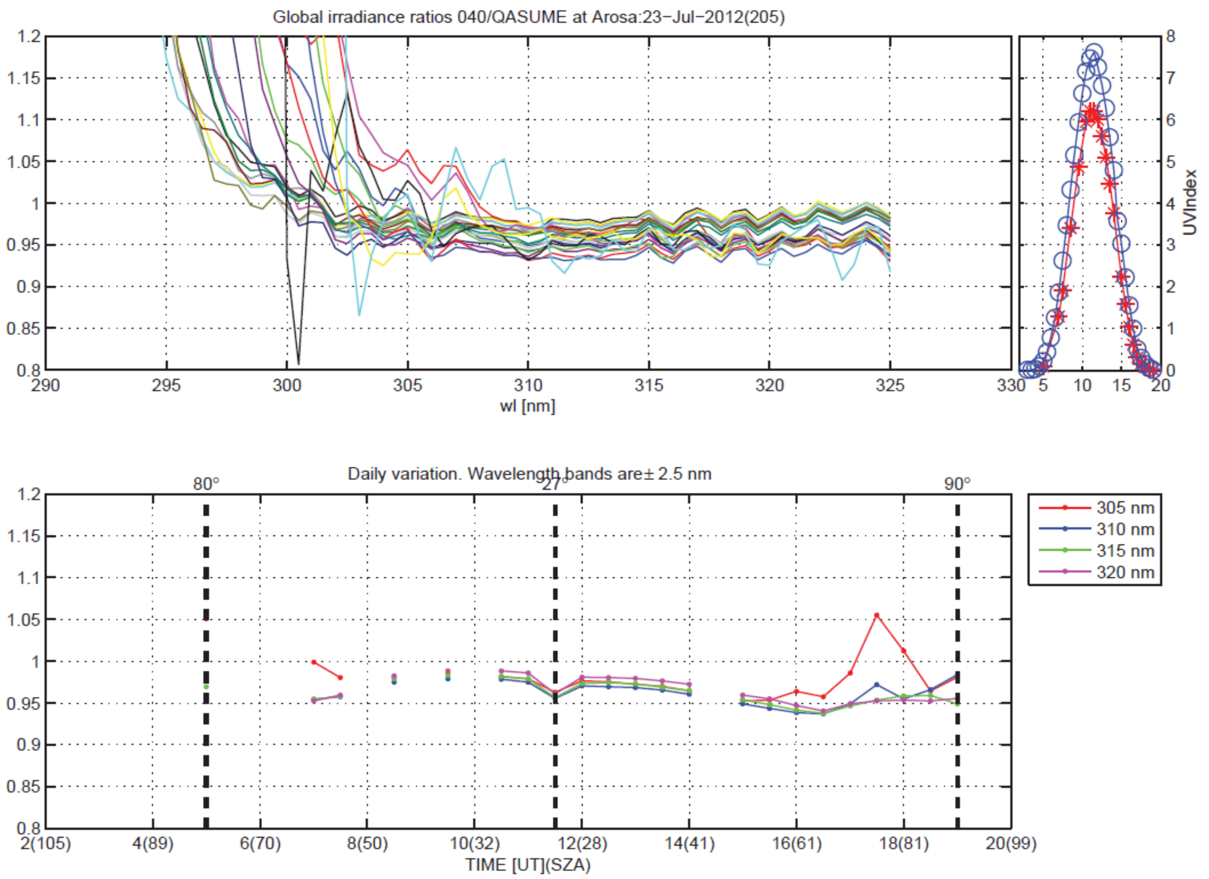


Figure 6. Idem to Figure 4 for 23 July 2012

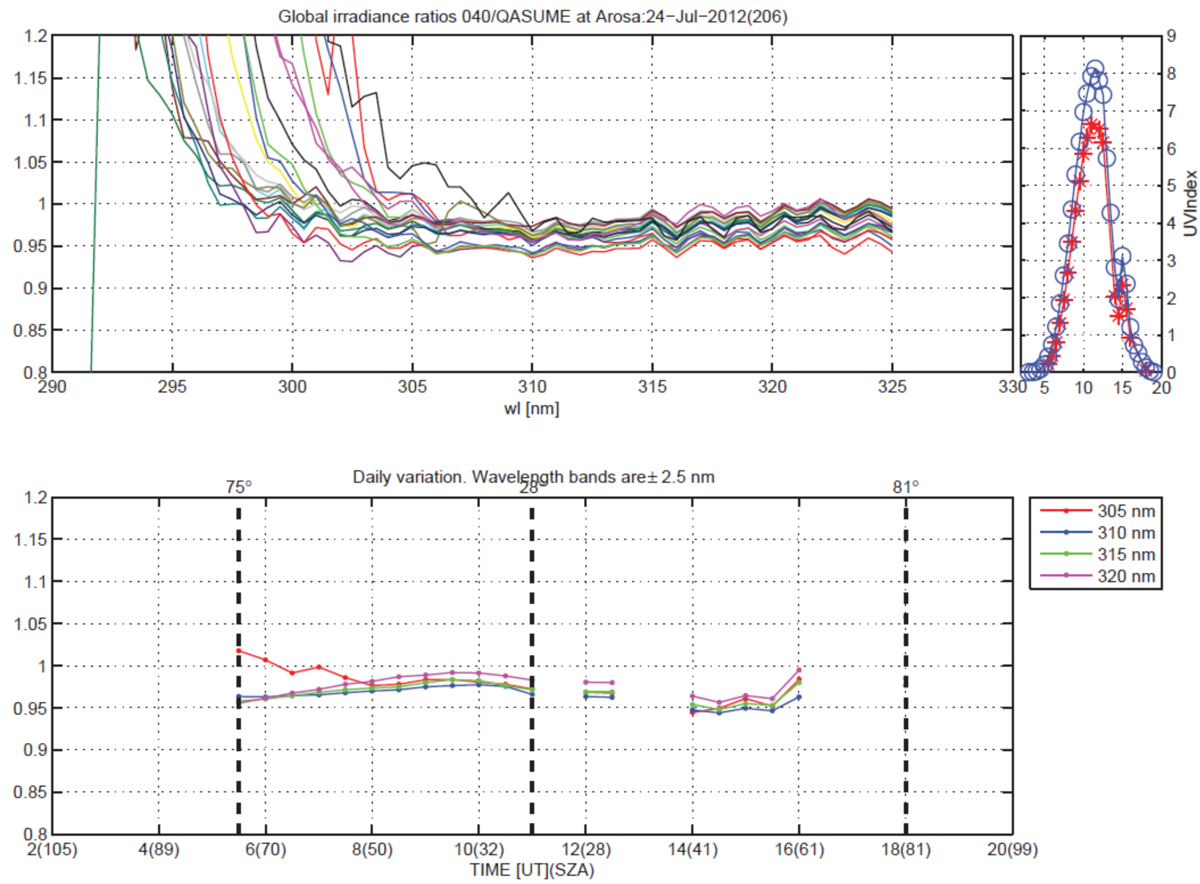


Figure 7. Idem to Figure 4 for 24 July 2012

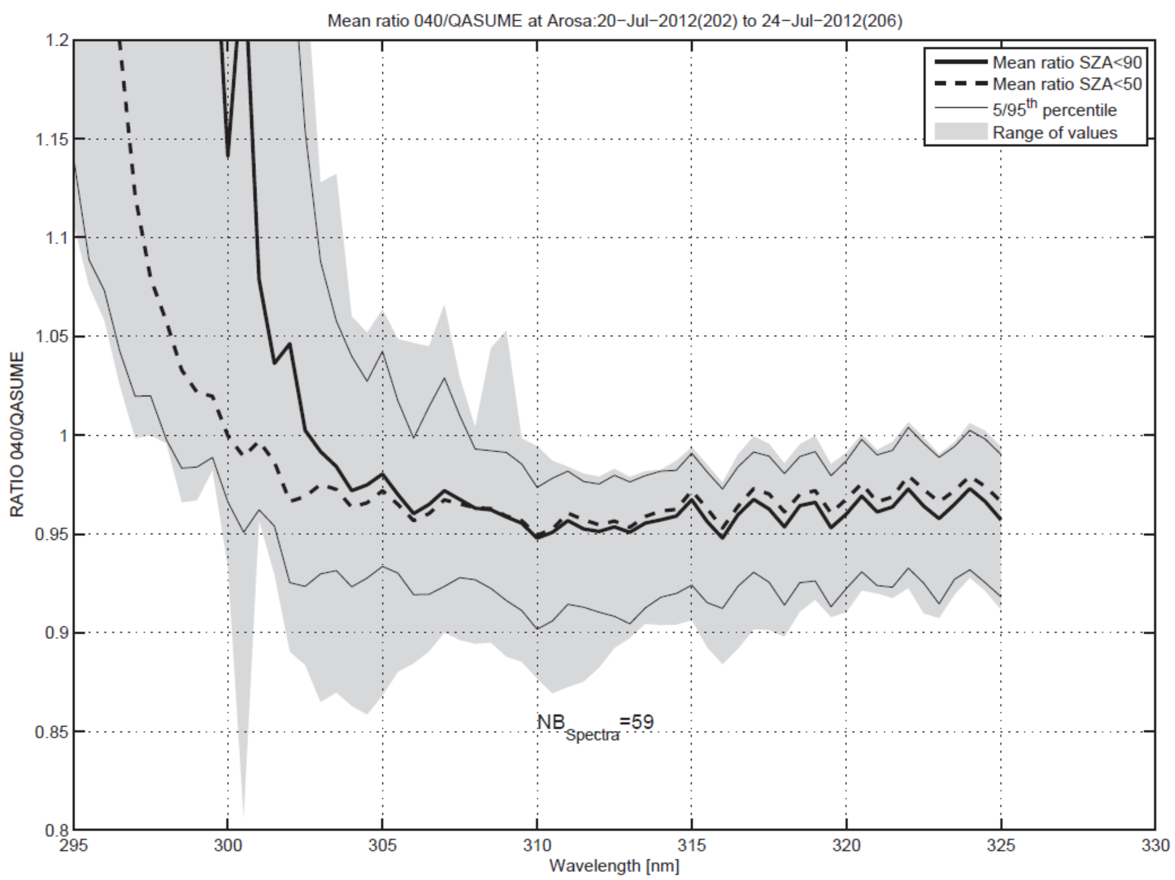


Figure 8. Average spectral ratios between Brewer #40 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

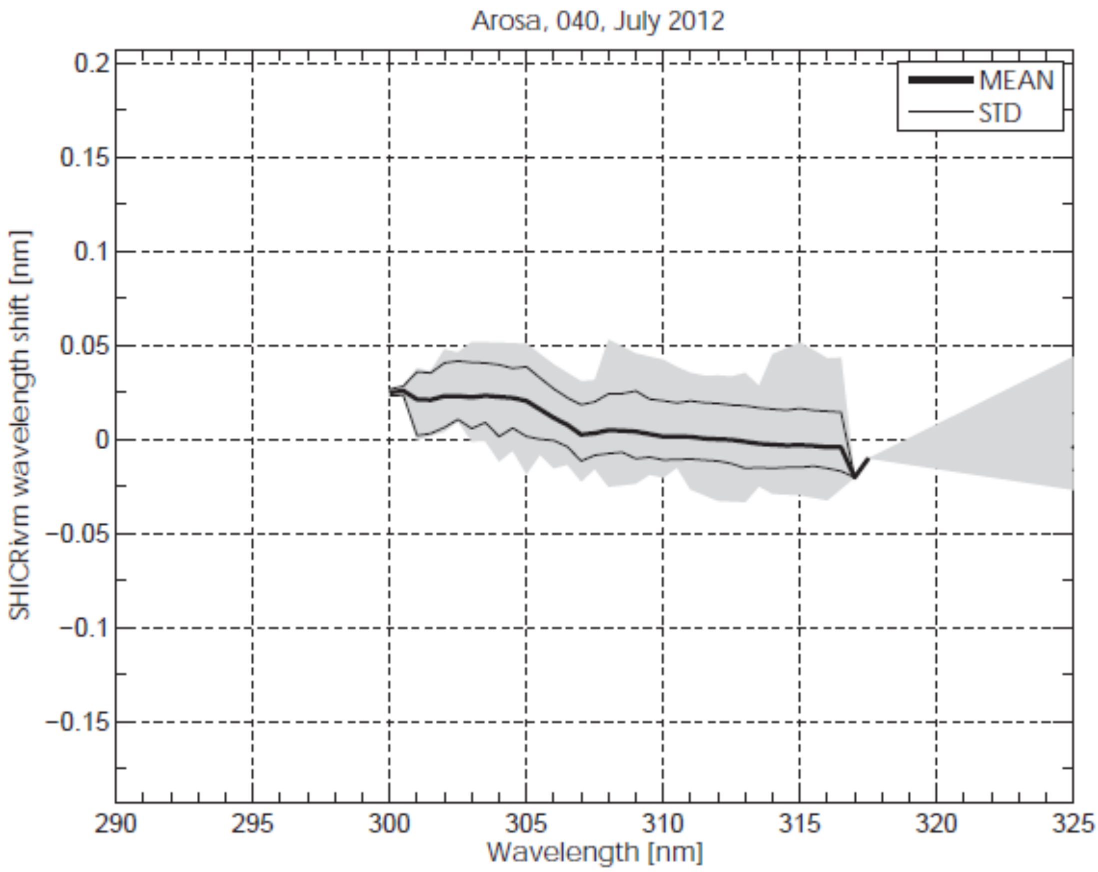


Figure 9. Average spectral wavelength shift of Brewer #40 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

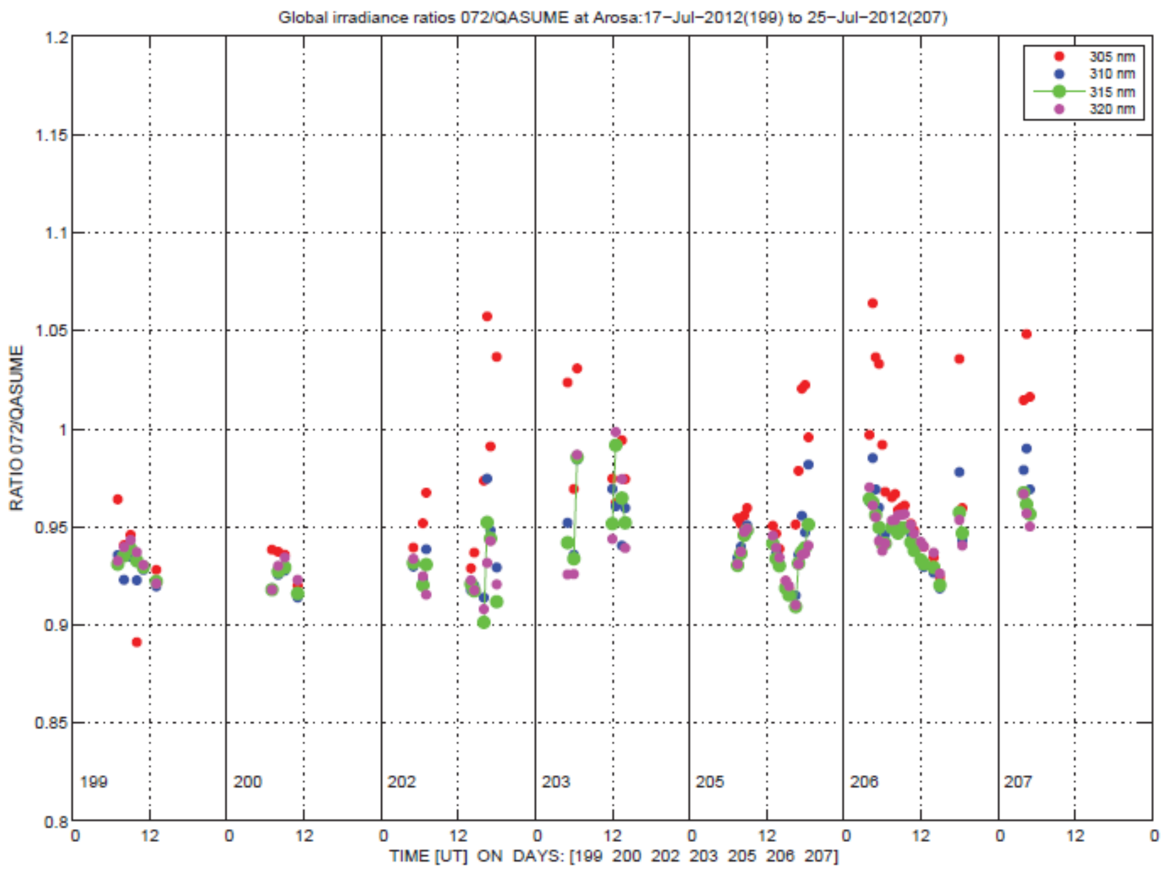


Figure 10. Diurnal variation of the ratio between Brewer #72 and QASUME at selected wavelength bands for the whole measurement period

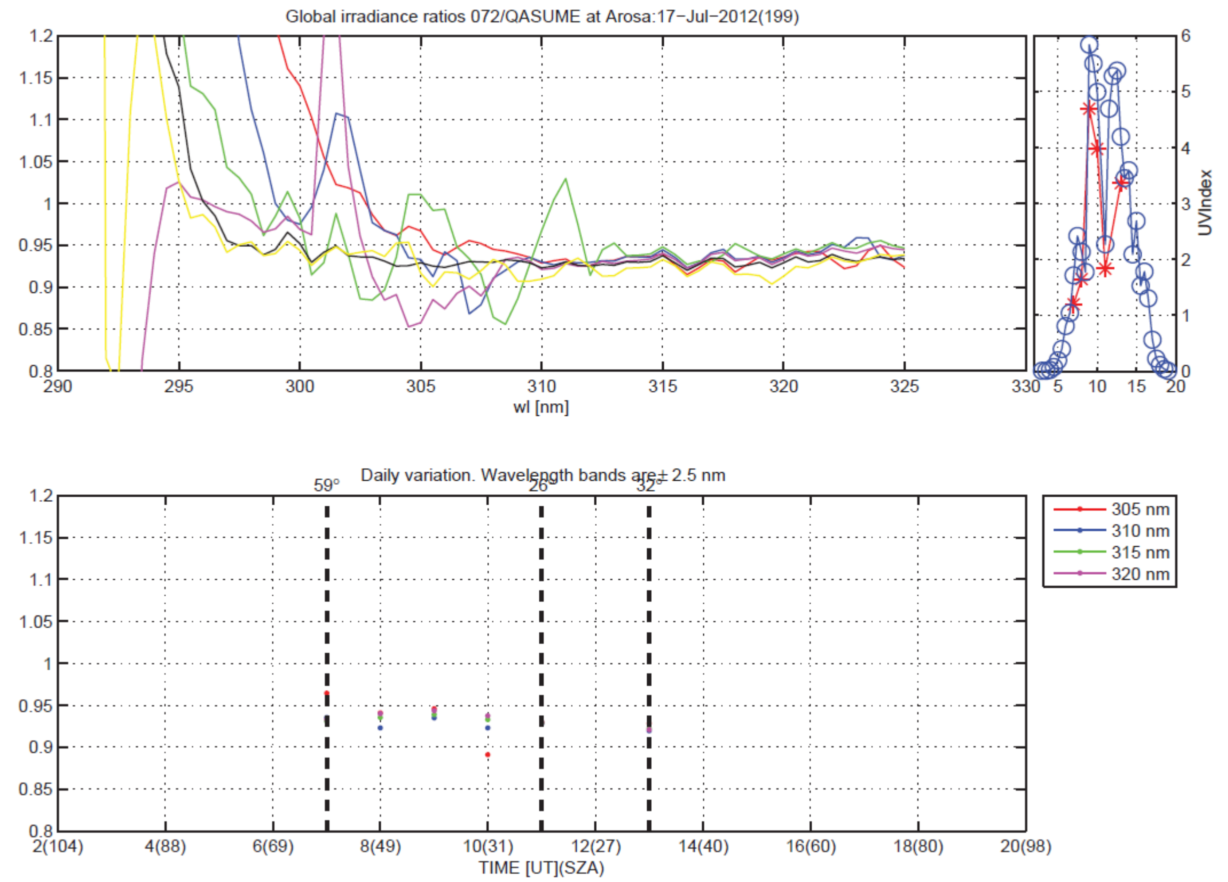


Figure 11. Upper figure: Spectral ratios between Brewer #72 and QASUME on 17 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #72 and QASUME at selected wavelength bands.

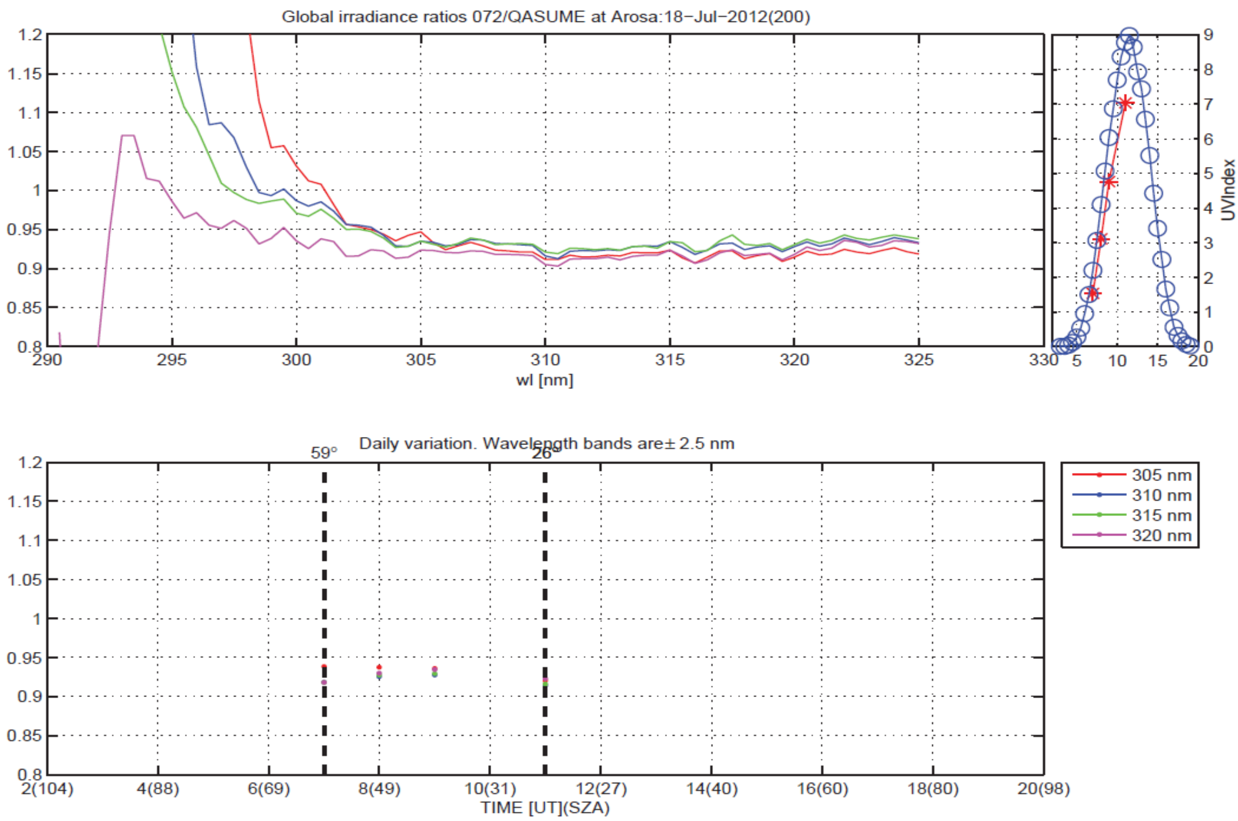


Figure 12. Idem to Figure 11 for 18 July 2012

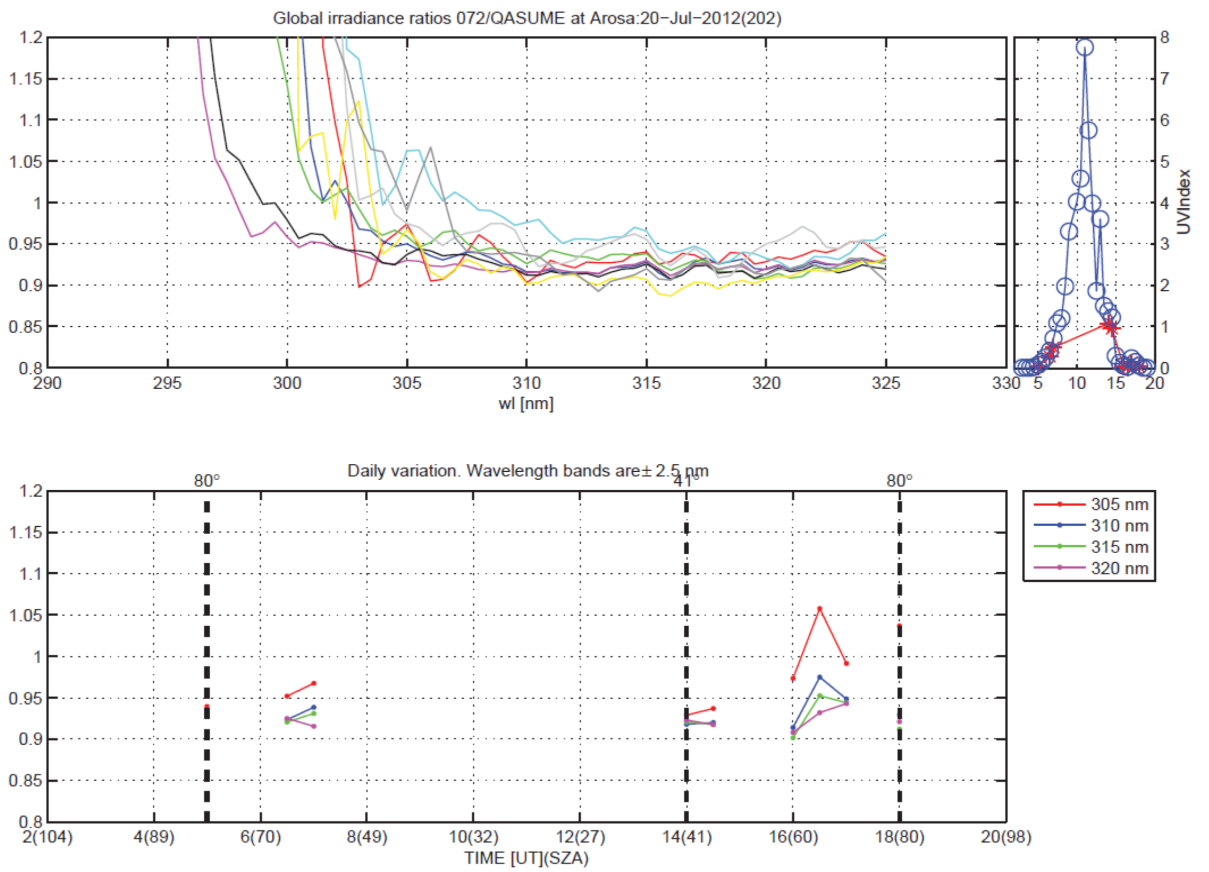


Figure 13. Idem to Figure 11 for 20 July 2012

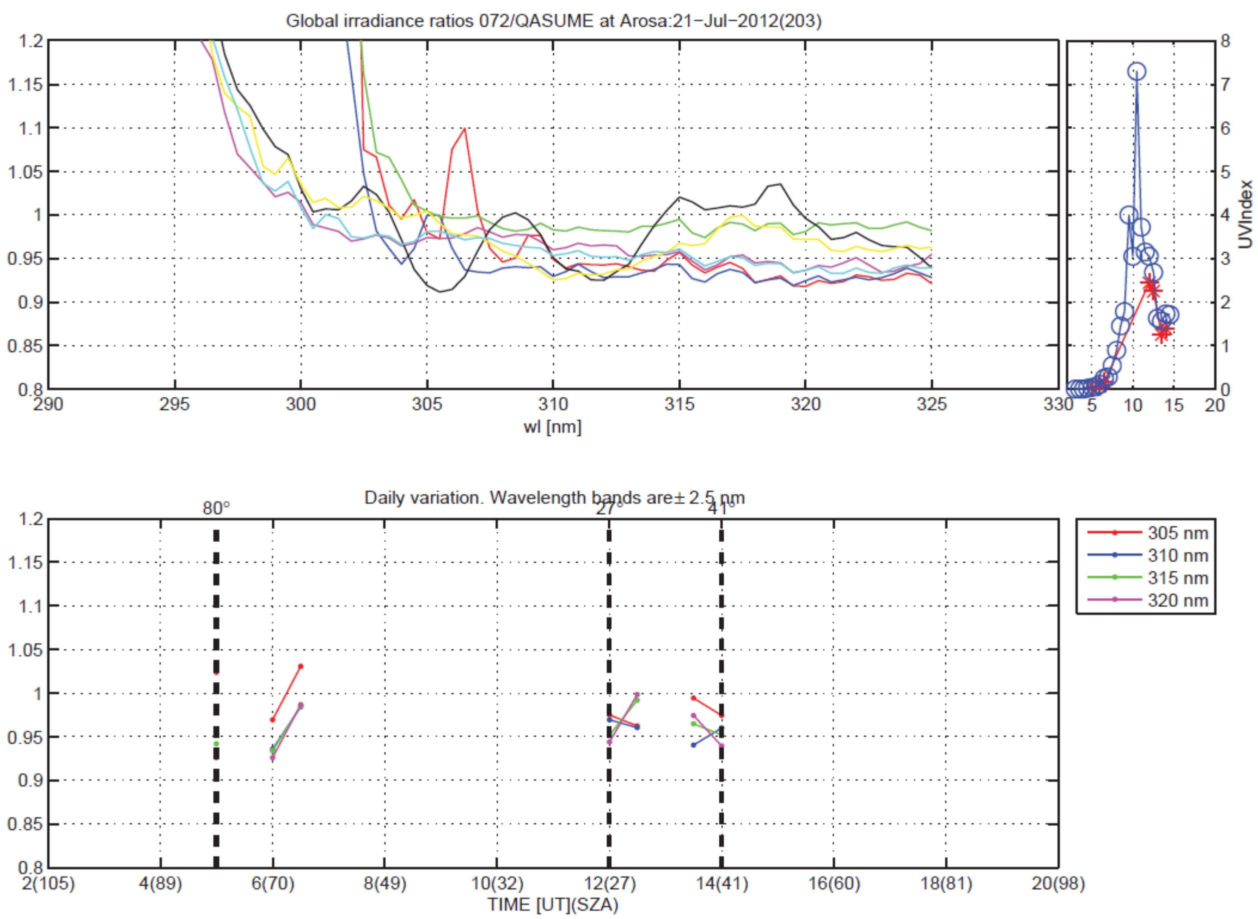


Figure 14. Idem to Figure 11 for 21 July 2012

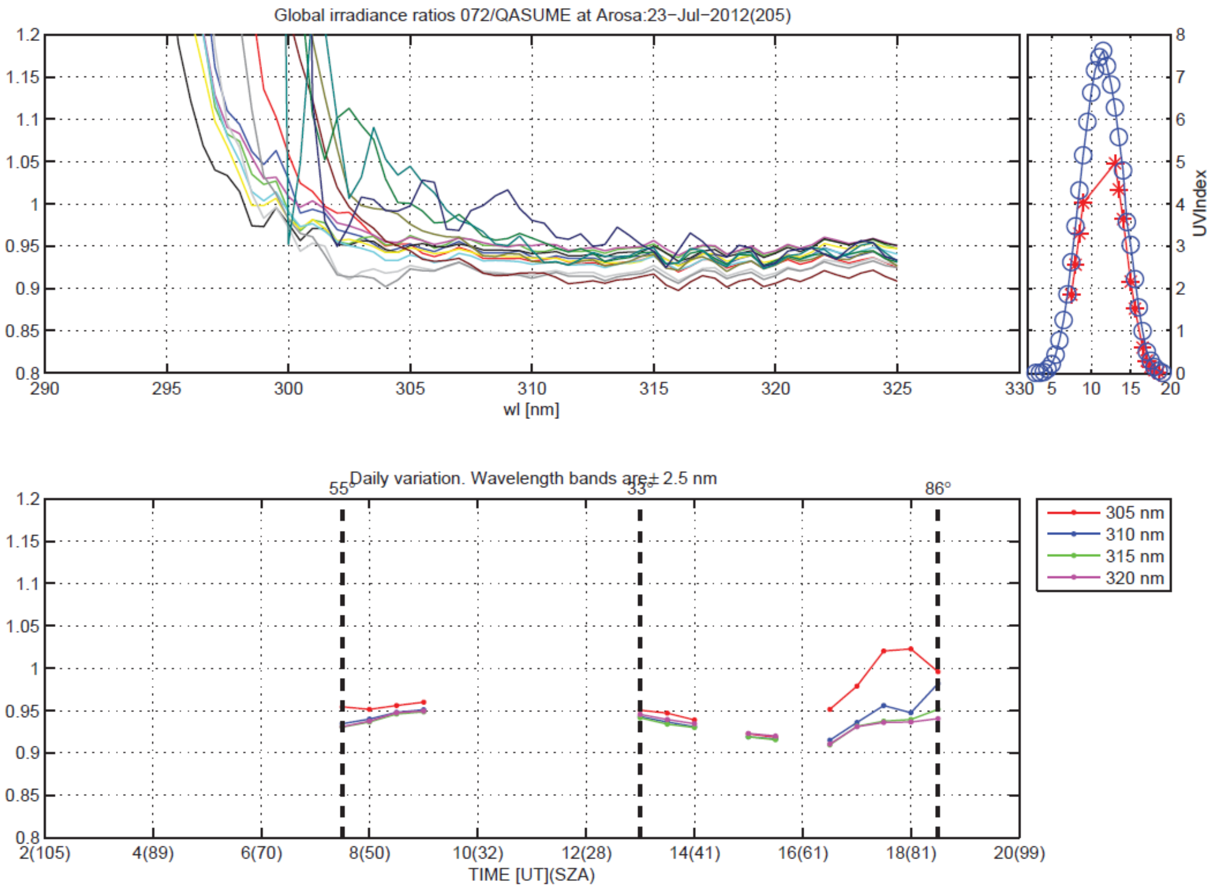


Figure 15. Idem to Figure 11 for 23 July 2012

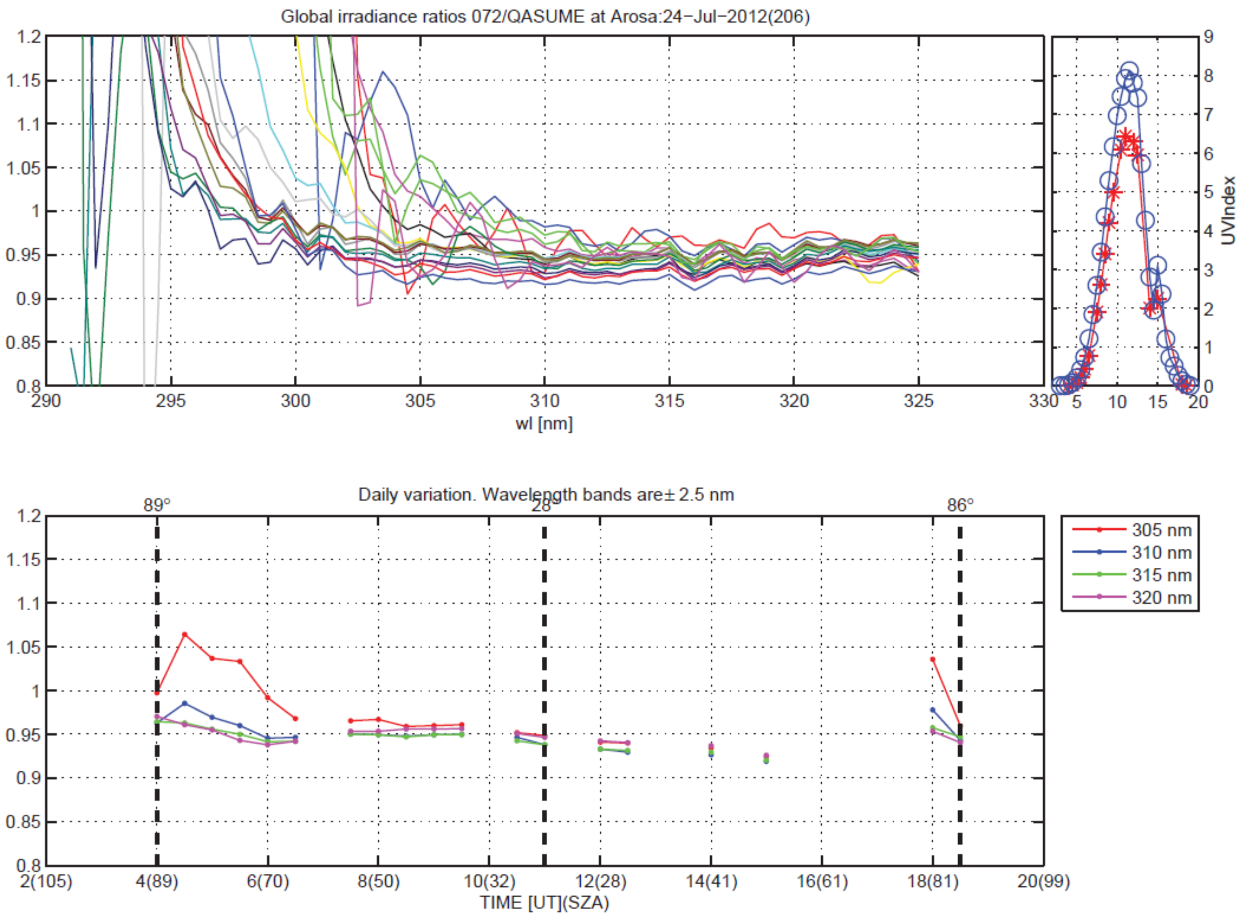


Figure 16. Idem to Figure 11 for 24 July 2012

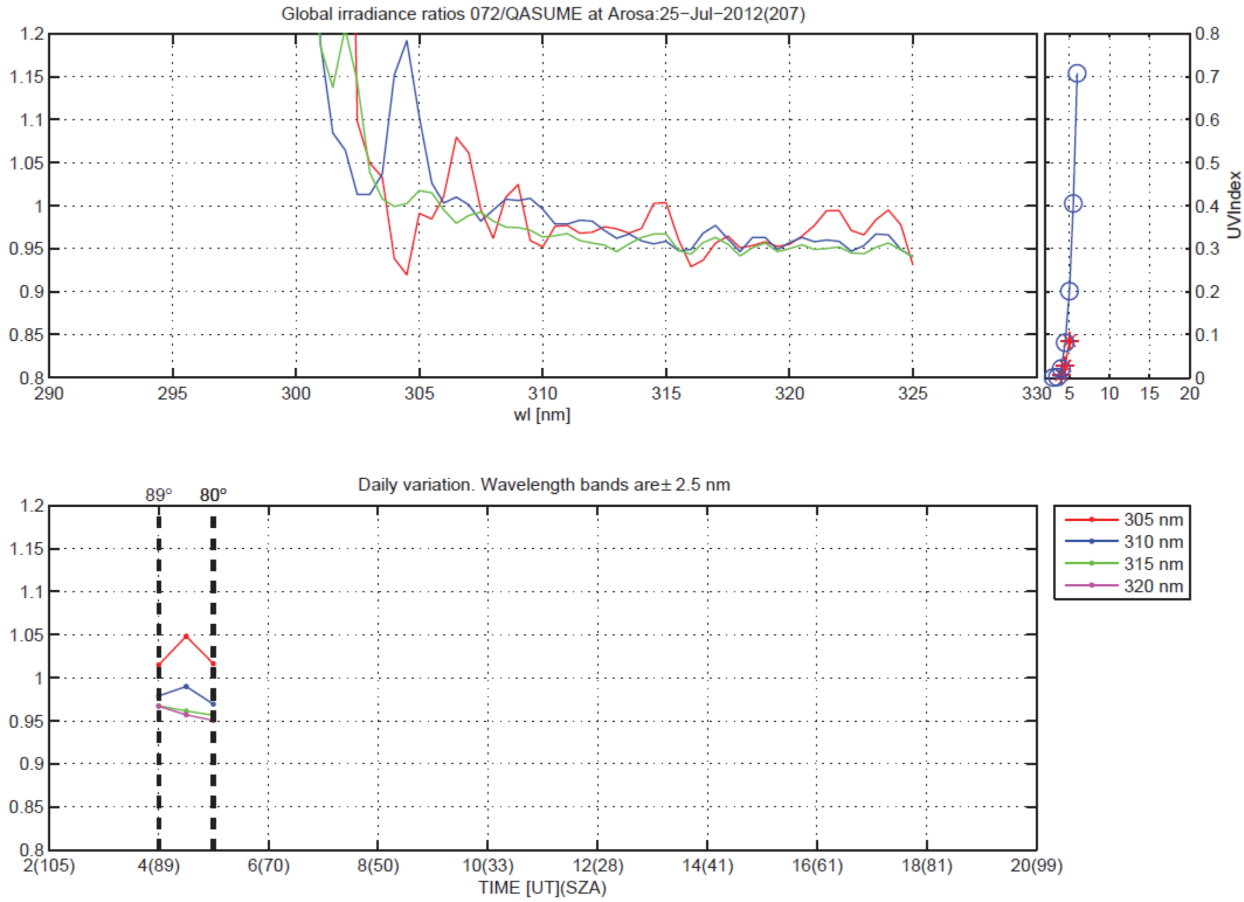


Figure 17. Idem to Figure 11 for 25 July 2012

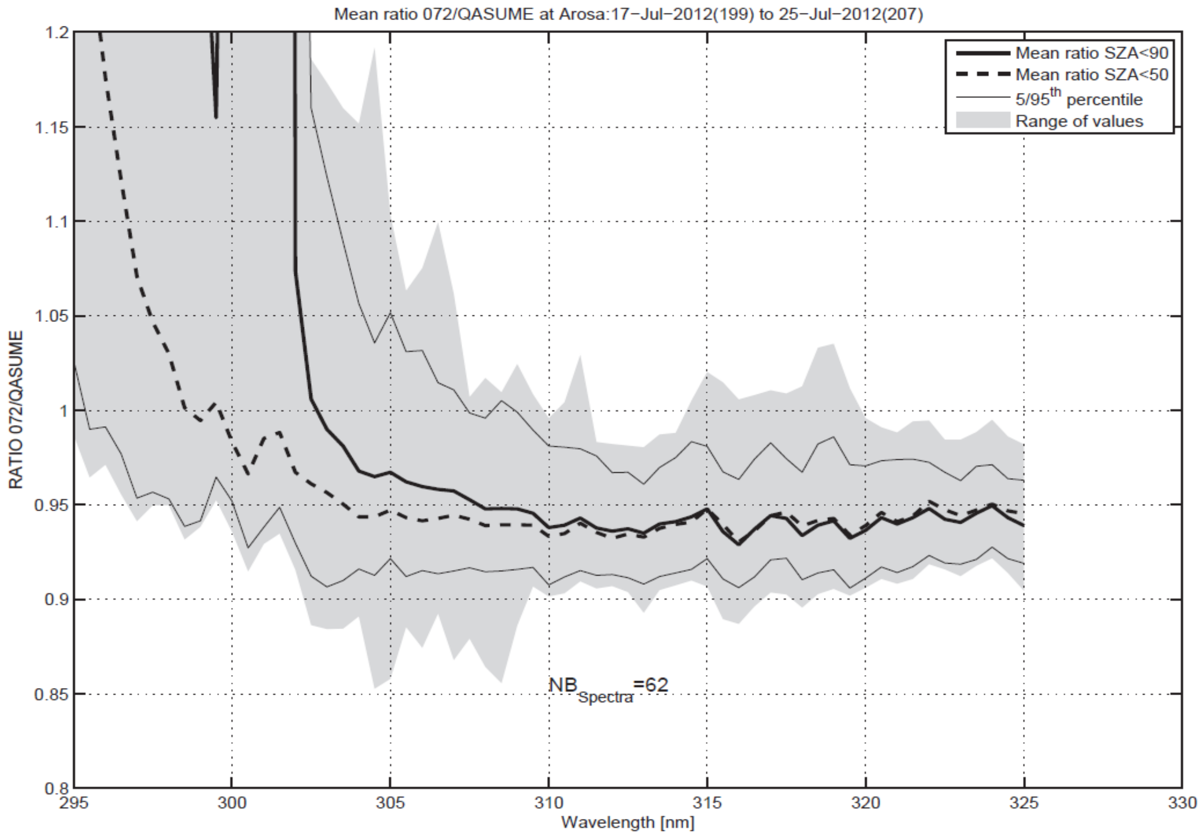


Figure 18. Average spectral ratios between Brewer #72 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

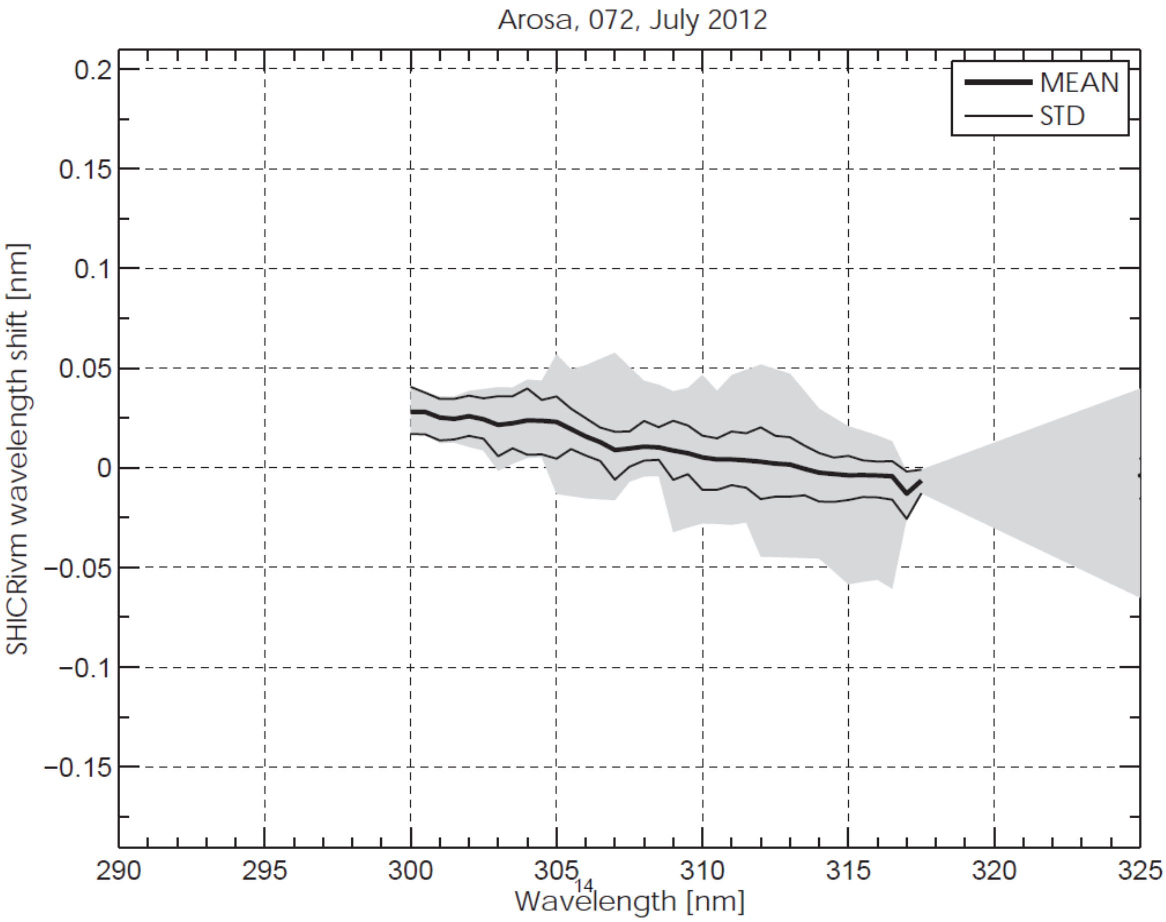


Figure 19. Average spectral wavelength shift of Brewer #72 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

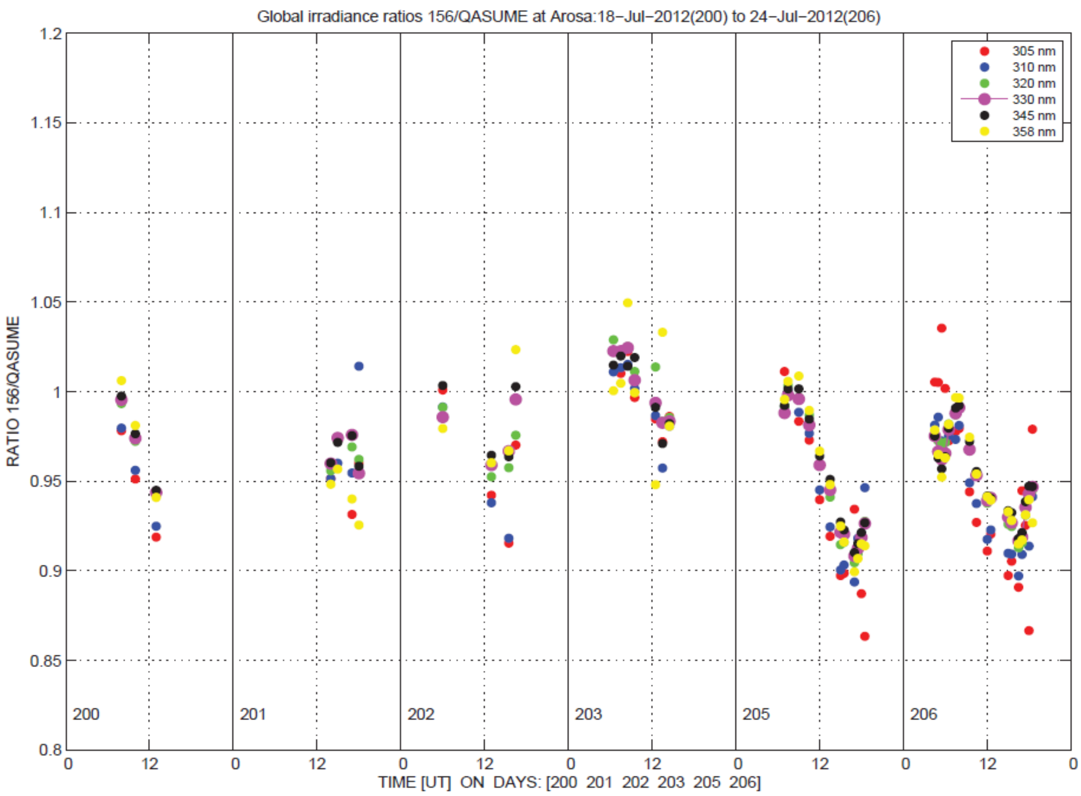


Figure 20. Diurnal variation of the ratio between Brewer #156 and QASUME at selected wavelength bands for the whole measurement period.

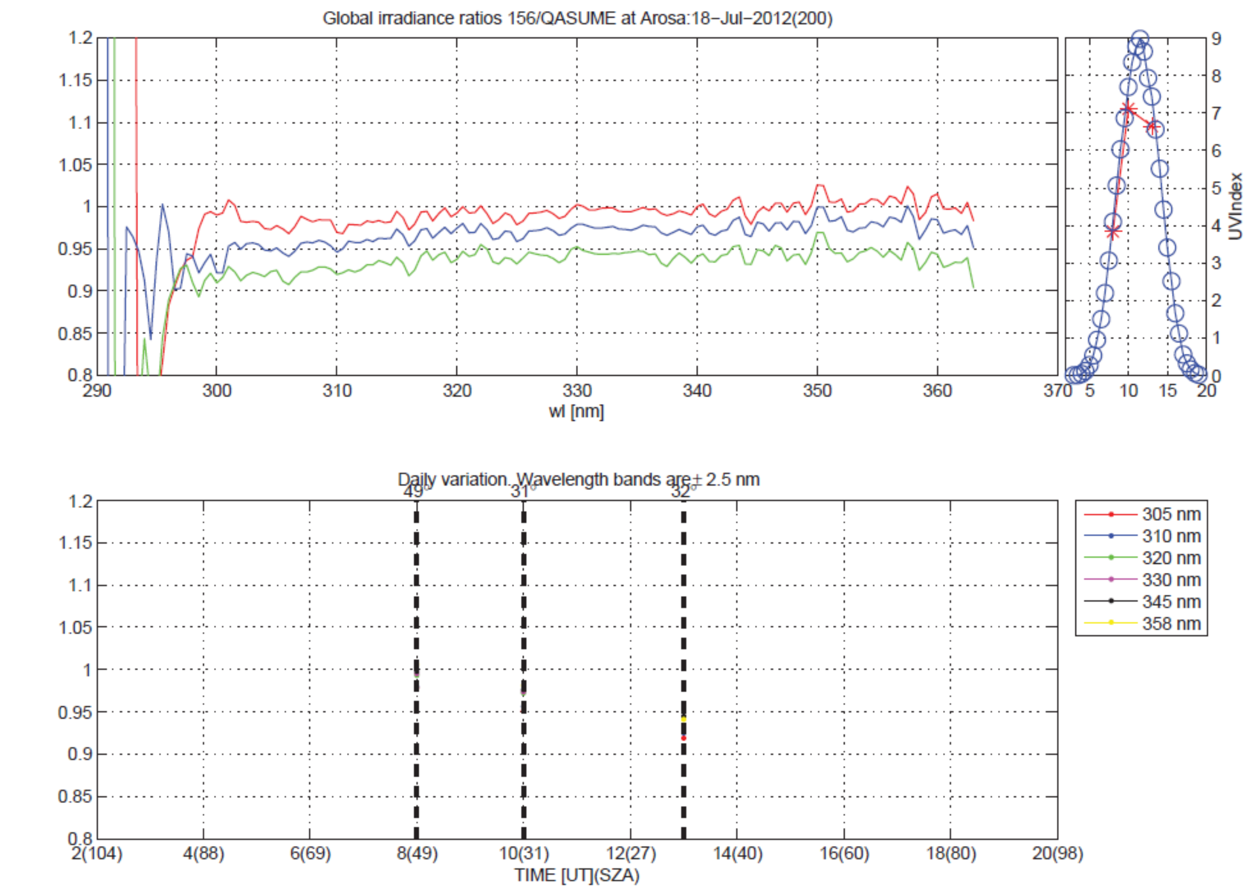


Figure 21. Upper figure: Spectral ratios between Brewer #156 and QASUME on 18 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #156 and QASUME at selected wavelength bands.

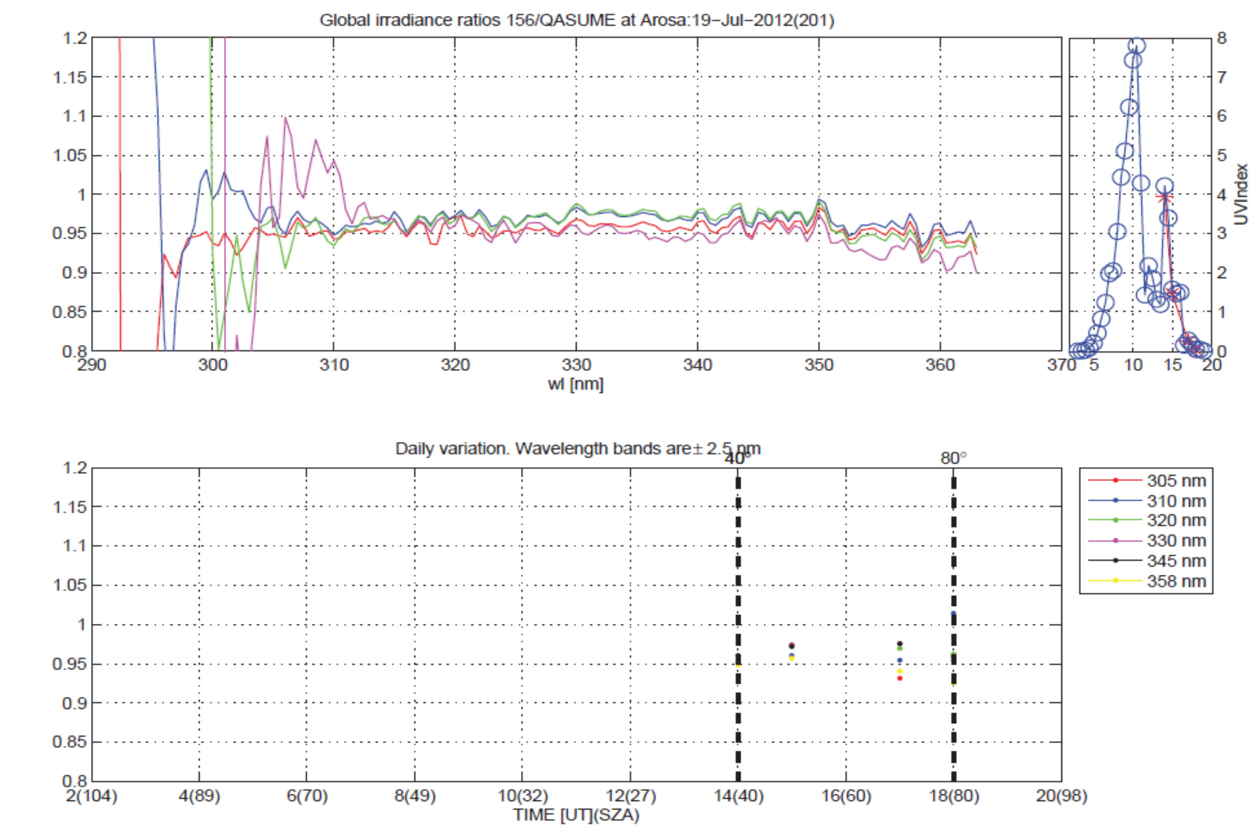


Figure 22. Idem to Figure 21 for 19 July 2012

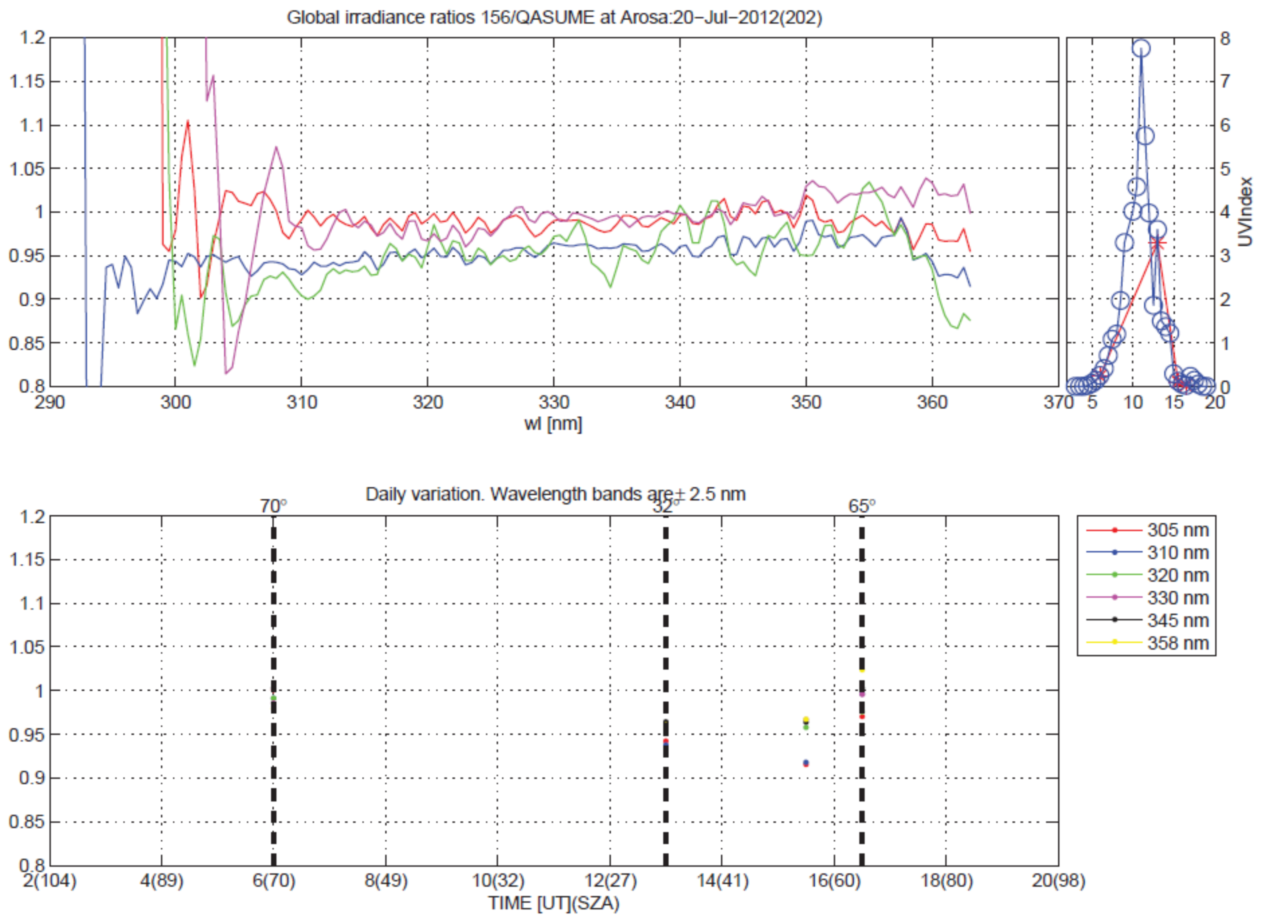


Figure 23. Idem to Figure 21 for 20 July 2012

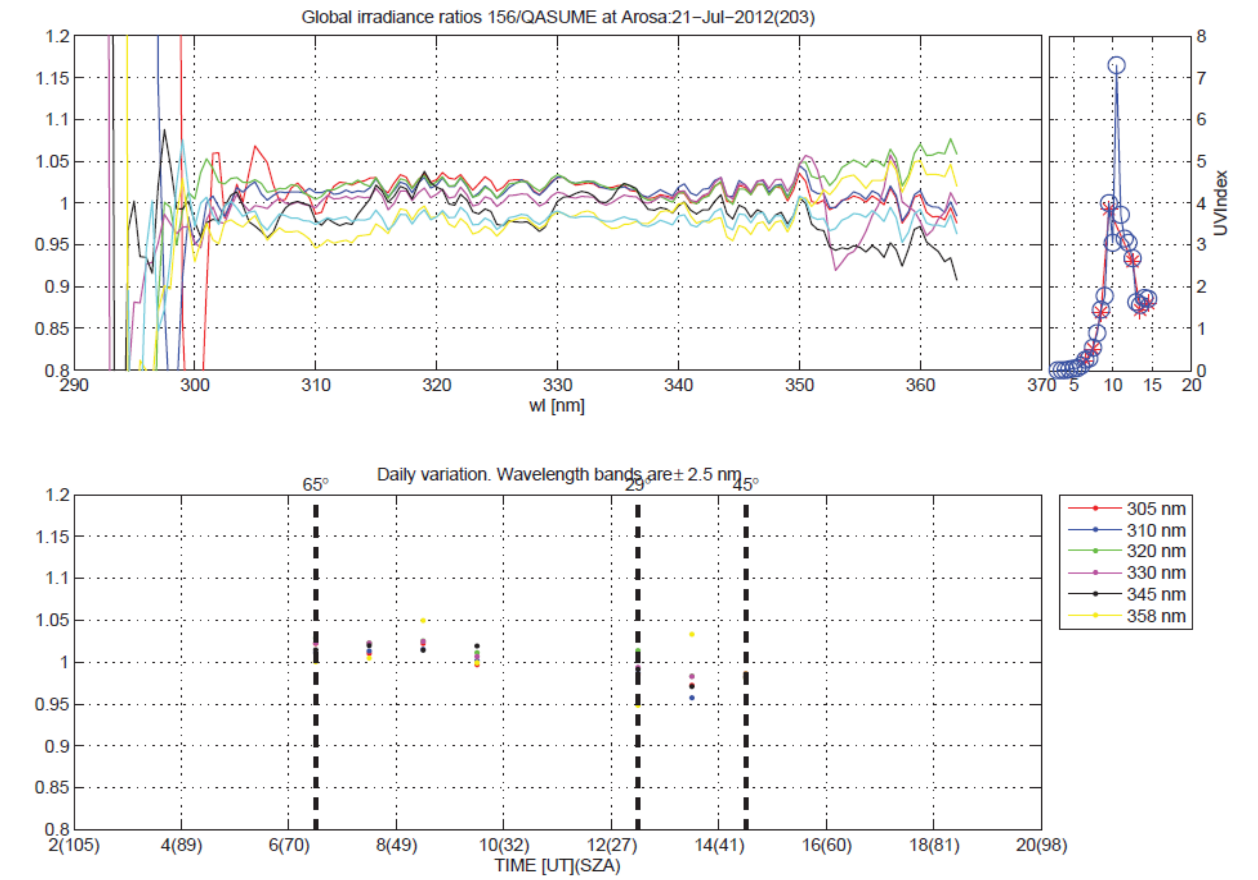


Figure 24. Idem to Figure 21 for 21 July 2012

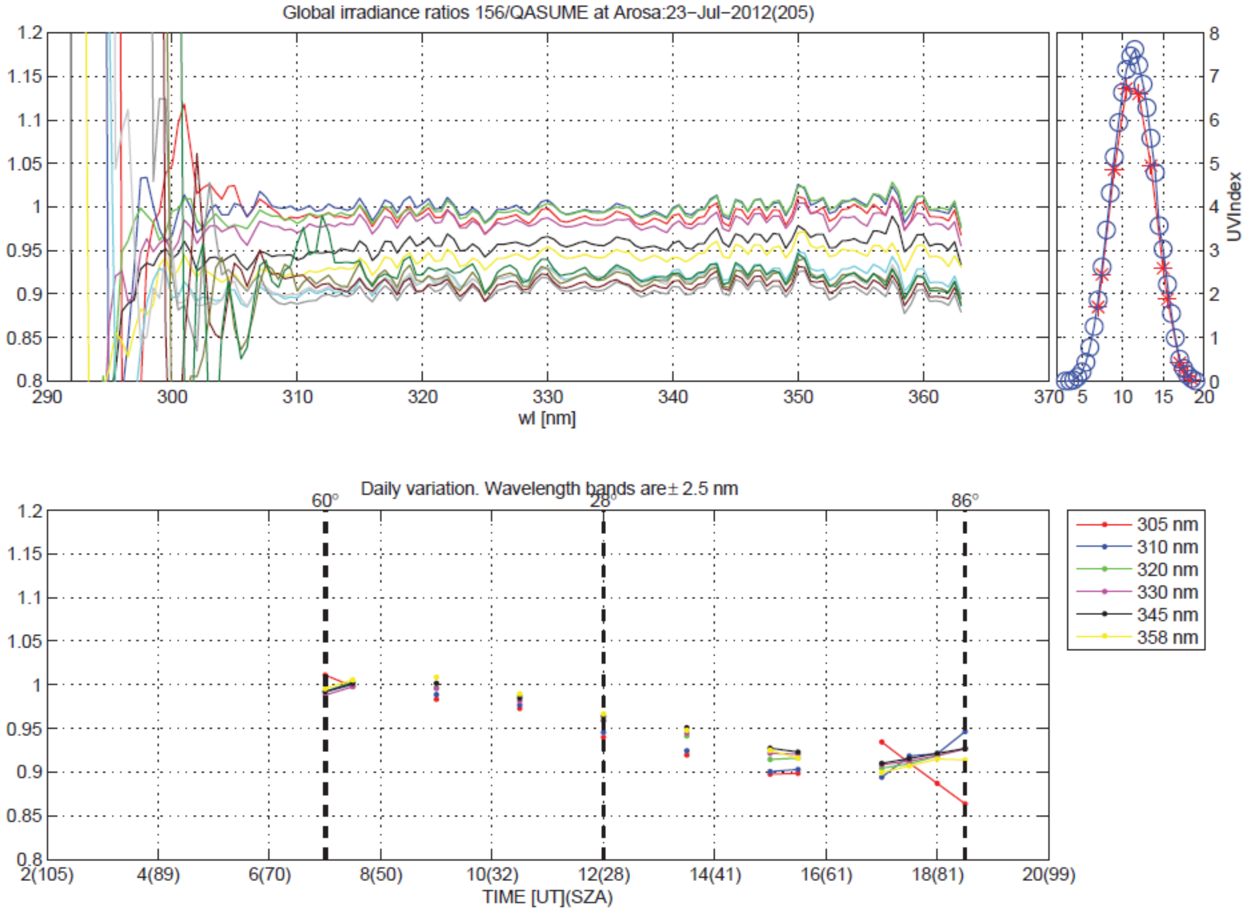


Figure 25. Idem to Figure 21 for 23 July 2012

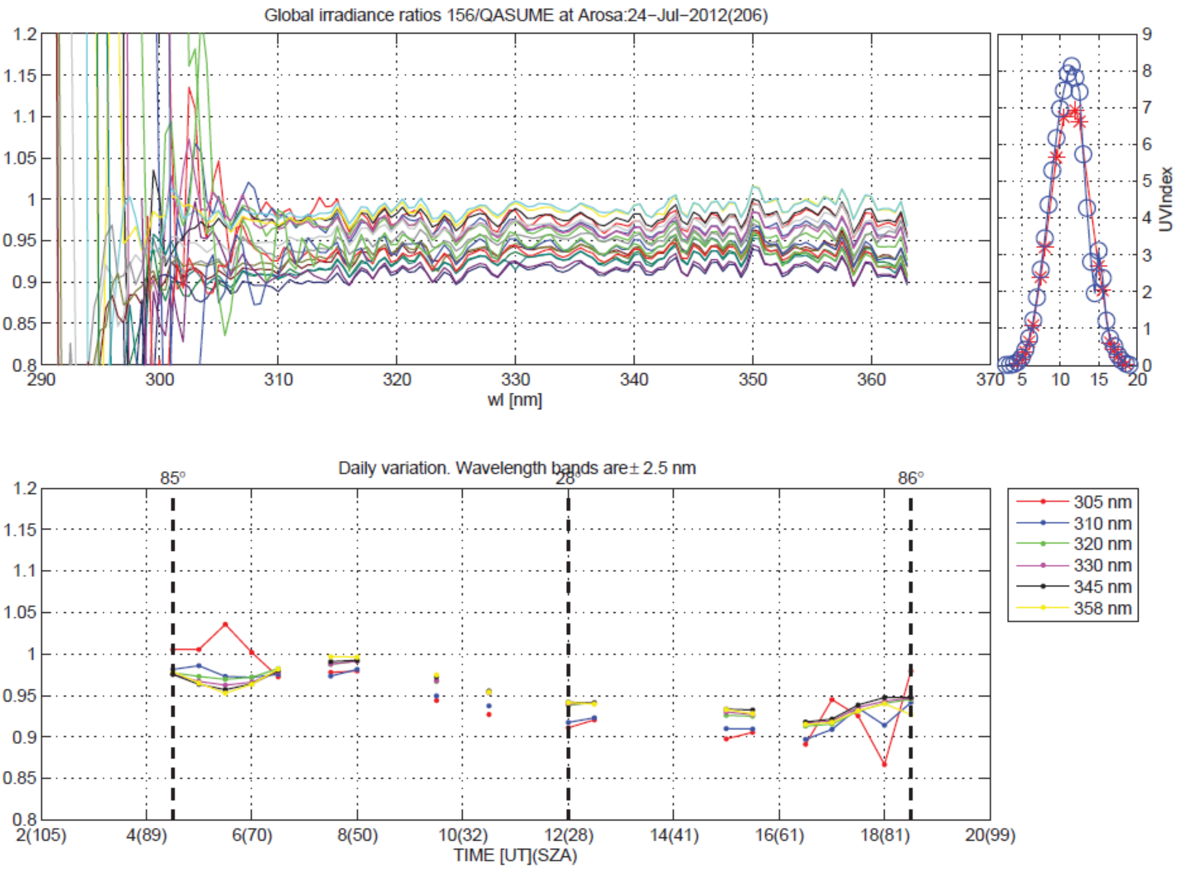


Figure 26. Idem to Figure 21 for 24 July 2012

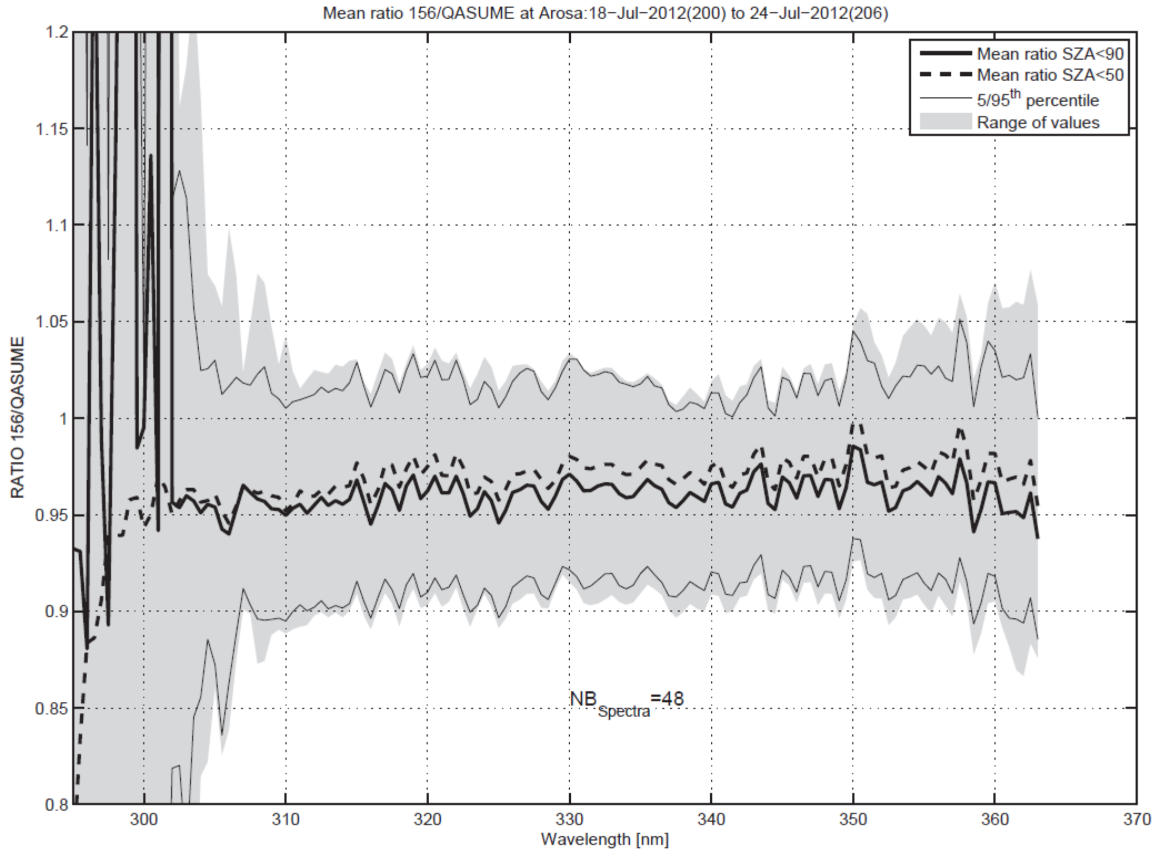


Figure 27. Average spectral ratios between Brewer #156 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

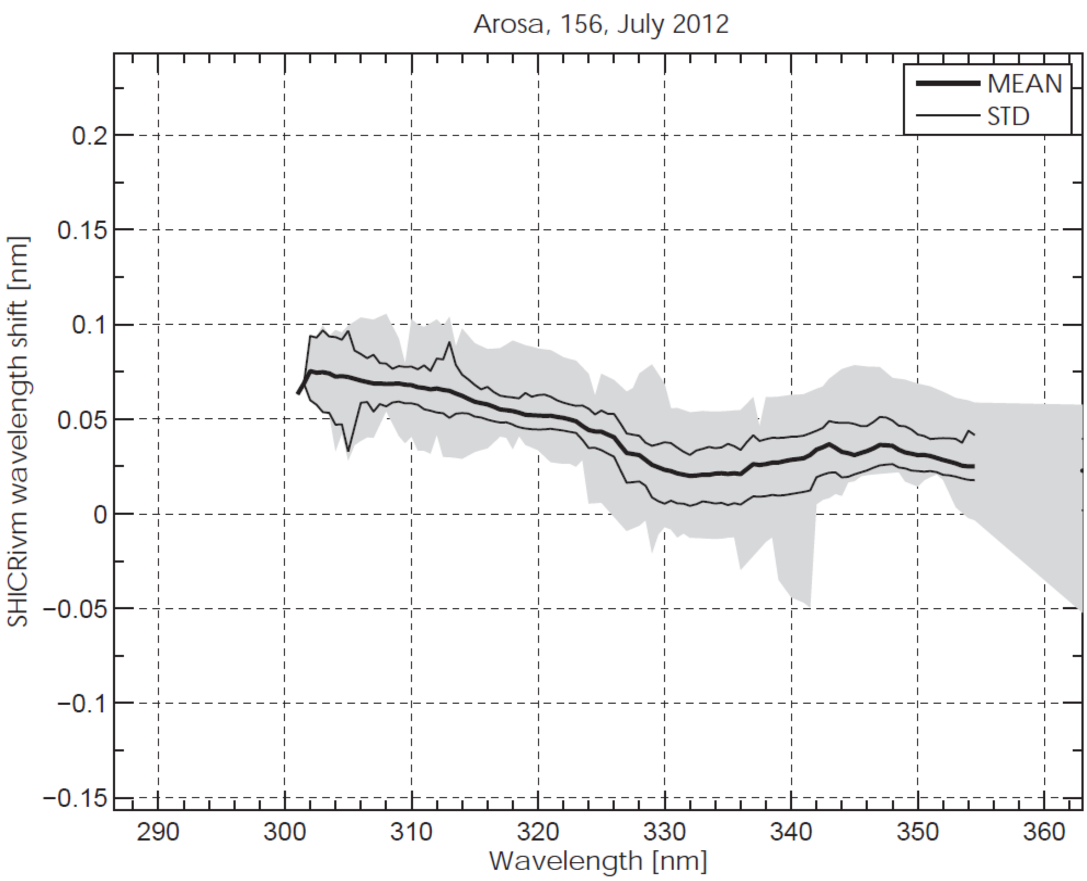


Figure 28. Average spectral wavelength shift of Brewer #156 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

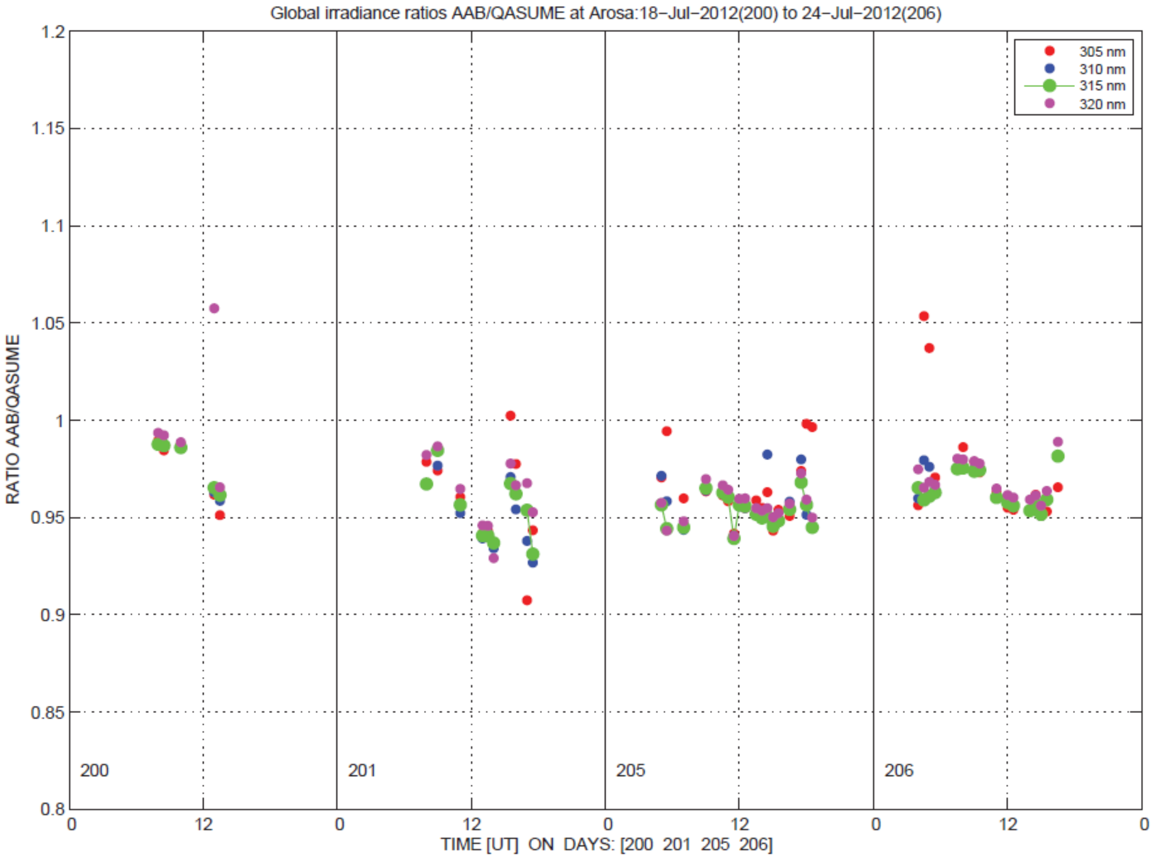


Figure 29. Diurnal variation of the ratio between Brewer #66 and QASUME at selected wavelength bands for the whole measurement period.

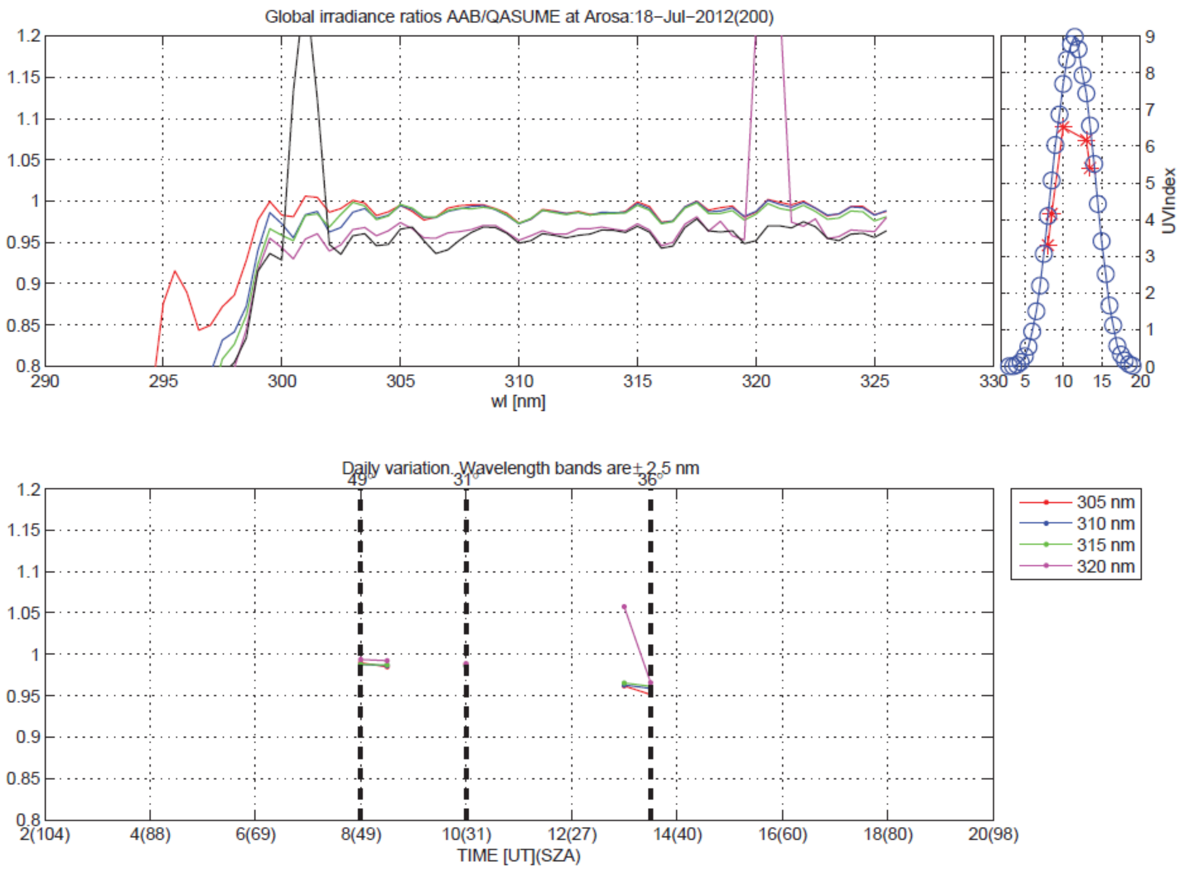


Figure 30. Upper figure: Spectral ratios between Brewer #66 and QASUME on 18 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #66 and QASUME at selected wavelength bands.

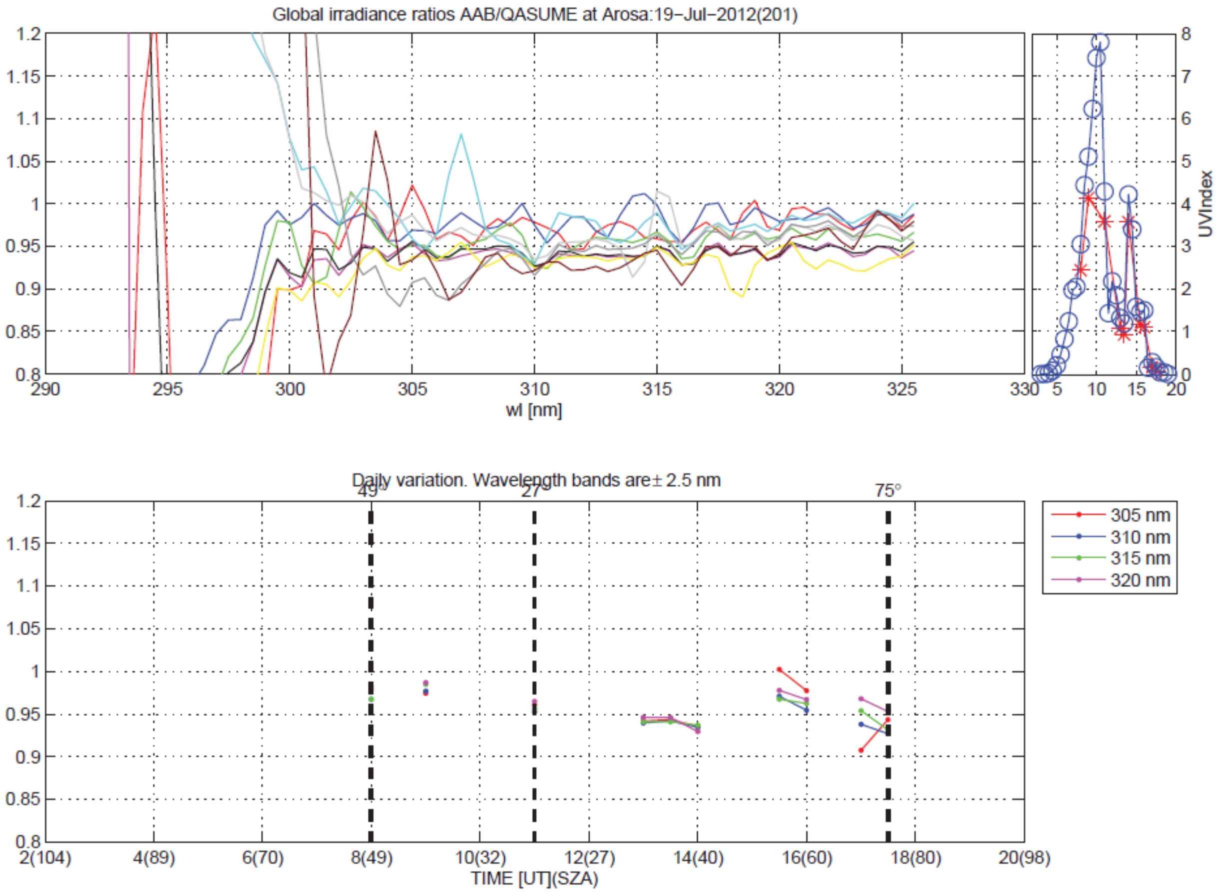


Figure 31. Idem to Figure 30 for 19 July 2012

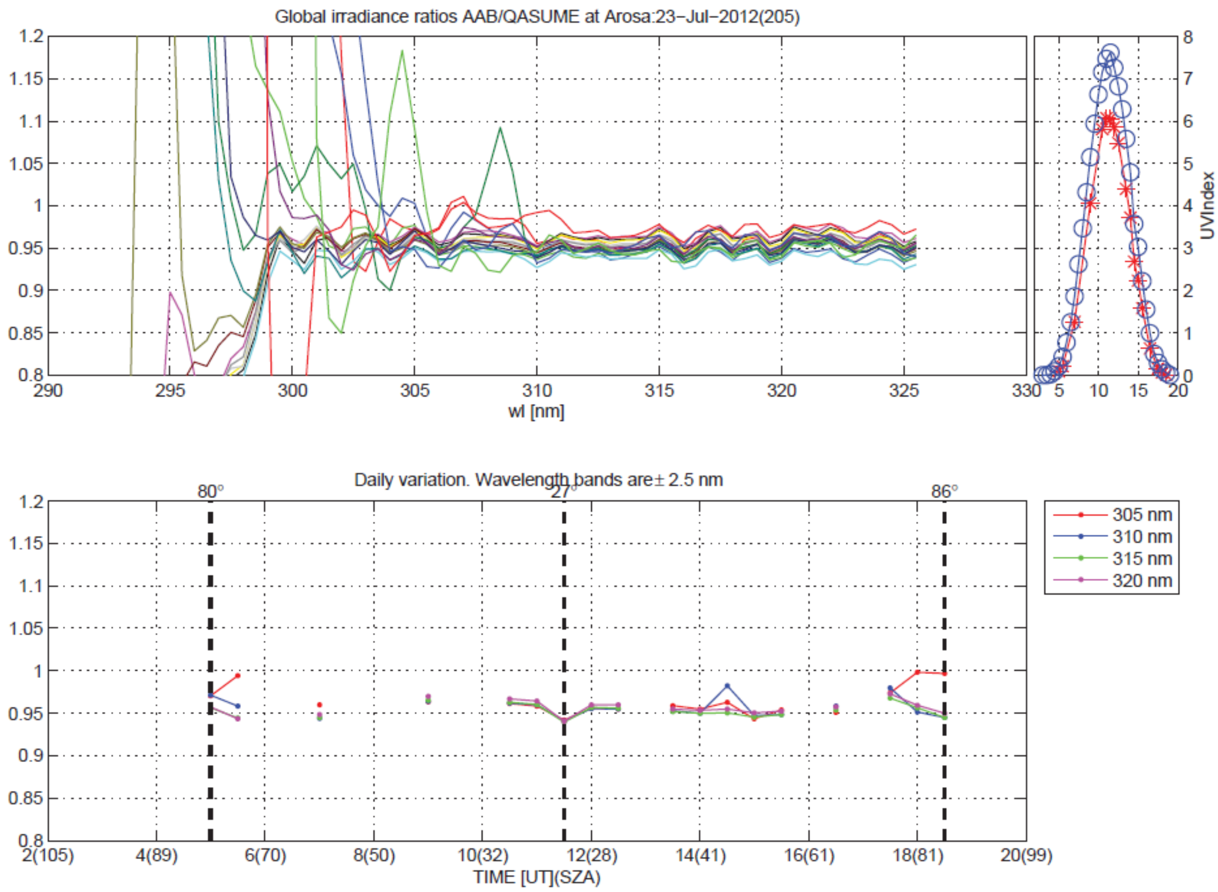


Figure 32. Idem to Figure 30 for 23 July 2012

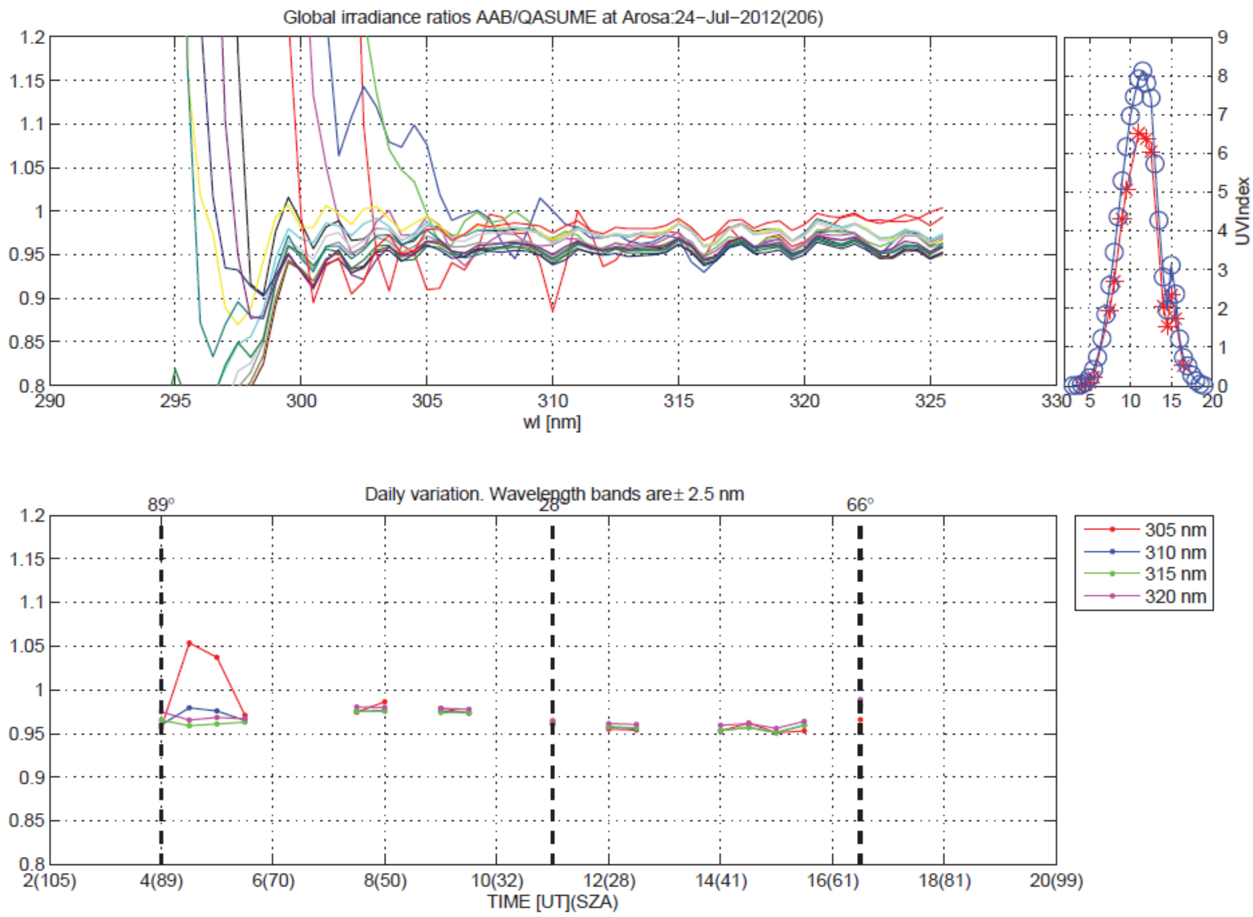


Figure 33. Idem to Figure 30 for 24 July 2012

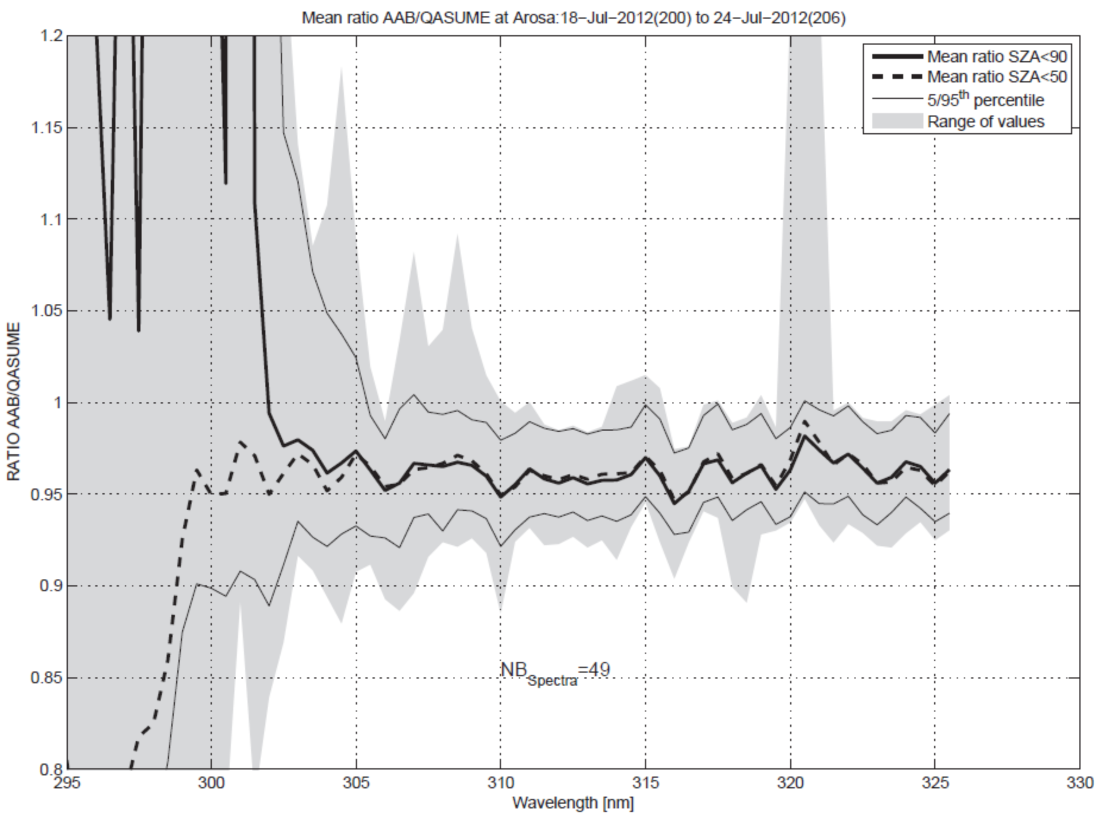


Figure 34. Average spectral ratios between Brewer #66 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

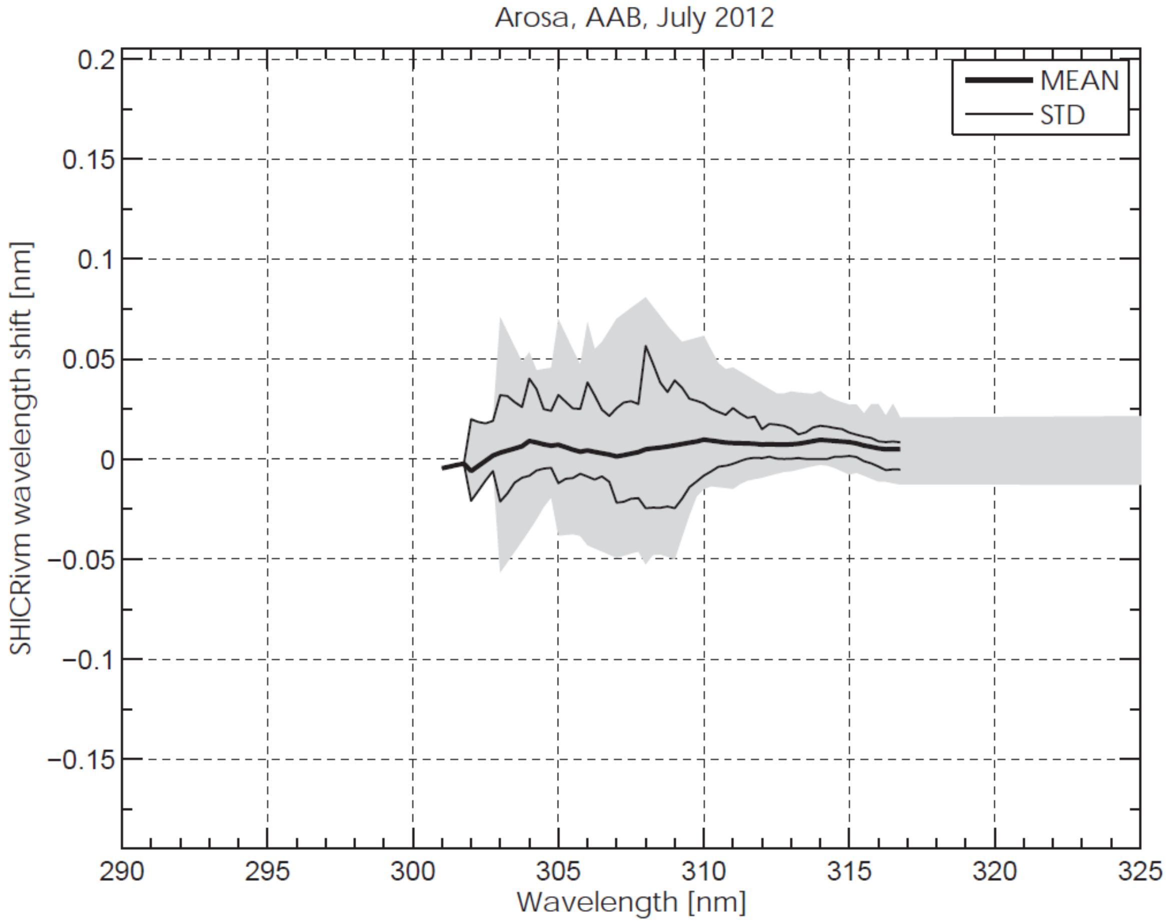


Figure 35. Average spectral wavelength shift of Brewer #66 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values

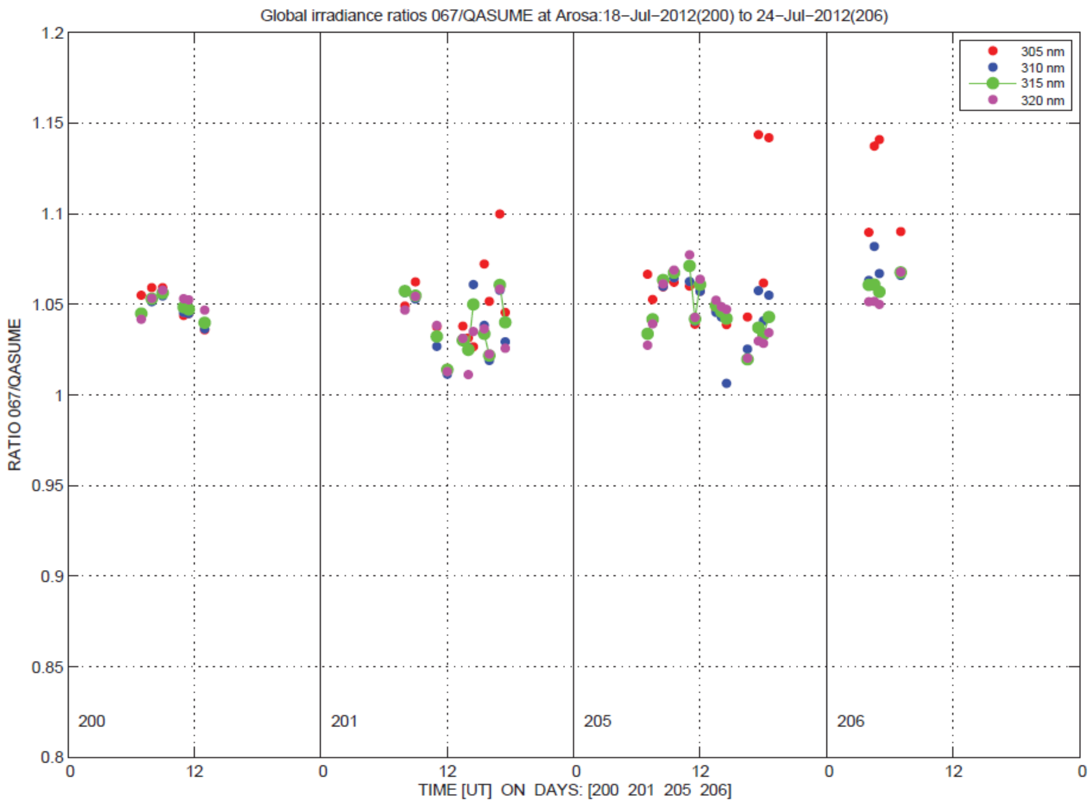


Figure 36. Diurnal variation of the ratio between Brewer #67 and QASUME at selected wavelength bands for the whole measurement period.

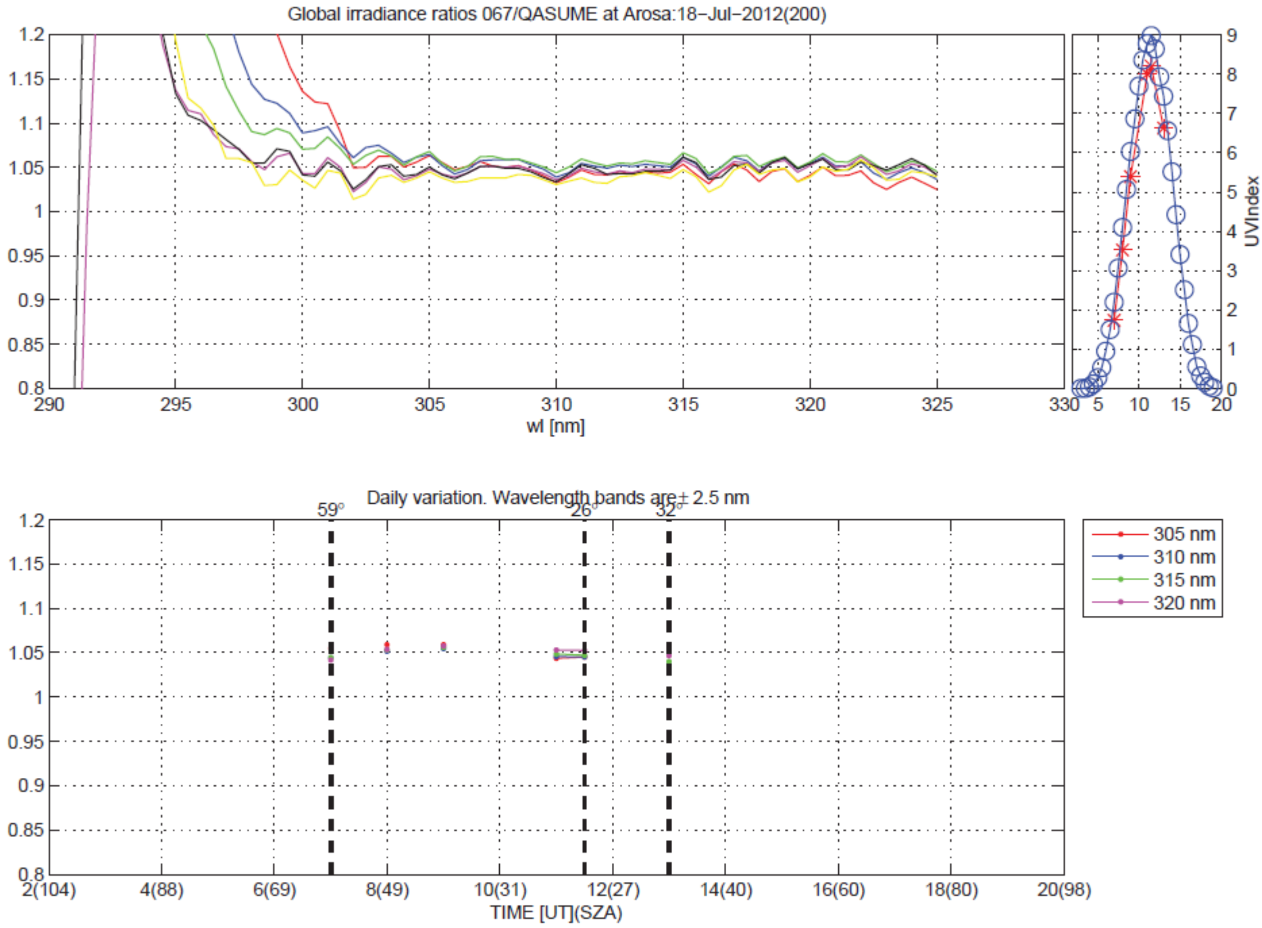


Figure 37. Upper Figure: Spectral ratios between Brewer #67 and QASUME on 18 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #67 and QASUME at selected wavelength bands.

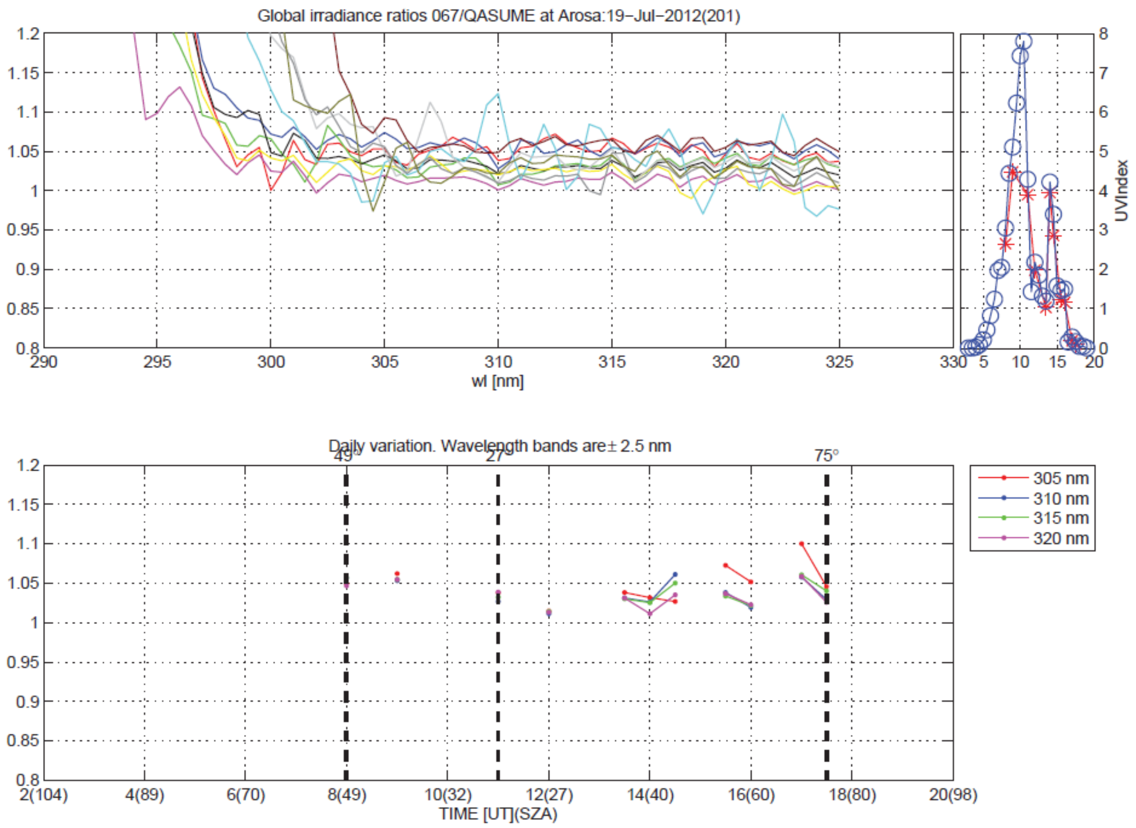


Figure 38. Idem to Figure 37 for 19 July 2012

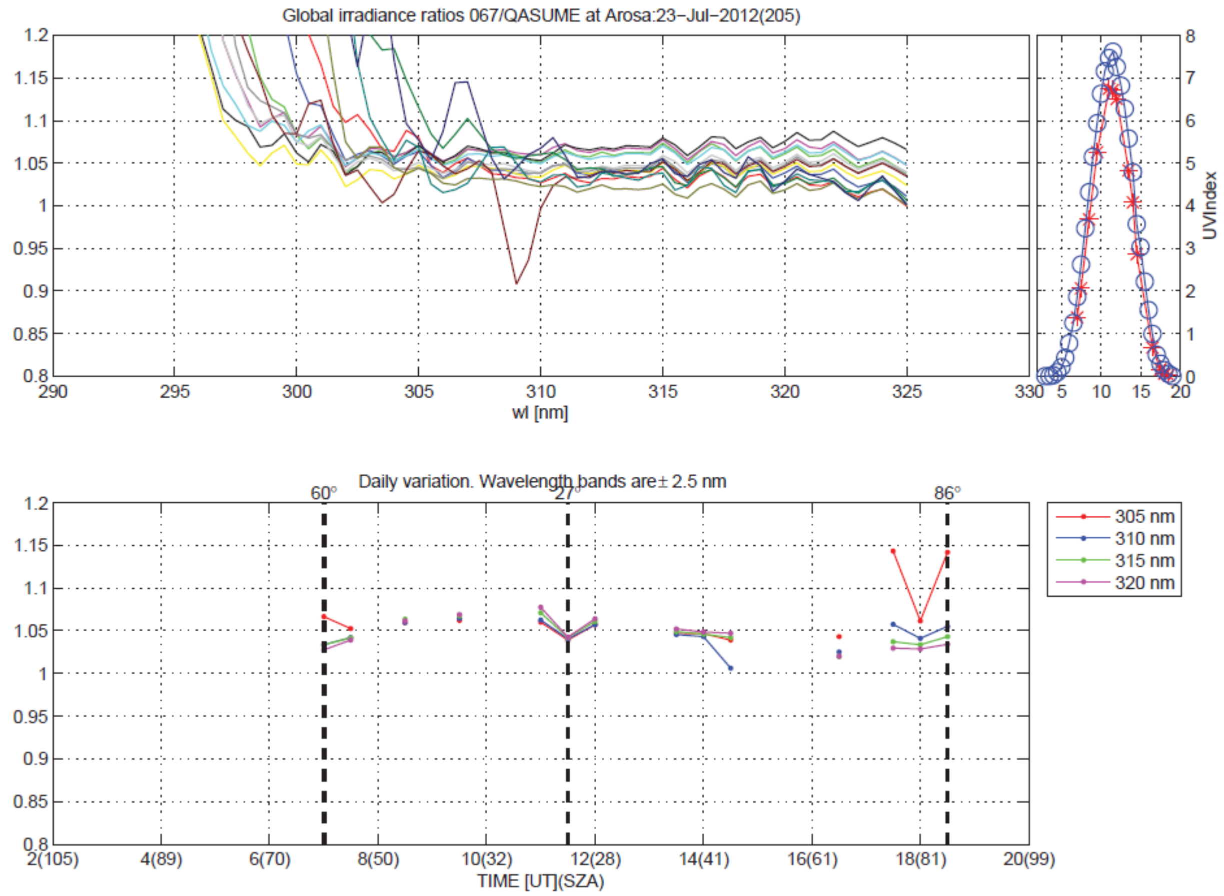


Figure 39. Idem to Figure 37 for 23 July 2012

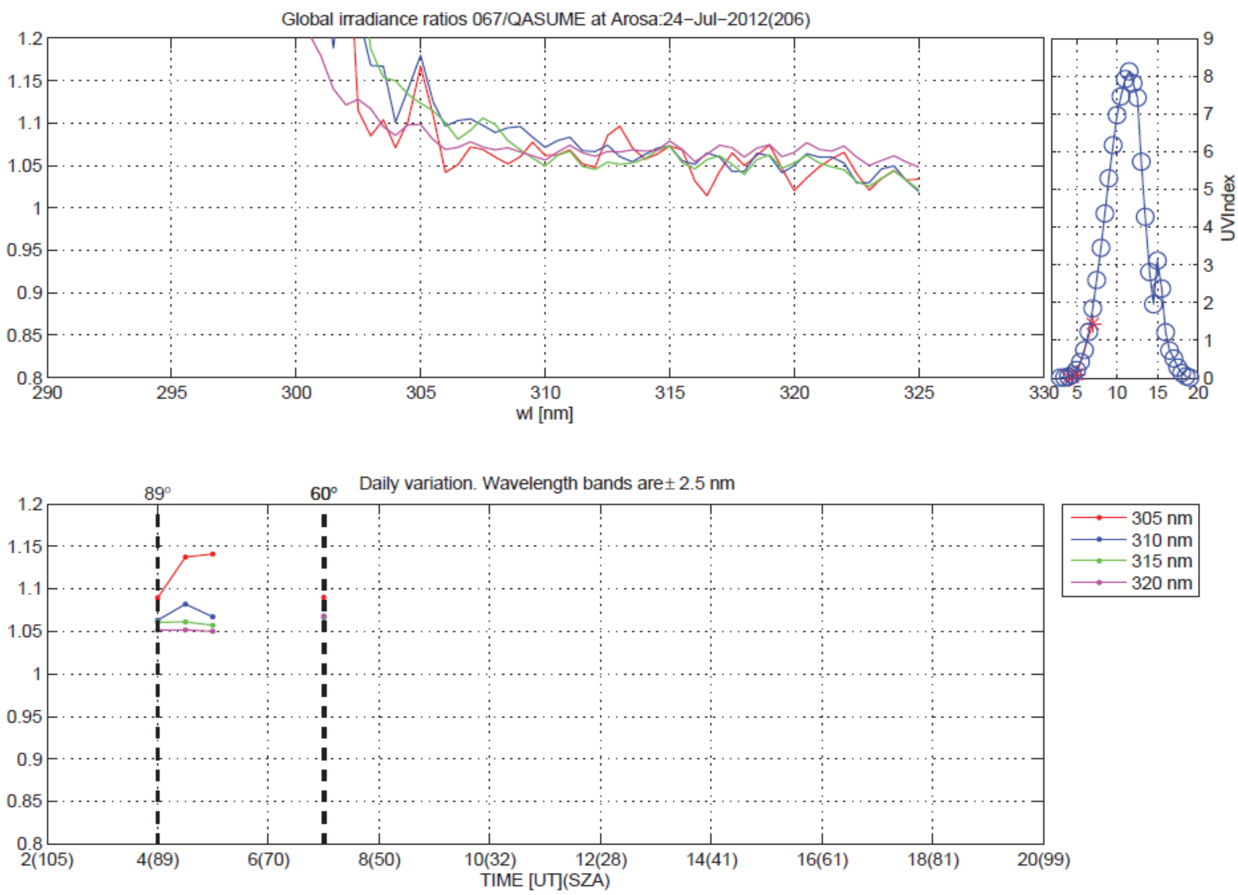


Figure 40. Idem to Figure 37 for 24 July 2012

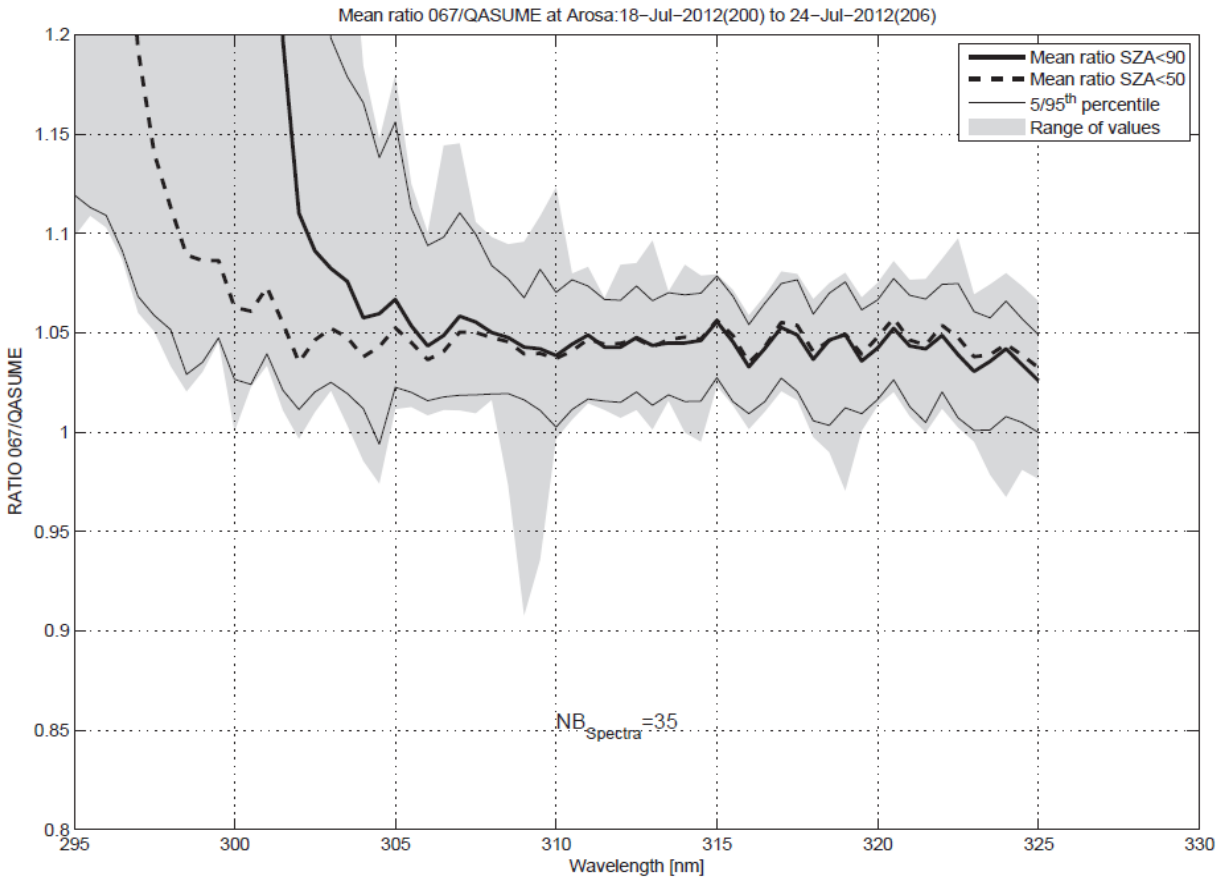


Figure 41. Average spectral ratios between Brewer #67 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

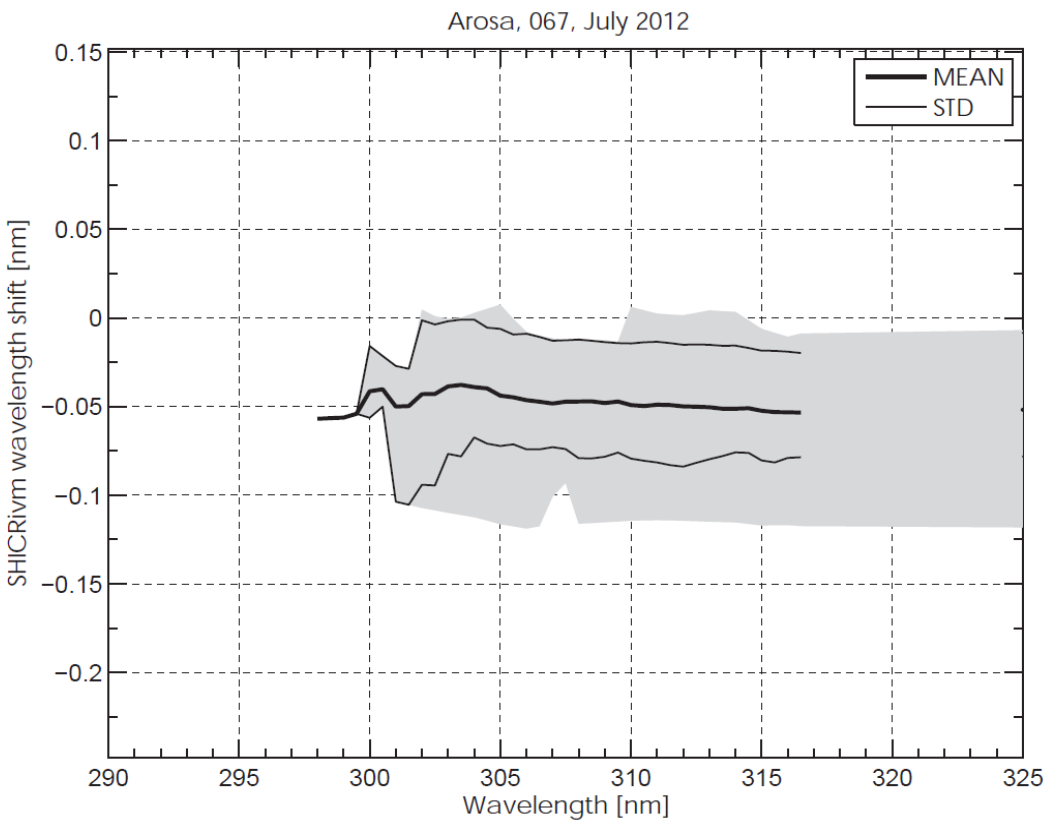


Figure 42. Average spectral wavelength shift of Brewer #67 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

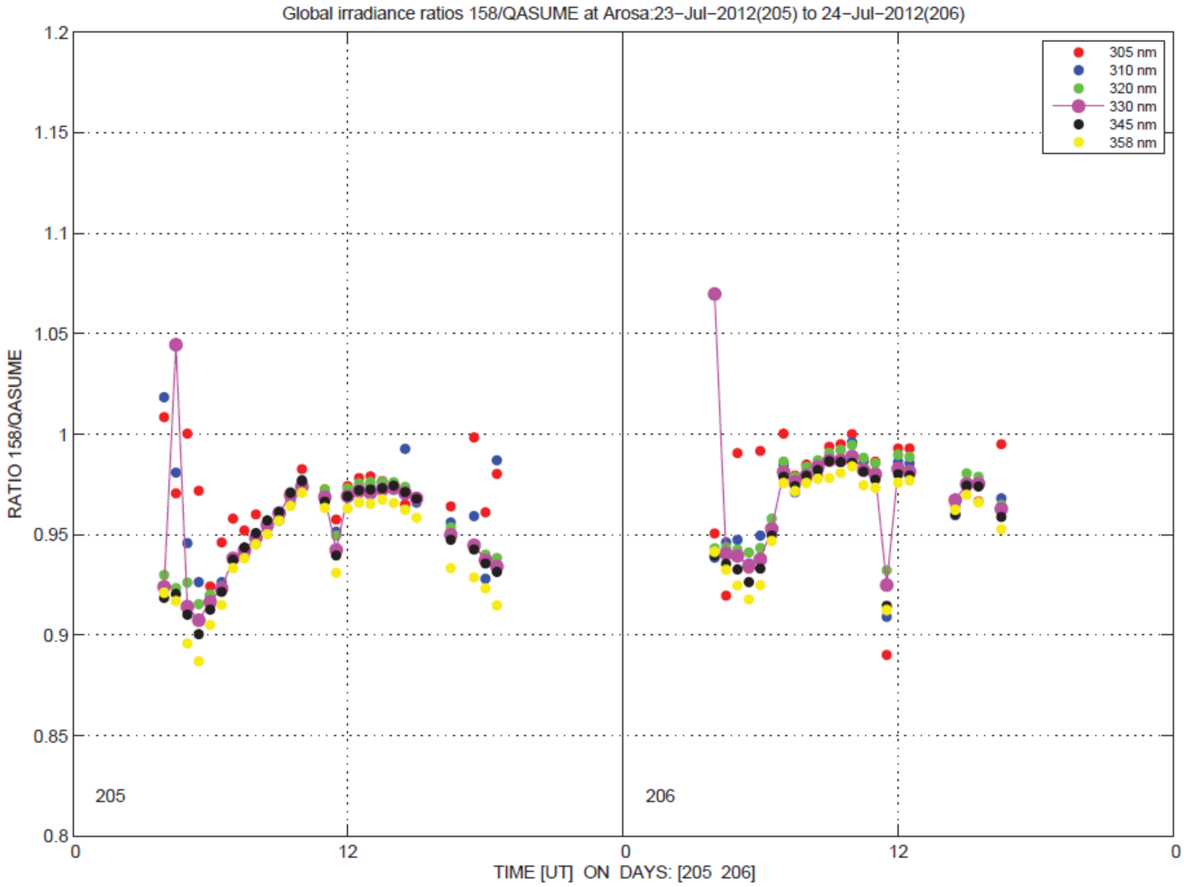


Figure 43. Diurnal variation of the ratio between Brewer #158 and QASUME at selected wavelength bands for the whole measurement period

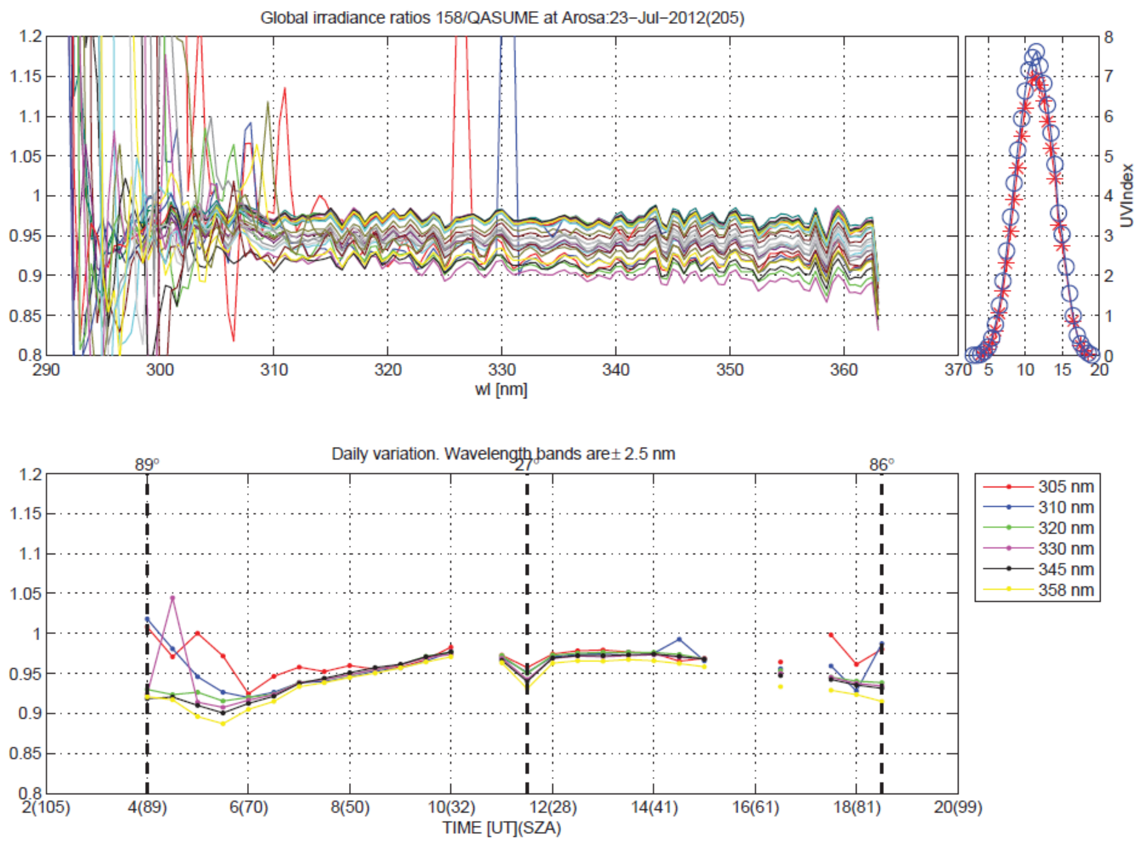


Figure 44. Upper Figure: Spectral ratios between Brewer #158 and QASUME on 23 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #158 and QASUME at selected wavelength bands.

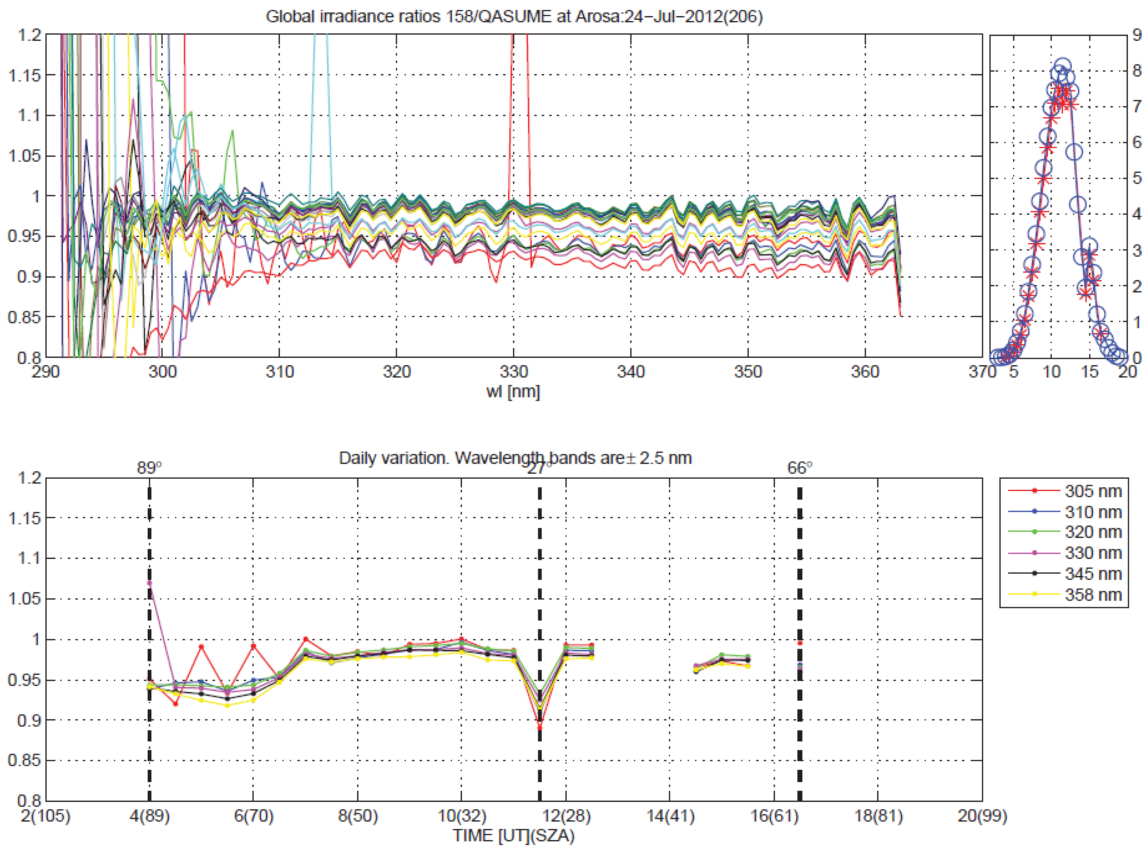


Figure 45. Idem to Figure 44 for 24 July 2012

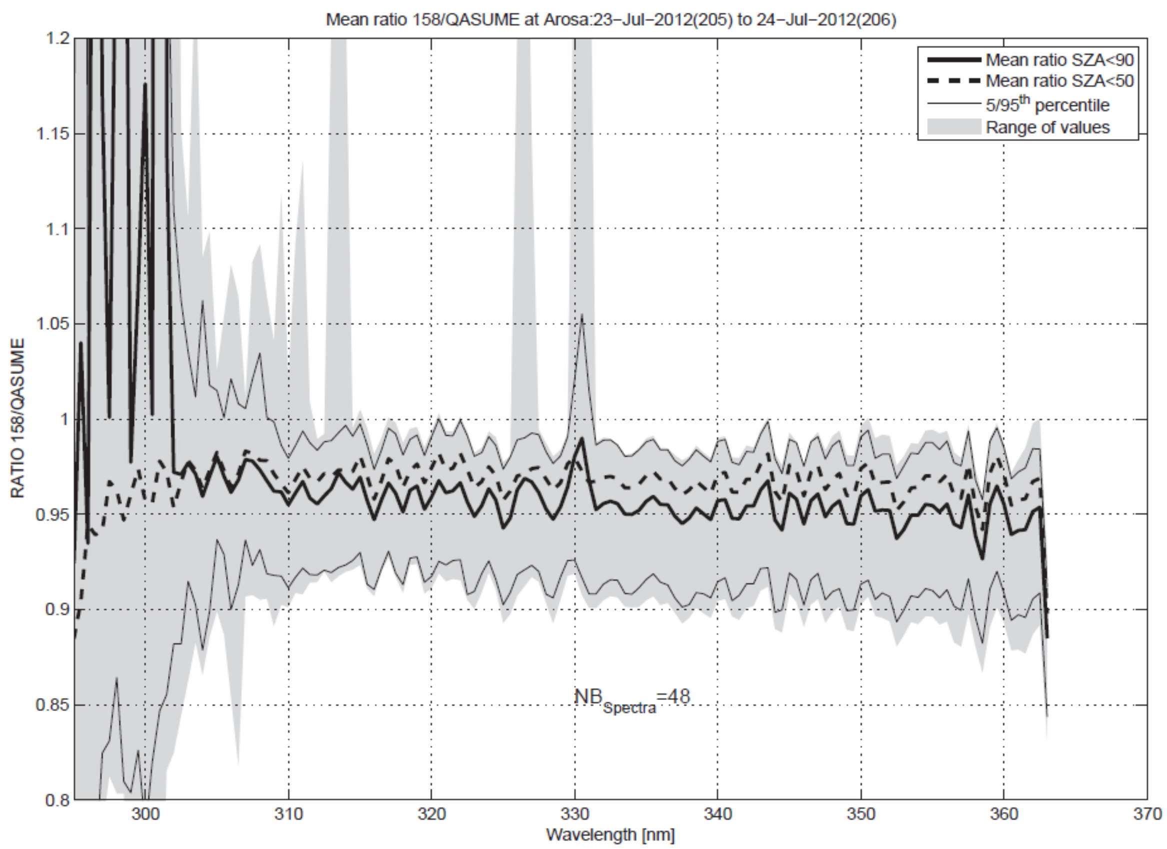


Figure 46. Average spectral ratios between Brewer #158 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

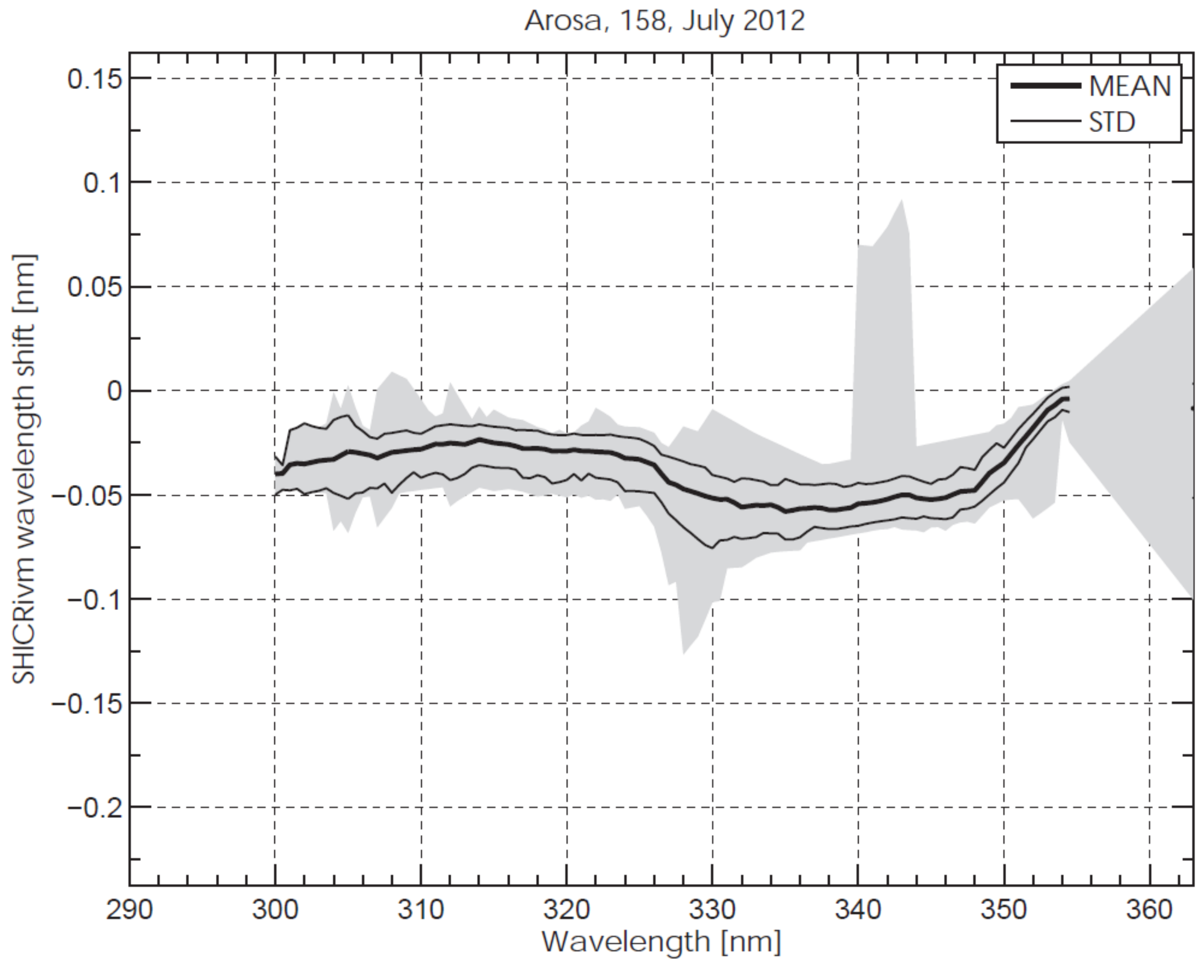


Figure 47. Average spectral wavelength shift of Brewer #158 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

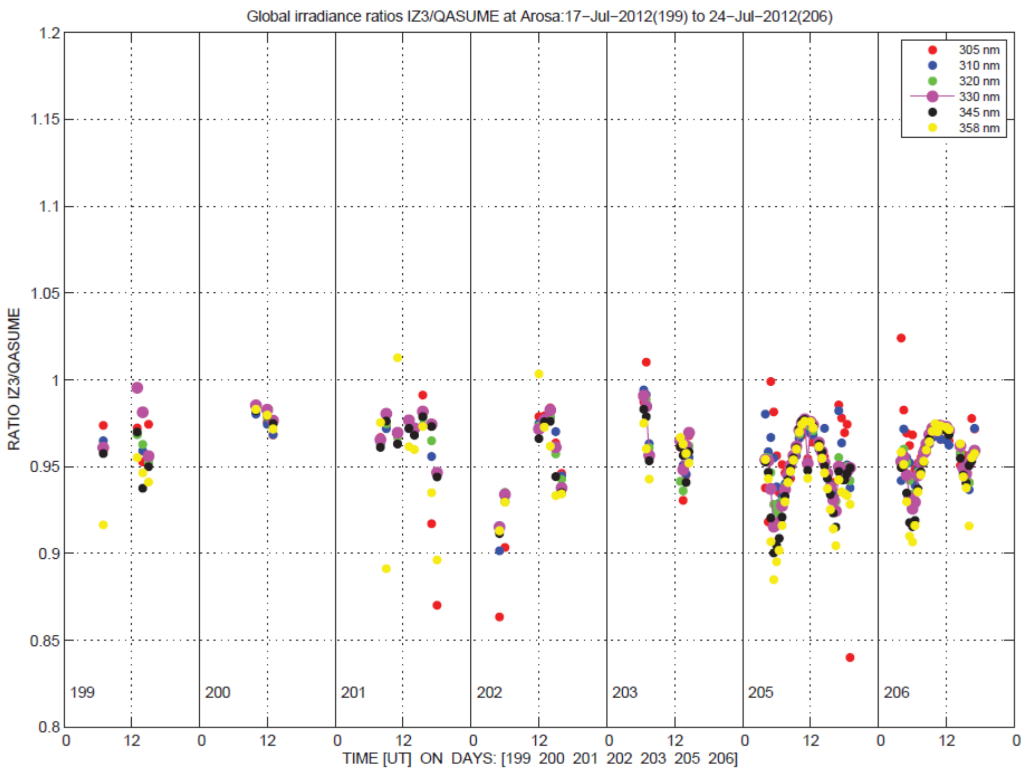


Figure 48. Diurnal variation of the ratio between Brewer #185 and QASUME at selected wavelength bands for the whole measurement period

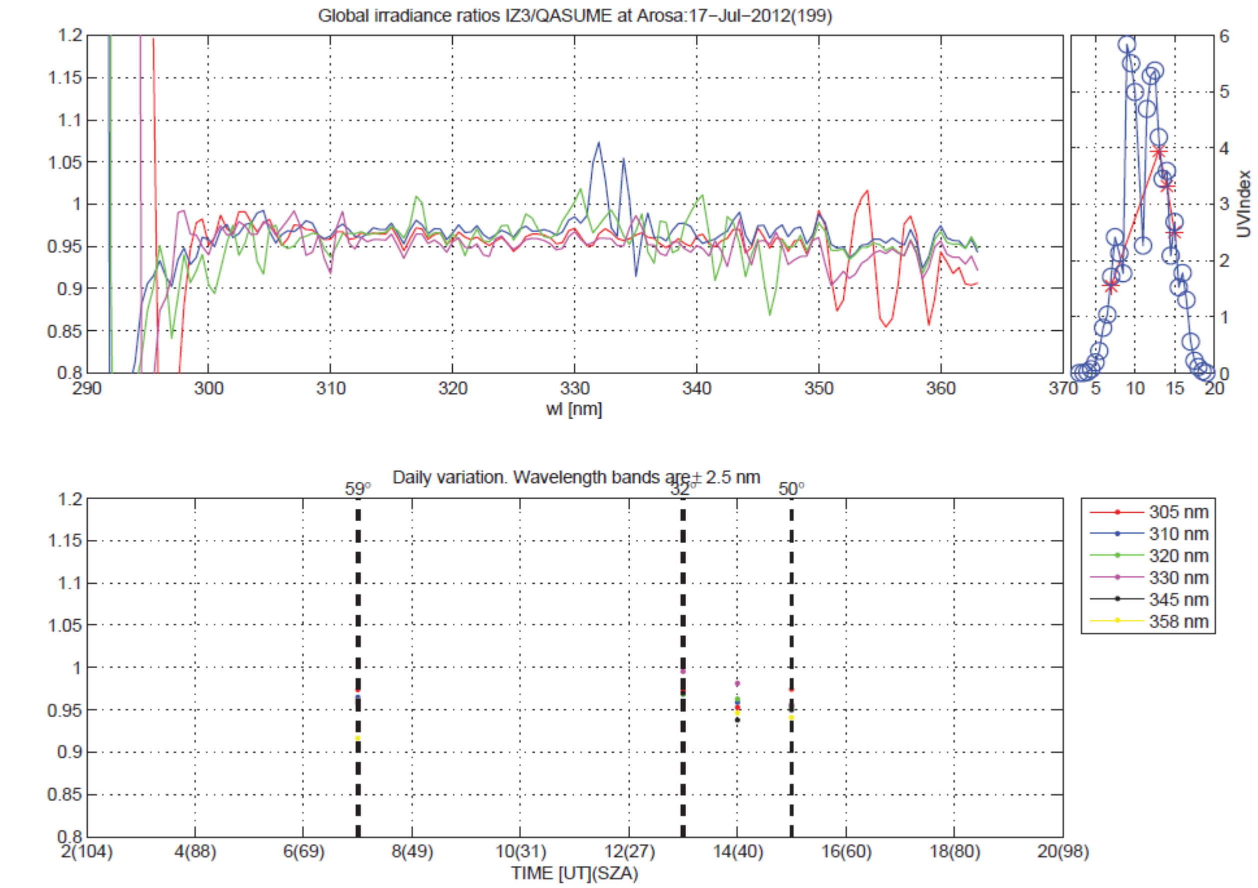


Figure 49. Upper Figure: Spectral ratios between Brewer #185 and QASUME on 17 July 2012. Lower figure: Diurnal variation of the ratio between Brewer #40 and QASUME at selected wavelength bands.

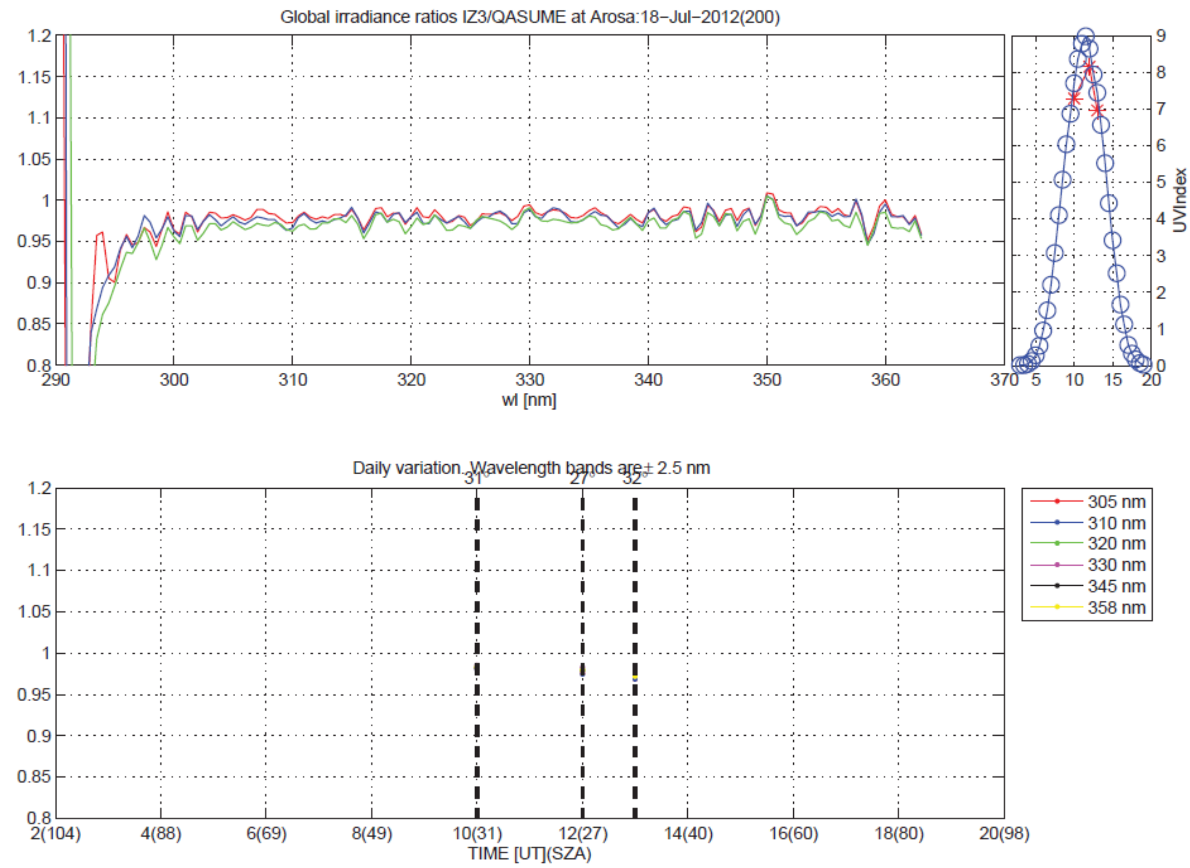


Figure 50. Idem to Figure 49 for 18 July 2012

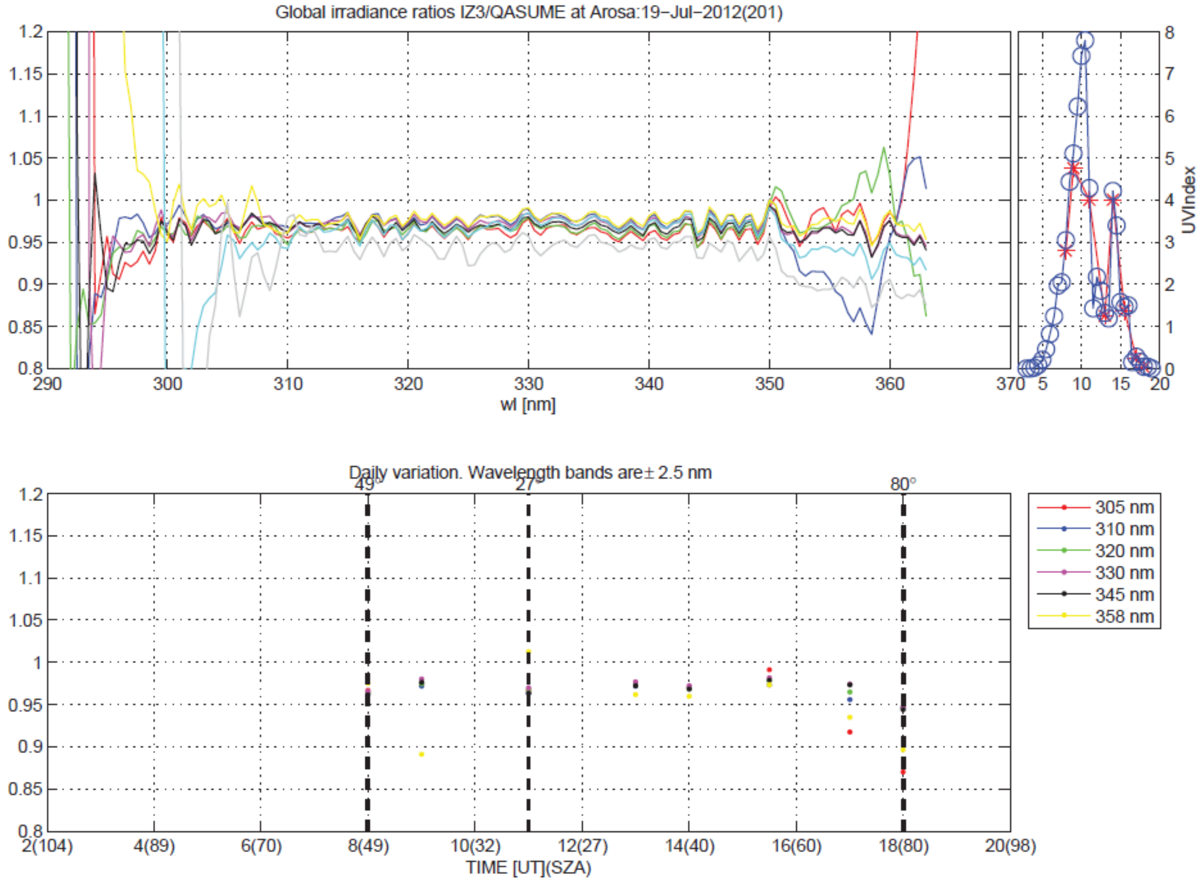


Figure 51. Idem to Figure 49 for 19 July 2012

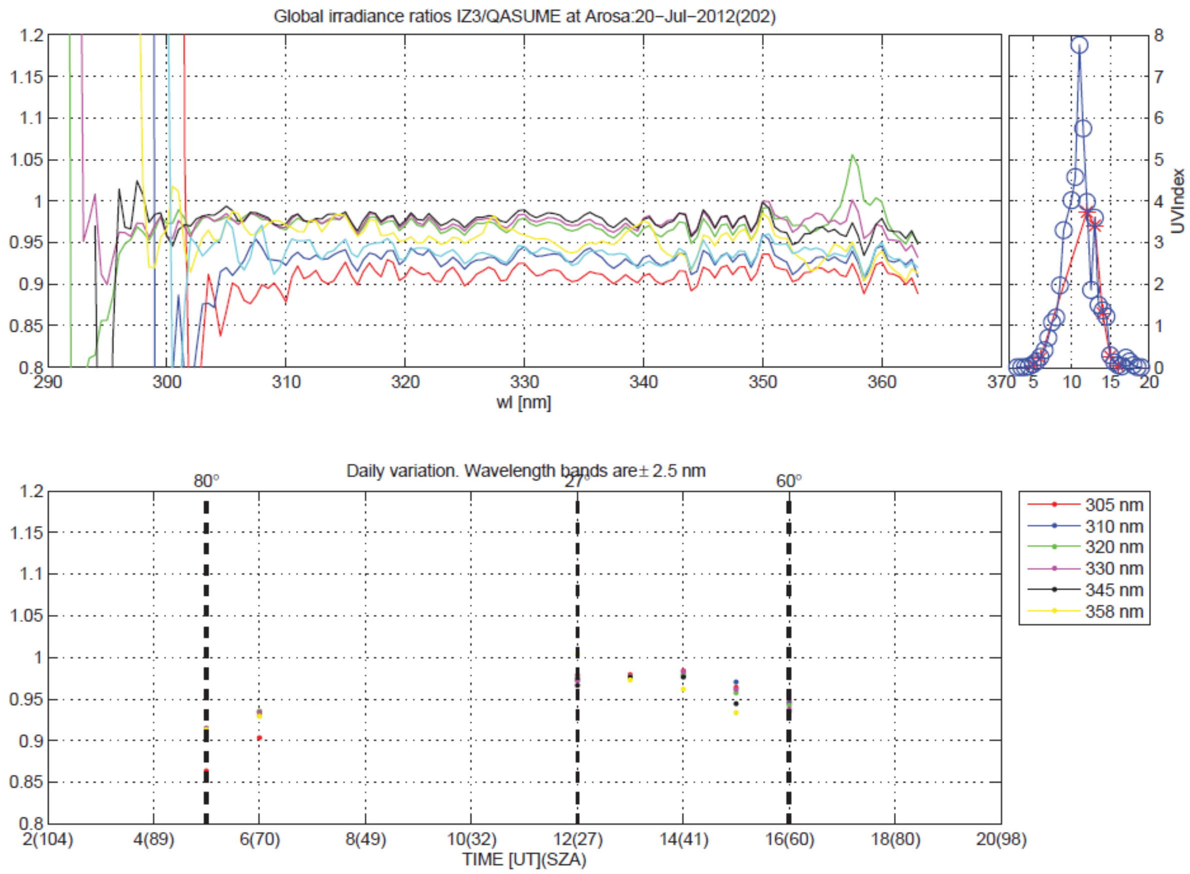


Figure 52. Idem to Figure 49 for 20 July 2012

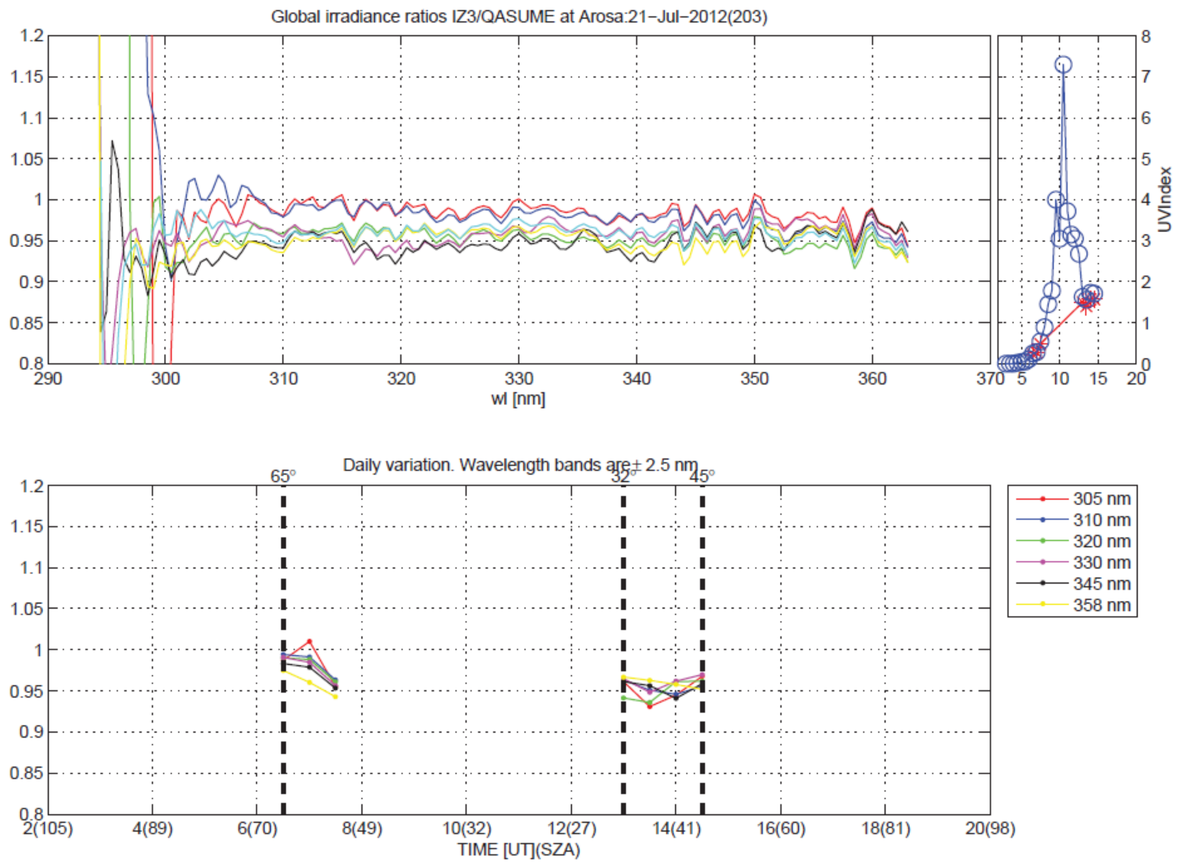


Figure 53. Idem to Figure 49 for 21 July 2012

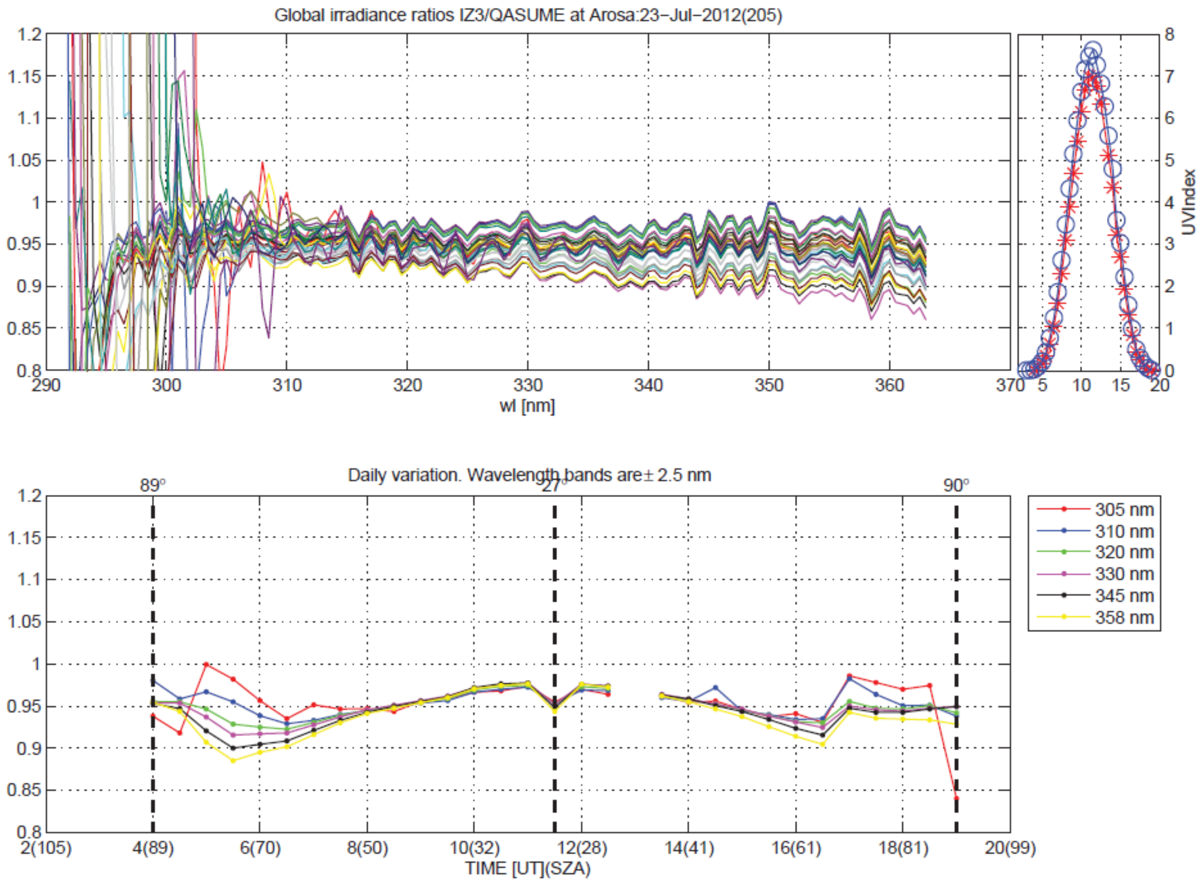


Figure 54. Idem to Figure 49 for 23 July 2012

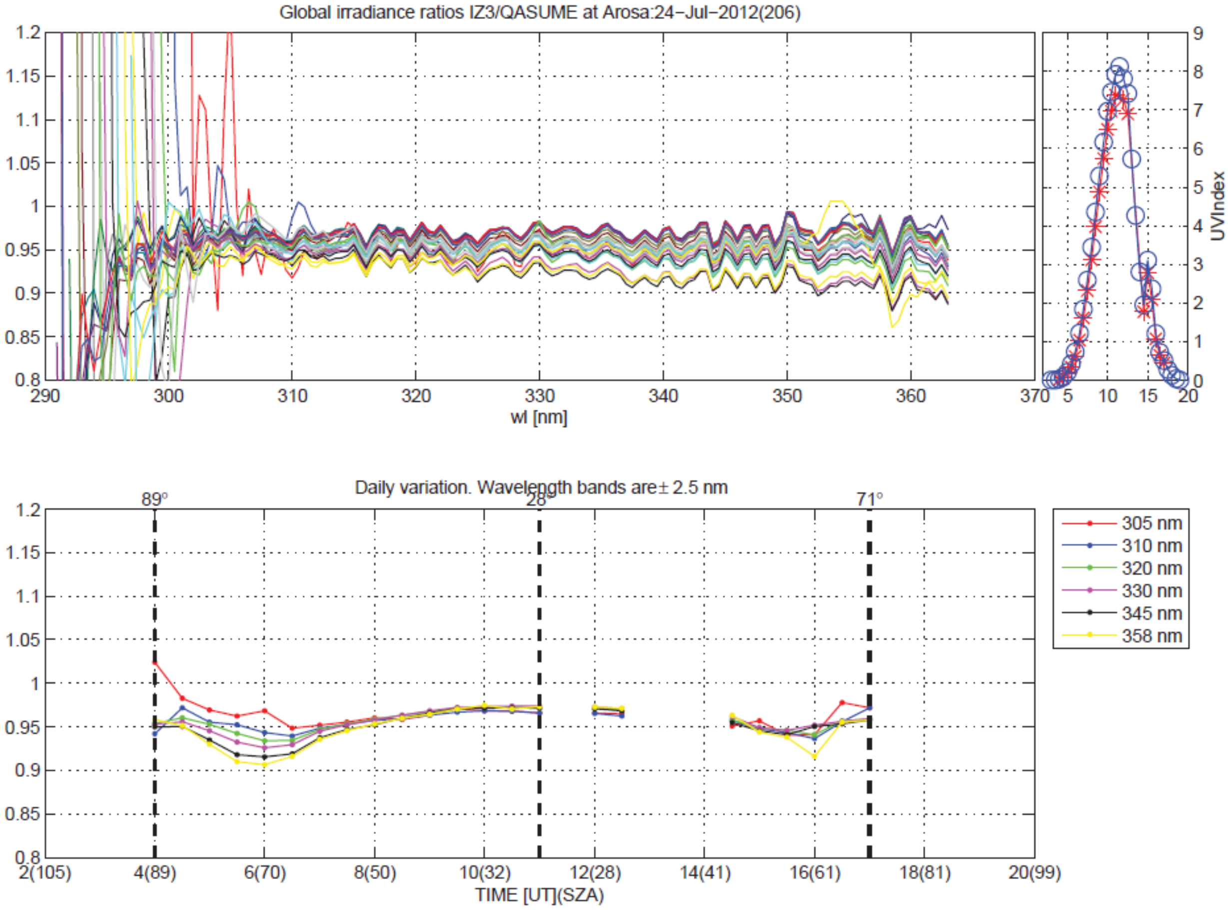


Figure 55. Idem to Figure 49 for 24 July 2012

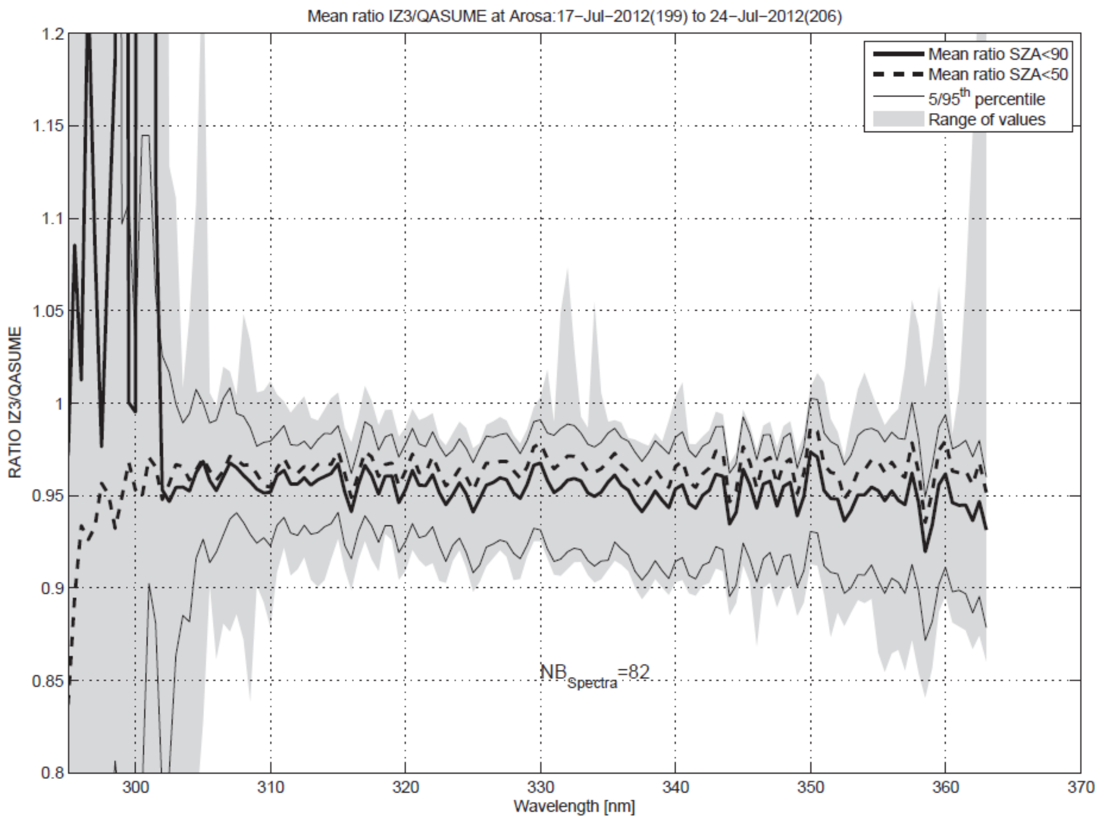


Figure 56. Average spectral ratios between Brewer #185 and QASUME for all measurements (thick line), and at SZA smaller than 50° (dashed line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

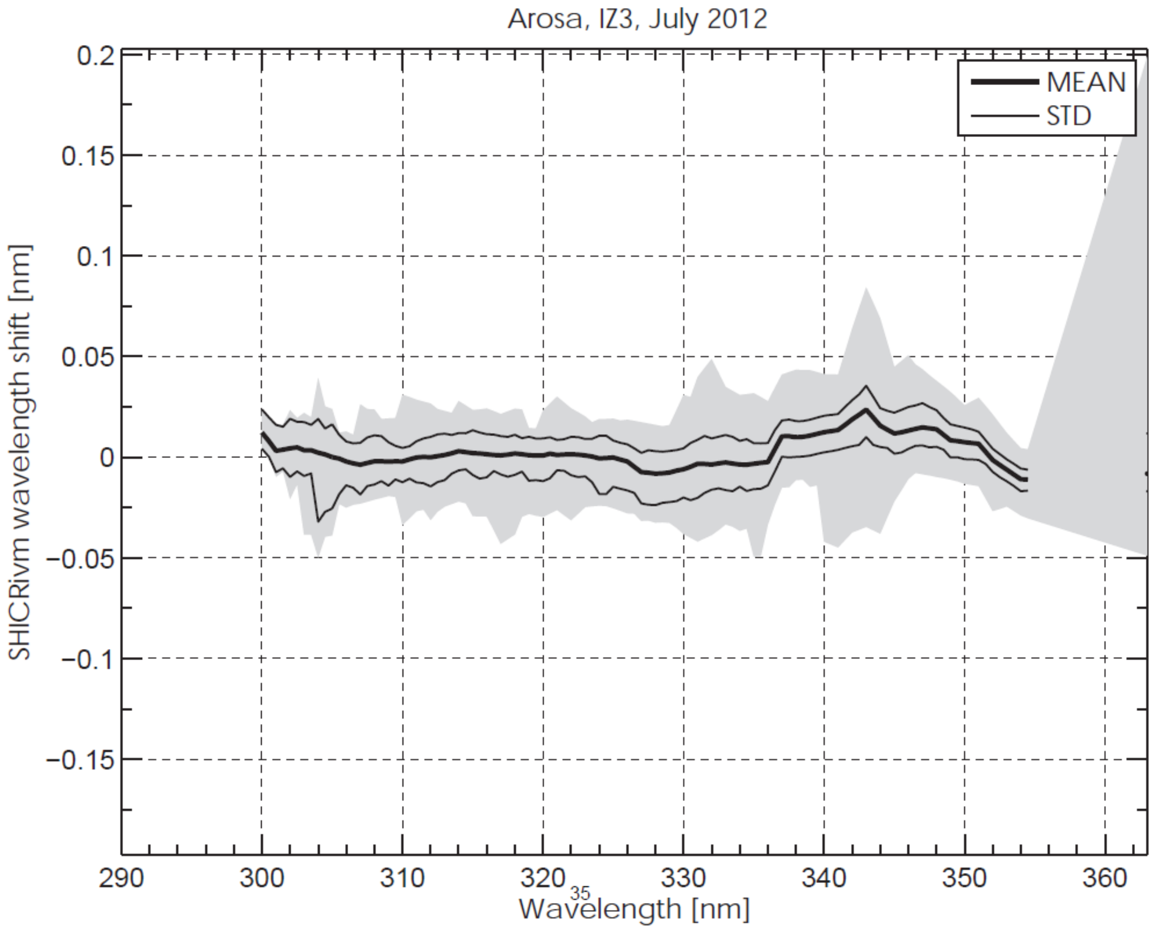


Figure 57. Average spectral wavelength shift of Brewer #185 determined with the SHICRivm package (thick line). The thin lines represent the 5 to 95 percentiles and the shaded area the whole range of values.

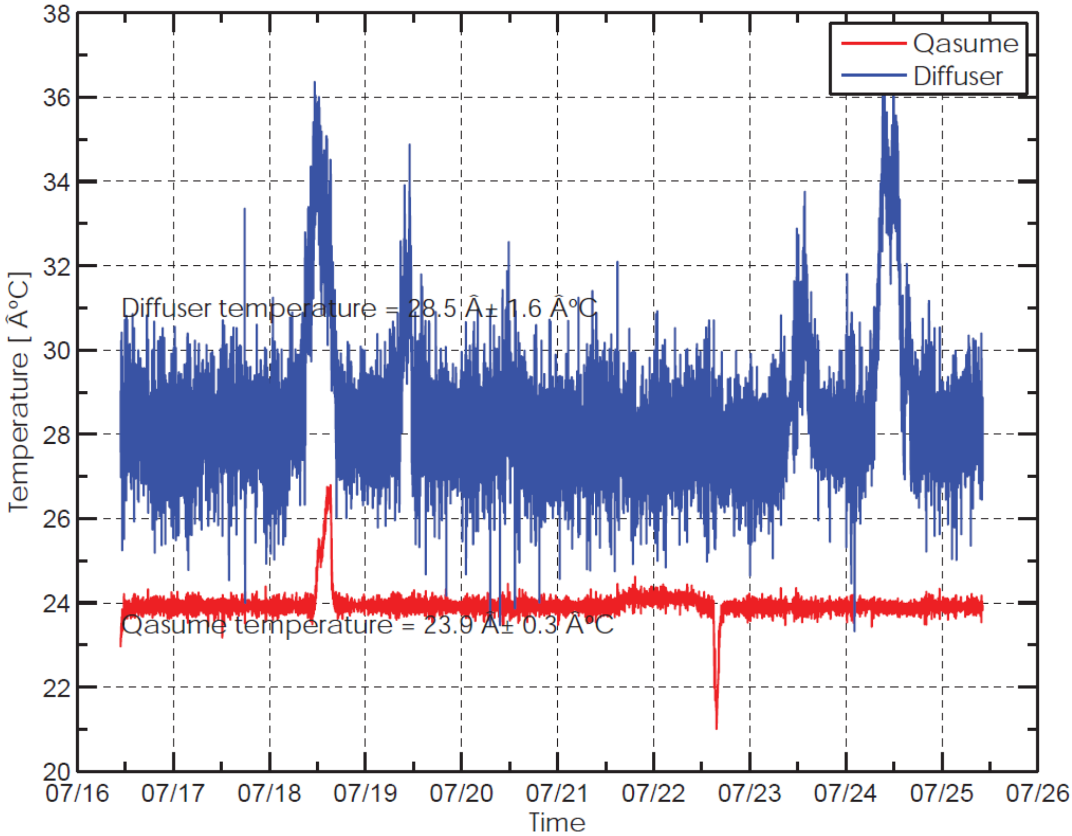


Figure 58. Internal (red curve) and head (blue curve) temperature of the QASUME spectroradiometer

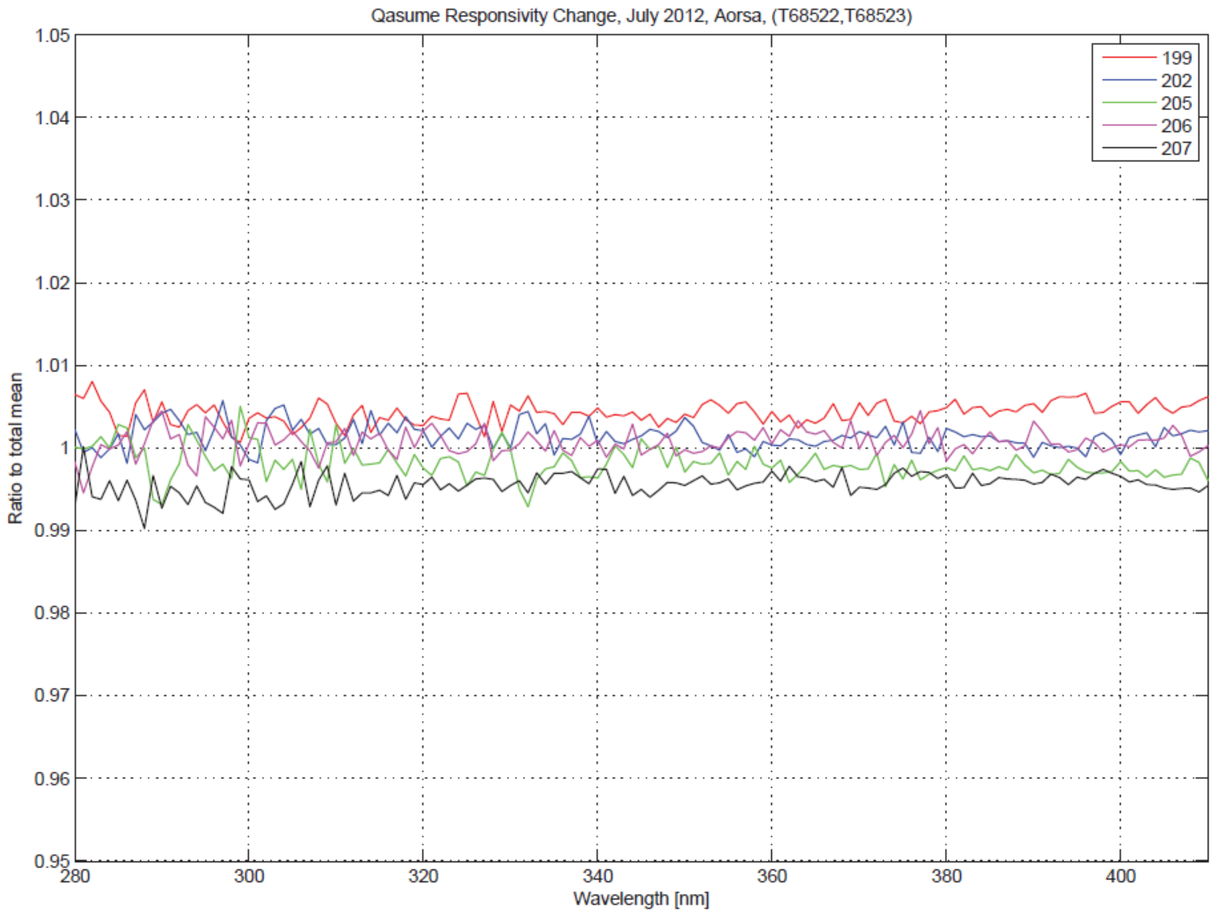


Figure 59. Relative spectral responsivity variations of the QASUME spectroradiometer relative to the average over the measurement period.
The calibrations were performed by a portable lamp calibration system.

4. CONTRIBUTION TO THE AROSA 2012 REPORT – DOBSON PART

U. Köhler, Deutscher Wetterdienst, Meteorological Observatory Hohenpeissenberg, Germany (Email: ulf.koehler@dwd.de)

4.1 Introduction

The installation of a global network for monitoring the ozone layer using Dobson spectrophotometers began in the International Geophysical Year (IGY) 1957/58. Regular intercomparisons of field Dobsons with reference instruments and calibration services have been carried out since the mid 1980s, when deficits in the stability and consistency of the calibration levels had been detected. In the meanwhile, a calibration system with one World Dobson Calibration Center (WDCC) at NOOA (Boulder, USA) and five Regional Dobson Calibration Centers (RDCCs) in different WMO Regional Associations have successfully been established (Figure 1).

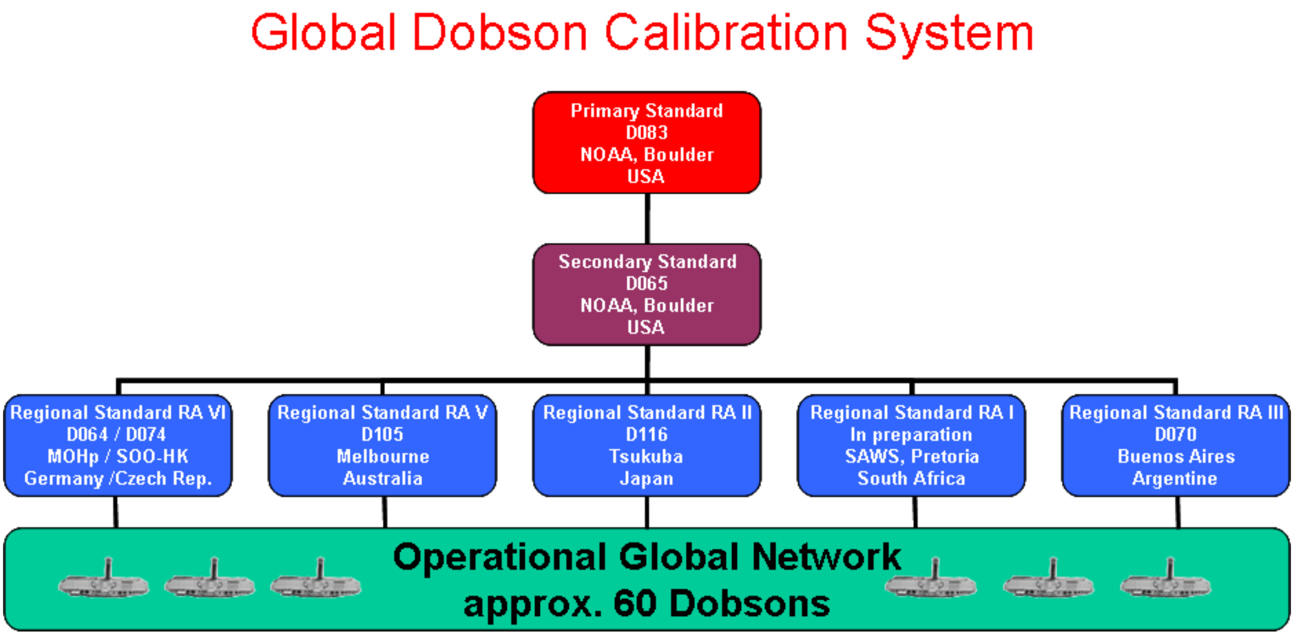


Figure 1. Structure of the Global Dobson Calibration System

These five RDCCs are responsible to guarantee the high quality of the total ozone column records, observed by Dobson spectrophotometers. The WDCC is on one hand responsible for the North American Dobson network and on the other hand to keep the regional standard Dobsons of the RDCCs on a stable and consistent calibration level. The outstanding success of this calibration system can be seen in Figure 2. More than 50% of the participating Dobsons show an agreement with the standard instruments better than ±1% for the past two decades. Thus, the majority fulfils the WMO limit for well calibrated and reliable instruments.

The RDCC for Europe at the Meteorological Observatory Hohenpeissenberg (Germany) started its work in 1999 and replaced the big campaigns in the 1980s and 1990s (mostly held at the Lichtklimatische Observatorium LKO in Arosa) with up to 17 instruments every four or five years by regular annual campaigns with a maximum of five Dobsons. This procedure also enables to have each European Dobson serviced and calibrated every four to five years. As the LKO employs three Dobsons, it was decided to perform the calibrations of the three Swiss instruments not at Hohenpeissenberg but on site at Arosa every four years.

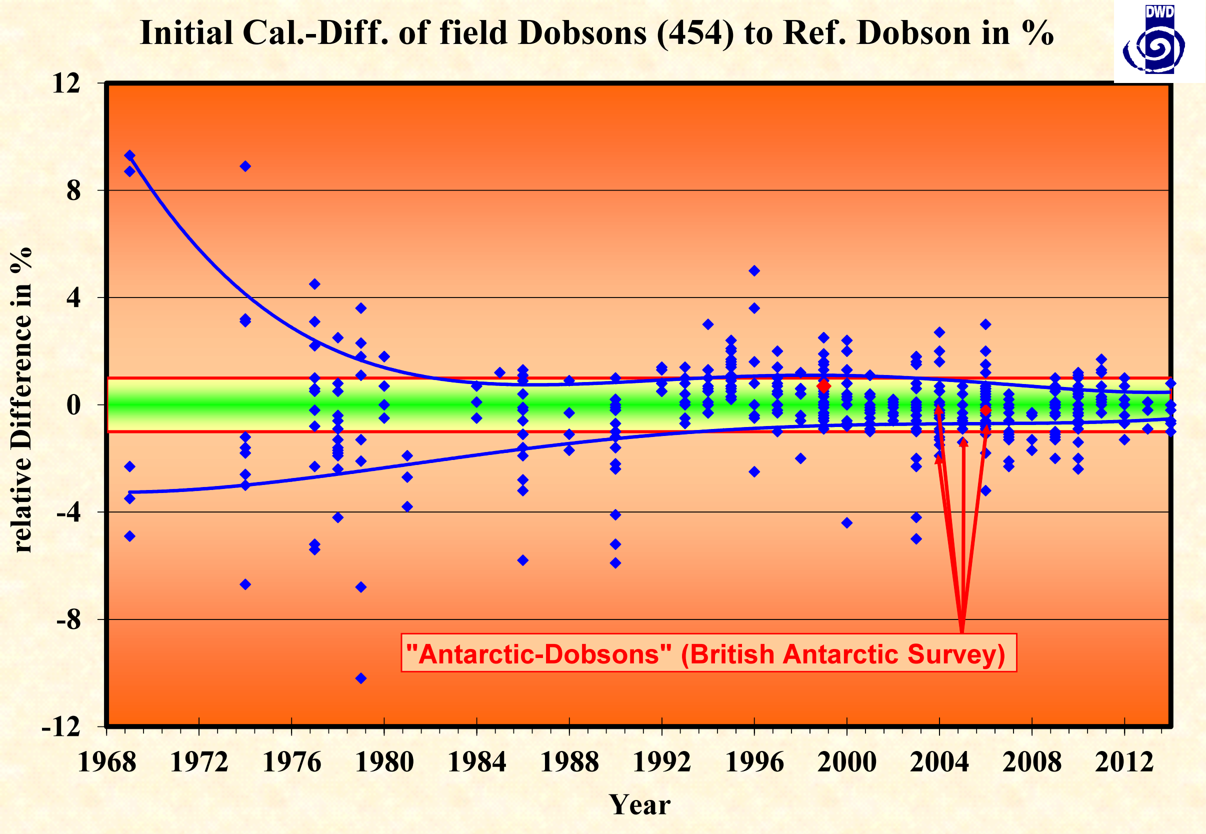


Figure 2. Success of the Global Calibration System: Blue diamonds show the relative differences between field Dobsons and the standard instruments at the beginning of the calibration service (so-called initial calibration) before any work was done

A similar calibration center for the Brewer spectrophotometer in Europe was established by the Izaña Atmospheric Research Center of the Spanish AEMET in Tenerife in 2003. In previous years several joint campaigns of the RDCC-E and the RBCC-E were organized within the ESA project “CEOS Intercalibration of Ground-Based Spectrometers and Lidars” at different places like El Arenosillo (Spain), Izaña (Tenerife) and Sodankylä (Finland). The main goals of these campaigns were to investigate and to understand the principal differences between both types of spectrometer under various atmospheric conditions. As the calibration service for the Swiss Dobsons was due in 2012 and the RBCC-E planned a Brewer intercomparison at the LKO as well, it was decided to combine both campaigns under the umbrella of this ESA project.

Results of the calibrations of the three Swiss Dobsons No. D051, D062 and D101 and the performed work are presented in detailed reports below.

4.2 Final Report: Instrument D051 Switzerland (Arosa)

Dobson Intercomparison, 16-27 July 2012 Arosa

Original Calibration Data

N-tables from 17.07.2006 and 16.07.2010, respectively, based on DSGQP-comparison with D064 on 17 July 2006 and D074 on 17 July 2012, Arosa, G-tables from 29.07.2003.
Reference Standard Lamp Values for lamps 051A1, 051B and 051C.
Lamp tests results used in data processing at home station.

Introductory Remarks

D051 was calibrated in 2006 towards D064 and in 2010 towards D074. It is assumed that the 2010-calibration was not applied and that the 2006-R-N-tables had been still in use. Instrument normally used only for automated Umkehr measurements, operation fully automated, thus some problems to run it during the comparisons in an appropriate manner.

Initial Calibration Results (Adjustments based on the results with Standard Lamp tests included) 18 July 2012 (2010 with D074 in brackets):

d_Na: 1.75 (1.55) d_Nc: 0.30 (-1.00) d_Nd: 1.24 (1.34)
d_Nad: 0.51 (0.21) d_Ncd: -0.94 (-2.34)

The d_Nad value implies an average **-0.7% (-0.3%) error** in calculated ozone value, Mu=1.15 to 2.5, Total Ozone = 300 Dobson Units. Moderate mue dependency in AD, thus no reprocessing necessary, very high CD-values may come from 2010-calibration with D074.

Optical, mechanical and electronical work performed

- Electric/Electronics: No work done, new US electronic MOHp modified already installed, operation in automated mode.
- Optical check: Optical parts very clean, inlet window with spotted surface due to contamination with snow, holder of S1 therefore humid and corroded.
- Symmetry test: Not done.
- Measurement of slit widths and parallelism with microscope: Not done.
- Shutter motor: O.K.
- PMT vertical position test: Not done, Focus L1: Not done.
- Optics: Wedge plates position not symmetrical and range only from 9.5^o up to much more than 300: corrected. S4 lens missing, installation done, otherwise wedge calibration not possible.
- Further work: Replacement of gaskets. Inlet window cleaned and humid parts dried.
- Discharge lamp: Done on 21.07.2012 and new Q-tables created.
- Wedge calibration: Done on 23.07.2012, new R-G-tables created and applied to derive new R-N-tables. Procedure of wedge calibration very difficult, as large noise on the results.

Final intercomparison
26 July 2012

Data of the final calibration processed with old R-N-tables and with new R-N-Tables derived from new R-G-tables (in brackets)**; highest difference against the standard ADDSGQP observations of D064 in mu range 1.15 to 3.2 was -0.19% (-0.29%) in total ozone. CD-agreement good too, only small Mu-dependency. Old R-N-tables kept as results with new R-N-tables from wedge calibration not better.**

Recommendations/Comments

- The results of the initial calibration are satisfactory, therefore no re-calculation is necessary.
- New calibration status with new R-N-tables defined based on the old R-N-tables from 2010 incl. determination of SL-reference values from corresponding tests (s. table with results), new R-G/N-tables not used.
- **Correction of new Q-tables after Komhyr's manual only necessary, when regular HG-tests show permanent higher differences tha +-0.3 degree.**
- Regular tests (monthly SL and HG, at least annual Symmetry Test) and cleaning of GQP/Sundirector.

Hohenpeissenberg, 18.12.2012

Intercomparison Results (Old R-N)
Arosa2012 from July 16 to July 27, 2012 at Arosa

Instrument D051
Switzerland (Arosa)

Initial calibration (18.07.2012):

	Date:	Comment:
G-Tables	29.7.03	based on wedge cal. on July 29, 2003 at Arosa2003
N-Tables	16.7.10	based on FC on July 16, 2010 at Arosa2010

Corrections to N-Tables	A	C	D	AD	CD
from SL-Test	-0.60	-0.50	-0.20	-0.40	-0.30
from Comparison	1.75	0.30	1.24	0.51	-0.94
Sum	1.15	-0.20	1.04	0.11	-1.24

Comments: Results acceptable in AD with moderate Mu-dependency, not good in CD
No data reprocessing necessary

Final Calibration (26.07.2012):

	Date:	Comment:
G-Tables	29.7.03	based on wedge cal. on July 29, 2003 at Arosa2003
N-Table old	26.7.12	from old R-N and FC on July 26, 2012 at Arosa

Corrections to old N-tables:	A	C	D	AD	CD
from SL-Test	0	-0.1	0.2	-0.20	-0.30
from Comparison	0.77	0.95	0.52	0.25	0.43
Sum	0.77	0.85	0.72	0.05	0.13

Comments: Very good agreement in AD and CD, only small Mu-dependence
New R-N-table derived from old R-N-table, use for future data processing.
Alternative: use old N-tables but include above mentioned corrections!!!

Reference Standard Lamp Data: Date: 26.7.12

for new R-N-table

Lamp No.	A		C		D	
	R	N	R	N	R	N
051A1	38.38	14.32	40.02	18.20	40.77	19.65
051B	38.82	14.80	40.55	18.81	41.23	20.15
051C	37.77	13.65	39.60	16.70	40.32	19.15
64Q1						

Q-Table: New Q-table derived from discharge-lamp test on 21. July 2012
Can be used in the future, as instruments remains on station
Correction after Komhyr's manual only necessary, when regular HG-tests
show permanent higher differences than +-0.3 degree

IC D051 vs. D064 on July 18, 2012
new R-N-table from 2010 with SL-corrections
Mean difference in AD acceptable
CD bad, much worse than with 2006 R-N-table
2010-R-N probably not used at station

```
12-14-2012    11:25:32

Instruments 064 and 051 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 051N Table dated: Date 16.07.2010
Adjustments based on Standard lamps:
To Na values add  -1.7
To Nc values add  -1.6
To Nd values add  -1.4
```

```
Data Summary using Inst. 051 N tables dated: Date 16.07.2010    Standard: 064 vs 051    07-18-2012

             1.15<mu<1.5    1.5<mu<2.0    2.0<mu<2.5    2.5<mu<3.2    3.2<mu<4.0    4.0<mu<5.0    1.15<mu<3.2

 XAD064     .305 (.002)    .303 (.001)    .300 (.001)    .299 (.001)    .301 (.000)                     .302 (.001) Atmo-CM
 XAD051*    .301 (.001)    .301 (.001)    .302 (.000)    .302 (.001)    .297 (.000)                     .301 (.001) Atmo-CM
  DXAD051*       -1.29          -0.74          +0.50          +0.81          -1.33                           -0.19 Percent
 XCD064     .302 (.002)    .302 (.001)    .300 (.001)    .301 (.001)    .302 (.000)                     .301 (.001) Atmo-CM
 XCD051*    .339 (.004)    .331 (.001)    .325 (.002)    .321 (.002)    .322 (.000)                     .329 (.001) Atmo-CM
  DXCD051*      +11.94          +9.86          +8.55          +6.93          +6.62                            9.33 Percent
 XA 064     .310 (.002)    .306 (.001)    .302 (.001)    .301 (.001)    .302 (.000)                     .305 (.001) Atmo-CM
 XA 051*    .301 (.001)    .300 (.001)    .300 (.000)    .300 (.001)    .297 (.000)                     .300 (.000) Atmo-CM
  DXA 051*       -2.98          -2.01          -0.70          -0.28          -1.66                           -1.51 Percent
 XC 064     .313 (.003)    .309 (.001)    .304 (.000)    .303 (.001)    .304 (.000)                     .307 (.001) Atmo-CM
 XC 051*    .320 (.003)    .315 (.001)    .312 (.001)    .310 (.001)    .310 (.000)                     .314 (.001) Atmo-CM
  DXC 051*       +2.07          +2.11          +2.42          +1.98          +1.97                            2.14 Percent
 XD 064     .326 (.005)    .317 (.001)    .310 (.001)    .307 (.001)    .307 (.000)                     .315 (.001) Atmo-CM
 XD 051*    .297 (.002)    .296 (.001)    .295 (.001)    .295 (.001)    .295 (.000)                     .296 (.001) Atmo-CM
  DXD 051*       -9.00          -6.80          -5.03          -3.95          -3.91                           -6.24 Percent
Corr. needed to Inst. 051 N Values          Mean      rsd                                                         mean
            Mu= 1.33   1.75   2.25   2.85   (1.15-2.5)                        Mu= 1.33   1.75   2.25   2.85   (1.15-2.5)
To NA ADD       2.13   1.78   0.75   0.27      1.55   0.12            To NAD ADD  0.71   0.47  -0.55  -1.01      0.21
To NC ADD      -0.70  -0.92  -1.38  -1.38     -1.00   0.05            To NCD ADD -2.12  -2.23  -2.68  -2.67     -2.34
To ND ADD       1.42   1.31   1.30   1.29      1.34   0.06
Data Summary using corrected Inst. 051 N tables (using mean)
             1.15<mu<1.5    1.5<mu<2.0    2.0<mu<2.5    2.5<mu<3.2    3.2<mu<4.0    4.0<mu<5.0    1.15<mu<3.2

 XAD064     .305 (.002)    .303 (.001)    .300 (.001)    .299 (.001)    .301 (.000)                     .302 (.001) Atmo-CM
 XAD051     .303 (.002)    .302 (.001)    .302 (.001)    .303 (.001)    .298 (.000)                     .302 (.001) Atmo-CM
  DXAD051        -0.93          -0.41          +0.71          +1.05          -1.00                            0.10 Percent

 XCD064     .302 (.002)    .302 (.001)    .300 (.001)    .301 (.001)    .302 (.000)                     .301 (.001) Atmo-CM
 XCD051     .299 (.002)    .300 (.002)    .303 (.001)    .303 (.002)    .307 (.000)                     .301 (.001) Atmo-CM
  DXCD051        -1.17          -0.50          +1.04          +0.89          +1.66                            0.06 Percent

 XA 064     .310 (.002)    .306 (.001)    .302 (.001)    .301 (.001)    .302 (.000)                     .305 (.001) Atmo-CM
 XA 051     .307 (.002)    .305 (.001)    .304 (.000)    .304 (.001)    .299 (.000)                     .305 (.001) Atmo-CM
  DXA 051        -0.82          -0.30          +0.62          +0.81          -0.99                            0.07 Percent

 XC 064     .313 (.003)    .309 (.001)    .304 (.000)    .303 (.001)    .304 (.000)                     .307 (.001) Atmo-CM
 XC 051     .310 (.002)    .308 (.001)    .306 (.001)    .305 (.001)    .306 (.000)                     .307 (.001) Atmo-CM
  DXC 051        -0.88          -0.22          +0.66          +0.55          +0.66                            0.02 Percent

 XD 064     .326 (.005)    .317 (.001)    .310 (.001)    .307 (.001)    .307 (.000)                     .315 (.001) Atmo-CM
 XD 051     .324 (.004)    .318 (.001)    .311 (.001)    .308 (.001)    .305 (.000)                     .315 (.001) Atmo-CM
  DXD 051        -0.53          +0.10          +0.08          +0.19          -0.65                           -0.04 Percent

Values in brackets are Standard Deviations.  New II BK O3 ABS COEFF Used.
```

IC D051 vs. D064 on July 18, 2012
old R-N-table from 2006 with SL-corrections
Mean difference in AD acceptable
CD not good, but better than with 2010 R-N-table
no reprocessing necessary, 2006-R-N probably in use at station

```
12-13-2012    16:39:19

Instruments 064 and 051 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 051N Table dated: Date 17.07.2006
Adjustments based on Standard lamps:
To Na values add  -0.6
To Nc values add  -0.5
To Nd values add  -0.2
```

Data Summary using Inst. 051 N tables dated: Date 17.07.2006   Standard: 064 vs 051   07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.301 (.000)		.302 (.001)	Atmo-CM
XAD051*	.300 (.001)	.300 (.001)	.301 (.000)	.301 (.001)	.297 (.000)		.300 (.001)	Atmo-CM
DXAD051*	-1.82	-1.13	+0.17	+0.48	-1.33		-0.58	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.301 (.001)	.302 (.000)		.301 (.001)	Atmo-CM
XCD051*	.315 (.003)	.312 (.001)	.312 (.001)	.311 (.002)	.313 (.000)		.313 (.001)	Atmo-CM
DXCD051*	+4.16	+3.62	+4.13	+3.33	+3.64		3.81	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.302 (.000)		.305 (.001)	Atmo-CM
XA 051*	.300 (.001)	.299 (.001)	.300 (.000)	.300 (.001)	.297 (.000)		.300 (.000)	Atmo-CM
DXA 051*	-3.25	-2.20	-0.79	-0.28	-1.66		-1.64	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.304 (.000)		.307 (.001)	Atmo-CM
XC 051*	.308 (.002)	.306 (.001)	.305 (.000)	.304 (.001)	.305 (.000)		.306 (.001)	Atmo-CM
DXC 051*	-1.78	-0.89	+0.25	+0.05	+0.33		-0.60	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.307 (.000)		.315 (.001)	Atmo-CM
XD 051*	.299 (.002)	.298 (.001)	.296 (.001)	.296 (.001)	.296 (.000)		.297 (.001)	Atmo-CM
DXD 051*	-8.37	-6.17	-4.59	-3.63	-3.58		-5.73	Percent

Corr. needed to Inst. 051 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	2.33	1.98	0.95	0.47	1.75	0.12
To NC ADD	0.60	0.38	-0.07	-0.08	0.30	0.05
To ND ADD	1.31	1.21	1.20	1.19	1.24	0.06

	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	1.02	0.77	-0.25	-0.71	0.51
To NCD ADD	-0.71	-0.83	-1.27	-1.27	-0.94

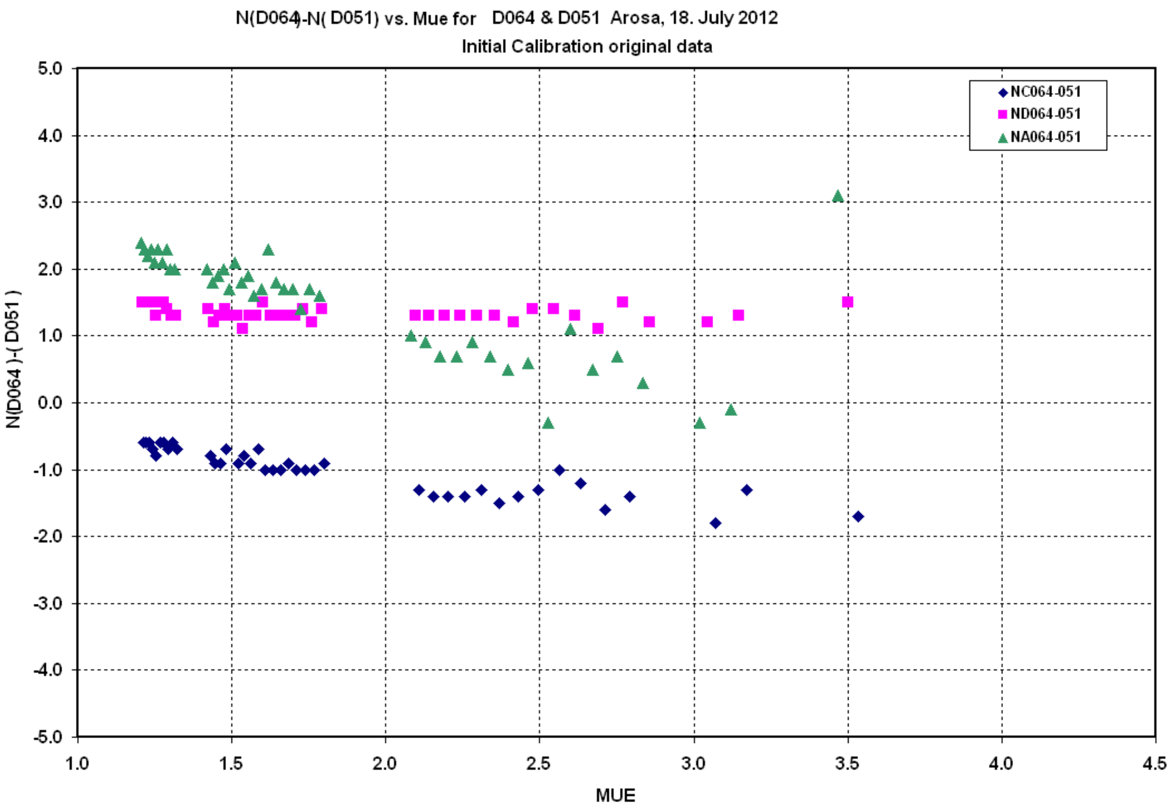
Data Summary using corrected Inst. 051 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.301 (.000)		.302 (.001)	Atmo-CM
XAD051	.303 (.002)	.302 (.001)	.302 (.001)	.303 (.001)	.298 (.000)		.302 (.001)	Atmo-CM
DXAD051	-0.93	-0.41	+0.71	+1.05	-1.00		0.10	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.301 (.001)	.302 (.000)		.301 (.001)	Atmo-CM
XCD051	.299 (.002)	.300 (.002)	.303 (.001)	.303 (.002)	.307 (.000)		.301 (.001)	Atmo-CM
DXCD051	-1.17	-0.50	+1.04	+0.89	+1.66		0.06	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.302 (.000)		.305 (.001)	Atmo-CM
XA 051	.307 (.002)	.305 (.001)	.304 (.000)	.304 (.001)	.299 (.000)		.305 (.001)	Atmo-CM
DXA 051	-0.82	-0.30	+0.62	+0.81	-0.99		0.07	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.304 (.000)		.307 (.001)	Atmo-CM
XC 051	.310 (.002)	.308 (.001)	.306 (.001)	.305 (.001)	.306 (.000)		.307 (.001)	Atmo-CM
DXC 051	-0.88	-0.22	+0.66	+0.55	+0.66		0.02	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.307 (.000)		.315 (.001)	Atmo-CM
XD 051	.324 (.004)	.318 (.001)	.311 (.001)	.308 (.001)	.305 (.000)		.315 (.001)	Atmo-CM
DXD 051	-0.53	+0.10	+0.08	+0.19	-0.65		-0.04	Percent

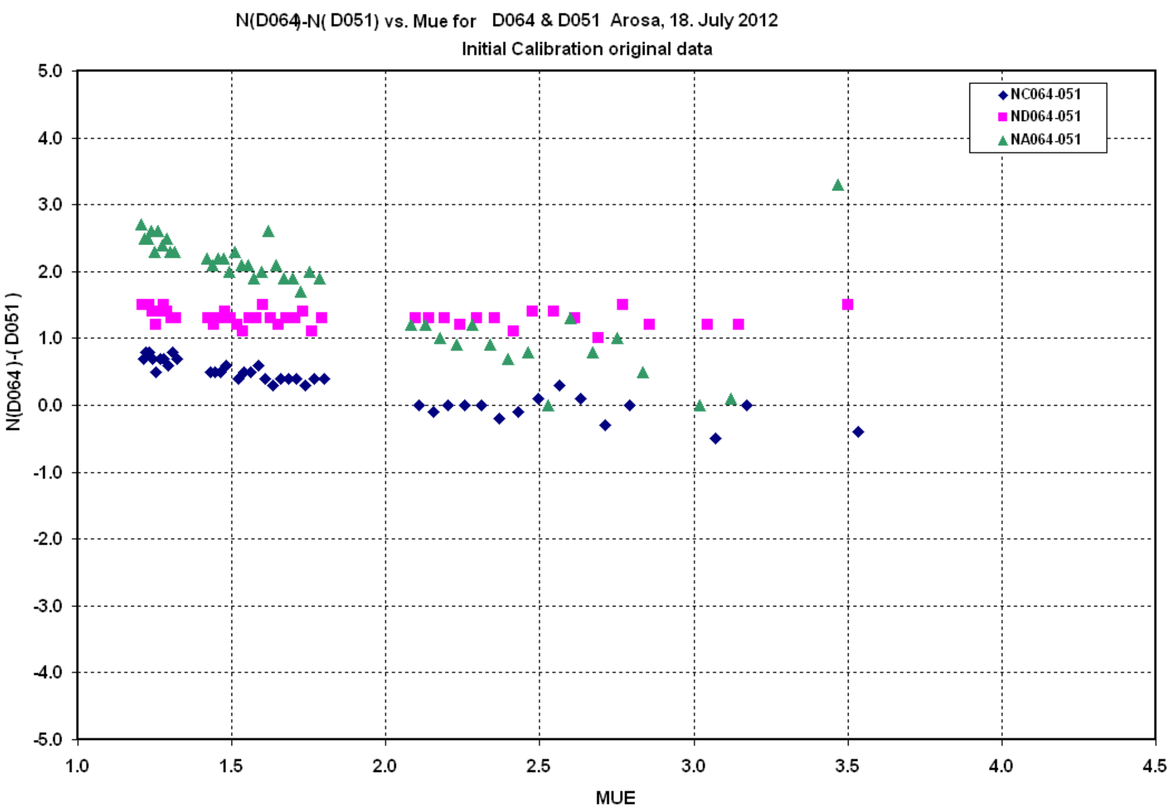
Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

Difference N_A-C-D to Reference Instrument D064
Initial Calibration on July 18, 2012

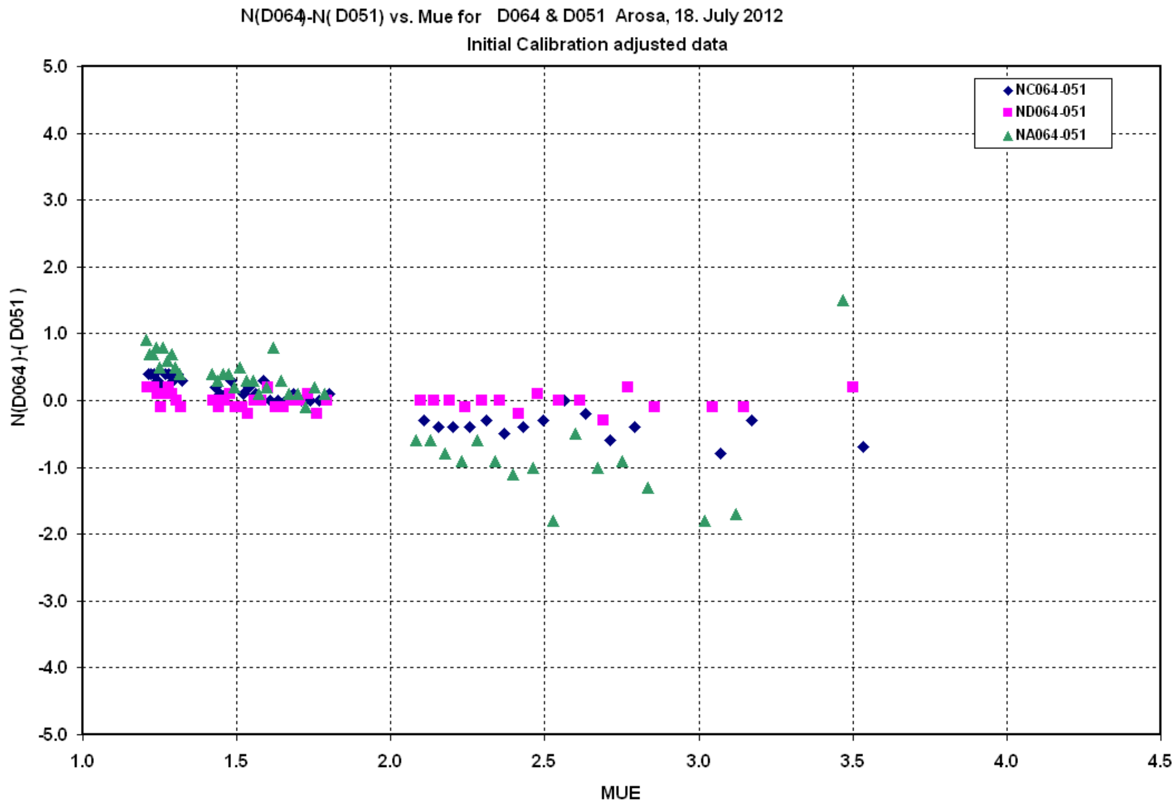
with R-N-tables 2010



with R-N-tables 2006



with R-N-tables 2010 and 2006



Final Comparison D051 vs. D064 on July 26, 2012
with new R-G-table from wedge calibration 2012
very good agreement in AD and CD
calibration not used to define new R-N table for the future

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08-21-2012    15:14:42
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08-21-2012    15:14:42
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```
Instruments 064 and 051 Compared
at LKO, Arosa, Switzerland On 07-26-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 051G Table dated: 23-July-2012
No Lamp Adjustments used.
```

Reference Standard Lamp Data:				**Date:**	**26.7.12**	
for new R-N-table						
Lamp No.	**A**		**C**		**D**	
	R	**N**	**R**	**N**	**R**	**N**
051A1	**38.38**	**13.88**	**40.02**	**17.10**	**40.77**	**19.36**
051B	**38.82**	**14.37**	**40.55**	**17.69**	**41.23**	**19.82**
051C	**37.77**	**13.19**	**39.60**	**16.64**	**40.32**	**18.90**
64Q1						

Data Summary using Inst. 051 G tables dated: 23-July-2012   Standard: 064 vs 051   07-26-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD051*	.327 (.002)	.323 (.001)	.315 (.001)	.313 (.001)	.315 (.001)		.319 (.001)	Atmo-CM
DXAD051*	+6.59	+5.51	+4.25	+3.56	+3.49		4.99	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.306 (.001)		.305 (.001)	Atmo-CM
XCD051*	.338 (.003)	.330 (.003)	.320 (.001)	.319 (.001)	.323 (.002)		.327 (.001)	Atmo-CM
DXCD051*	+10.36	+7.96	+5.04	+4.63	+5.69		7.00	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.311 (.000)	Atmo-CM
XA 051*	.417 (.007)	.393 (.006)	.368 (.003)	.357 (.003)	.349 (.002)		.384 (.003)	Atmo-CM
DXA 051*	+32.60	+25.85	+19.60	+16.27	+13.05		23.64	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 051*	.527 (.014)	.480 (.012)	.432 (.005)	.413 (.007)	.394 (.005)		.463 (.005)	Atmo-CM
DXC 051*	+63.57	+50.04	+36.89	+30.94	+24.76		45.47	Percent
XD 064	.342 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 051*	.759 (.029)	.663 (.023)	.571 (.010)	.528 (.016)	.483 (.014)		.630 (.010)	Atmo-CM
DXD 051*	%+121.84	+96.78	+73.21	+61.08	+47.17		88.63	Percent

Corr. needed to Inst. 051 G Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	-24.07	-24.32	-24.83	-25.06	-24.41	0.11
To NC ADD	-22.27	-22.35	-22.50	-22.90	-22.37	0.08
To ND ADD	-20.34	-20.40	-20.80	-20.86	-20.51	0.11

	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	-3.74	-3.92	-4.03	-4.19	-3.90
To NCD ADD	-1.94	-1.95	-1.70	-2.04	-1.86

Data Summary using corrected Inst. 051 G tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD051	.306 (.001)	.306 (.001)	.303 (.001)	.302 (.001)	.306 (.002)		.304 (.000)	Atmo-CM
DXAD051	-0.29	+0.07	+0.22	+0.17	+0.72		0.04	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.306 (.001)		.305 (.001)	Atmo-CM
XCD051	.307 (.002)	.307 (.002)	.303 (.001)	.306 (.002)	.313 (.003)		.306 (.001)	Atmo-CM
DXCD051	+0.38	+0.35	-0.38	+0.37	+2.29		0.18	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.311 (.000)	Atmo-CM
XA 051	.313 (.001)	.312 (.001)	.309 (.000)	.309 (.001)	.310 (.001)		.311 (.000)	Atmo-CM
DXA 051	-0.47	-0.09	+0.38	+0.37	+0.49		0.04	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 051	.321 (.001)	.320 (.001)	.316 (.001)	.317 (.000)	.319 (.001)		.319 (.000)	Atmo-CM
DXC 051	-0.29	-0.02	+0.21	+0.63	+0.95		0.13	Percent
XD 064	.342 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 051	.339 (.001)	.335 (.002)	.333 (.001)	.331 (.001)	.326 (.003)		.334 (.001)	Atmo-CM
DXD 051	-1.10	-0.53	+1.06	+1.03	-0.61		0.10	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

Final Comparison D051 vs. D064 on July 26, 2012
with old R-N-table from 2006
very good agreement in AD and CD
calibration used to define new R-N table for the future

```
12-14-2012    13:40:25

Instruments 064 and 051 Compared
at LKO, Arosa, Switzerland On 07-26-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 051N Table dated: Date 17.07.2006
Adjustments based on Standard lamps:
To Na values add   0.0
To Nc values add  -0.1
To Nd values add   0.2
```

Reference Standard Lamp Data: **Date:** **26.7.12**

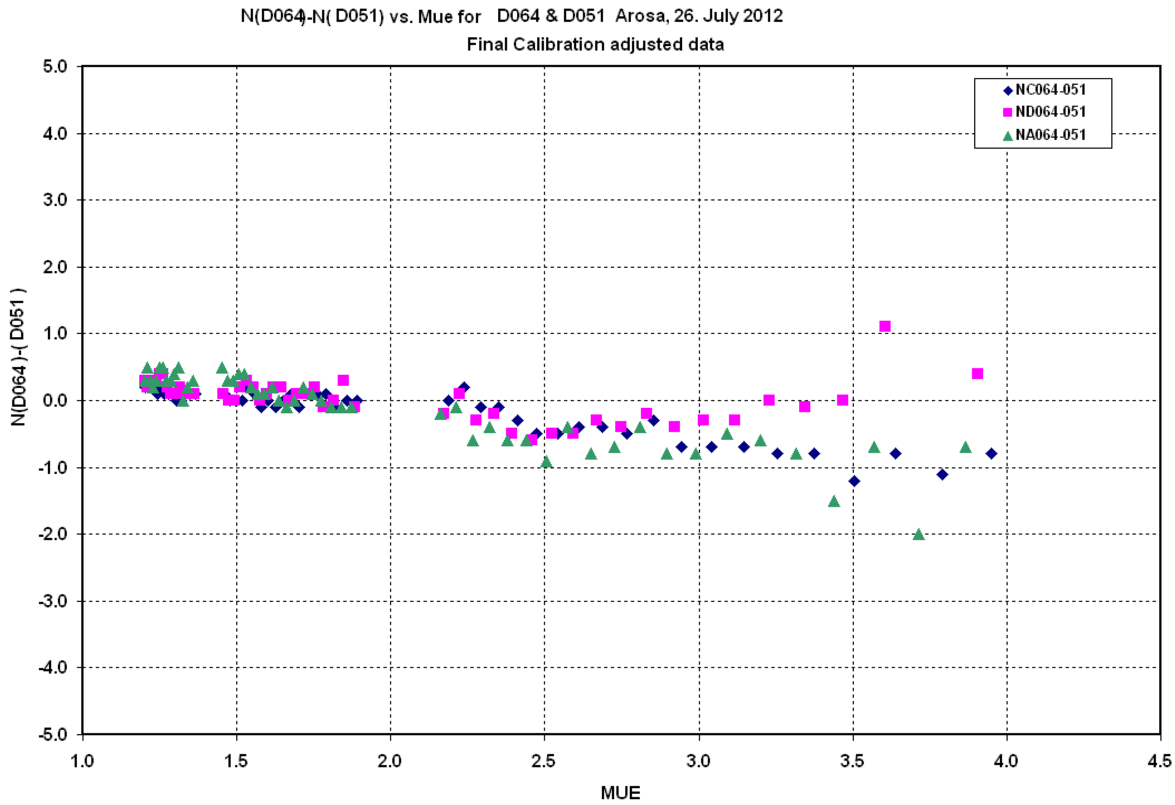
for new R-N-table

Lamp No.	A		C		D	
	R	N	R	N	R	N
051A1	38.38	14.32	40.02	18.20	40.77	19.65
051B	38.82	14.80	40.55	18.81	41.23	20.15
051C	37.77	13.65	39.60	16.70	40.32	19.15

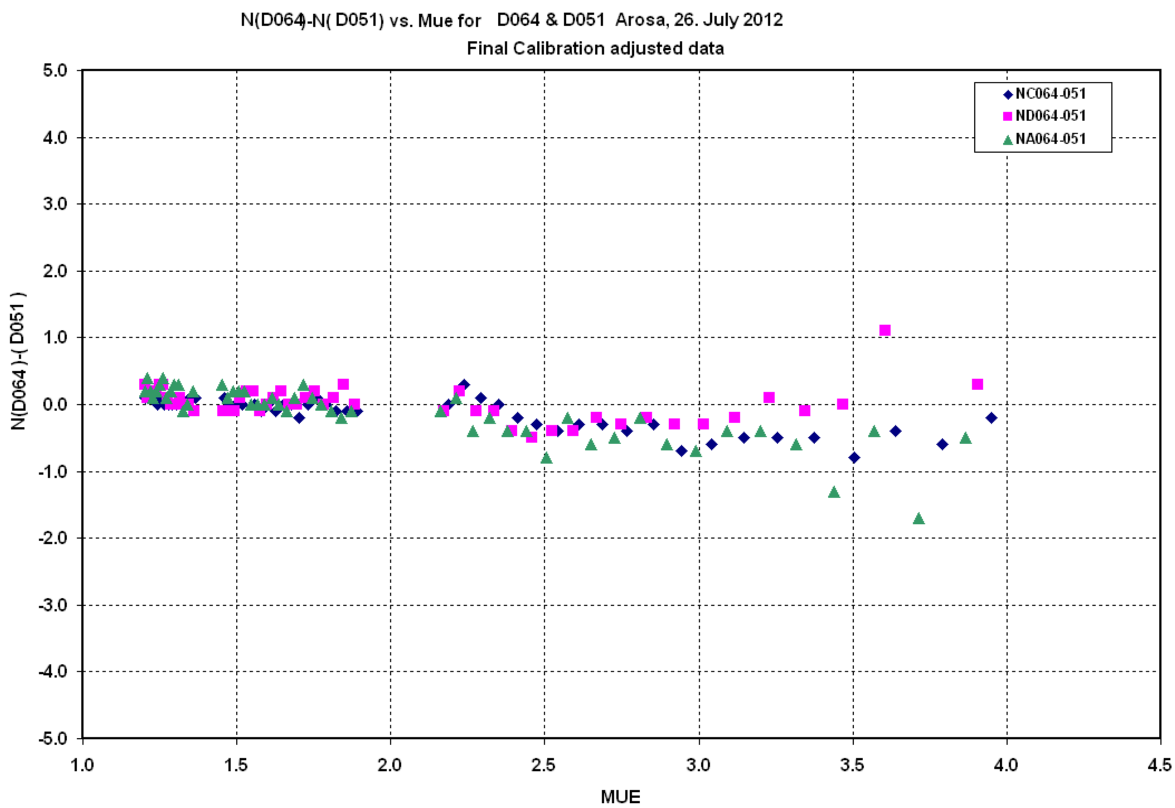
```
Data Summary using Inst. 051 N tables dated: Date 17.07.2006    Standard: 064 vs 051    07-26-2012

            1.15<mu<1.5    1.5<mu<2.0    2.0<mu<2.5    2.5<mu<3.2    3.2<mu<4.0    4.0<mu<5.0    1.15<mu<3.2

 XAD064     .307 (.001)    .306 (.001)    .302 (.001)    .302 (.001)    .304 (.001)                       .304 (.000) Atmo-CM
 XAD051*    .305 (.001)    .305 (.001)    .302 (.001)    .301 (.001)    .305 (.002)                       .303 (.000) Atmo-CM
  DXAD051*       -0.67          -0.26          -0.17          -0.17          +0.39                            -0.32 Percent
 XCD064     .306 (.002)    .306 (.001)    .305 (.001)    .305 (.001)    .306 (.001)                       .305 (.001) Atmo-CM
 XCD051*    .299 (.001)    .302 (.002)    .299 (.001)    .303 (.002)    .308 (.003)                       .301 (.001) Atmo-CM
  DXCD051*       -2.19          -1.33          -1.70          -0.70          +0.72                            -1.48 Percent
 XA 064     .314 (.001)    .313 (.001)    .308 (.001)    .307 (.001)    .309 (.001)                       .311 (.000) Atmo-CM
 XA 051*    .310 (.001)    .310 (.000)    .307 (.001)    .307 (.001)    .309 (.001)                       .308 (.000) Atmo-CM
  DXA 051*       -1.31          -0.85          -0.38          -0.24          +0.11                            -0.70 Percent
 XC 064     .322 (.001)    .320 (.001)    .316 (.001)    .315 (.000)    .316 (.001)                       .318 (.000) Atmo-CM
 XC 051*    .313 (.001)    .313 (.001)    .311 (.000)    .313 (.001)    .314 (.001)                       .312 (.000) Atmo-CM
  DXC 051*       -2.83          -2.04          -1.48          -0.79          -0.53                            -1.79 Percent
 XD 064     .342 (.004)    .337 (.001)    .330 (.002)    .328 (.001)    .328 (.001)                       .334 (.001) Atmo-CM
 XD 051*    .330 (.001)    .327 (.002)    .326 (.002)    .325 (.001)    .322 (.003)                       .327 (.001) Atmo-CM
  DXD 051*       -3.59          -2.93          -1.16          -0.69          -1.77                            -2.11 Percent
Corr. needed to Inst. 051 N Values          Mean     rsd                                                        mean
            Mu= 1.33   1.75   2.25   2.85   (1.15-2.5)                           Mu= 1.33   1.75   2.25   2.85   (1.15-2.5)
To NA ADD       0.97   0.79   0.55   0.31      0.77   0.10                To NAD ADD  0.38   0.18   0.20   0.06      0.25
To NC ADD       1.01   0.93   0.92   0.50      0.95   0.08                To NCD ADD  0.42   0.32   0.57   0.25      0.43
To ND ADD       0.59   0.61   0.35   0.25      0.52   0.10
Data Summary using corrected Inst. 051 N tables (using mean)
            1.15<mu<1.5    1.5<mu<2.0    2.0<mu<2.5    2.5<mu<3.2    3.2<mu<4.0    4.0<mu<5.0    1.15<mu<3.2

 XAD064     .307 (.001)    .306 (.001)    .302 (.001)    .302 (.001)    .304 (.001)                       .304 (.000) Atmo-CM
 XAD051     .306 (.001)    .306 (.001)    .303 (.001)    .302 (.001)    .306 (.002)                       .304 (.000) Atmo-CM
  DXAD051        -0.19          +0.11          +0.17          +0.17          +0.53                             0.06 Percent

 XCD064     .306 (.002)    .306 (.001)    .305 (.001)    .305 (.001)    .306 (.001)                       .305 (.001) Atmo-CM
 XCD051     .307 (.002)    .307 (.002)    .303 (.001)    .306 (.002)    .310 (.002)                       .306 (.001) Atmo-CM
  DXCD051        +0.19          +0.46          -0.33          +0.29          +1.51                             0.15 Percent

 XA 064     .314 (.001)    .313 (.001)    .308 (.001)    .307 (.001)    .309 (.001)                       .311 (.000) Atmo-CM
 XA 051     .313 (.001)    .312 (.001)    .309 (.001)    .308 (.000)    .310 (.001)                       .311 (.000) Atmo-CM
  DXA 051        -0.26          -0.02          +0.27          +0.28          +0.43                             0.07 Percent

 XC 064     .322 (.001)    .320 (.001)    .316 (.001)    .315 (.000)    .316 (.001)                       .318 (.000) Atmo-CM
 XC 051     .322 (.001)    .320 (.001)    .316 (.000)    .317 (.000)    .317 (.001)                       .319 (.000) Atmo-CM
  DXC 051        -0.13          +0.10          +0.05          +0.52          +0.53                             0.13 Percent

 XD 064     .342 (.004)    .337 (.001)    .330 (.002)    .328 (.001)    .328 (.001)                       .334 (.001) Atmo-CM
 XD 051     .341 (.001)    .335 (.002)    .332 (.002)    .331 (.001)    .326 (.003)                       .335 (.001) Atmo-CM
  DXD 051        -0.52          -0.45          +0.61          +0.88          -0.61                             0.12 Percent

Values in brackets are Standard Deviations.  New II BK O3 ABS COEFF Used.
```

Difference N_A-C-D to Reference Instrument D064
Final Calibration on July 26, 2012

With new G-Table (not used for definition of new R-N-tables):



Derived from R-N-tables 2006 (used for definition of new R-N-tables 2012)



4.3 Final Report: Instrument D062 Switzerland (Arosa)

Dobson Intercomparison 16 - 27 July 2012, Arosa

Original Calibration Data

N-tables from 16 July 2010 based on DSGQP-comparison with D074 on July 16 2012, Arosa, G-tables from 16.07.2006.
Reference Standard Lamp Values for lamps Q62W and Q62Z.
Lamp tests results used in data processing at home station.

Introductory Remarks

Instrument fully automated incl. encoder system, therefore some problems to synchronize the calibration measurements. Attempts to measure with encoder and manually reveal different results.

Initial Calibration Results (Adjustments based on the results with Standard Lamp tests included)
18 July 2012

d_Na: -0.26 d_Nc: -0.88 d_Nd: -0.11 d_Nad: -0.15 d_Ncd: -0.77

The d_Nad value implies an average **+0.2% error** in calculated ozone value, Mu=1.15 to 2.5, Total Ozone = 300 Dobson Units. Moderate mue dependency in AD, thus no reprocessing necessary, too high CD-values may come from 2010-calibration with D074.

Optical, mechanical and electronical work performed

- Electric/Electronics: No work done, new US electronic MOHp modified already installed, operation in automated mode.
- Optical check: Optical parts incl. wedge plates clean, only slight dust.
- Symmetry test: Very good.
- Measurement of slit widths and parallelism with microscope: Not done.
- Shutter motor: Speed measured with 830 r.p.m., O.K..
- PMT vertical position test: Not done, Focus L1: Not done.
- Optics: Movement of the sliding carriage of the wedge on the track somewhat stiff, cleaned and lubricated with high vacuum grease.
- Further work: Replacement of gaskets.
- Discharge lamp: Done on 20.07.2012 and new Q-tables created.
- Wedge calibration: Not done.

Final intercomparison
26 July 2012:

Data of final calibration processed with old R-N-tables**; highest difference against the standard ADDSGQP observations of D064 in mu range 1.15 to 3.2 was +0.28% in total ozone. CD-agreement good too, only small Mu-dependency in the common Mu-range up to 3.2. New R-N-tables derived from old R-N-tables using the corrections of this final calibration.**

Recommendations/Comments

- The results of the initial calibration are good, therefore no re-calculation necessary.
- New calibration status with new R-N-tables defined based on the old R-N-tables from 2010 incl. determination of SL-reference values from corresponding tests (s. table with results).
- **Correction of new Q-tables after Komhyr's manual only necessary, when regular HG-tests show permanent higher differences tha +-0.3 degree.**
- Regular test (monthly SL and HG, at least annual Symmetry Test) and cleaning of GQP/Sundirector.

Hohenpeissenberg, 20.12.2012

Intercomparison Results
Arosa2012 from July 16 to July 27, 2012 at Arosa

Instrument D062
Switzerland (Arosa))

Initial calibration (18.07.2012):

	Date:	Comment:
G-Tables	16.7.06	based on wedge cal. on July 16, 2006 at Arosa2006
N-Tables	16.7.10	based on FC on July 16, 2010 at Arosa2010

Corrections to N-Tables	A	C	D	AD	CD
from SL-Test	-0.60	-0.30	-0.80	0.20	0.50
from Comparison	-0.26	-0.88	-0.11	-0.15	-0.77
Sum	-0.86	-1.18	-0.91	0.05	-0.27

Comments: Mean difference in AD good with moderate Mu-dependence
CD too high probably due to 2010-calibration with D074
no reprocessing necessary for AD; CD recommended if need

Final Calibration (26.07.2012):

	Date:	Comment:
G-Tables	16.7.06	based on wedge cal. on July 16, 2006 at Arosa2006
N-Table	26.7.12	from old R-N and FC on July 26, 2012 at Arosa

Corrections to old N-tables:	A	C	D	AD	CD
from SL-Test	0.5	0.8	0.2	0.30	0.60
from Comparison	-0.49	-0.78	-0.20	-0.29	-0.58
Sum	0.01	0.02	0.00	0.01	0.02

Comments: Very good agreement in AD and CD, only small Mu-dependence
New R-N-table derived from old R-N-table, use for future data processing.

Reference Standard Lamp Data: Date: 26.7.12

for new R-N-table partly average from 2 SL-tests

Lamp No.	A		C		D	
	R	N	R	N	R	N
062W	20.55	7.19	22.00	12.79	22.92	14.75
062Z	21.95	8.66	23.39	14.23	24.38	15.23
062Q1	19.18	5.77	20.63	11.39	21.54	13.35
062X	19.80	6.41	21.32	12.10	22.25	14.07
062Y	19.85	6.46	21.33	12.11	22.23	14.04
062Z	21.48	8.16	22.97	13.79	24.00	15.88

Q-Table:

New Q-table derived from discharge-lamp test on 20. July 2012
Can be used in the future, as instruments remains on station
Correction after Komhyr's manual only necessary, when regular HG-tests
show permanent higher differences than +-0.3 degree

IC D062 vs. D064 on July 18, 2012
old R-N-table with correct SL-corrections
Mean difference in AD good with moderate Mu-dependence
CD too high probably due to 2010-calibration with D074
no reprocessing necessary for AD; CD recommended if needed

```
07-19-2012    13:03:32

Instruments 064 and 062 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add  -0.1
To Nd values add  -0.1


Instrument 062N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add  -0.6
To Nc values add  -0.3
To Nd values add  -0.8
```

Data Summary using Inst. 062 N tables dated: July-2010   Standard: 064 vs 062   07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.000)	.300 (.001)			.302 (.001)	Atmo-CM
XAD062*	.304 (.002)	.302 (.001)	.302 (.000)	.299 (.007)			.302 (.002)	Atmo-CM
DXAD062*	-0.58	-0.30	+0.67	-0.29			-0.13	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.000)	.300 (.002)			.301 (.001)	Atmo-CM
XCD062*	.314 (.004)	.311 (.002)	.307 (.000)	.305 (.002)			.309 (.001)	Atmo-CM
DXCD062*	+3.83	+3.29	+2.33	+1.79			2.81	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.000)	.301 (.000)			.305 (.001)	Atmo-CM
XA 062*	.308 (.002)	.305 (.001)	.305 (.000)	.301 (.005)			.305 (.002)	Atmo-CM
DXA 062*	-0.43	-0.24	+0.99	-0.05			0.06	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)			.307 (.001)	Atmo-CM
XC 062*	.320 (.004)	.314 (.001)	.310 (.000)	.307 (.001)			.313 (.001)	Atmo-CM
DXC 062*	+2.17	+1.67	+1.97	+1.40			1.81	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.000)	.307 (.001)			.315 (.001)	Atmo-CM
XD 062*	.326 (.004)	.317 (.002)	.314 (.000)	.310 (.001)			.317 (.001)	Atmo-CM
DXD 062*	+0.10	-0.03	+1.29	+0.98			0.57	Percent

Corr. needed to Inst. 062 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	0.32	0.21	-1.30	0.14	-0.26	0.07
To NC ADD	-0.71	-0.75	-1.20	-1.00	-0.88	0.08
To ND ADD	-0.03	-0.01	-0.30	-0.31	-0.11	0.09

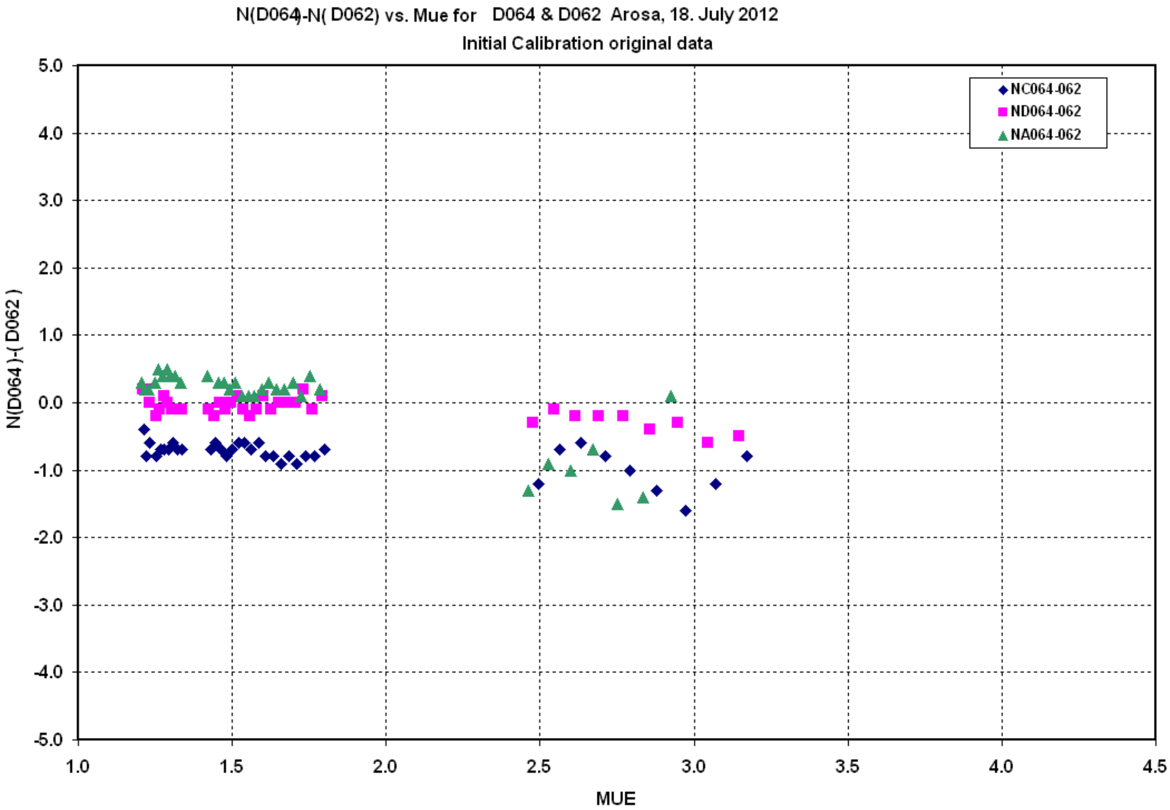
	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	0.35	0.22	-1.00	0.46	-0.15
To NCD ADD	-0.67	-0.74	-0.90	-0.69	-0.77

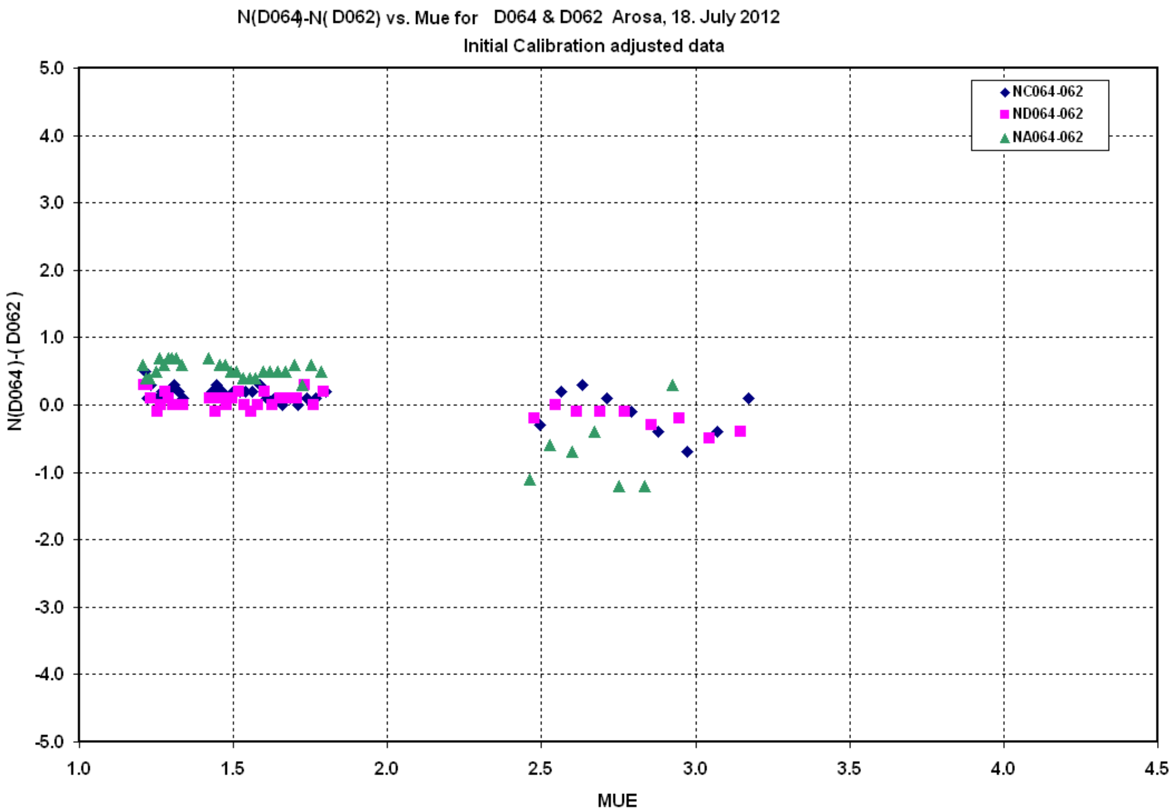
Data Summary using corrected Inst. 062 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.000)	.300 (.001)			.302 (.001)	Atmo-CM
XAD062	.303 (.002)	.301 (.001)	.302 (.000)	.298 (.007)			.301 (.002)	Atmo-CM
DXAD062	-0.85	-0.60	+0.67	-0.38			-0.30	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.000)	.300 (.002)			.301 (.001)	Atmo-CM
XCD062	.301 (.003)	.301 (.002)	.300 (.000)	.299 (.002)			.300 (.001)	Atmo-CM
DXCD062	-0.42	-0.08	+0.00	-0.21			-0.18	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.000)	.301 (.000)			.305 (.001)	Atmo-CM
XA 062	.307 (.002)	.305 (.001)	.304 (.000)	.301 (.005)			.304 (.001)	Atmo-CM
DXA 062	-0.82	-0.54	+0.66	-0.19			-0.23	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)			.307 (.001)	Atmo-CM
XC 062	.311 (.003)	.308 (.001)	.305 (.000)	.304 (.001)			.307 (.001)	Atmo-CM
DXC 062	-0.50	-0.37	+0.33	+0.16			-0.10	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.000)	.307 (.001)			.315 (.001)	Atmo-CM
XD 062	.324 (.004)	.315 (.002)	.312 (.000)	.309 (.001)			.315 (.001)	Atmo-CM
DXD 062	-0.60	-0.63	+0.65	+0.61			-0.01	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

Difference N_A-C-D to Reference Instrument D064
Initial Calibration on July 18, 2012





Final Comparison D062 vs. D064 on July 26, 2012 with old R-N-table
very good agreement in AD and CD in normal Mu-range
calibration used to define new R-N table for the future

```
12-17-2012    15:04:10

Instruments 064 and 062 Compared
at LKO, Arosa, Switzerland On 07-26-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 062N Table dated: 16-July-2010
Adjustments based on Standard lamps:
To Na values add   0.5
To Nc values add   0.8
To Nd values add   0.2
```

Reference Standard Lamp Data: **Date:** **26.7.12**

for new R-N-table **partly average from 2 SL-tests**

Lamp No.	A		C		D	
	R	N	R	N	R	N
062W	20.55	7.19	22.00	12.79	22.92	14.75
062Z	21.95	8.66	23.39	14.23	24.38	15.23
062Q1	19.18	5.77	20.63	11.39	21.54	13.35
062X	19.80	6.41	21.32	12.10	22.25	14.07
062Y	19.85	6.46	21.33	12.11	22.23	14.04
062Z	21.48	8.16	22.97	13.79	24.00	15.88

Data Summary using Inst. 062 N tables dated: 16-July-2010   Standard: 064 vs 062   07-26-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD062*	.308 (.001)	.306 (.001)	.304 (.000)	.302 (.001)	.296 (.005)		.305 (.000)	Atmo-CM
DXAD062*	+0.33	+0.17	+0.61	+0.00	-2.52		0.28	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.305 (.001)		.305 (.001)	Atmo-CM
XCD062*	.316 (.002)	.313 (.001)	.310 (.001)	.308 (.002)	.309 (.002)		.312 (.001)	Atmo-CM
DXCD062*	+3.15	+2.48	+1.97	+1.03	+1.31		2.16	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.311 (.000)	Atmo-CM
XA 062*	.315 (.001)	.314 (.001)	.311 (.001)	.309 (.001)	.305 (.004)		.312 (.000)	Atmo-CM
DXA 062*	+0.22	+0.32	+0.92	+0.49	-1.40		0.49	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 062*	.327 (.001)	.325 (.001)	.321 (.001)	.320 (.001)	.322 (.001)		.323 (.000)	Atmo-CM
DXC 062*	+1.61	+1.75	+1.69	+1.55	+1.85		1.65	Percent
XD 064	.342 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 062*	.342 (.003)	.340 (.001)	.335 (.001)	.335 (.001)	.336 (.001)		.338 (.001)	Atmo-CM
DXD 062*	-0.10	+0.85	+1.52	+2.25	+2.44		1.11	Percent

Corr. needed to Inst. 062 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	-0.16	-0.31	-1.02	-0.79	-0.49	0.12
To NC ADD	-0.56	-0.77	-1.02	-1.19	-0.78	0.07
To ND ADD	-0.00	-0.19	-0.42	-0.77	-0.20	0.06

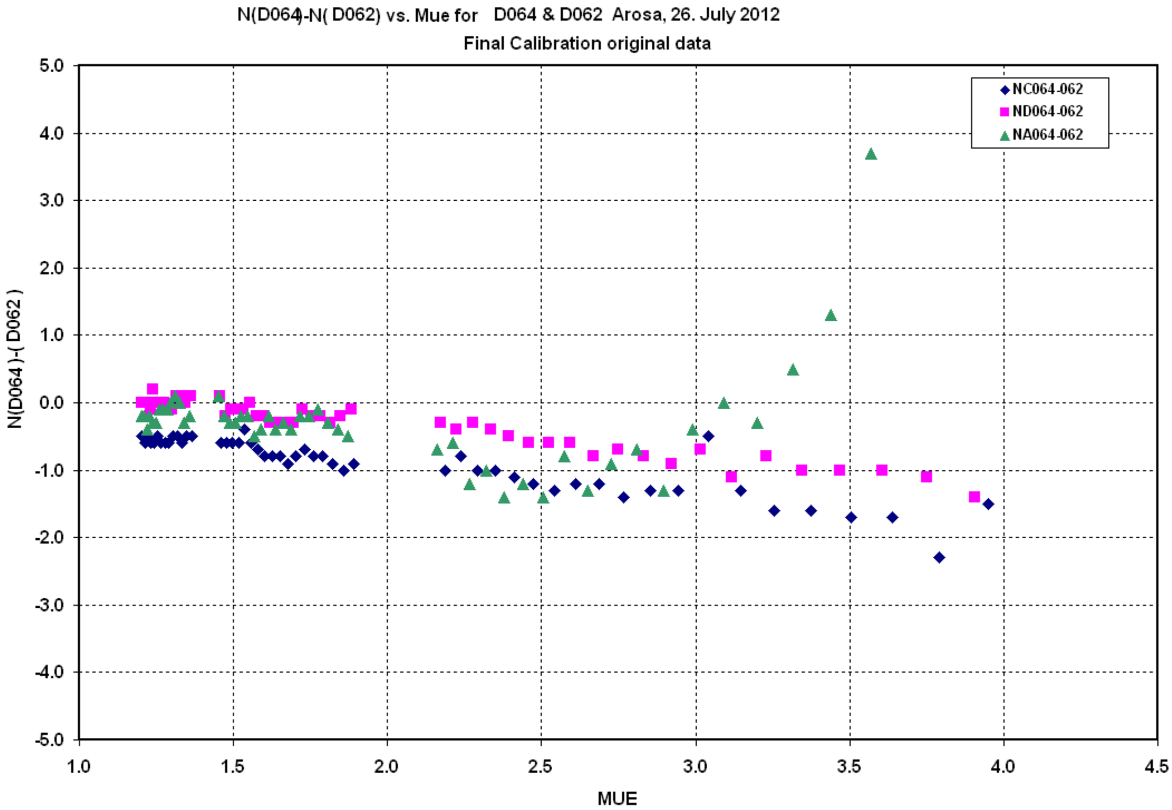
	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	-0.16	-0.11	-0.60	-0.01	-0.29
To NCD ADD	-0.56	-0.57	-0.60	-0.41	-0.58

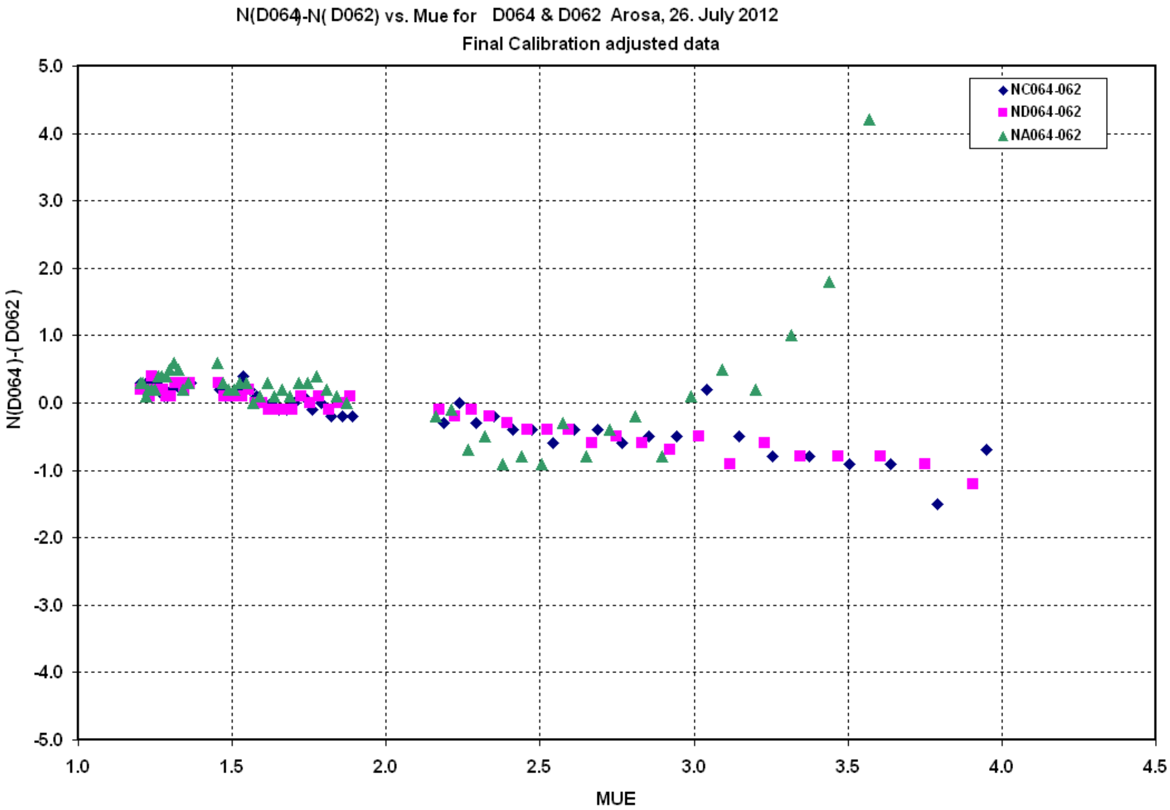
Data Summary using corrected Inst. 062 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD062	.306 (.001)	.305 (.001)	.303 (.000)	.301 (.001)	.295 (.005)		.304 (.000)	Atmo-CM
DXAD062	-0.23	-0.20	+0.28	-0.21	-2.74		-0.09	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.305 (.001)		.305 (.001)	Atmo-CM
XCD062	.306 (.002)	.306 (.001)	.305 (.001)	.303 (.002)	.306 (.002)		.305 (.001)	Atmo-CM
DXCD062	+0.00	+0.04	+0.16	-0.41	+0.16		-0.05	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.311 (.000)	Atmo-CM
XA 062	.313 (.001)	.312 (.001)	.309 (.000)	.308 (.001)	.304 (.004)		.310 (.000)	Atmo-CM
DXA 062	-0.43	-0.23	+0.43	+0.20	-1.73		-0.01	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 062	.320 (.001)	.320 (.001)	.317 (.000)	.317 (.001)	.319 (.001)		.318 (.000)	Atmo-CM
DXC 062	-0.62	+0.04	+0.42	+0.48	+1.00		0.08	Percent
XD 064	.342 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 062	.338 (.003)	.337 (.001)	.332 (.001)	.333 (.001)	.335 (.001)		.335 (.001)	Atmo-CM
DXD 062	-1.32	-0.12	+0.81	+1.60	+1.93		0.22	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

Difference N_A-C-D to Reference Instrument D064
Final Calibration on July 26, 2012





4.4 Final Report: Instrument D101 Switzerland (Arosa)

Dobson Intercomparison 16 - 27 July 2012, Arosa

Original Calibration Data

N-tables from 16. July 2010 based on DSGQP-comparison with D074 on July 16, 2012, Arosa, G-tables from 15.07.2006.
Reference Standard Lamp Values for lamps 101B and 101C. Lamp tests results used in data processing at home station.

Introductory Remarks

Problems with variable offset of the microamperemeter, which causes strongly variable readings in the SL-tests. In addition data with encoder somewhat different and more noisy than manually obtained data. No recommendation for reprocessing possible, as not clear, how the microamperemeter offset effects the regular observations.

Initial Calibration Results (Adjustments based on the results with Standard Lamp tests included.)
18 July 2012 (first and second line: SL-corrections with offset, manual results in brackets, third and fourth line: Sl-corrections without offset, manual results in brackets):

with offset:
d_Na: +0.07 (+0.50) d_Nc: -0.73 (-0.57) d_Nd: -0.89 (-0.80)
d_Nad: +0.96 (+1.30) d_Ncd: +0.16 (+0.23)
without offset:
d_Na: -0.97 (-0.52) d_Nc: -1.34 (-1.18) d_Nd: -1.28 (-1.18)
d_Nad: +0.31 (+0.66) d_Ncd: -0.06 (0.00)

The d_Nad value implies averages between **-1.90% error (manual with offset) and -0.40% (with encoder without offset)** in calculated ozone value, Mu=1.15 to 2.5, Total Ozone = 300 Dobson Units. Recommendations see under **Introductory Remarks**.

Optical, mechanical and electronical work performed

- Electric/Electronics: No work done, new US electronic MOHp modified already installed, operation in automated mode.
- Optical check: Optical parts incl. wedge plates clean, only slight dust.
- Symmetry test: Good results.
- Measurement of slit widths and parallelism with microscope: Not done.
- Shutter motor: *Text.* Speed measured with 860 r.p.m., acceptable.
- PMT vertical position test: Not done, Focus L1: Not done.
- Optics: Q-plates cleaned, as somewhat dusty from removing gaskets.
- Further work: Replacement of gaskets und the small lids.
- Discharge lamp: Not done.
- Wedge calibration: Not done.

Final intercomparison
26. July 2012 with encoder (manual in brackets)

Data of final calibration processed with old R-N-tables**; highest difference against the standard ADDSGQP observations of D064 in mu range 1.15 to 3.2 was -0.54% (-0.54%) in total ozone. CD-agreement good too, only small Mu-dependency in the common Mu-range up to 3.2. New R-N-tables derived from old R-N-tables using the corrections of this final calibration (encoder data).**

Recommendations/Comments

- The results of the initial calibration are partly unsatisfactory with differences in the encoder and manual operation mode, respectively. In addition the encoder data are noisier than the manual data. As the SL-corrections are not clear due to micrometer offsets and the differences to the D064 reference Dobson are not to extreme (around 1%) no re-calculation is recommended.
- New calibration status with new R-N-tables defined based on old R-G/N-tables incl. determination of SL-reference values from corresponding tests (s. table with results). Data with encoder used for new R-N-tables, although noisier than manual data. Regular measurements, however, are done with encoder.
- **Correction of new Q-tables after Komhyr's manual only necessary, when regular HG-tests show permanent higher differences tha +-0.3 degree.**
- Regular test (monthly SL and HG, at least annual Symmetry Test) and cleaning of GQP/Sundirector.

Hohenpeissenberg, 20.12.2012

With Microamperemeter Offset
Without Microamperemeter Offset

Intercomparison Results
Arosa2012 from July 16 to July 27, 2012 at Arosa

Instrument D101
Switzerland (Arosa)

Initial calibration (18.07.2012):

	Date:
G-Tables	15.6.06
N-Tables	16.7.10

Comment:
based on wedge cal. on July 15, 2006 at Arosa2006
based on FC on July 16, 2010 at Arosa2010

Corrections to N-Tables	A	C	D	AD	CD
from SL-Test	0.30	0.30	0.20	0.10	0.10
from Comparison with enc.	-0.97	-1.34	-1.28	0.31	-0.06
from comparison manual	-0.52	-1.18	-1.18	0.66	0.00
Sum with encoder	-0.67	-1.04	-1.08	0.41	0.04
Sum manual	-0.22	-0.88	-0.98	0.76	0.10

Comments: Problems with offset microamperemeter, determination of SL-correction difficult, here correction without offset used; also differences of results with encoder (more noisy) and manual readings.
AD < 1%, but no recommendation to reprocess possible (see other results)

Final Calibration (26.07.2012):

	Date:
G-Tables	15.6.06
N-Table (new)	26.7.12

Comment:
based on wedge cal. on July 15, 2006 at Arosa2006
from old R-N and FC on July 26, 2012 at Arosa

Corrections to old N-tables:	A	C	D	AD	CD
from SL-Test	0.5	0.4	0.4	0.10	0.00
from Comparison	0.03	-0.33	-0.53	0.56	0.20
Sum	0.53	0.07	-0.13	0.66	0.20

Comments: Very good agreement in AD and CD, only small Mu-dependence
New R-N-table derived from old R-N-table, use for future data processing.
Encoder data used

Reference Standard Lamp Data:

Date: 26.7.12

for new R-N-table

Lamp No.	A		C		D	
	R	N	R	N	R	N
101B	51.57	12.72	48.65	18.12	48.70	19.42
101C	51.40	12.53	48.56	18.02	48.52	19.22
01A3	51.47	12.61	48.52	17.98	48.53	19.23
64Q1	51.48	12.62	48.68	18.15	48.73	19.45

Q-Table:

Original Q-table used
Can be used in the future, as instruments remains on station
Correction after Komhyr's manual only necessary, when regular HG-tests show permanent higher differences than +-0.3 degree

IC with encoder D101 vs. D064 on July 18, 2012
old R-N-table, SL-corrections with microamperemeter offset
Mean difference in AD > 1% with Mu-dependence, CD acceptable
no reprocessing recommended, as SL-corrections not confirmed

07-19-2012 12:13:14

Instruments 064 and 101 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add -0.1
To Nc values add -0.1
To Nd values add -0.1

Instrument 101N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add -0.7
To Nc values add -0.3
To Nd values add -0.2

Data Summary using Inst. 101 N tables dated: July-2010   Standard: 064 vs 101   07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101*	.298 (.003)	.298 (.001)	.299 (.002)	.298 (.001)	.297 (.001)		.298 (.001)	Atmo-CM
DXAD101*	-2.36	-1.76	-0.42	-0.63	-0.45		-1.30	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101*	.299 (.008)	.298 (.004)	.299 (.004)	.297 (.003)	.297 (.005)		.299 (.003)	Atmo-CM
DXCD101*	-1.12	-1.05	-0.21	-0.83	-0.67		-0.81	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101*	.308 (.003)	.305 (.001)	.303 (.001)	.302 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
DXA 101*	-0.45	-0.35	+0.33	+0.29	+0.06		-0.05	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101*	.321 (.005)	.314 (.002)	.308 (.002)	.307 (.001)	.304 (.003)		.312 (.001)	Atmo-CM
DXC 101*	+2.37	+1.64	+1.36	+1.20	+0.72		1.65	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101*	.347 (.008)	.332 (.003)	.319 (.004)	.318 (.003)	.313 (.001)		.329 (.002)	Atmo-CM
DXD 101*	+6.40	+4.51	+2.94	+3.66	+2.29		4.41	Percent

Corr. needed to Inst. 101 N Values

Mu=	1.33	1.75	2.25	2.85	(1.15-2.5) Mean	rsd
To NA ADD	0.32	0.32	-0.43	-0.37	0.07	0.21
To NC ADD	-0.78	-0.71	-0.71	-0.86	-0.73	0.19
To ND ADD	-0.99	-0.89	-0.79	-1.17	-0.89	0.15

Mu=	1.33	1.75	2.25	2.85	(1.15-2.5) mean
To NAD ADD	1.31	1.21	0.36	0.80	0.96
To NCD ADD	0.22	0.18	0.07	0.31	0.16

Data Summary using corrected Inst. 101 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101	.303 (.003)	.302 (.002)	.302 (.002)	.300 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
DXAD101	-0.67	-0.36	+0.58	+0.08	+0.22		-0.09	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101	.302 (.008)	.301 (.004)	.301 (.005)	.299 (.003)	.298 (.005)		.300 (.003)	Atmo-CM
DXCD101	-0.20	-0.36	+0.29	-0.42	-0.39		-0.17	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101	.309 (.003)	.305 (.001)	.304 (.001)	.302 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
DXA 101	-0.34	-0.33	+0.41	+0.33	+0.11		0.02	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101	.314 (.004)	.308 (.002)	.304 (.002)	.304 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
DXC 101	+0.18	-0.12	+0.04	+0.21	-0.17		0.08	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101	.328 (.007)	.317 (.002)	.309 (.003)	.310 (.002)	.306 (.002)		.316 (.002)	Atmo-CM
DXD 101	+0.67	-0.10	-0.44	+0.94	+0.11		0.27	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

IC with encoder D101 vs. D064 on July 18, 2012
old R-N-table, SL-corrections without microamperemeter offset
Mean difference in AD < 1% with Mu-dependence, CD good
no reprocessing recommended, as SL-corrections not confirmed

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07-18-2012    17:38:24

Instruments 064 and 101 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add  -0.1
To Nd values add  -0.1


Instrument 101N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add   0.3
To Nc values add   0.3
To Nd values add   0.2
```

Data Summary using Inst. 101 N tables dated: July-2010   Standard: 064 vs 101   07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101*	.302 (.003)	.301 (.001)	.301 (.002)	.299 (.001)	.299 (.001)		.301 (.001)	Atmo-CM
DXAD101*	-1.23	-0.80	+0.25	-0.17	+0.06		-0.49	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101*	.303 (.008)	.301 (.004)	.301 (.004)	.299 (.003)	.299 (.005)		.301 (.003)	Atmo-CM
DXCD101*	+0.20	-0.03	+0.50	-0.33	-0.22		0.08	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101*	.313 (.003)	.308 (.002)	.306 (.001)	.304 (.001)	.303 (.001)		.308 (.001)	Atmo-CM
DXA 101*	+0.97	+0.73	+1.12	+0.95	+0.67		0.94	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101*	.326 (.005)	.318 (.002)	.312 (.002)	.309 (.001)	.306 (.003)		.316 (.001)	Atmo-CM
DXC 101*	+4.20	+3.07	+2.42	+2.02	+1.38		2.94	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101*	.355 (.008)	.338 (.003)	.324 (.004)	.322 (.003)	.316 (.002)		.335 (.002)	Atmo-CM
DXD 101*	+8.82	+6.46	+4.35	+4.88	+3.21		6.17	Percent

Corr. needed to Inst. 101 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	-0.73	-0.70	-1.49	-1.41	-0.97	0.21
To NC ADD	-1.39	-1.31	-1.31	-1.47	-1.34	0.19
To ND ADD	-1.39	-1.27	-1.18	-1.55	-1.28	0.15

	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	0.66	0.57	-0.31	0.14	0.31
To NCD ADD	0.00	-0.03	-0.14	0.08	-0.06

Data Summary using corrected Inst. 101 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101	.303 (.003)	.302 (.002)	.302 (.002)	.300 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
DXAD101	-0.67	-0.36	+0.58	+0.08	+0.22		-0.09	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101	.302 (.008)	.301 (.004)	.301 (.005)	.299 (.003)	.298 (.005)		.301 (.003)	Atmo-CM
DXCD101	-0.12	-0.25	+0.38	-0.42	-0.33		-0.10	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101	.309 (.003)	.305 (.001)	.304 (.001)	.302 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
DXA 101	-0.37	-0.33	+0.41	+0.33	+0.11		0.01	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101	.314 (.004)	.308 (.002)	.304 (.002)	.304 (.001)	.302 (.003)		.308 (.001)	Atmo-CM
DXC 101	+0.20	-0.12	+0.04	+0.21	-0.17		0.08	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101	.328 (.007)	.317 (.002)	.309 (.003)	.310 (.003)	.306 (.002)		.316 (.002)	Atmo-CM
DXD 101	+0.64	-0.10	-0.48	+0.90	+0.00		0.24	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

IC manual D101 vs. D064 on July 18, 2012
old R-N-table, SL-corrections with microamperemeter offset
Mean difference in AD > 1% with Mu-dependence, CD acceptable
no reprocessing recommended, as SL-corrections not confirmed

```
07-19-2012    10:51:16

Instruments 064 and 101 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add  -0.1
To Nd values add  -0.1


Instrument 101N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add  -0.7
To Nc values add  -0.3
To Nd values add  -0.2
```

Data Summary using Inst. 101 N tables dated: July-2010 Standard: 064 vs 101 07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101*	.297 (.002)	.297 (.001)	.297 (.000)	.297 (.001)	.297 (.001)		.297 (.001)	Atmo-CM
DXAD101*	-2.70	-2.09	-1.04	-0.88	-0.67		-1.68	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101*	.299 (.004)	.299 (.003)	.297 (.001)	.297 (.002)	.296 (.004)		.298 (.001)	Atmo-CM
DXCD101*	-1.16	-0.77	-1.00	-1.08	-1.17		-1.00	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101*	.307 (.002)	.304 (.001)	.302 (.000)	.301 (.001)	.300 (.001)		.303 (.001)	Atmo-CM
DXA 101*	-0.92	-0.73	-0.17	-0.21	-0.22		-0.51	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101*	.319 (.004)	.313 (.002)	.306 (.001)	.305 (.002)	.302 (.003)		.311 (.001)	Atmo-CM
DXC 101*	+1.83	+1.50	+0.78	+0.49	+0.11		1.16	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101*	.344 (.008)	.330 (.002)	.319 (.001)	.314 (.002)	.311 (.001)		.327 (.002)	Atmo-CM
DXD 101*	+5.43	+4.02	+2.74	+2.36	+1.47		3.66	Percent

Corr. needed to Inst. 101 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	0.65	0.66	0.19	0.29	0.50	0.12
To NC ADD	-0.63	-0.64	-0.45	-0.35	-0.57	0.10
To ND ADD	-0.85	-0.80	-0.75	-0.76	-0.80	0.08

	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	1.51	1.46	0.94	1.05	1.30
To NCD ADD	0.23	0.16	0.30	0.41	0.23

Data Summary using corrected Inst. 101 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101	.304 (.002)	.302 (.001)	.301 (.001)	.300 (.001)	.300 (.001)		.302 (.001)	Atmo-CM
DXAD101	-0.41	-0.25	+0.25	+0.21	+0.28		-0.05	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101	.303 (.004)	.302 (.003)	.299 (.002)	.299 (.002)	.298 (.004)		.301 (.001)	Atmo-CM
DXCD101	+0.12	+0.25	-0.25	-0.50	-0.56		-0.10	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101	.309 (.003)	.306 (.001)	.303 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
DXA 101	-0.24	-0.22	+0.21	+0.12	-0.06		-0.03	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101	.314 (.003)	.309 (.002)	.304 (.001)	.302 (.002)	.301 (.003)		.307 (.001)	Atmo-CM
DXC 101	+0.20	+0.15	-0.12	-0.37	-0.55		-0.03	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101	.327 (.007)	.317 (.002)	.310 (.001)	.307 (.001)	.305 (.001)		.315 (.002)	Atmo-CM
DXD 101	+0.34	-0.10	-0.24	-0.16	-0.49		-0.04	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

IC manual D101 vs. D064 on July 18, 2012
old R-N-table, SL-corrections without microamperemeter offset
Mean difference in AD < 1% with Mu-dependence, CD good
no reprocessing recommended, as SL-corrections not confirmed

```
07-19-2012    07:29:48

Instruments 064 and 101 Compared
at LKO, Arosa, Switzerland On 07-18-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add  -0.1
To Nd values add  -0.1


Instrument 101N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add   0.3
To Nc values add   0.3
To Nd values add   0.2
```

Data Summary using Inst. 101 N tables dated: July-2010   Standard: 064 vs 101   07-18-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101*	.301 (.002)	.300 (.001)	.299 (.001)	.299 (.001)	.298 (.001)		.300 (.001)	Atmo-CM
DXAD101*	-1.51	-1.13	-0.42	-0.33	-0.28		-0.85	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101*	.303 (.004)	.302 (.004)	.299 (.002)	.299 (.002)	.297 (.005)		.301 (.001)	Atmo-CM
DXCD101*	+0.08	+0.19	-0.29	-0.50	-0.61		-0.13	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101*	.311 (.003)	.307 (.001)	.304 (.000)	.303 (.001)	.301 (.001)		.306 (.001)	Atmo-CM
DXA 101*	+0.48	+0.41	+0.62	+0.50	+0.22		0.50	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101*	.325 (.004)	.318 (.002)	.310 (.001)	.307 (.002)	.305 (.003)		.315 (.001)	Atmo-CM
DXC 101*	+3.70	+2.94	+1.89	+1.40	+0.77		2.49	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101*	.352 (.008)	.337 (.002)	.324 (.001)	.318 (.002)	.314 (.001)		.332 (.002)	Atmo-CM
DXD 101*	+7.85	+6.01	+4.23	+3.54	+2.40		5.45	Percent

Corr. needed to Inst. 101 N Values	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	-0.37	-0.36	-0.85	-0.74	-0.52	0.12
To NC ADD	-1.24	-1.24	-1.05	-0.95	-1.18	0.10
To ND ADD	-1.23	-1.17	-1.15	-1.13	-1.18	0.07

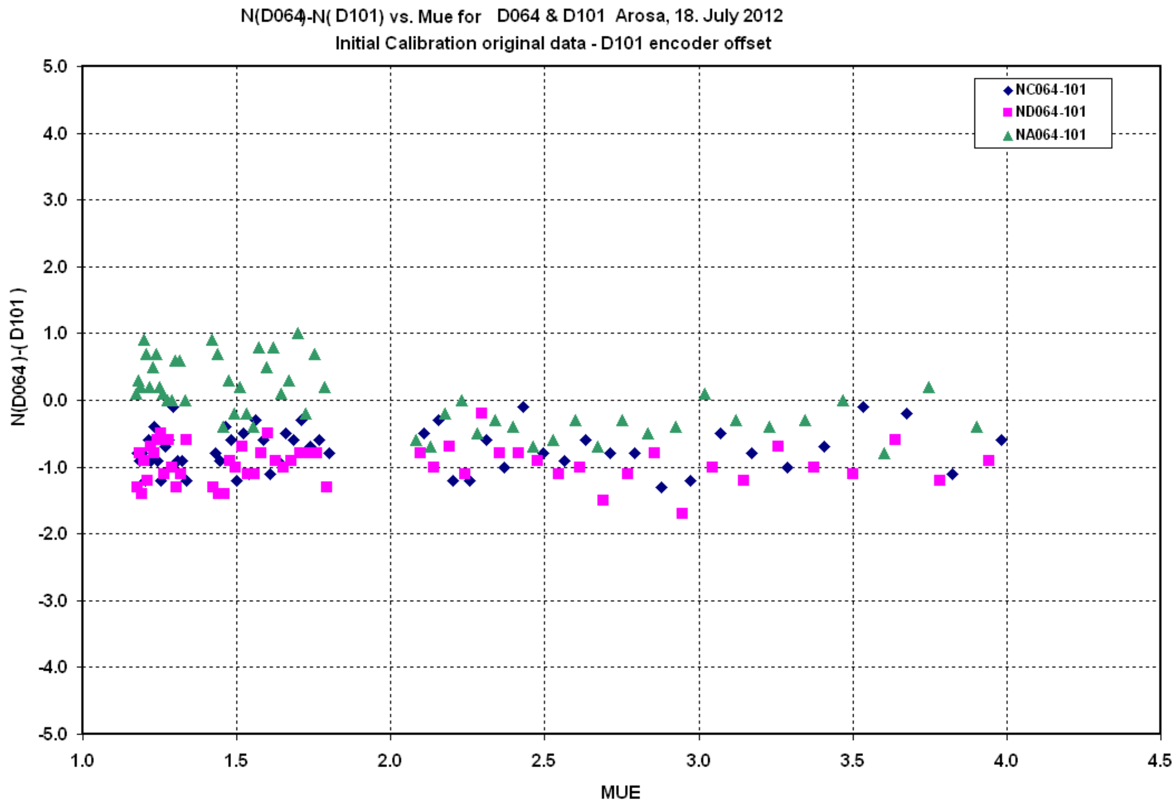
	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	0.87	0.81	0.30	0.39	0.66
To NCD ADD	-0.00	-0.07	0.10	0.18	0.01

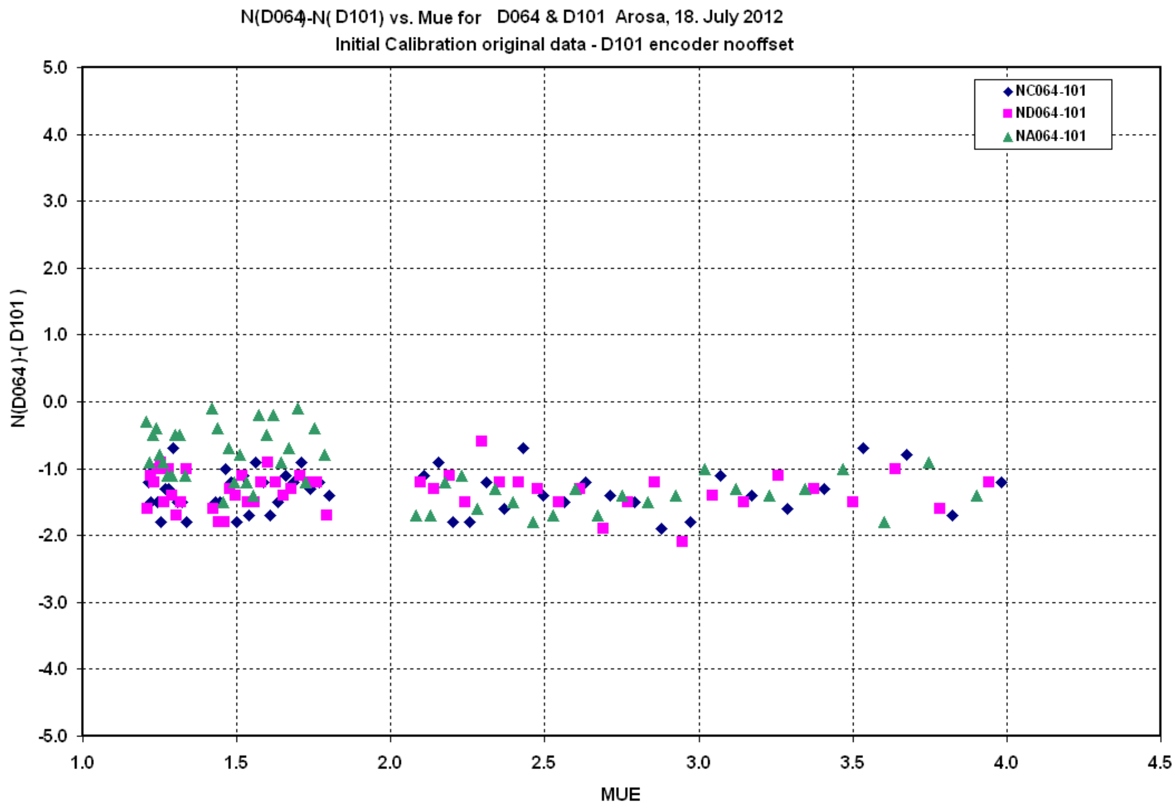
Data Summary using corrected Inst. 101 N tables (using mean)

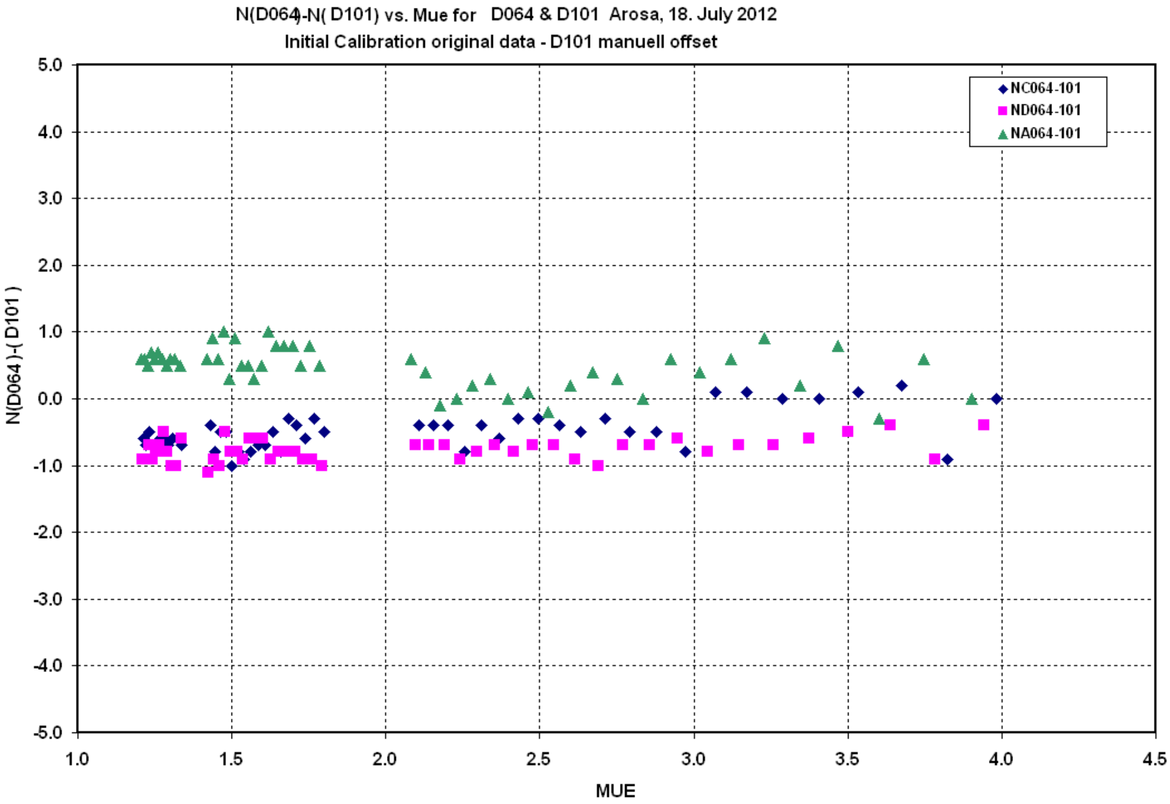
	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.305 (.002)	.303 (.001)	.300 (.001)	.299 (.001)	.299 (.001)		.302 (.001)	Atmo-CM
XAD101	.304 (.002)	.302 (.001)	.301 (.001)	.300 (.001)	.300 (.001)		.302 (.001)	Atmo-CM
DXAD101	-0.39	-0.25	+0.25	+0.21	+0.28		-0.05	Percent
XCD064	.302 (.002)	.302 (.001)	.300 (.001)	.300 (.002)	.299 (.005)		.301 (.001)	Atmo-CM
XCD101	.303 (.004)	.302 (.004)	.299 (.002)	.299 (.002)	.298 (.004)		.301 (.001)	Atmo-CM
DXCD101	+0.20	+0.28	-0.21	-0.50	-0.50		-0.06	Percent
XA 064	.310 (.002)	.306 (.001)	.302 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
XA 101	.309 (.003)	.306 (.001)	.303 (.001)	.301 (.001)	.301 (.001)		.305 (.001)	Atmo-CM
DXA 101	-0.21	-0.22	+0.21	+0.12	-0.06		-0.03	Percent
XC 064	.313 (.003)	.309 (.001)	.304 (.000)	.303 (.001)	.302 (.003)		.307 (.001)	Atmo-CM
XC 101	.314 (.003)	.309 (.002)	.304 (.001)	.302 (.002)	.301 (.003)		.307 (.001)	Atmo-CM
DXC 101	+0.20	+0.17	-0.04	-0.33	-0.55		0.00	Percent
XD 064	.326 (.005)	.317 (.001)	.310 (.001)	.307 (.001)	.306 (.000)		.315 (.001)	Atmo-CM
XD 101	.327 (.007)	.317 (.002)	.310 (.001)	.307 (.001)	.305 (.001)		.315 (.002)	Atmo-CM
DXD 101	+0.34	-0.10	-0.24	-0.16	-0.49		-0.04	Percent

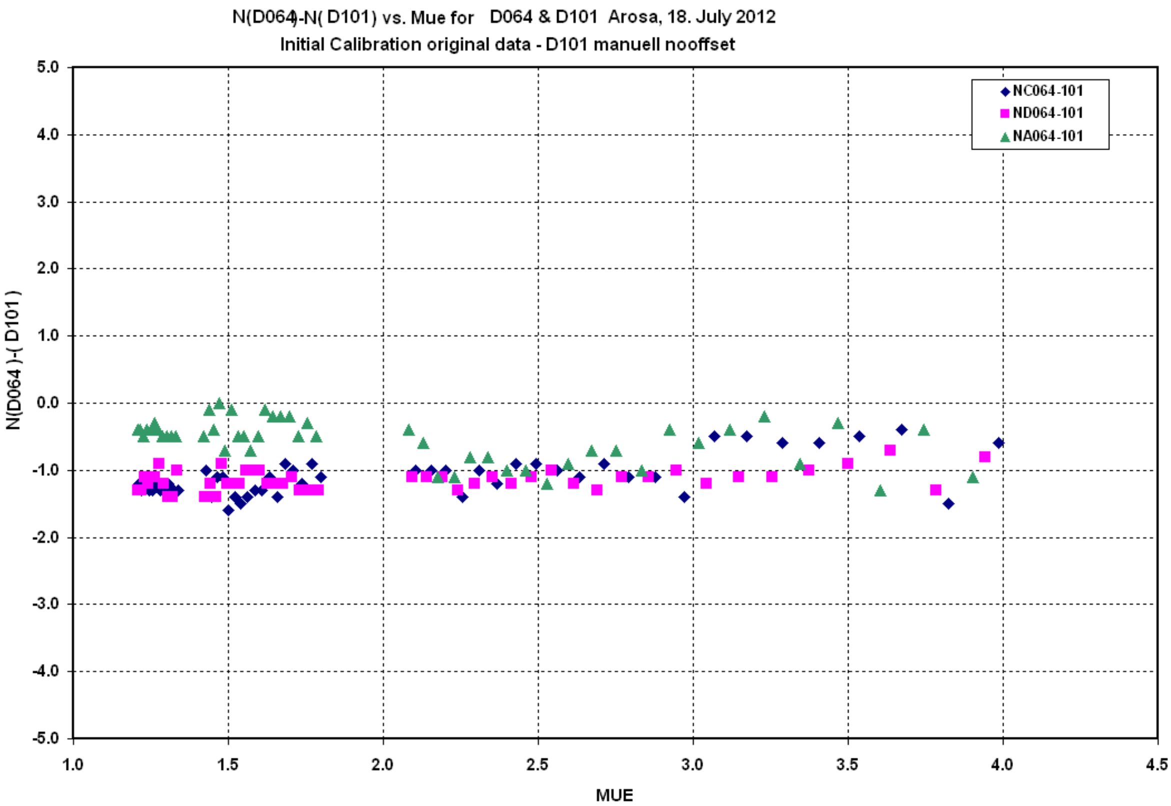
Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

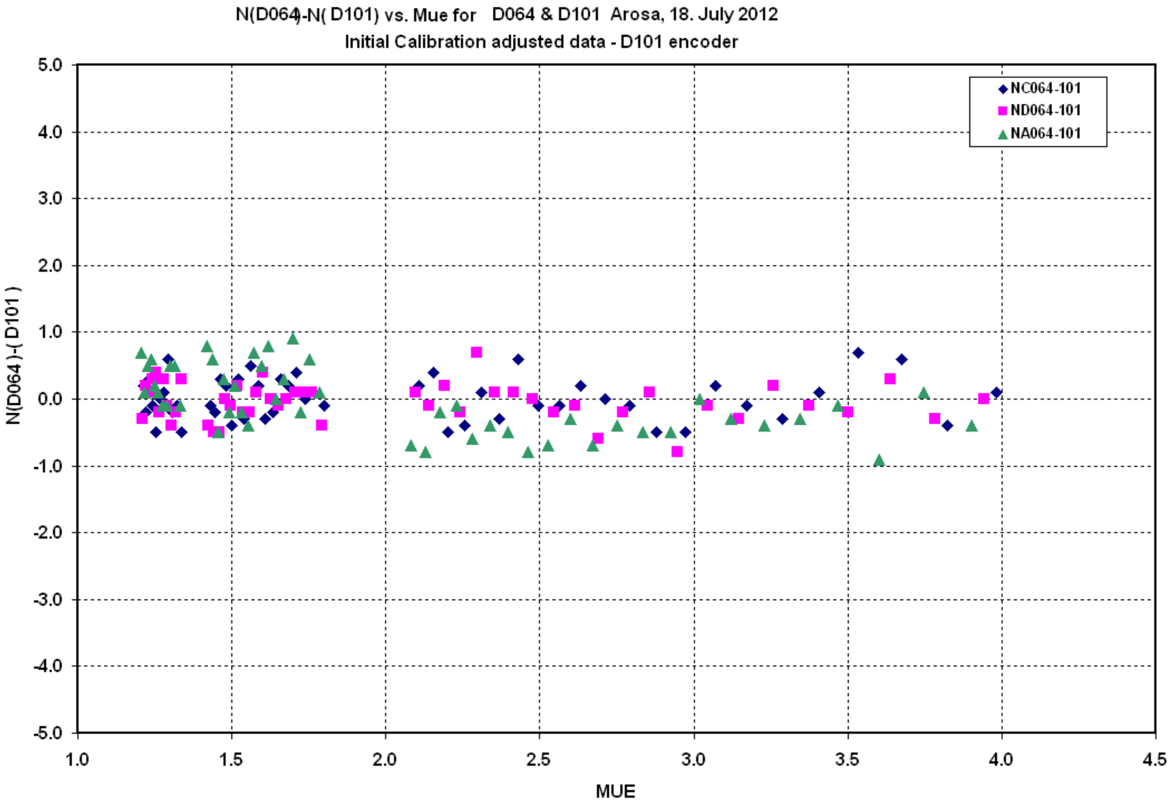
Difference N_A-C-D to Reference Instrument D064
Initial Calibration on July 18, 2012

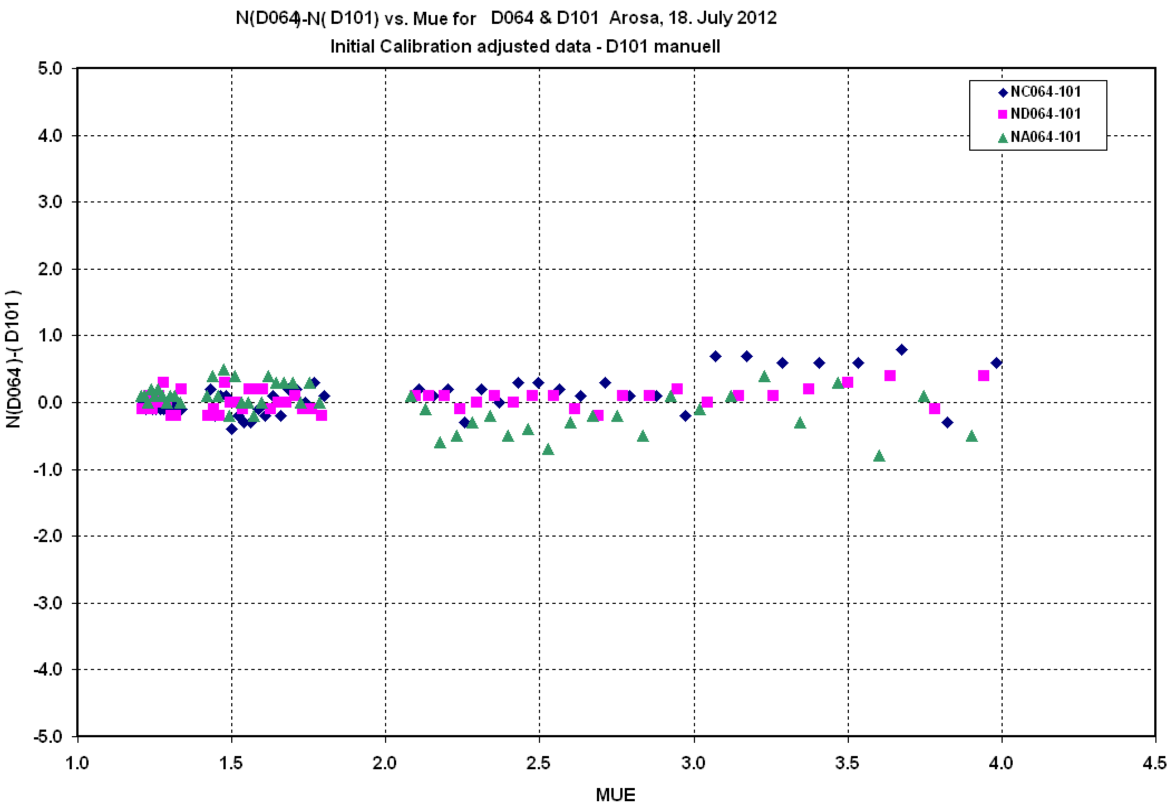





N(D064)-N(D101) vs. Mue for D064 & D101 Arosa, 18. July 2012
Initial Calibration original data - D101 manuell offset
N(D064)-(D101)
MUE
NC064-101
ND064-101
NA064-101


N(D064)-N(D101) vs. Mue for D064 & D101 Arosa, 18. July 2012
Initial Calibration original data - D101 manuell nooffset
N(D064)-(D101)
MUE
NC064-101
ND064-101
NA064-101


N(D064)-N(D101) vs. Mue for D064 & D101 Arosa, 18. July 2012
Initial Calibration adjusted data - D101 encoder
N(D064)-(D101)
MUE
NC064-101
ND064-101
NA064-101
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5


N(D064)-N(D101) vs. Mue for D064 & D101 Arosa, 18. July 2012
Initial Calibration adjusted data - D101 manuell
N(D064)-(D101)
MUE
NC064-101
ND064-101
NA064-101
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

FC with encoder D101 vs. D064 on July 26, 2012
old R-N-table, SL-corrections without microamperemeter offset
Mean difference in AD and CD good with small Mu-dependence
New R-N-tables defined and used for future data processing
although data more noisy than with the manual operation

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07-26-2012    17:00:06

Instruments 064 and 101 Compared
at LKO, Arosa, Switzerland On 07-26-2012
Mark II BK O3 abs. coefficients used.

Instrument 064N Table dated: 22-April-2006
Adjustments based on Standard lamps:
To Na values add  -0.1
To Nc values add   0.0
To Nd values add  -0.1


Instrument 101N Table dated: July-2010
Adjustments based on Standard lamps:
To Na values add   0.5
To Nc values add   0.4
To Nd values add   0.4
```

Reference Standard Lamp Data: for new R-N-table			**Date:**		**26.7.12**	
Lamp No.	**A**		**C**		**D**	
	R	**N**	**R**	**N**	**R**	**N**
101B	**51.57**	**12.72**	**48.65**	**18.12**	**48.70**	**19.42**
101C	**51.40**	**12.53**	**48.56**	**18.02**	**48.52**	**19.22**
01A3	**51.47**	**12.61**	**48.52**	**17.98**	**48.53**	**19.23**
64Q1	**51.48**	**12.62**	**48.68**	**18.15**	**48.73**	**19.45**

Data Summary using Inst. 101 N tables dated: July-2010 Standard: 064 vs 101 07-26-2012

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD101*	.302 (.002)	.303 (.001)	.302 (.002)	.300 (.001)	.300 (.001)		.302 (.001)	Atmo-CM
DXAD101*	-1.49	-0.87	-0.17	-0.46	-1.21		-0.75	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.305 (.001)		.305 (.001)	Atmo-CM
XCD101*	.303 (.004)	.302 (.005)	.304 (.004)	.301 (.005)	.302 (.003)		.302 (.002)	Atmo-CM
DXCD101*	-1.21	-1.16	-0.16	-1.23	-1.15		-0.94	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.310 (.000)	Atmo-CM
XA 101*	.313 (.001)	.312 (.001)	.308 (.001)	.308 (.001)	.307 (.001)		.310 (.001)	Atmo-CM
DXA 101*	-0.36	-0.09	+0.22	+0.12	-0.54		-0.03	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 101*	.325 (.002)	.322 (.002)	.317 (.001)	.316 (.001)	.316 (.001)		.320 (.001)	Atmo-CM
DXC 101*	+0.93	+0.77	+0.53	+0.16	+0.11		0.60	Percent
XD 064	.341 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 101*	.353 (.005)	.346 (.004)	.335 (.004)	.333 (.004)	.334 (.002)		.342 (.002)	Atmo-CM
DXD 101*	+3.42	+2.81	+1.52	+1.79	+1.73		2.40	Percent

Corr. needed to Inst. 101 N Values

	Mu= 1.33	1.75	2.25	2.85	Mean (1.15-2.5)	rsd
To NA ADD	0.29	0.05	-0.27	-0.18	0.03	0.25
To NC ADD	-0.32	-0.33	-0.33	-0.16	-0.33	0.12
To ND ADD	-0.58	-0.59	-0.42	-0.61	-0.53	0.14

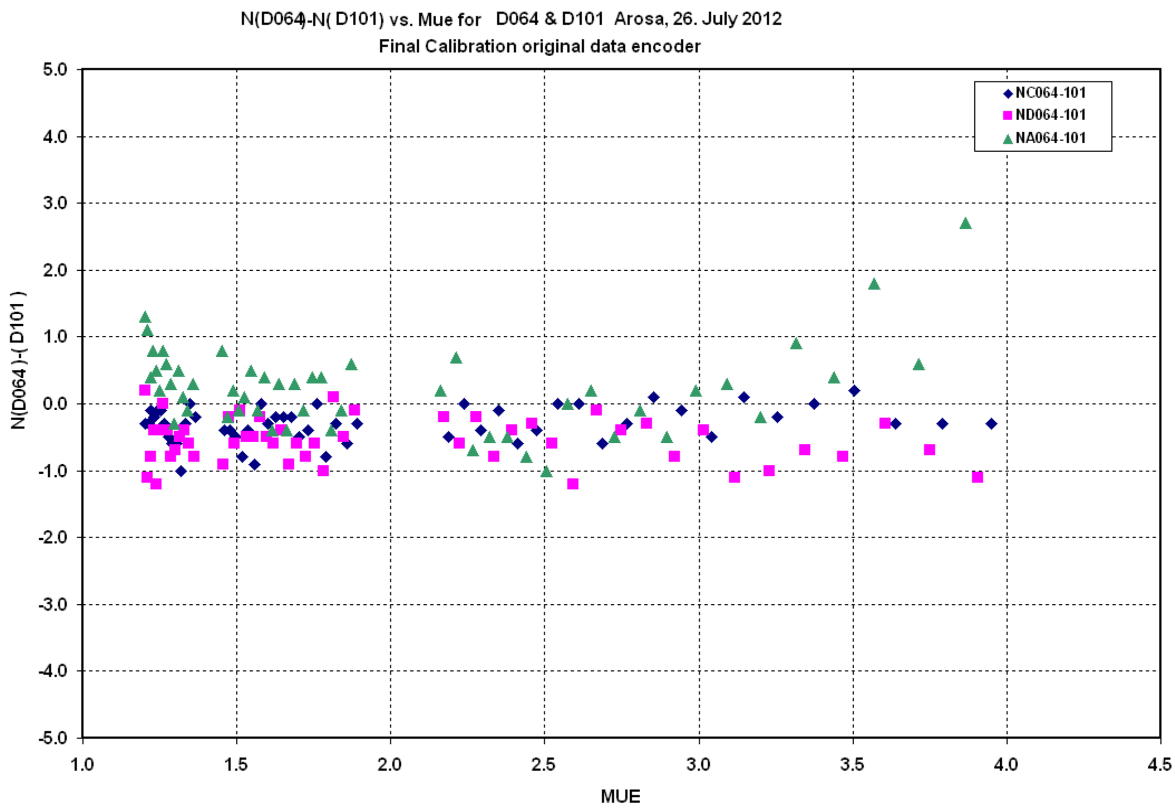
	Mu= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	0.88	0.64	0.15	0.43	0.56
To NCD ADD	0.27	0.26	0.08	0.45	0.20

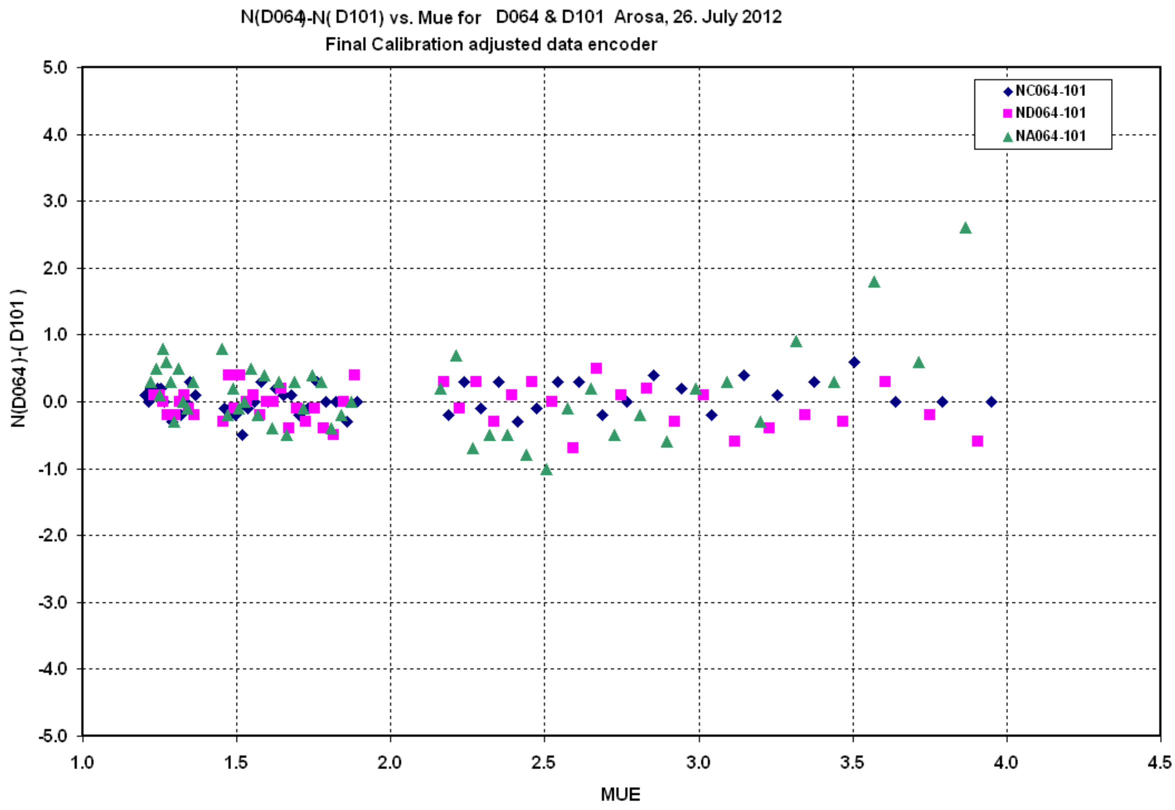
Data Summary using corrected Inst. 101 N tables (using mean)

	1.15<mu<1.5	1.5<mu<2.0	2.0<mu<2.5	2.5<mu<3.2	3.2<mu<4.0	4.0<mu<5.0	1.15<mu<3.2	
XAD064	.307 (.001)	.306 (.001)	.302 (.001)	.302 (.001)	.304 (.001)		.304 (.000)	Atmo-CM
XAD101	.305 (.002)	.306 (.001)	.303 (.001)	.302 (.001)	.301 (.001)		.304 (.001)	Atmo-CM
DXAD101	-0.54	-0.09	+0.44	+0.17	-0.82		-0.01	Percent
XCD064	.306 (.002)	.306 (.001)	.305 (.001)	.305 (.001)	.305 (.001)		.305 (.001)	Atmo-CM
XCD101	.306 (.004)	.305 (.005)	.306 (.004)	.303 (.005)	.303 (.003)		.305 (.002)	Atmo-CM
DXCD101	-0.08	-0.26	+0.38	-0.57	-0.82		-0.13	Percent
XA 064	.314 (.001)	.313 (.001)	.308 (.001)	.307 (.001)	.309 (.001)		.310 (.000)	Atmo-CM
XA 101	.313 (.001)	.312 (.001)	.308 (.001)	.308 (.001)	.307 (.001)		.310 (.001)	Atmo-CM
DXA 101	-0.36	-0.04	+0.22	+0.12	-0.54		-0.02	Percent
XC 064	.322 (.001)	.320 (.001)	.316 (.001)	.315 (.000)	.316 (.001)		.318 (.000)	Atmo-CM
XC 101	.322 (.001)	.320 (.002)	.316 (.001)	.314 (.001)	.315 (.001)		.318 (.001)	Atmo-CM
DXC 101	+0.04	+0.02	+0.00	-0.28	-0.21		-0.05	Percent
XD 064	.341 (.004)	.337 (.001)	.330 (.002)	.328 (.001)	.328 (.001)		.334 (.001)	Atmo-CM
XD 101	.342 (.005)	.338 (.004)	.329 (.004)	.328 (.003)	.330 (.002)		.334 (.002)	Atmo-CM
DXD 101	+0.27	+0.26	-0.30	+0.23	+0.56		0.12	Percent

Values in brackets are Standard Deviations. New II BK O3 ABS COEFF Used.

Difference N_A-C-D to Reference Instrument D064
Final Calibration on July 26, 2012





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100. Report of the Workshop on UV-B for the Americas, Buenos Aires, Argentina, 22-26 August 1994.

101. Report of the WMO Workshop on the Measurement of Atmospheric Optical Depth and Turbidity, Silver Spring, USA, 6-10 December 1993, (edited by Bruce Hicks) (WMO TD No. 659).

102. Report of the Workshop on Precipitation Chemistry Laboratory Techniques, Hradec Kralove, Czech Republic, 17-21 October 1994 (WMO TD No. 658).

103. Report of the Meeting of Experts on the WMO World Data Centres, Toronto, Canada, 17 - 18 February 1995, (prepared by Edward Hare) (WMO TD No. 679).

104. Report of the Fourth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the First Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE, Garmisch-Partenkirchen, Germany, 13 to 17 March 1995 (WMO TD No. 689).

105. Report of the Fourth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Garmisch, Germany, 6-11 March 1995) (WMO TD No. 718).

106. Report of the Global Acid Deposition Assessment (edited by D.M. Whelpdale and M-S. Kaiser) (WMO TD No. 777).

107. Extended Abstracts of Papers Presented at the WMO-IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change (Beijing, China, 9-14 October 1995) (WMO TD No. 710).

108. Report of the Tenth WMO International Comparison of Dobson Spectrophotometers (Arosa, Switzerland, 24 July - 4 August 1995).

109. Report of an Expert Consultation on 85Kr and 222Rn: Measurements, Effects and Applications (Freiburg, Germany, 28-31 March 1995) (WMO TD No. 733).

110. Report of the WMO-NOAA Expert Meeting on GAW Data Acquisition and Archiving (Asheville, NC, USA, 4-8 November 1995) (WMO TD No. 755).

111. Report of the WMO-BMBF Workshop on VOC Establishment of a "World Calibration/Instrument Intercomparison Facility for VOC" to Serve the WMO Global Atmosphere Watch (GAW) Programme (Garmisch-Partenkirchen, Germany, 17-21 December 1995) (WMO TD No. 756).

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* *(A full list is available at http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html)*

118. Report of the International Workshops on Ozone Observation in Asia and the Pacific Region (IWOAP, IWOAP-II), (IWOAP, 27 February-26 March 1996 and IWOAP-II, 20 August-18 September 1996) (WMO TD No. 827).

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120. WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22 to 23 April 1996) (WMO TD No. 894).

121. Report of the Eighth WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques (prepared by Thomas Conway) (Boulder, CO, 6-11 July 1995) (WMO TD No. 821).

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124. Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997) (WMO TD No. 898).

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127. Report of the WMO-WHO Meeting of Experts on Standardization of UV Indices and their Dissemination to the Public (Les Diablerets, Switzerland, 21-25 July 1997) (WMO TD No. 921).

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135. Sixth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Zurich, Switzerland, 8-11 March 1999) (WMO TD No.1002).

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149. Comparison of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions (prepared by J. Staehelin, J. Kerr, R. Evans and K. Vanicek) (WMO TD No. 1147).

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180. Towards a Better Knowledge of Umkehr Measurements: A Detailed Study of Data from Thirteen Dobson Intercomparisons (WMO TD No. 1456), 50 pp, December 2008.

181. Joint Report of COST Action 728 and GURME – Overview of Tools and Methods for Meteorological and Air Pollution Mesoscale Model Evaluation and User Training (WMO TD No. 1457), 121 pp, November 2008.

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183. Operations Handbook – Ozone Observations with a Dobson Spectrophotometer (WMO TD No. 1469), 91 pp, March 2009.

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196. Report of the Second Session of the CAS JSC OPAG-EPAC and GAW 2009 Workshop (Geneva, Switzerland, 5-8 May 2009) (WMO TD No. 1577).

197. Addendum for the Period 2012 – 2015 to the WMO Global Atmosphere Watch (GAW) Strategic Plan 2008 – 2015, 57 pp, May 2011.

198. Data Quality Objectives (DQO) for Solar Ultraviolet Radiation Measurements (Part I). Addendum to WMO/GAW Report No. 146 - Quality Assurance in Monitoring Solar Ultraviolet Radiation: State of the Art (*electronic version only*).

199. Second Tropospheric Ozone Workshop. Tropospheric Ozone Changes: observations, state of understanding and model performances (Météo France, Toulouse, France, 11-14 April 2011), 226 pp, September 2011.

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202. Workshop on Modelling and Observing the Impacts of Dust Transport/Deposition on Marine Productivity (Sliema, Malta, 7-9 March 2011), 50 pp, November 2011.

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204. Standard Operating Procedures (SOPs) for Air Sampling in Stainless Steel Canisters for Non-Methane Hydrocarbons Analysis (Prepared by Rainer Steinbrecher and Elisabeth Weiß), 25 pp. September 2012.

205. WMO/IGAC Impacts of Megacities on Air Pollution and Climate, 309 pp. September 2012 (ISBN: 978-0-9882867-0-2).

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209. Guidelines for Continuous Measurements of Ozone in the Troposphere (Prepared by Ian E. Galbally and Martin G. Schultz), 80 pp, February 2013 (WMO-No. 1110, ISBN: 978-92-63-11110-4)

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212. Standard Operating Procedures (SOPs) for Spectral Instruments Measuring Spectral Solar Ultraviolet Irradiance, 21 pp. June 2014

213. 17th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques (GGMT-2013), (Beijing, China, 10 - 13 June 2013), 168 pp. July 2014

214. Report of the GAW 2013 Symposium and the Fourth Session of the CAS JSC OPAG-EPAC, Geneva, Switzerland, 18-20 March 2013, 82 pp, October 2014.

215. Report of the First Session of the CAS Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee (EPAC SSC), (Geneva, Switzerland, 10-12 June 2014), 32 pp. December 2014.