FIRST IBERO-AMERICAN BREWER INTERCOMPARISON CAMPAIGN

Santa Maria 2024

REGIONAL BREWER CALIBRATION CENTER EUROPE RBCCE

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Issue	Date	Page	Observations
1	7th August 2024	All	First Draft.

1 Introduction

The First Ibero-American Brewer Ozone Spectrophotometers Intercomparison Campaign has been organ- ized by the Regional Brewer Calibration Center for Europe (RBCC-E) in collaboration with the Federal University of Santa Maria (UFSM) in Brazil, with support from the Global Atmospheric Watch (GAW) program of the World Meteorological Organization (WMO). In this campaign 27 experts and operators with 9 Brewer spectrophotometers from Argentina, Bolivia, Brazil, Chile, and Ecuador have participated. The instruments have been serviced and calibrated using the global reference provided by the RBCC-E. This reference is shared with the Toronto Centre, managed by Environment and Climate Change Canada (ECCC), which will also participate remotely in the campaign.

The following operations were performed by the RBCC-E during the intercomparison:

1. Ozone calibration against the RBCC-E travelling reference (B#256).
2. Compilation of the calibration histories of the instruments.
3. Evaluation of the Level 2 Eubrewnet ozone data for the period between intercomparisons.

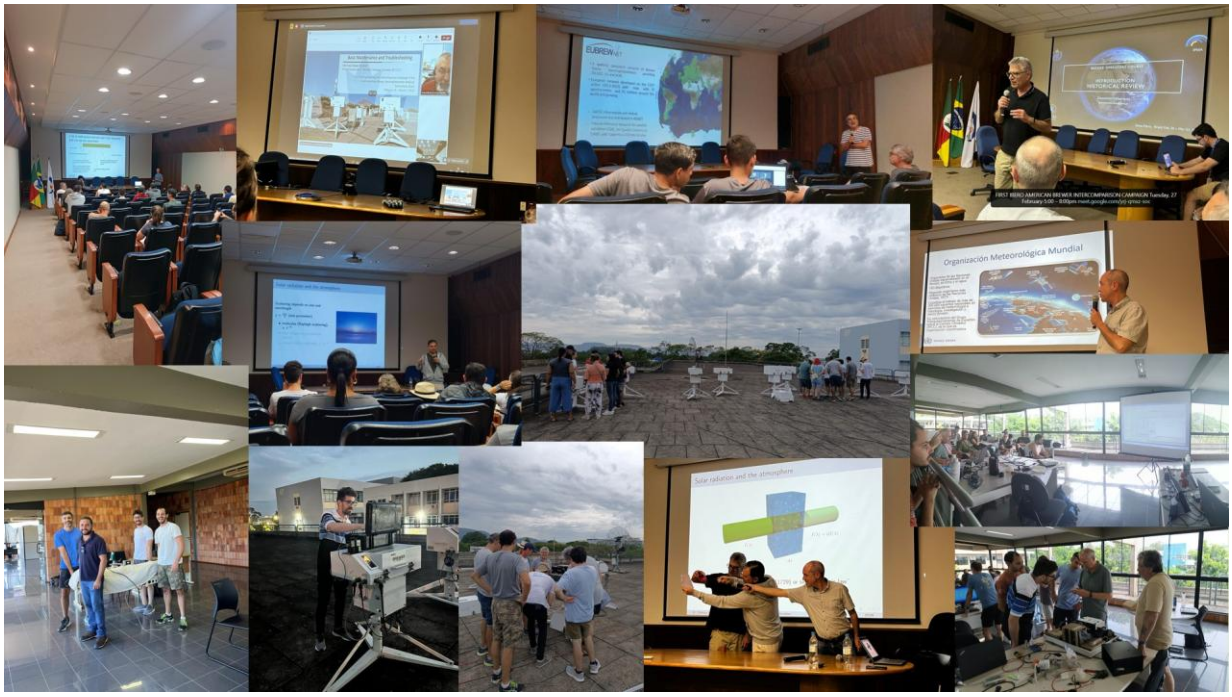


Figure 1-1 – Some moments during the First Ibero-American Brewer Intercomparison Campaign.

During this intercomparison, the RBCC-E transferred its own absolute ozone calibration, obtained by the Langley method at the Izaña Observatory (IZO). A discussion about the calibration of the reference instrument (B#256) is presented in Sec.3. All the participating instruments were provided with a provisional calibration at the end of the campaign, which can be considered final calibration constants for most of them. A detailed calibration report for each instrument is available online. A calibration history

of the Brewers which have participated in previous campaigns was also included in this document. A participant's list is presented in Table 1-1.

The results of the blind comparison with the reference instrument Brewer #258 can be seen in Fig. 2-6. Brewers #068, #073 and #081 have not been included in the analysis of the blind days as ther were serviced at the beginning of the campaign and are therefore considered as new instruments. Four instruments show an agreement better than 1%. A good agreement with the reference instrument Brewer #256 using the final calibration constants, within the range ±0.5%, is achieved for most instruments (see Fig. 2-9).

Table 1-1 – Participant List at Santa Maria 2024 campaign.

INSTITUTION	IP	BREWER	COUNTRY
UMSA	M.F. Andrade	056	Bolivia
UFSM	J.V. Bageston	068	Brazil
INPE	F. Raimundo	073	Brazil
INPE	M. Paulete	081	Brazil
IAA	N. Tintes	162	Argentina
UFSM	D. Kirsch	167	Brazil
UMAG	C. Casiccia	180	Chile
INAMHI	C.D. Tonato	218	Ecuador
CITEDEF	P. Facundo	229	Argentina
RBCC-E / AEMET	A. Redondas	256	Spain

2 Summary

2.1 Campaign conditions and schedule

The weather during the campaign at Santa Maria (139 m.a.s.l.) was partly cloudy, especially after the maintenance of the instruments, which reduced the number of measurements available for the final calibration. Due to these conditions, it has not been possible to reach the recommended number of 100 near-simultaneous direct sun ozone measurements with the reference instrument Brewer #256 during blind days for three of the instruments: #180, #218 and #229 (Fig. 2-1). In addition, Brewers #068, #073 and #081 were serviced on its arrival, and there are thus no blind days for these instruments. The recommended number of near-simultaneous direct sun ozone measurements could neither be reached for Brewers #180 and #229 during the final days.

As shown in Fig. 2-2, total ozone content during the campaign ranged between 245 and 270 DU. Most observations (≈ 70%) were within the 350-600 DU ozone slant column (OSC) range, see Fig. 2-3. The internal temperature was approx. 35±10°C, see Fig. 2-4.

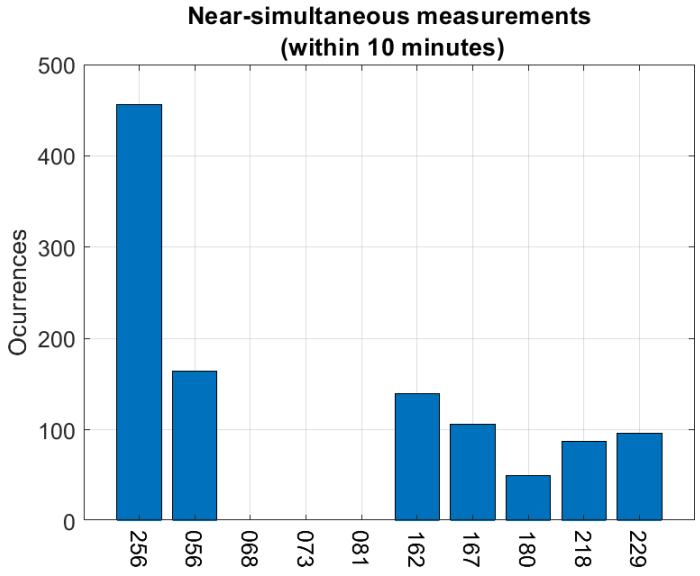


Figure 2-1 – Number of near-simultaneous ozone measurements.

The actions carried out each day of the campaign are shown in Table 2-1. The first day is dedicated to the installation of the instrument. The next days are for blind comparison and for maintenace for those instruments that need to be served. The maintenance carried out on each instrument is summarised in Section 13 and can be accessed online on the maintenance sheet.

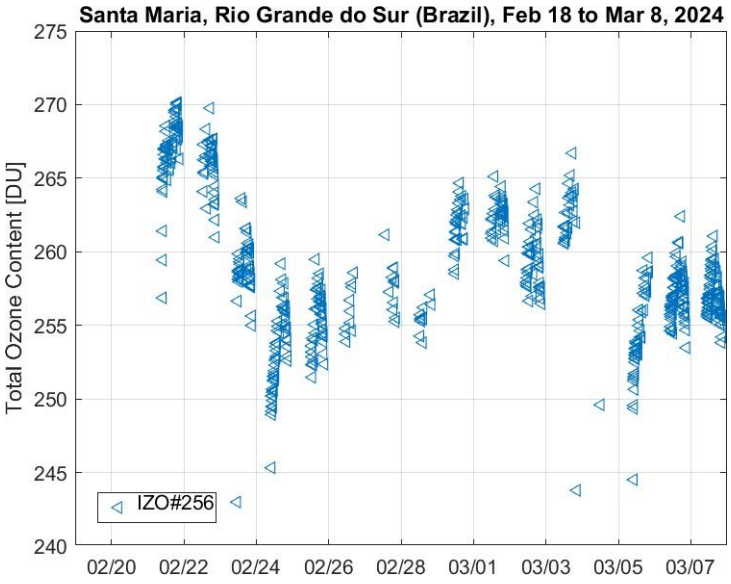


Figure 2-2 – Total ozone for the campaign.

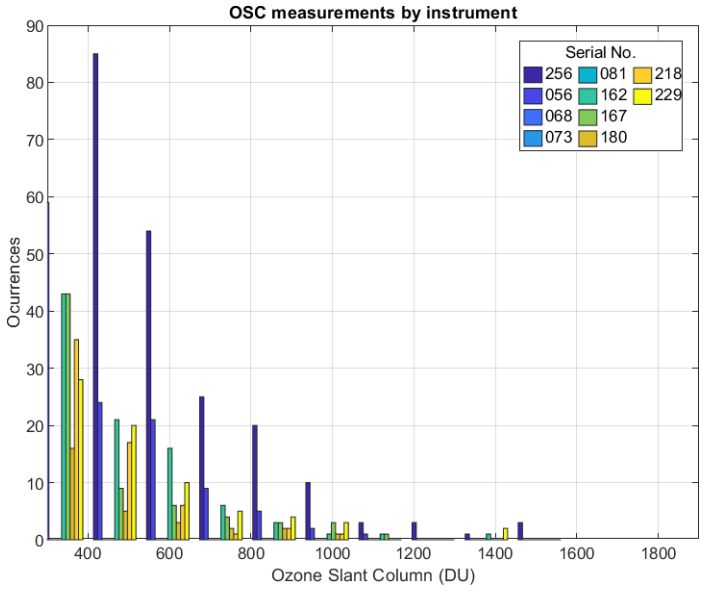


Figure 2-3 – Frequency distribution of ozone slant column ranges.

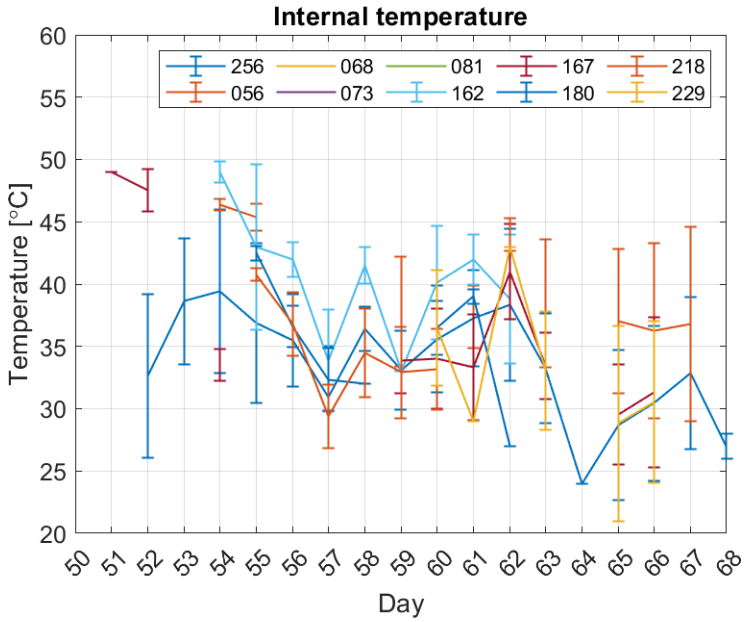


Figure 2-4 – Internal temperature of participating Brewer instruments.

Table 2-1 – Santa Maria 2024 campaign schedule.

DAY	ACTION
Mon Feb. 19th (050)	Installation
Tue Feb. 20th (051)	Blind day & Maintenance
Wed Feb. 21st (052)	Blind day & Maintenance
Thu Feb. 22nd (053)	Blind day & Maintenance
Fri Feb. 23th (054)	Blind day & Maintenance
Sat Feb. 24th (055)	Blind day & Maintenance
Sun Feb. 25th (056)	Blind day & Maintenance
Mon Feb. 26th (057)	Blind day & Maintenance
Tue Feb. 27th (058)	Blind day & Maintenance
Wed Feb. 28st (059)	Blind day & Maintenance
Thu Feb. 29th (060)	Blind day & Maintenance
Fri Mar. 1st (061)	Blind day & Maintenance
Sat Mar. 2nd (062)	Ozone final calibration
Sun Mar. 3rd (063)	Ozone final calibration
Mon Mar. 4th (064)	Ozone final calibration
Tue Mar. 5th (065)	Ozone final calibration
Wed Mar. 6th (066)	Ozone final calibration
Thu Mar. 7th (067)	Ozone final calibration
Fri Mar. 8st (068)	Ozone final calibration & Packing

2.2 Blind Comparison

During the blind period, the instruments are working with their home calibration and the ozone is calculated using these calibration constants. An initial comparison with the reference Brewer 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). Moreover, it is possible to detect changes of the instrument response due to the travel from internal tests, such as the Standard Lamp one, performed before and after the travel.

The Standard Lamp (SL) test is an ozone measurement using the internal halogen lamp as a source. In the local station, this test is performed routinely to track the spectral response of the instrument and therefore the ozone calibration. A reference value for the SL R6 ratio is provided as part of the calibration of the instrument. The ozone measurement is routinely corrected assuming that deviations of the R6 value from the reference value are the same that changes 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 were the case, then the ETC constant should be corrected by the same change in SL R6 ratio as $ETCnew = ETCold - (SLref - SLmeasured)$.

Figure 2-5 and Table 2-2 show the difference between the calculated and reference R6 values, and as it can be observed, most of the Brewers presented changes far greater than 10 units, except for Brewer #218.

The blind comparison with the reference instrument Brewer #256, Fig. 2-6 shows that, after SL correction, four Brewers (#056, #162, #167 and #218) have a mean difference of less than 1.0%.

Table 2-2 – Standard Lamp record during blind days with comparison with the reference value, mean total ozone deviation with the reference for the blind days without and with correction (SLC), the last column shows the Standard Lamp correction improves the comparison with the reference.

	brw	SL_blind_Reference	mean_SL	difference	std
LPZ#056	56	1690	1704	-14	5
CFR#068	68	1570	NaN	NaN	NaN
NAT#073	73	2000	NaN	NaN	NaN
SJC#081	81	1584	NaN	NaN	NaN
SMA#162	162	2073	2150	-77	5
STM#167	167	200	322	-122	2
PUQ#180	180	297	144	153	8
QTO#218	218	420	424	-4	4
RGA#229	229	355	402	-47	8
IZO#256	256	433	443	-10	1

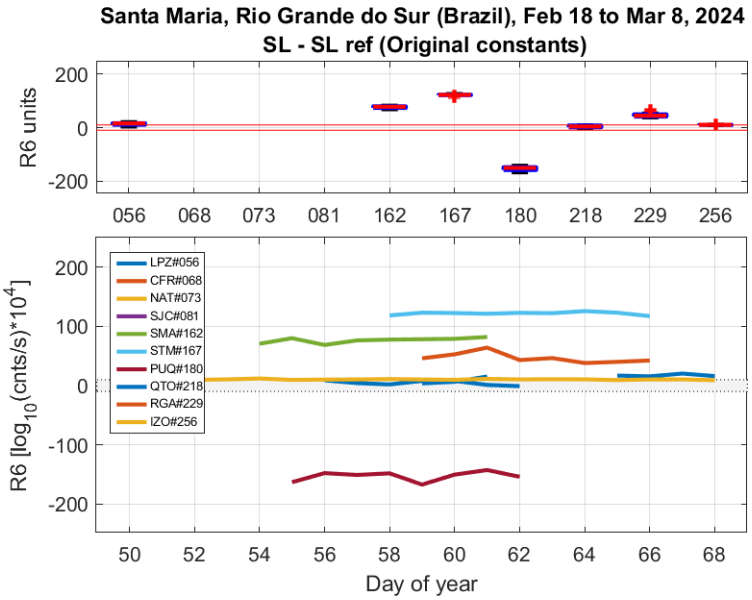


Figure 2-5 – Standard lamp R6 difference to R6 reference value from last calibration during the blind days, before the maintenance. Variations within the ±10 range (≈ 1% in ozone) are considered normal, whereas larger changes would require further analysis of the instrument performance.

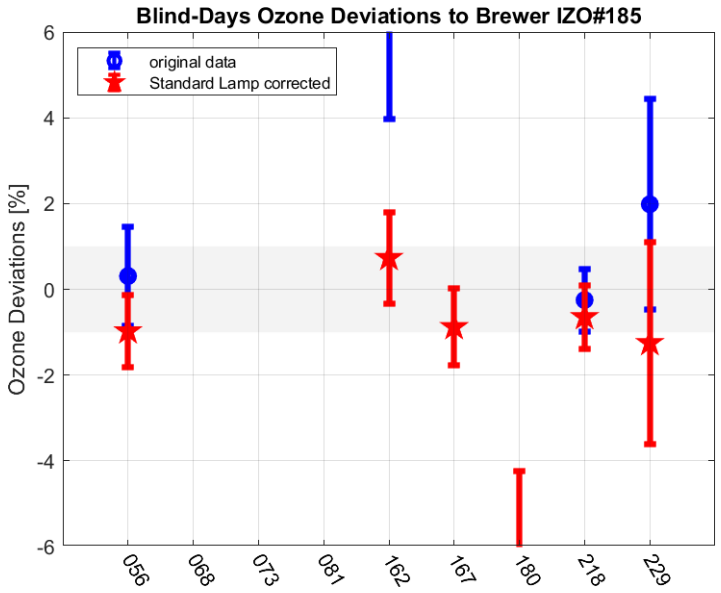


Figure 2-6 – Ozone relative percentage differences of all Santa Maria 2024 participating instruments to RBCC-E travelling standard IZO#256. Ozone measurements collected during the blind period are reprocessed using the original calibration constants, with (red) and without (blue) Standard Lamp correction. Error bars represent the standard deviation.

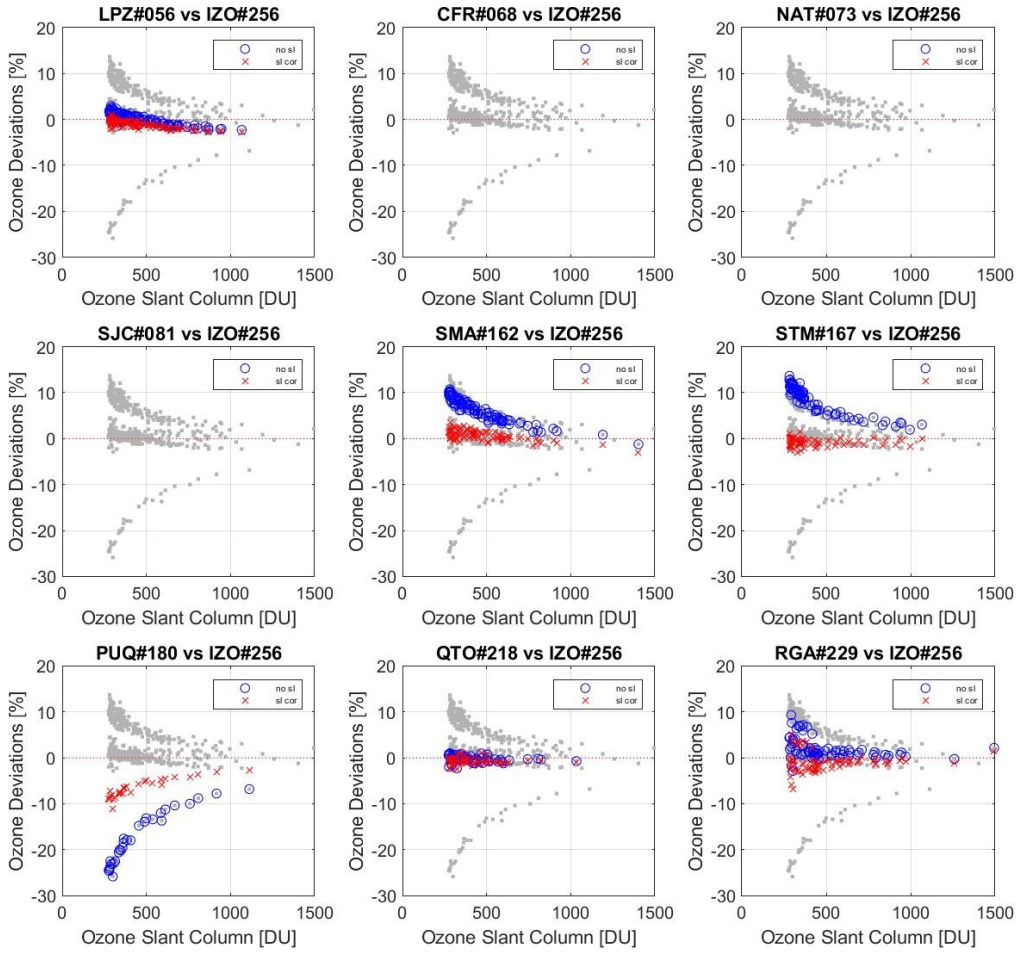


Figure 2-7 – Blind-days ozone relative differences (percentage) of all Santa Maria 2024 Brewer instruments with respect to the RBCC-E travelling standard Brewer #256. Ozone measurements collected during the blind period (before the maintenance) were reprocessed using the original calibration constants, with (red stars) and without (blue stars) standard lamp correction. Grey dots mean ozone deviations for all participating instruments.

2.3 Final Calibration

We define the final days as those available after the maintenance work has been finished for each participating instrument. These days are used to calculate the final calibration constants, so we tried not to manipulate the instruments during this period. Furthermore, the SL R6 value recorded during the final days is normally adopted as the new reference value. It is also expected that this parameter will not vary more than 5 units during this period.

Figure 2-8 shows 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 #229 which had slightly larger variations of this parameter.

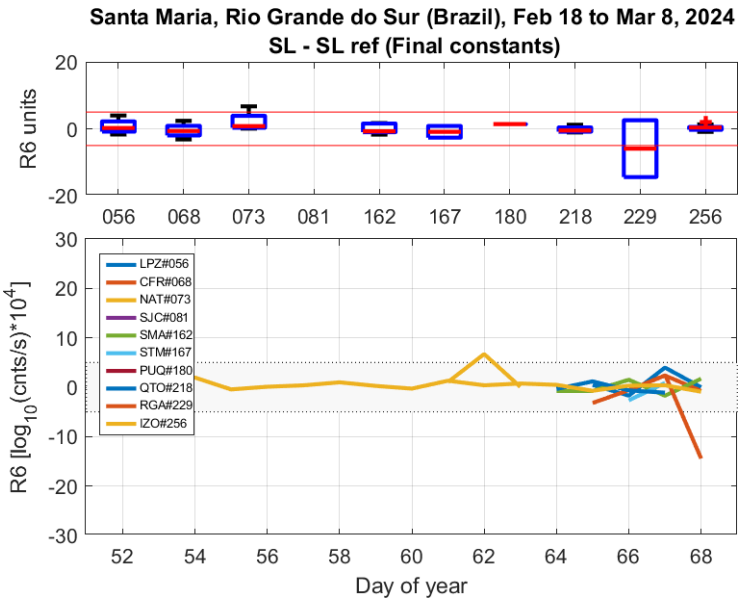


Figure 2-8 – Standard lamp R6 ratio to R6 reference from last calibration differences during the final days grouped by Brewer serial number (above) and as a function of time (below). The shadow area represents the tolerance range (±5 R6 units).

Deviations of ozone values for all the participating instruments from the RBCC-E travelling standard Brewer IZO#256 are shown in Fig. 2-9. We have recalculated the ozone measurements using the final calibration constants, with and without Stray Light correction in the case of single Brewer instruments. The ozone underestimation due to the effect of the Stray Light in single Brewers (Fig. 2-10). To correct for this effect, iterative Eq. 1 is used, where X_i stands for ozone in each iteration. Details of these corrections can be found in Redondas et al. [2018].

$$X_{i+1} = X_i + \frac{k(X_i\mu)^s}{a\mu} \tag{1}$$

All Brewers were calibrated using the One Parameter ETC transfer method, i.e., the ozone absorption coefficient was derived from the wavelength calibration (dispersion test) and only the ozone ETC constant

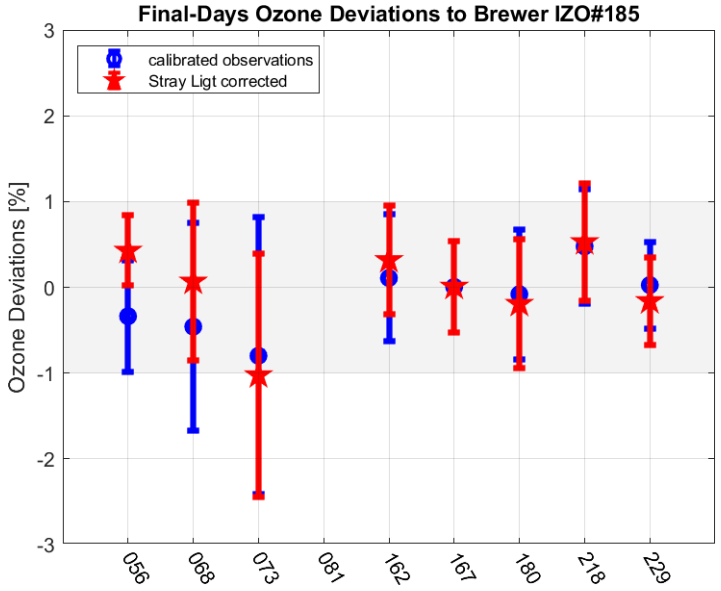


Figure 2-9 – Ozone relative percentage differences of all Santa Maria 2024 participating instruments with respect to the RBCC-E travelling standard IZO#256. Ozone measurements collected during the final period are reprocessed using the proposed calibration constants, with (red plots) and without (blue plots) Stray Light correction. Error bars represent the standard deviation.

is transferred from the reference instrument. The two parameters calibration method, where both the ozone absorption coefficient and the ETC are calculated from the reference, is also used as a quality indicator. But the difference between these ETC transfer methods is below the ±10 units limit only for two Brewers, #180 and #218.

In Table 2-3 we summarize the mean differences, with and without applying the Stray Light correction, respect to the reference instrument. The ozone was calculated using the final calibration of the instrument. Finally, in Fig. 2-11 we show the individual differences, with and without applying the Stray Light correction, with respect to the reference instrument.

Table 2-3 – Ozone deviation with respect to the reference calculated with the final calibration.

	mean (no stray-l corr.)	std (no stray-l corr.)	mean (stray-l corr.)	std (stray-l corr.)
LPZ#056	-0.6	0.7	0.4	0.4
CFR#068	-0.8	1.4	-0.1	0.9
NAT#073	-1.2	1.7	-1	1.3
SJC#081	NaN	NaN	NaN	NaN
SMA#162	0	0.7	0.3	0.6

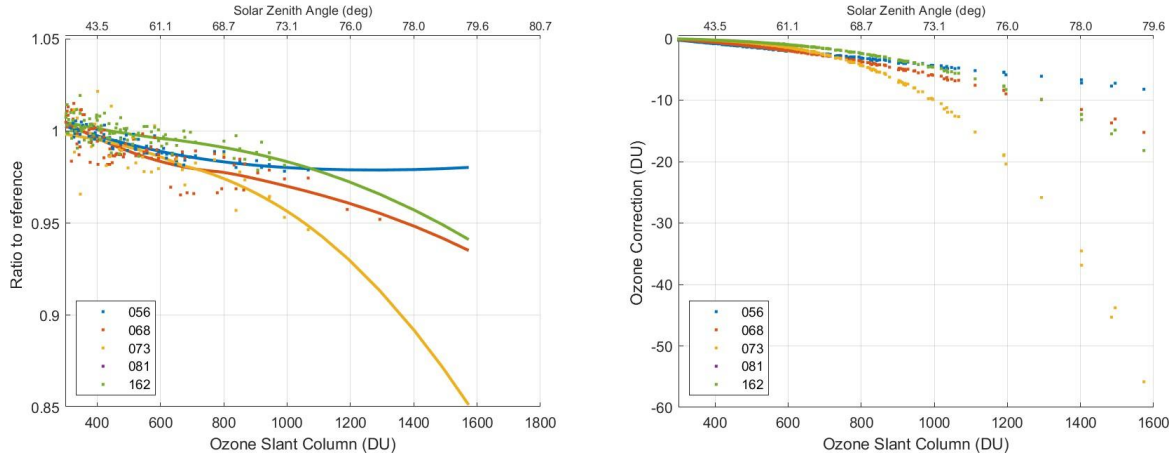


Figure 2-10 – Ozone relative percentage differences of the single Brewers at Santa Maria 2024 with respect to RBCC-E travelling standard IZO#256, showing the underestimation of the Ozone measurements for solar Zenith angle above 70° (left) and the correction applied by the model in Dobson Units (right).

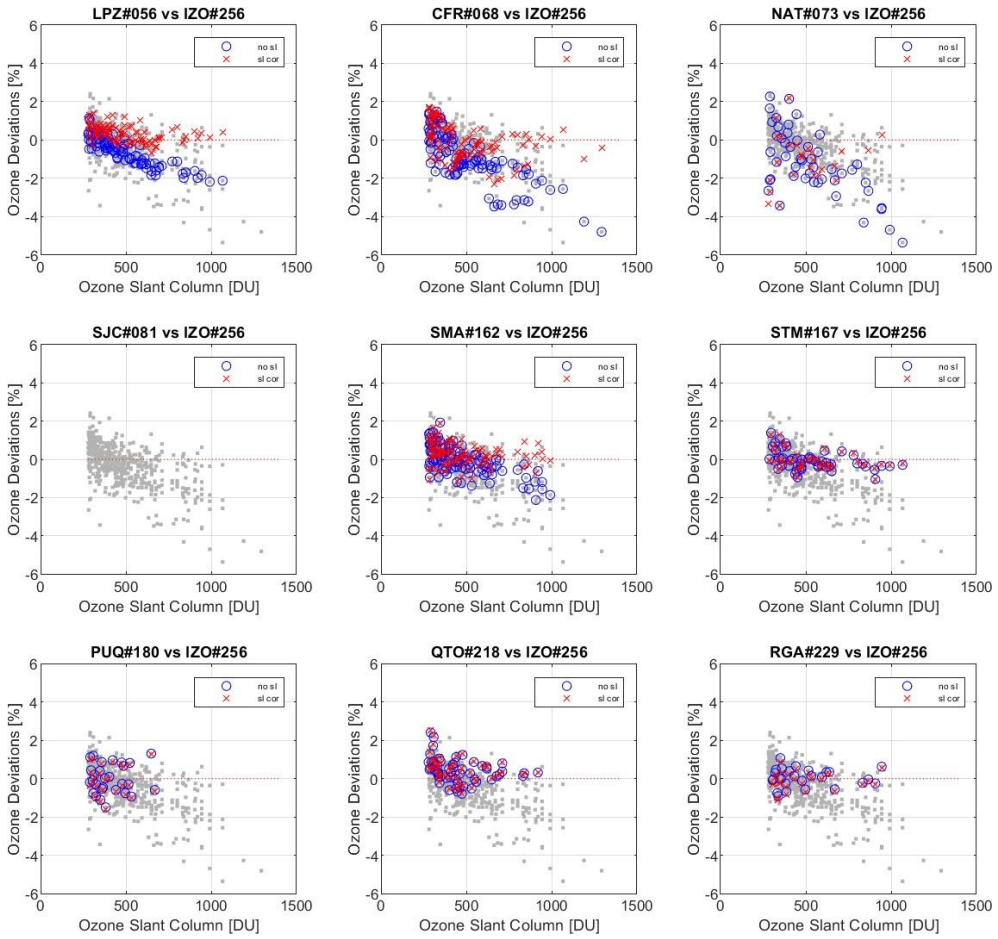


Figure 2-11 – Final-days ozone relative differences (percentage) of all Brewer instruments at Santa Maria 2024 with respect to the RBCC-E travelling standard Brewer #256. Ozone measurements collected during the final period (after the maintenance) were reprocessed using the final calibration constants, with (red stars) and without (blue stars) Stray Light correction. Grey dots mean ozone deviations for all participating instruments.

References

Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018. ISSN 1680-7316. doi: https://doi.org/10.5194/acp-18-9441-2018. URL https://www.atmos-chem-phys.net/18/9441/2018/acp-18-9441-2018.html.

3 RBCC-E Brewer Reference

The RBCC-E was established at the Izaña Atmospheric Research Centre in 2003. It comprises three MkIII Brewer spectrophotometers: a Regional Primary Reference (Brewer #157), a Regional Secondary Reference (Brewer #183) and a Regional Travelling Standard (Brewer #185). The WMO scientific advisory group (WMO-SAG) on Ozone authorised in 2011 the RBCC-E to transfer its own ozone absolute calibration. Most recently, in 2021, AEMET procured three new brewers (#256, #257 and #258) as a new triad for the RBCC-E.

The IZO-CCL (Central Calibration Laboratory) reference transferred to the campaigns is the mean of the three independently calibrated Brewer instruments. This methodology can be summarised in three steps:

1. Instrumental characterisation : Determination of linearity [Fountoulakis et al., 2016], temperature coefficients [Berjón et al., 2018], and filter attenuation [Redondas et al., 2018c].
2. The Absorption coefficient is determined by measurements of the spectral lamp emission lines using the methodology of Gröbner et al. [1998] and Redondas et al. [2018b].
3. The ETC is onsite determined by Langley Method [León-Luis et al., 2018, Redondas, 2003, Ito et al., 2014, Redondas et al., 2014].

The points 1 and 2 of this methodology were tested and validated with the cooperation of Metrology Institutes during the ATMOZ project [Gröbner et al., 2017], in which the RBCC-E participated together with the Dobson World and Brewer European Calibration Centres. Finally, the methodology used to calculate the ETC is described in Redondas [2003], Redondas et al. [2018c], and Ito et al. [2014]. The current status and maintenance of the RBCC-E is discussed in León-Luis et al. [2018].

Regarding the IZO CCL is worth to highlight that:

- The instruments are calibrated independently. The Langley calibration is performed continuously onsite.
- The methodology, code and data used on the calibration are publicly available on the web, so are reproducible. This includes the QA/QC protocol (http://rbcce.aemet.es/svn/iberonesia/RBCC_E) and the Triad Langley calibration (http://rbcce.aemet.es/svn/iberonesia/RBCC_E/Triad).
- There is continuous assessment of the triad based on the comparison with the total ozone observations at Izaña Observatory provided with the FTIR, DOAS and ECC Ozone Sondes techniques, which are recognised as part of the NDACC program. This makes Izaña a supersite for ozone measurement.

During the RBCC-E Brewer intercomparison campaigns, the travelling standard is compared with other reference instruments when it is possible (Table 3-1). These reference instruments are: IOS travelling reference #017, Brewers #145 and #190, operated by Environment and Climate Change Canada (ECCC), the Kipp & Zonen travelling reference #158 and the Brewer #174 operated by Japan Meteorological Agency. The first three instruments provide a direct link to the WBT: a report of the comparison between references can be found in Redondas et al. [2018c]. As suggested by WMO-SAG the link to the WBT will be conducted by joint Langley campaigns at Mauna Loa or Izaña stations. Last intercomparison between the WBT and the RBCC-E Triad and was held in Izaña in August 2023.

During the present campaign, the Brewer #256 was used for the first time as the reference instrument. This Brewer has been calibrated independently at Izaña by Langley Method. Comparison with the RBCC- E Triad (Brewers #157, #183 and #185) shows that the difference between the ozone of the #256 and the mean ozone of the Triad is negligible. Therefore, the configuration of the brewer #256 will be used directly for the calibration transfer during the campaign.

The travelling reference (Brewer #256) remains stable before and after the campaign. We check the performance of the reference with four steps:

(a) Instrumental analysis is performed to check possible changes of the instrument as summarized on Table 3-2

(b) Absolute Langley plot calibration is performed before and after the campaign (Fig. 3-2), this allow us asses the reference stability.

(c) Comparison with the other instruments of the triad remaining in Izaña (Fig. 3-4)

(d) Cross calibration before and after the campaign help us to determine the source the possible changes of the reference (Table 3-8).

3.1 RBCC-E Brewer Reference spectrometer calibration

As a preliminary and subsequent task during all the intercomparison campaign, the reference instrument is analysed in detail. So, its instrumental parameters – dead time (DT), temperature dependence, filter characterisation as well as its ozone absorption coefficient calculated from a dispersion test – are compared with the values recorded prior and after the campaign. A summary with the main parameters of Brewer #256 checked before the instrument departed for the campaign is presented in Table 3-2. A detailed instrumental report is available at Redondas et al. [2023a].

Table 3-1 – Differences, in %, between the RBCC-E travelling reference and other reference instruments during the blind days of RBCC-E campaigns.

Site	Year	IOS #017	K&Z #158	ECCC #145 & #190	Japan #174	RBCCE #185	Reference
Arosa	2008	-0.6					Redondas and Rodriguez-Franco [2008]
Huelva	2009	-0.6	0.8	-0.1			Roozendael et al. [2012]
Arosa	2010	-0.6					Roozendael et al. [2013]
Huelva	2011	-0.1	-0.2	-0.6			Roozendael et al. [2014]
Arosa	2012		-0.1				Redondas et al. [2015]
Huelva	2013	-1.0	0.7				Redondas and Rodriguez-Franco [2015a]
Izan˜a	2014			-2.2			Redondas et al. [2014]
Arosa	2014	-1.2	1.5				Redondas and Rodriguez-Franco [2015b]
Huelva	2015	-0.5	-0.5				Redondas et al. [2018c]
Arosa/Davos	2016						in preparation
Izan˜a	2016	-1.6 (-3.5)					Cuevas et al. [2017]
Huelva	2017	-0.7					Redondas et al. [2019b]
Izan˜a	2017		1.0				Redondas et al. [2018a]
Arosa	2018		0.7				Redondas et al. [2019a]
Huelva	2019	-0.8		-0.9	-2.5		Redondas et al. [2021]
Davos	2021		-1.4				Redondas et al. [2022a]
Davos	2022		-0.6	-0.8			Redondas et al. [2022b]
Huelva	2023		-1.1			0.5	Redondas et al. [2023b]

Table 3-2 – Calibration and instrument checklist of Brewer#256.

Ref. checklist: B#256	Description	Passed?	Value	Comments
Calibration data				
Ref. of travelling standard	RBCC-E B#256			Own Langley
Is the standard calibrated?		Y		
% difference before travel			−0.18	
% difference after travel			−0.17	
Calibration data				
HP/HG	Test repeatable within 0.2 steps?	Y		
SH	Shutter delay is correct?	-		
RS	test within ± 0.003 from unity for illuminated slits and between 0.5 and 2 for the dark counts	Y		
Dead time	Is it between 28 and 45 ns for multiple-board Brewers and 16 and 25 ns for single-board ones?	N	29	
Standard lamp	SL ratio R6 is within 5 units from calibration?	Y	442	
Standard lamp	SL ratio R5 is within 10 units from calibration?	Y	627	

Table 3-3 – Standard Lamp R6 ratio, for the reference instrument. SL refers to the mean of the R6 ratio, se to its standard error and N to the number of data used to make the statistics.

	Date	SL	se	N
"ARE2023"	05-Sep-2023	441.5	0	1
"At Izana"	19-Sep-2023	441.6	0.1	45
"CalStep Update"	03-Nov-2023	441.1	0.2	45
"STM2024"	19-Feb-2024	443.2	0.2	19
"At Izana "	06-May-2024	443.1	0.3	18
"Cal change"	24-May-2024	442.5	0.2	38

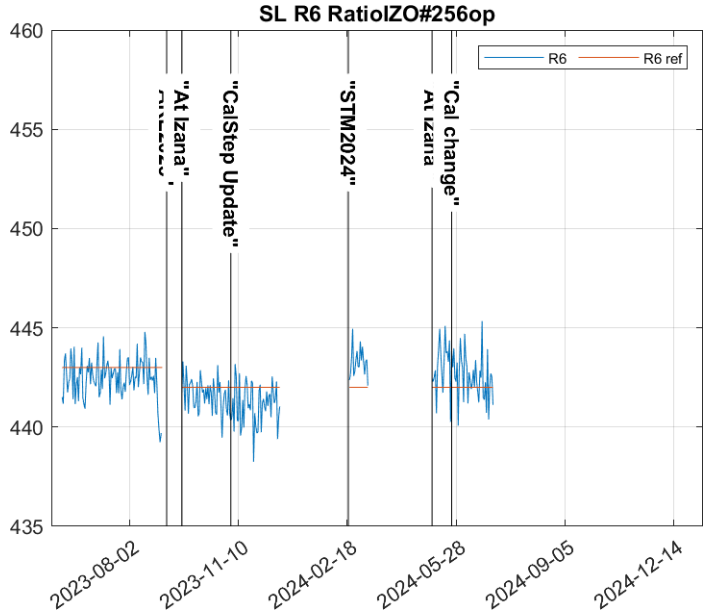


Figure 3-1 – Standard lamp R6 measurements for Brewer #256 during the year. The vertical lines indicate relevant events in the instrument's operation.

The stability of the instruments of the Triad are analysed in periods determined by events than can affect the calibration. During this periods, the Langley Plot are averaged to obtain the ETC. The events associated to Brewer#256 are summarised at Table 3-3 and plotted as vertical lines on the figure of the Standard Lamp record, Figure 3-1. These include an event in November 2023, when the calibration step nuber (CSN) was changed from 1026 to 1028, leading to a change of the ETC from 1660 to 1680. Also the travels to and from the intercomparison campaigns are included as events. We can see how the value of the The SL remains stable except for a small change of about 2 units on the trip to Brazil. This change is negligible and will not be taken into account.

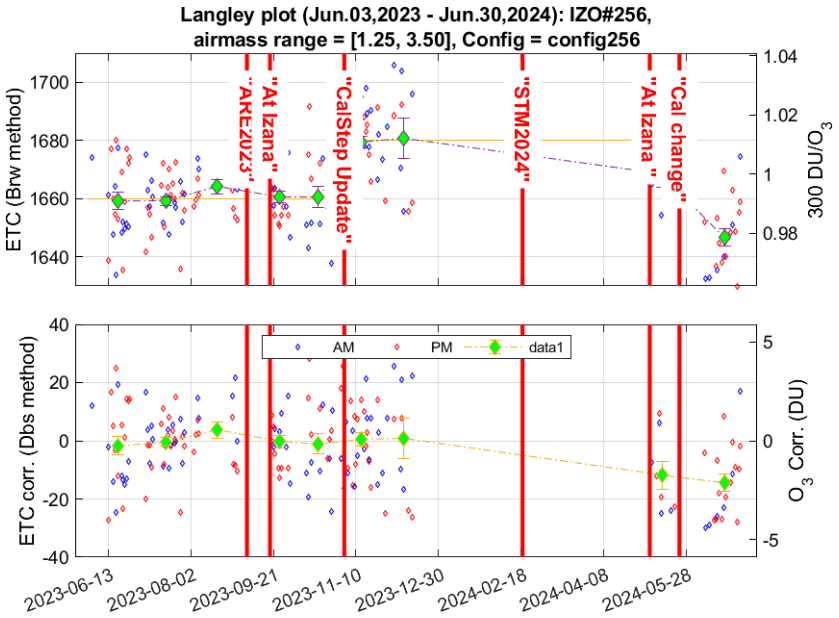


Figure 3-2 – Langley ETC calculation for Brewer #256 during the year. In the upper panel, the Brewer Langley (standard) is plotted, and in the lower panel the Langley using the Dobson Method, which gives the ETC correction. The blue (red) dots correspond to Langley results derived from AM (PM) data. The dashed line represents monthly means of both AM and PM Langley results. The vertical red lines indicate relevant events in the instrument's operation.

Figure 3-2 shows the Langley values calculated before and after the campaign from the morning and afternoon observations made during this year, summarised on Table 3-4. As it can be observed, the ETC values obtained before and after the campaign differ by 10 units which is quite high. Similar results are obtaining using the Dobson Langley plot method [Dobson and Normand, 1958, Kiedron and Michalsky, 2016]. However, it should be noted that while the pre-campaign analysis period was a month and a half with almost 40 correct langleys for the ETC evaluation, the post-campaign analysis was reduced to half a month with only 9 langleys due to a change in the instrument's behaviour at the end of May, being this number of langleys insufficient for the correct determination of the ETC.

The stability of Brewer#256 can also be checked comparing it with the other Brewers of the RBCC-E Triad, which remain at IZO during the campign, Brewers #157, #183 and #185. This comparison has been done in two periods: before the campaign, using data from 2023-11-03 to 2023-12-19, and after the campaign, using data from 2024-05-07 to 2024-05-24. Fig. 3-3 shows the daily relative difference

Table 3-4 – Extraterrestrial constant in the configuration of Brewer#256 (ETC), mean constant using the standard langley method (brw), standard deviations (std), standard error of mean (sem), number of Langley events (N) and Dobson method (dbs) before and after El Arenosillo campaign.

Period	ETC	brw	sem.brw	dbs	sem.dbs	N
Before Campaign	1680	1681	2.2	0	2.3	39
After Campaign	1680	1668	4.6	-12	4.8	8

with respect to the Triad's mean for the ozone observations of the three instruments before and after the intercomparison campaign. Fig. 3-4 and Tables 3-6 and 3-7 further show the relative differences with respect to the Triad's mean by OSC range. The average differences between brewer #256 and the Triad before and after the campaign are in both cases almost the same, respectively −0.18% and −0.17%. We will therefore consider that the Brewer #256 has remained stable throughout the Santa Maria 2024 campaign. It is important to note that it is the mean of Triad instruments which is transferred during the campaign (Table 3-5). But, as it is showed, we can say that in this case it coincides with the value of the travelling reference #256.

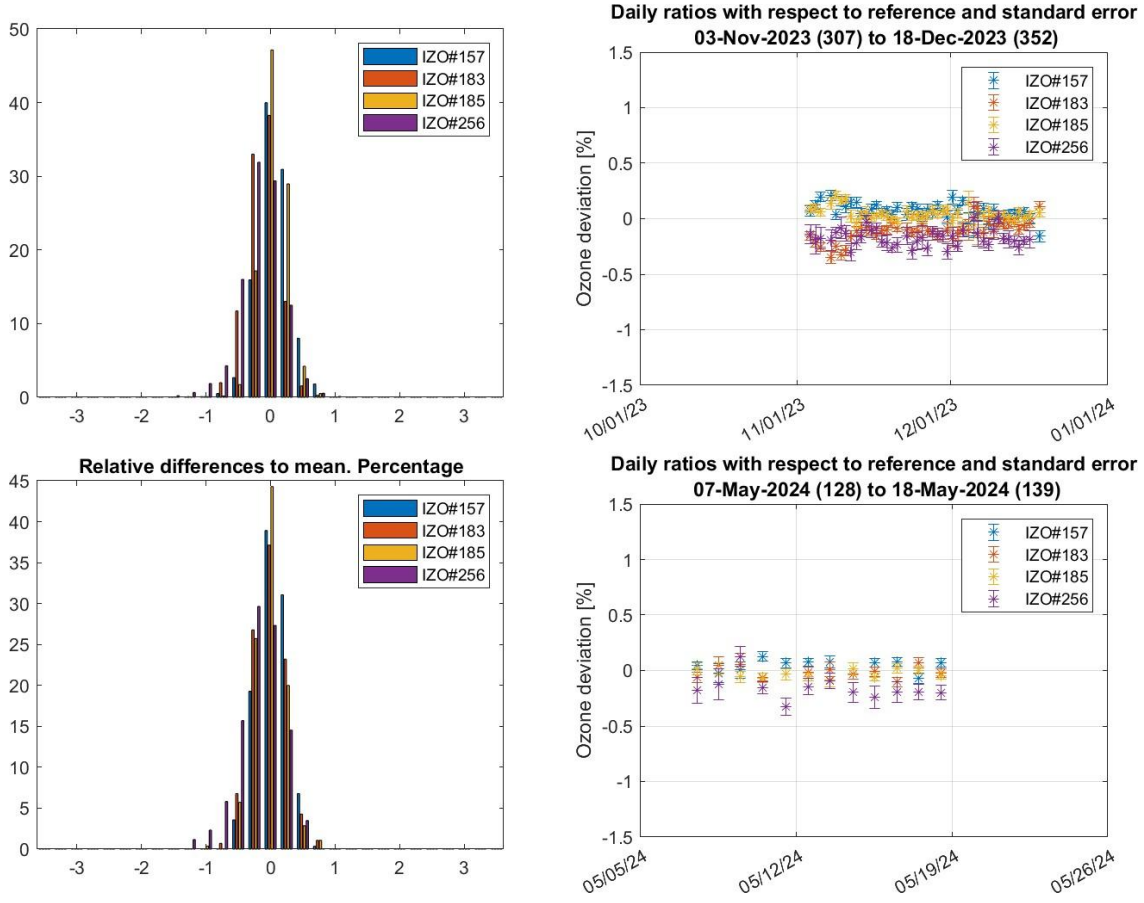


Figure 3-3 – Deviations of near-simultaneous ozone measurements of RBCC-E Brewers (serial nos. #157, #183 and #256) to the Triad's mean (left) and temporal evolution of daily mean deviation of near-simultaneous ozone measurements (right). The upper part shows the data before the intercomparison, while the lower part shows the subsequent data.

Table 3-5 – Instrument constant file for Brewers #256 in the campaign.

	ICF24823.256
o3 Temp coef 1	0
o3 Temp coef 2	-0.15314
o3 Temp coef 3	-0.18805
o3 Temp coef 4	-0.49051
o3 Temp coef 5	-0.51035
Micrometer steps/deg	0
O3 on O3 Ratio	0.3459
SO2 on SO2 Ratio	2.8
O3 on SO2 Ratio	1.16
ETC on O3 Ratio	1680
ETC on SO2 Ratio	1
Dead time (sec)	2.9e-08
WL cal step number	1028
Slitmask motor delay	14
Umkehr Offset	2449
ND filter 0	0
ND filter 1	5190
ND filter 2	9502
ND filter 3	13995
ND filter 4	17672
ND filter 5	24411
Zenith steps/rev	2972
Brewer Type	3
COM Port #	2
o3 Temp coef hg	0
n2 Temp coef hg	0
n2 Temp coef 1	0
n2 Temp coef 2	0
n2 Temp coef 3	0
n2 Temp coef 4	0
n2 Temp coef 5	0
O3 Mic #1 Offset	0
Mic #2 Offset	0
O3 FW #3 Offset	242
NO2 absn Coeff	-3
NO2 ds etc	770
NO2 zs etc	740
NO2 Mic #1 Offset	8028
NO2 FW #3 Offset	178
NO2/O3 Mode Change	2515
Grating Slope	0.99724
Grating Intercept	-4.35
Micrometer Zero	1723
Iris Open Steps	250
Buffer Delay (s)	0
NO2 FW#1 Pos	64
O3 FW#1 Pos	256
FW#2 Pos	0
uv FW#2 Pos	0
Zenith Offset	0
Zenith UVB Position	2198

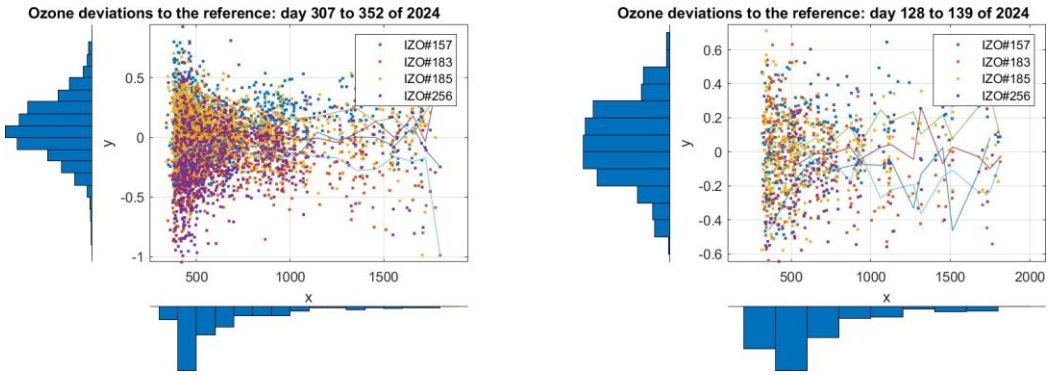


Figure 3-4 – Deviation of near-simultaneous ozone measurements by OSC. Data before (left) and after (right) the intercomparison.

Table 3-6 – Deviation of near-simultaneous ozone measurements by OSC. Data before the inter-comparison.

	IZO#157	IZO#183	IZO#185	IZO#256
All	0.1 +/-0.24	-0.1 +/-0.25	0 +/-0.2	-0.2 +/-0.32
< 350	0.1 +/-0.05	-0.3 +/-0.41	0.2 +/-0.36	-1.2 +/-0
< 500	0.1 +/-0.28	-0.1 +/-0.28	0.1 +/-0.21	-0.3 +/-0.39
< 700	0 +/-0.2	-0.1 +/-0.2	0 +/-0.18	-0.2 +/-0.25
< 1000	0.1 +/-0.16	-0.2 +/-0.18	0 +/-0.15	-0.1 +/-0.19
< 1200	0.2 +/-0.13	-0.1 +/-0.17	0 +/-0.18	-0.1 +/-0.24
> 1200	0.2 +/-0.26	-0.2 +/-0.31	0.1 +/-0.27	0 +/-0.3

Tables 3-6 and 3-7 show the deviation of each Brewer in the Triad from the Triad mean ozone for different OSC ranges respectively before and after the campaign. As can be seen, Brewer #256 shows no dependence on the OSC in either period. Table 3-8 shows the ETC values calculated from 1-point and 2-point methods when Brewer #256 is compared with the other two instruments of the RBCC-E Triad. The operative values of the ETC and ozone absorption coefficient are also included in Table 3-8. This comparison shows a very good agreement between the ETC values obtained by Langley and the cross-calibration between the reference instruments, especially for the 1P calibration, where the differences obtained are below 5 units. For the 2P comparison, the differences are slightly greater, mainly due to the difference with the absorption coefficient obtained from the dispersion tests.

Finally, to check the stability of the Brewers which remained in IZO during the campaign, the ozone measured by the two instruments is compared since 2023-11-03 to 2024-05-24. Fig. 3-5 and Table 3-9 show the daily relative difference of #157, #183 and #185 with respect to their mean. Differences between these instruments are below 0.3% for the whole period.

Table 3-7 – Deviation of near-simultaneous ozone measurements by OSC. Data after the intercomparison.

	IZO#157	IZO#183	IZO#185	IZO#256
All	0 +/-0.22	0 +/-0.25	0 +/-0.23	-0.2 +/-0.33
< 350	0 +/-0.25	-0.1 +/-0.26	0.1 +/-0.36	-0.6 +/-0.31
< 500	0 +/-0.23	0.1 +/-0.27	-0.1 +/-0.26	-0.3 +/-0.36
< 700	0 +/-0.19	0 +/-0.23	-0.1 +/-0.18	-0.1 +/-0.29
< 1000	0.1 +/-0.16	0 +/-0.16	0 +/-0.13	-0.1 +/-0.23
< 1200	0.2 +/-0.21	-0.2 +/-0.15	0 +/-0.17	-0.1 +/-0.26
> 1200	0.2 +/-0.2	-0.2 +/-0.17	0 +/-0.18	-0.1 +/-0.3

3.2 Summary

As a summary, the analysis of RBCC-E Brewer reference shows the following:

- During the Santa Maria 2024 , the calibration transferred is the mean of the RBCC-E triad reference. As it is showed, in this case, ozone absorption coefficient of the travelling reference #256 coincides with the value of the traveling reference #256.
- The ETC values for Brewer #256 obtained using the Langley plot method before and after the campaign differ in 10 units. However, it should be noted that, due to a change in the instrument's behaviour, the post-campaign analysis was reduced to half a month with only 9 langleys, being this number of langleys insufficient for the correct determination of the ETC.
- Comparison of the #256 calibration against the Brewers of the RBCC-E Triad (#157, #183 and #185) does allow us to verify the stability of the Brewer #256. Differences are bellow 5 units from the reference ETC before and after the Santa Maria 2024 . The 1P and 2P comparison show an excellent result, with difference below 5 units in almost all cases.
- The comparison with the triad also shows no dependence of Brewer #256 on the OSC, either before or after the campaign.

Table 3-8 – ETC values calculated from comparison between the RBCC-E instruments.

	Initial Date	Final Date	ETC Operative	O_3 Abs. Coeff. Op.	ETC 1P	ETC 2P	O_3 Abs. Coeff. 2P
157	03/11/23	19/12/23	1680.0	0.3459	1675.1	1673.6	0.346
183	03/11/23	19/12/23	1680.0	0.3459	1678.4	1673.6	0.347
185	03/11/23	19/12/23	1680.0	0.3459	1675.7	1668.9	0.348
157	07/05/24	24/05/24	1680.0	0.3459	1676.2	1674.6	0.346
183	07/05/24	24/05/24	1680.0	0.3459	1677.3	1680.7	0.345
185	07/05/24	24/05/24	1680.0	0.3459	1676.8	1675.8	0.346

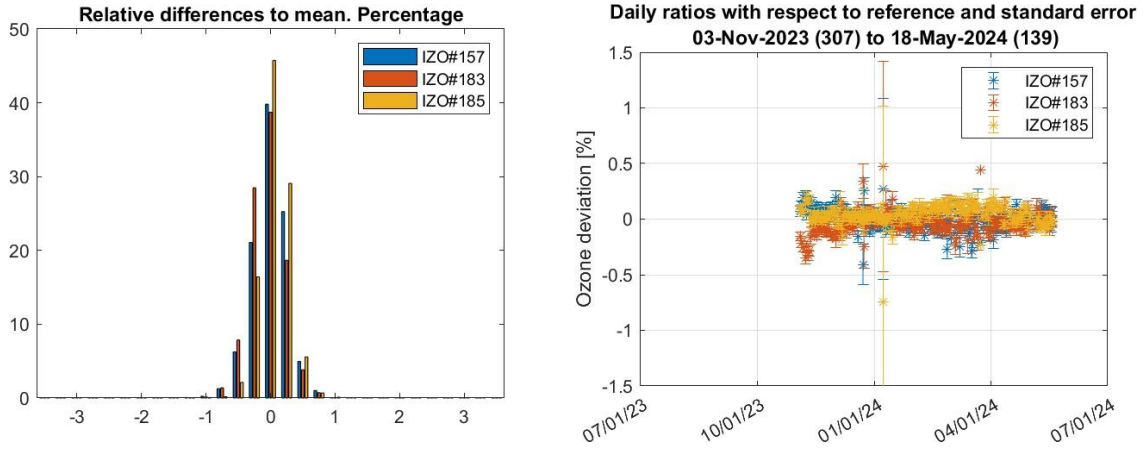


Figure 3-5 – Deviations from near-simultaneous ozone measurements of Brewers #157 and #183 with respect to their mean (left) and temporal evolution of daily mean deviation of near-simultaneous ozone measurements (right). In the latter figure, the error bars represent the standard error. Data covers the campaign period.

Table 3-9 – Relative differences from ozone mean value for Brewers #157,#183 and #185 from 2023-11-03 to 2024-05-24.

	Initial Date	Final Date	Mean O_3 diff [%]	Std O_3 diff [%]	Num.
IZO#157	03-Nov-2023	24-May-2024	0	0	4496
IZO#183	03-Nov-2023	24-May-2024	0.05	0	4496
IZO#185	03-Nov-2023	24-May-2024	0.05	0	4496

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16 Brewer LPZ#056

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer LPZ#056 participated in the campaign in the period from February 10th to March 8th, the campaign days of Brewer LPZ#056 thus correspond to Julian days 50 to 68.

The instrument received some maintenance by IOS from day 57 to 60. There were some software problems afterwards, so we have used **154** simultaneous DS ozone measurements taken from day **65** to **68** to calibrate the instrument (Fig. 16-2)

16.1.1 Instrument's history and stability

The R6 standard lamp measurements have been quite stable in the last two years (Fig. 16-6). The run/stop tests present some noticeable noise, specially in slit 0 (Fig. 16-9). The results of the dead time tests are also noisy, and a change in the dt value is apparent at the campaign (Fig. 16-10). The results of the AP tests (Fig. 16-11) show a noticeable change in the SL current and HT Voltage in August 2023, while the +5V channel remains slightly above the upper tolerance limit all of the time.

To further check the stability of the instrument, we have compared EUBREWNET's level 1.5 ozone product with the ERA5 data for the station of Brewer LPZ#056, for the two years between intercomparison campaigns. The relative difference between both datasets is shown in Fig. 16-1. Overall, the behaviour of this Brewer seems quite stable until mid 2023, when a change in trend is apparent.

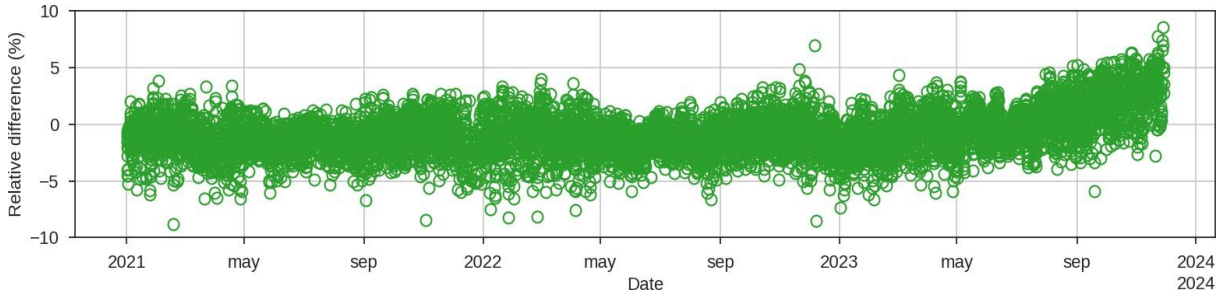


Figure 16-1 – Relative difference of EUBREWNET's level 1.5 ozone product with respect to the ERA5 data for the station of Brewer LPZ#056

16.1.2 Maintenance

IOS performed maintenance on the instrument on days 57 to 60. Maintenance work included adjustments to the micrometers, replacing the Hg lamp and communications cable, and changing the sealing rubber.

16.1.3 Instrumental parameters during the campaign

After the maintenance, the standard lamp ratios stabilized around values **1706** and **3383** for R6 and R5 respectively (Figs. 16-6 and 16-7, respectively). The deadtime also changed with respect to the previous configuration, and we propose a new value of 27 ns, which is 3 ns lower than the current value, a very noticeable difference.

16.1.4 Temperature dependence and filters

Brewer LPZ#056 shows a noticeable temperature dependence (Fig. 16-13), but the current temperature coefficients seems to perform correctly, so we don't recommed any updates at this time.

Concerning the performance of the filters, the results of the FIOAVG tests show a noticeable non-linear behaviour. However, these measurements are usually very noisy and thus not completely reliable. We have not identified any large effect of the filters in the comparison with the reference instrument, so we don't recommend the adoption of any filter correction at this time.

16.1.5 Sun scan and dispersion tests

Sun scans do not seem to have been carried out at the instrument's home station before the campaign. During the campaign, there is little sun scan data, but it seems to confirm the current optimal cal step number, nan.

The dispersion tests during the campaign result in an ozone absorption coefficient of 0.3407, almost 3 steps lower than the current value of 0.3434. This is a noticeable difference and we thus recommend updating the ozone absorption coefficient.

16.1.6 ETC transfer

As shown in Fig. 16-2, after the maintenance and using the new calibration, Brewer LPZ#056's ozone is within 0.4% with respect to reference Brewer IZO#256.

Being a Mk. II model, Brewer LPZ#056 measurements are affected by stray light. This produces the downward tail at large ozone slant path values shown in Fig. 16-2. However, as show in Fig. 16-3, the comparison with the Mk. III Brewer IZO#256 allows us to correct the effect of the stray light using the method described in [1].

16.1.7 Recommendations and Remarks

1. The R6 reference value should be updated to **1706**.
2. We suggest a new R5 reference value of **3383**.
3. The SL seems to have been quite stable in the 2-3 years before the campaign, and we have applied the SL correction to the Brewer data in the ERA5 comparison. The comparison with the reanalysis product itself seems quite stable, although there is some change in trend starting in mid 2023.
4. We suggest updating the DT to $\mathbf{2.7 \cdot 10^{-8}}$ seconds, which is 3 units less than the value proposed in the last calibration. This is a noticeable difference.

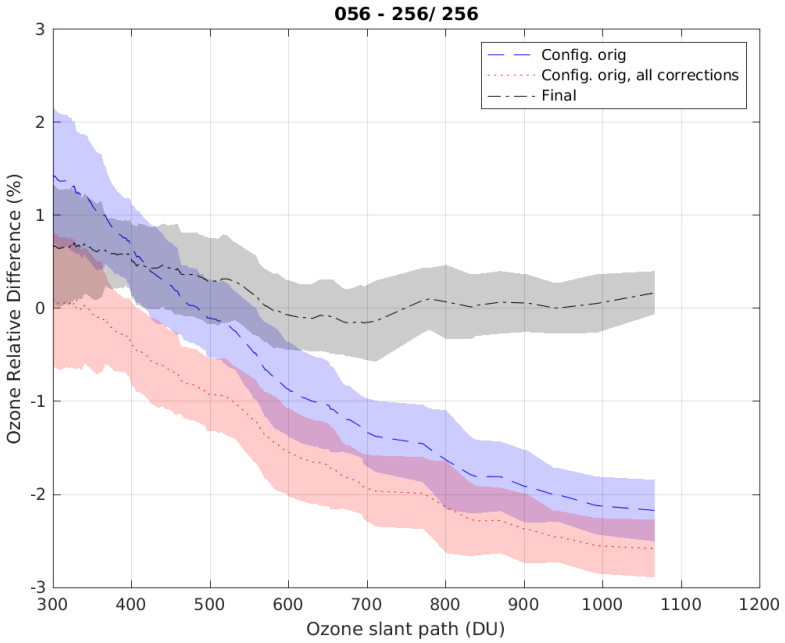


Figure 16-2 – Mean DS ozone column percentage difference between Brewer LPZ#056 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

5. From the dispersion tests conducted during the campaign, a new ozone absorption coefficient is suggested, **0.3407**
6. For Brewer LPZ#056, stray light has an important effect on measurements taken at large ozone slant paths. We suggest applying a stray light correction with parameters $k = a$ =**-72.8**, and $s = b$ =**2.2**.
7. Finally, we suggest updating the ETC value to **2850**.
8. We have not adopted new temperature coefficients, but they should be checked once enough data is available from the Brewer operating at Copenhaguen.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/056/ICF06624.056

Calibration Report

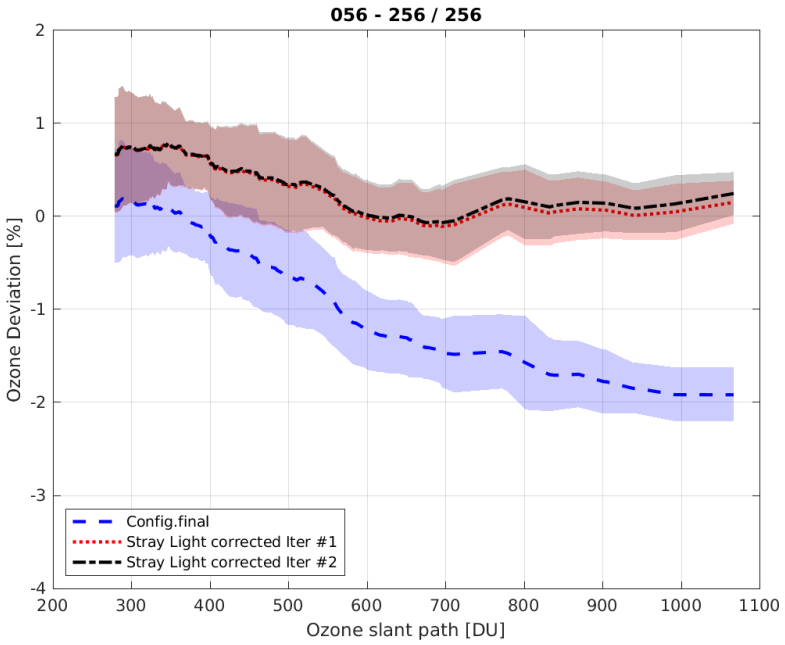


Figure 16-3 – Mean DS ozone column percentage difference between Brewer LPZ#056 and Brewer IZO#256, plotted as a function of the ozone slant path. Results for the final (issued in this calibration campaign) configuration are show in blue; the red dotted line corresponds to the same configuration, but with the stray light correction obtained after 1 iteration; the black line corresponds to results obtained after 2 iterations. The shadow areas represent the standard deviation of the mean. The plot corresponds to the final days of the campaign.

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=754835468#gid=754835468

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/056/html/cal_report_056a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/056/html/cal_report_056a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/056/html/cal_report_056b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/056/html/cal_report_056c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF34107.056)	Final (ICF06624.056)
o3 Temp coef 1	0	0
o3 Temp coef 2	-0.2569	-0.2569
o3 Temp coef 3	-0.9042	-0.9042
o3 Temp coef 4	-1.8832	-1.8832
o3 Temp coef 5	-3.4765	-3.4765
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3434	0.3407
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.151	1.151
ETC on O3 Ratio	2835	2850
ETC on SO2 Ratio	2930	2930
Dead time (sec)	3e-08	2.7e-08
WL cal step number	165	165
Slitmask motor delay	80	80
Umkehr Offset	1644	1636
ND filter 0	0	0
ND filter 1	3860	3860
ND filter 2	9640	9640
ND filter 3	13055	13055
ND filter 4	18433	18433
ND filter 5	22455	22455
Zenith steps/rev	2816	2816
Brewer Type	2	2
COM Port #	2	2
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	2917	2917
Mic #2 Offset	0	0
O3 FW #3 Offset	0	0
NO2 absn Coeff	0	0
NO2 ds etc	0	0
NO2 zs etc	0	0
NO2 Mic #1 Offset	0	0
NO2 FW #3 Offset	0	0
NO2/O3 Mode Change	0	0
Grating Slope	0	0
Grating Intercept	0	0
Micrometer Zero	3469	3469
Iris Open Steps	75	75
Buffer Delay (s)	0.2	0.2
NO2 FW#1 Pos	0	0
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	64	64
Zenith Offset	31	31
Zenith UVB Position	2109	2109

16.3 Appendix: Summary Plots

Figure 16-4 in this appendix shows the ozone during the campaign as determined by Brewer LPZ#056 using the final calibration (ICF06624.056), and by reference Brewer IZO#256. Fig. 16-5 shows the daily ozone data in detail.

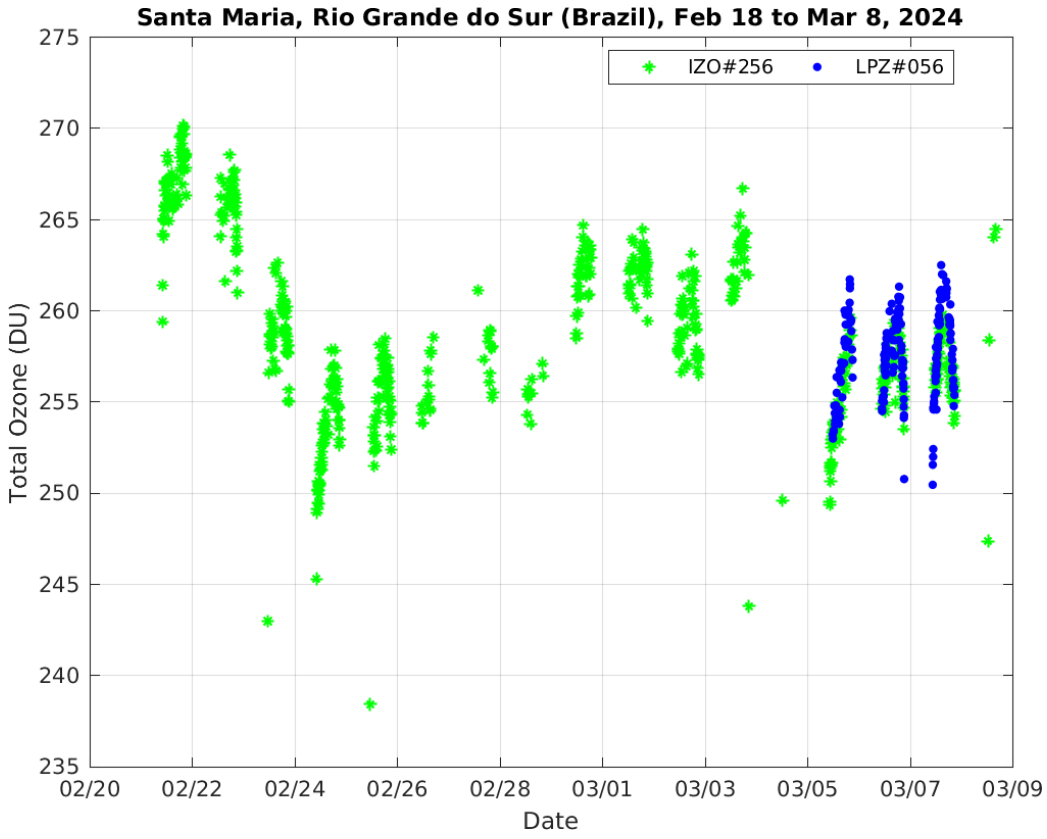
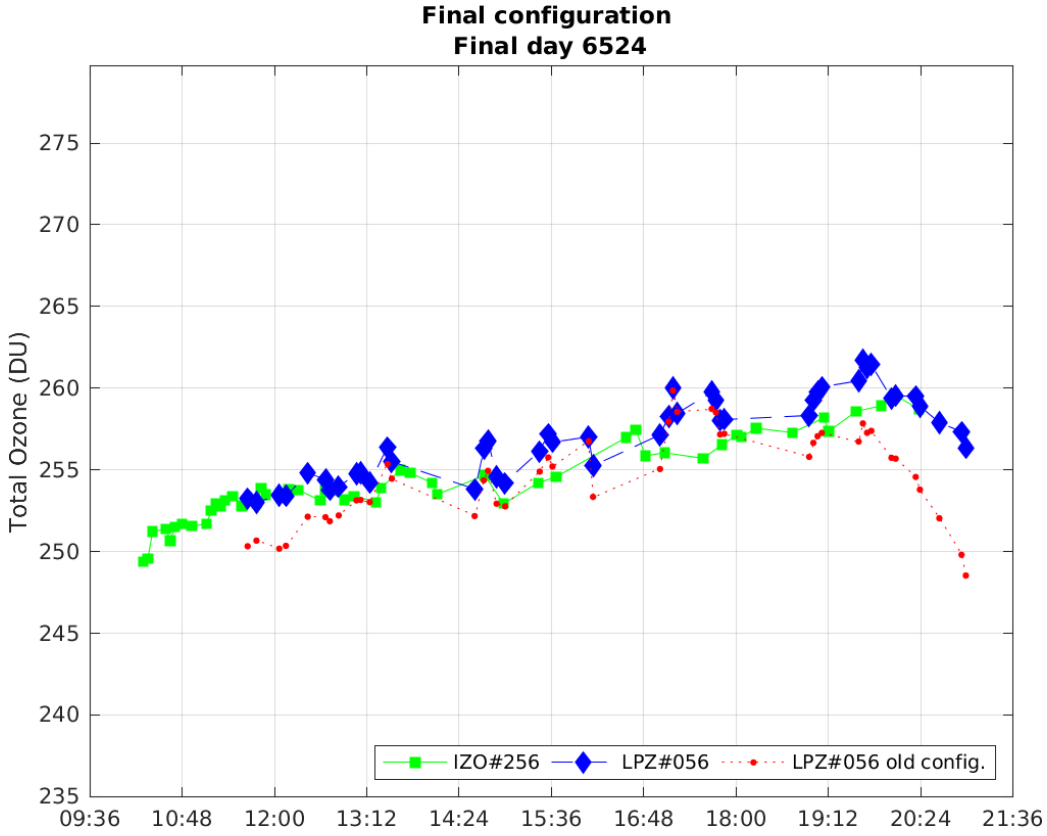
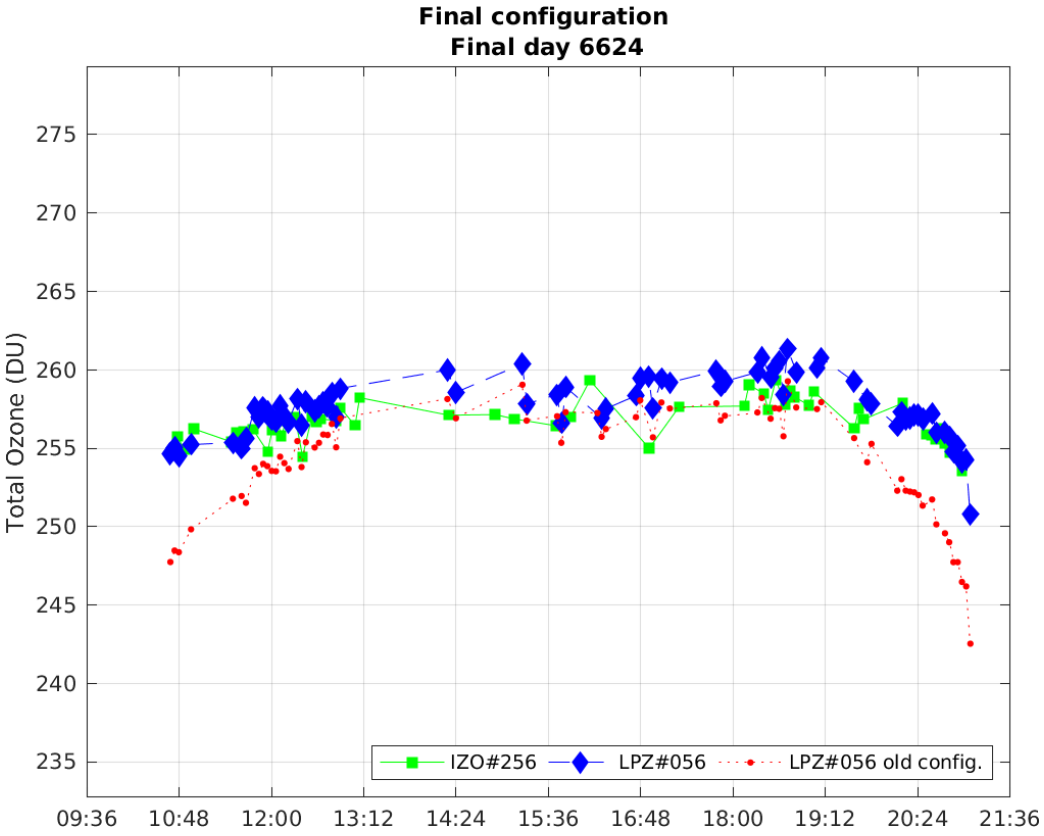


Figure 16-4 – Overview of the intercomparison. For the final days starting on day 65, Brewer LPZ#056's data are evaluated using the final constants (blue circles) provided in the ICF06624.056 file.


Final configuration
Final day 6524
Total Ozone (DU)
275
270
265
260
255
250
245
240
235
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
21:36
IZO#256
LPZ#056
LPZ#056 old config.



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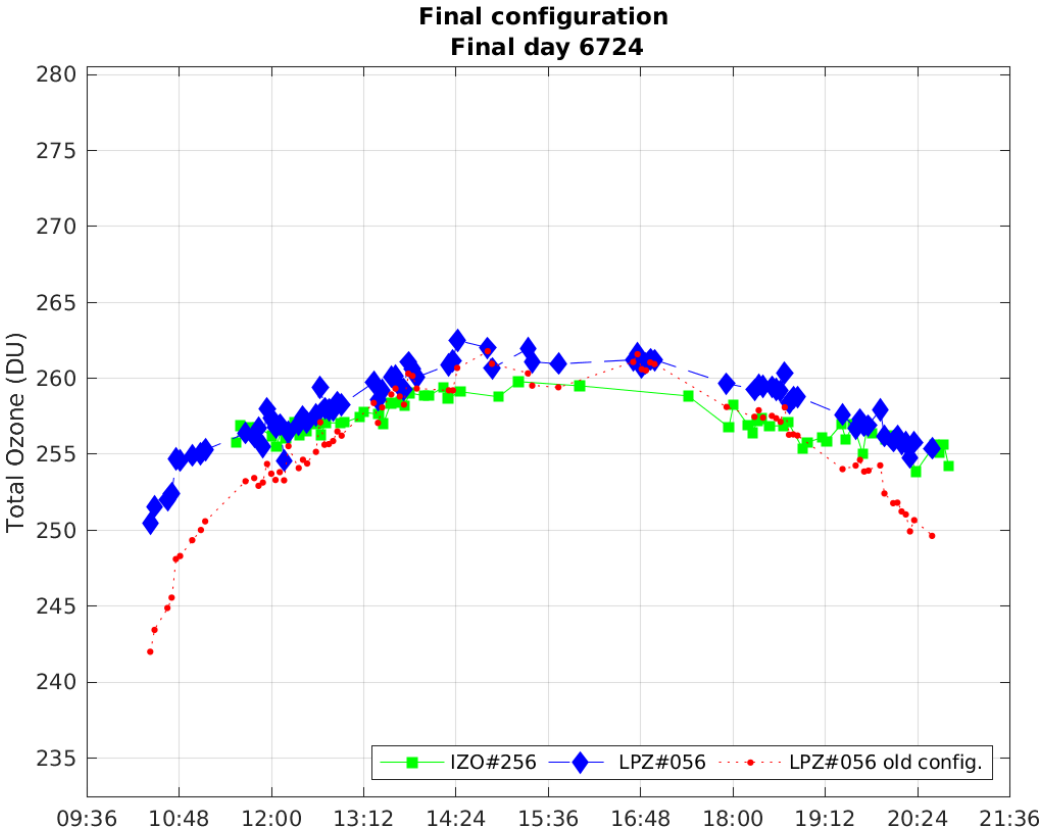


Figure 16-5 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF34107.056, red) and final (ICF06624.056, blue) configurations of Brewer LPZ#056, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-6) and R5 (Fig. 16-7) ratios, and the intensity of slit 5 (Fig. 16-8), results of the Run/Stop (Fig. 16-9), Dead Time (Fig. 16-10), and analog voltages and intensity (Fig. 16-11), analysis of the temperature coefficient's performance (Figs. 16-12, 16-13, 16-14, and 16-15), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-16), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-17) tests.

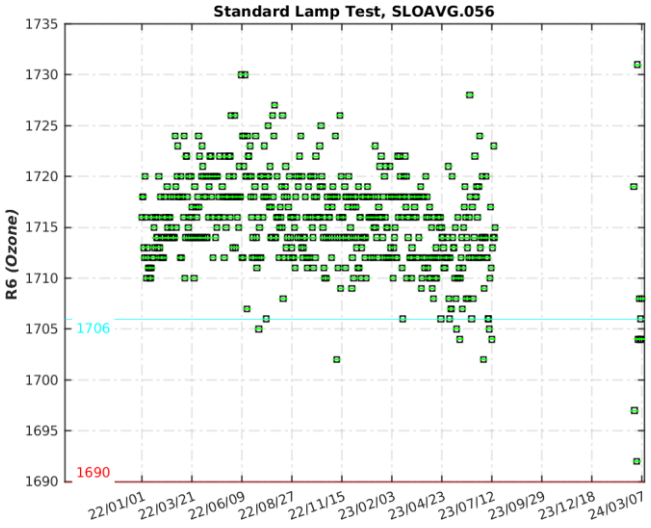


Figure 16-6 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

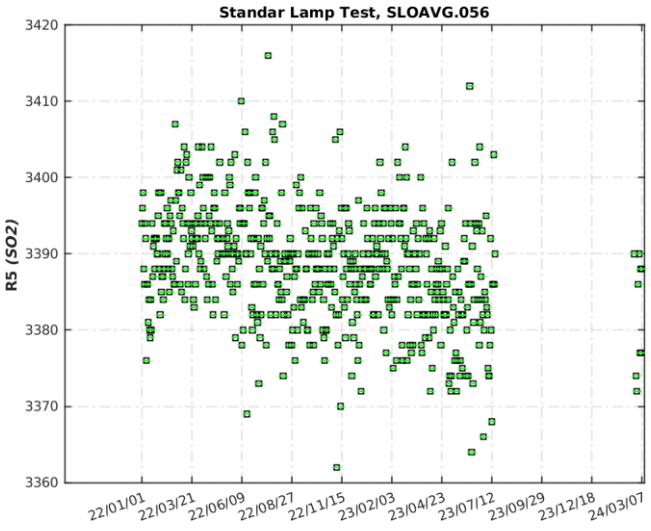


Figure 16-7 – Standard Lamp test R5 (SO_2) ratios

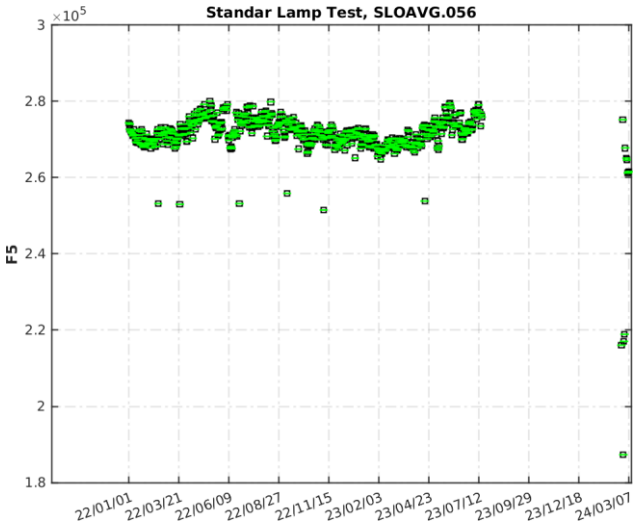


Figure 16-8 – SL intensity for slit five.

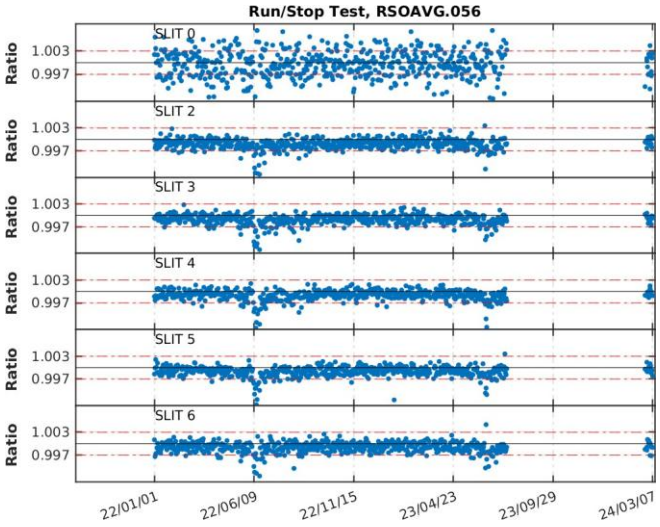


Figure 16-9 – Run/stop test

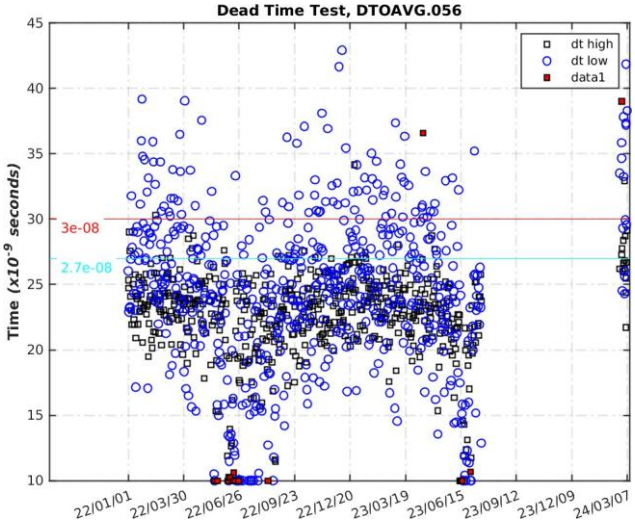


Figure 16-10 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

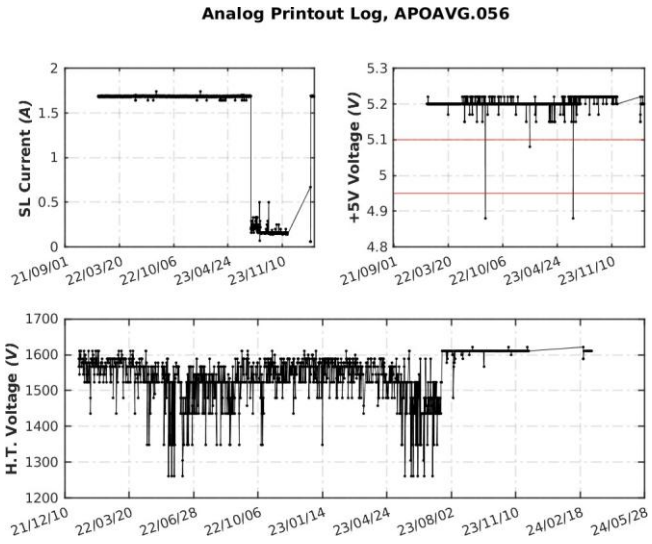


Figure 16-11 – Analog voltages and intensity.

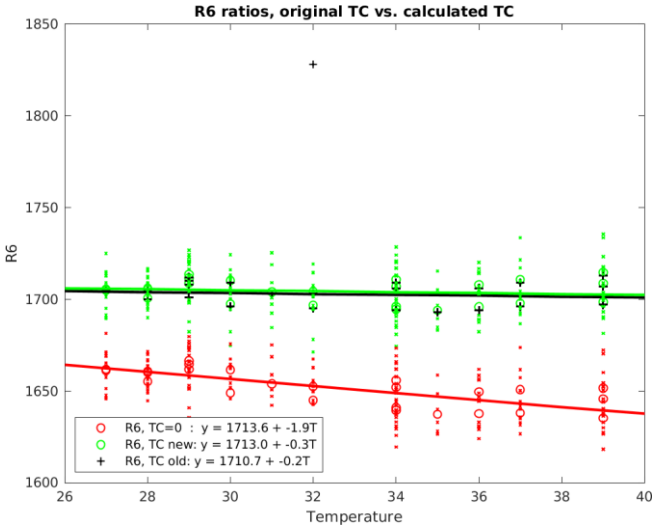


Figure 16-12 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

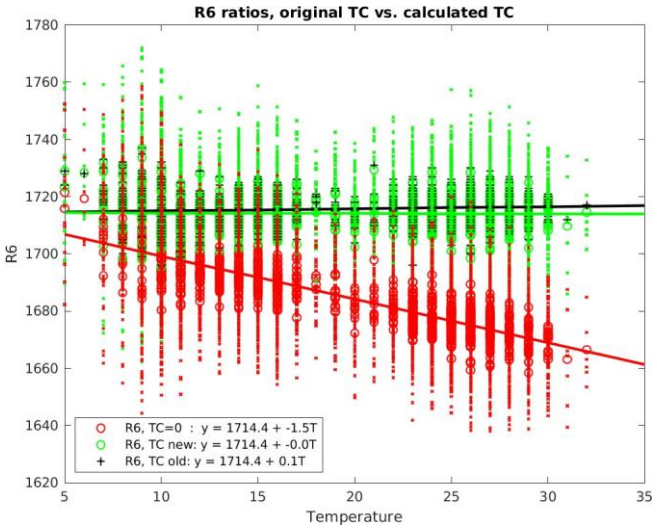


Figure 16-13 – Same as Fig. 16-12 but for the two years before the present campaign.

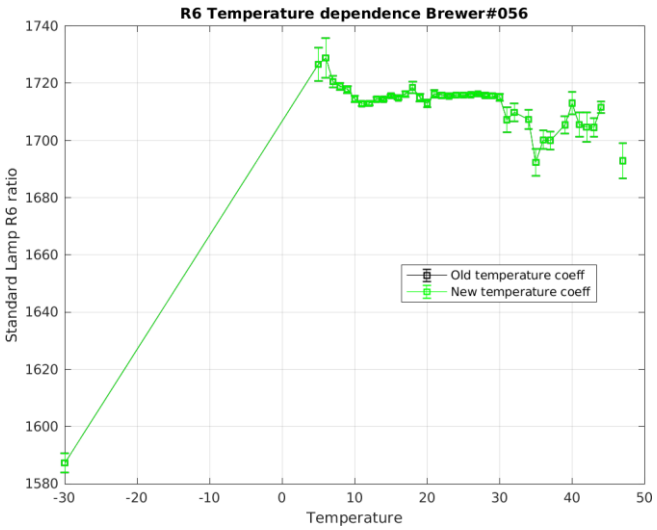


Figure 16-14 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

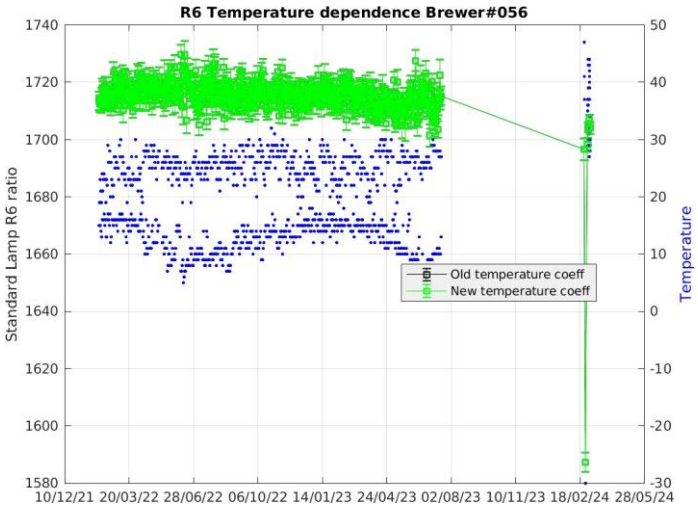


Figure 16-15 – Same as Fig. 16-14, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	-2	18	7	-39	35
ETC Filt. Corr. (mean)	10.4	10	-3.1	-42.6	11.9
ETC Filt. Corr. (mean 95% CI)	[-11.9 30.2]	[-15.9 41.9]	[-36.3 29.1]	[-83.7 -1.4]	[-86.9 105.6]

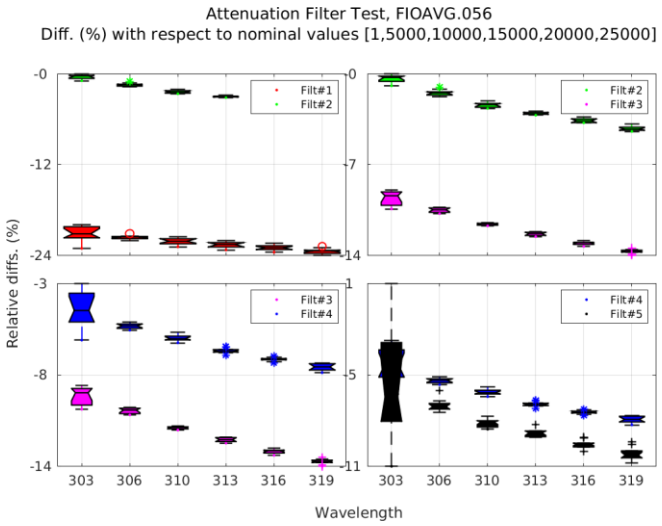


Figure 16-16 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	165	0.3434	2.3500	1.1510
02-Mar-2024	NaN	NaN	NaN	NaN
04-Mar-2024	165	0.3407	2.8244	1.1425
11-Mar-1999	165	0.3399	2.8107	1.1416
Final	165	0.3407	2.3500	1.1510

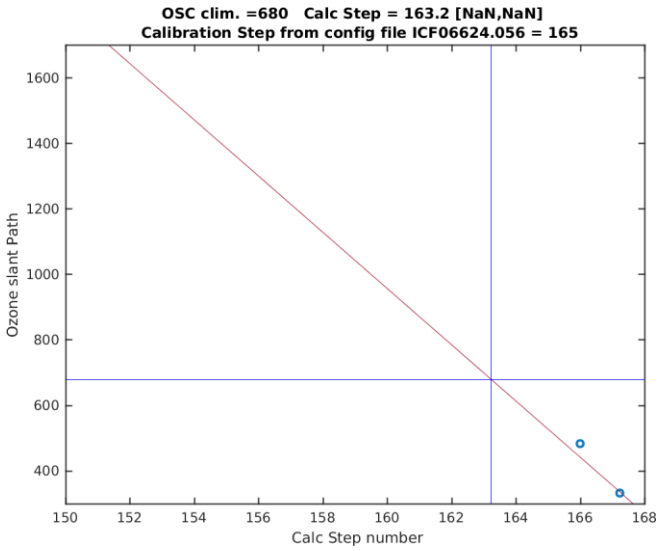


Figure 16-17 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16.5 References

[1] Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018.

16 Brewer CFR#068

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 19th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer CFR#068 participated in the campaign in the period from February 19th to March 8th. The campaign days of Brewer CFR#068 thus correspond to Julian days 50 to 68.

The Brewer received extensive maintenance almost the same day of its arrival, on February 21st. There are thus almost no blind days no evaluate the status of the instrument. Because of bad weather conditions and communication problems (likely caused by software) after the maintenance, we have used **135** simultaneous DS ozone measurements taken from day **65** to **68** to calibrate the instrument after the maintenance (Fig. 16-1)

16.1.1 Instrument's history and stability

There is very little data from the last 2-3 years, so we can't make any comments regarding the state of the instrument before the campaign. Given the extensive maintenance the instrument received (see next section), CFR#068 can be considered a new instrument.

16.1.2 Maintenance

IOS performed maintenance on the instrument on day 52. Maintenance work included new shock mounts, new UV filter, new lid gasket, adding a humidity sensor, replacement of the SPS (because the HV could not be set in the old power supply), replacement of the clock board to accomodate a new temperature circuit, replacement of some ribbon cables, and replacement of the Hg and Standard lamps. After the maintenance, communication problems were also detected, likely caused by an update in the Brewer software, which was thus reversed to its previous version.

16.1.3 Instrumental parameters during the campaign

After maintenance, the SL data was not completely stable, with some large peaks in R6 and R5 (Figs. 16-5 and 16-6, respectively), and the SL intensity decreasing (Fig. 16-7). Still, the R6 and R5 ratios seem to stabilize around **1582** and **2972** by the end of the campaign.

The unstability of the SL might be related to that of the deadtime tests (Fig. 16-9), which changed from 39 to 35 ns during the campaign. We suggest using this last value, which was also the dt value in the previous configuration, in the new configuration.

Run/stop and AP tests results are within acceptable limits (Figs. 16-8 and 16-10)

16.1.4 Temperature dependence and filters

Although the SL has not been stable during the whole campaign, the data of Brewer CFR#068 in the last days of the campaign show that the current temperature coefficients are performing correctly (Fig. 16-11). The instrument continued operating at Santa Mar´ıa after the campaign, giving us the opportunity to check the evolution of the SL and its temperature dependence. As shown in Fig. 16-15, the R6 value

is not completely stable after the campaign, and some temperature dependence is apparent. We can also compare the ozone data with that of Brewer #167, which also continued operating at Santa Mar´ıa after the campaign. In this comparison we do not find any clear temperature dependece, see Fig. 16-16. Because of that, we do not suggest changes to the temperature coefficients at this time.

Concerning the performance of the filters, data from the FIOAVG tests show some large values out of spec, but these tests are usually noisy and not very reliable. During the comparison with Brewers #256 and #167 we have not detected any clear filter effect, so we don't recommed any filter correction.

16.1.5 Sun scan and dispersion tests

Data from the sun-scan tests (SC) during the campaign confirm the current cal step number, nan, see Figure 16-18.

Dispersion tests during the campaign produce an ozone absorption coefficient of 0.34. The current value is 0.3315, so the difference is 0.008, or 8 steps – this is a rather large difference and we suggest the adoption of the new value.

16.1.6 ETC transfer

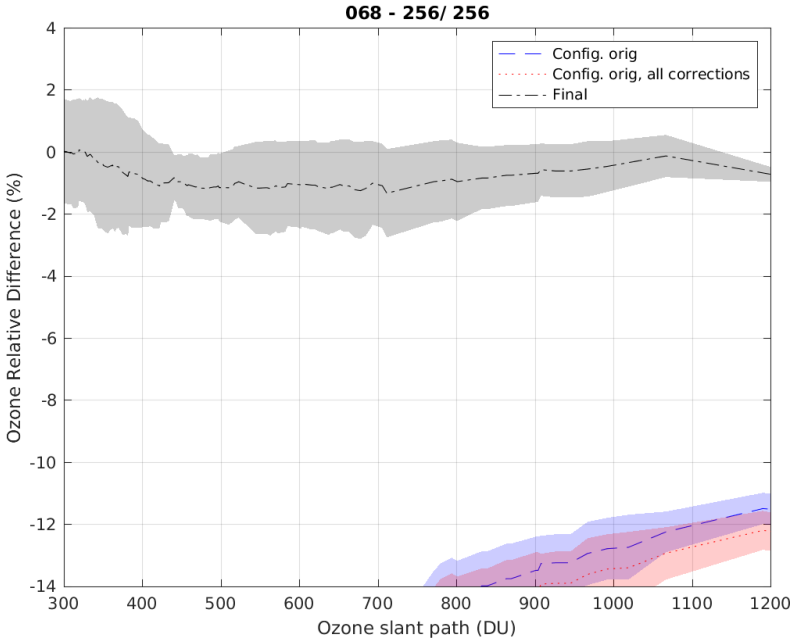


Figure 16-1 – Mean DS ozone column percentage difference between Brewer CFR#068 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

As shown in Fig. 16-1, after the maintenance and using the new calibration, Brewer CFR#068's ozone is within −0.6% with respect to reference Brewer IZO#256. Note the previous calibration produces a much worse comparison.

Being a Mk. IV model, Brewer CFR#068 measurements are affected by stray light. This produces the downward tail at large ozone slant path values shown in Fig. 16-1. However, as show in Fig. 16-2, the comparison with the Mk. III Brewer IZO#256 allows us to correct the effect of the stray light using the method described in [1].

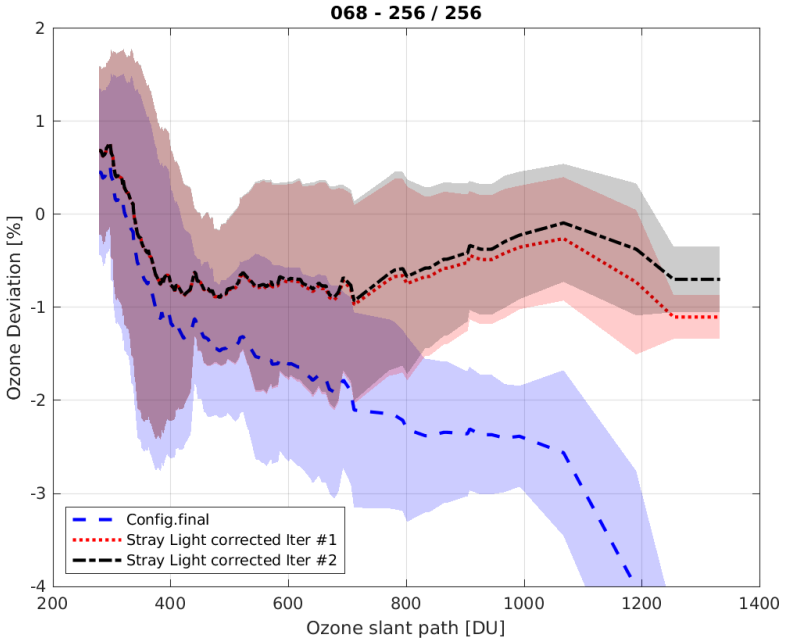


Figure 16-2 – Mean DS ozone column percentage difference between Brewer CFR#068 and Brewer IZO#256, plotted as a function of the ozone slant path. Results for the final (issued in this calibration campaign) configuration are show in blue; the red dotted line corresponds to the same configuration, but with the stray light correction obtained after 1 iteration; the black line corresponds to results obtained after 2 iterations. The shadow areas represent the standard deviation of the mean. The plot corresponds to the final days of the campaign.

16.1.7 Recommendations and Remarks

1. The R6 reference value should be updated to **1582**.
2. We suggest a new R5 reference value of **2972**.
3. According to the dispersion tests performed during the campaign, the ozone absorption coefficient should be updated to **0.34**.
4. For Brewer CFR#068, stray light has an important effect on measurements taken at large ozone slant paths. We suggest applying a stray light correction with parameters $k = a = -\mathbf{86}$, and

$s = b =$**3**.

5. Finally, we suggest updating the ETC value to **2750**.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/068/ICF05324.068

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=79941402#gid=79941402

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/068/html/cal_report_068a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/068/html/cal_report_068a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/068/html/cal_report_068b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/068/html/cal_report_068c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF18316.068)	Final (ICF05324.068)
o3 Temp coef 1	0	0
o3 Temp coef 2	-0.2645	-0.2645
o3 Temp coef 3	-0.8192	-0.8192
o3 Temp coef 4	-1.6676	-1.6676
o3 Temp coef 5	-2.855	-2.855
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3315	0.34
SO2 on SO2 Ratio	2.35	2.76
O3 on SO2 Ratio	1.097	1.1443
ETC on O3 Ratio	3145	2750
ETC on SO2 Ratio	3520	3520
Dead time (sec)	3.5e-08	3.5e-08
WL cal step number	159	159
Slitmask motor delay	78	78
Umkehr Offset	1637	1637
ND filter 0	0	0
ND filter 1	5000	5000
ND filter 2	10000	10000
ND filter 3	15000	15000
ND filter 4	20000	20000
ND filter 5	25000	25000
Zenith steps/rev	2816	2816
Brewer Type	0	0
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	2317	2317
Mic #2 Offset	0	0
O3 FW #3 Offset	244	244
NO2 absn Coeff	-3	-3
NO2 ds etc	677	677
NO2 zs etc	631	631
NO2 Mic #1 Offset	4970	4970
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2653	2653
Grating Slope	0	0
Grating Intercept	0	0
Micrometer Zero	3469	3469
Iris Open Steps	75	75
Buffer Delay (s)	0.8	0.8
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	64	64
Zenith Offset	45	45
Zenith UVB Position	2130	2130

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer CFR#068 using the final calibration (ICF05324.068), and by reference Brewer IZO#256. Fig. 16-4 shows the daily ozone data in detail.

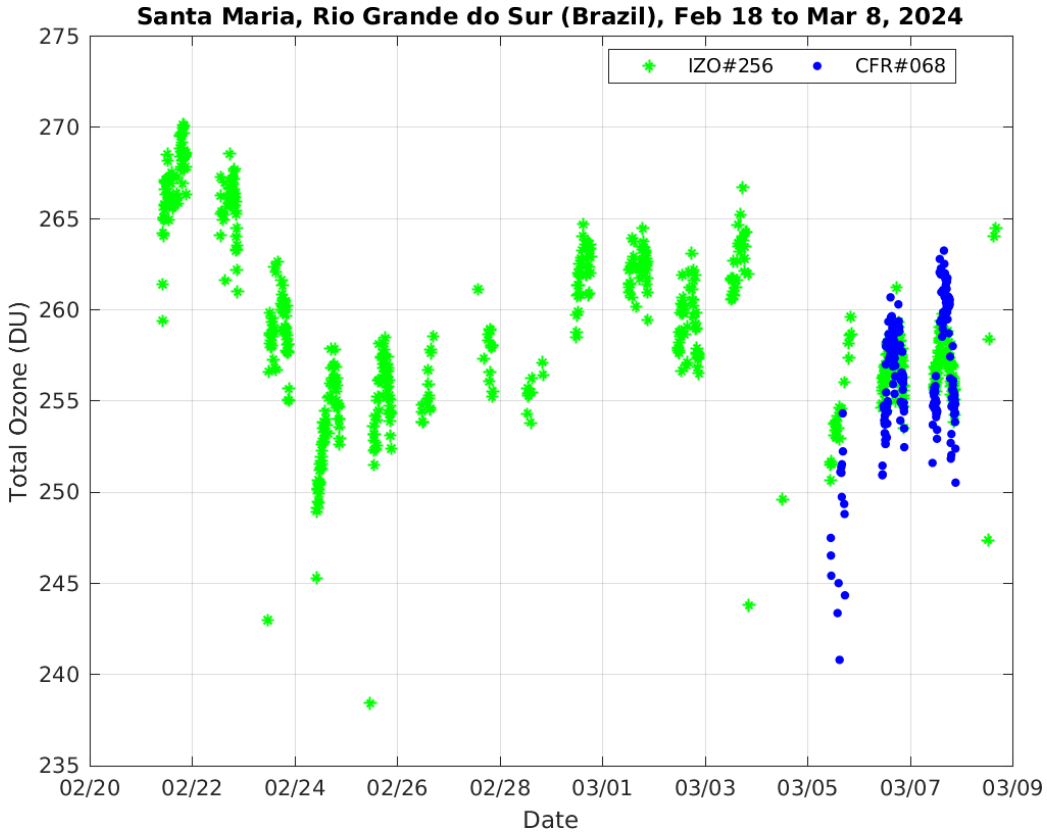
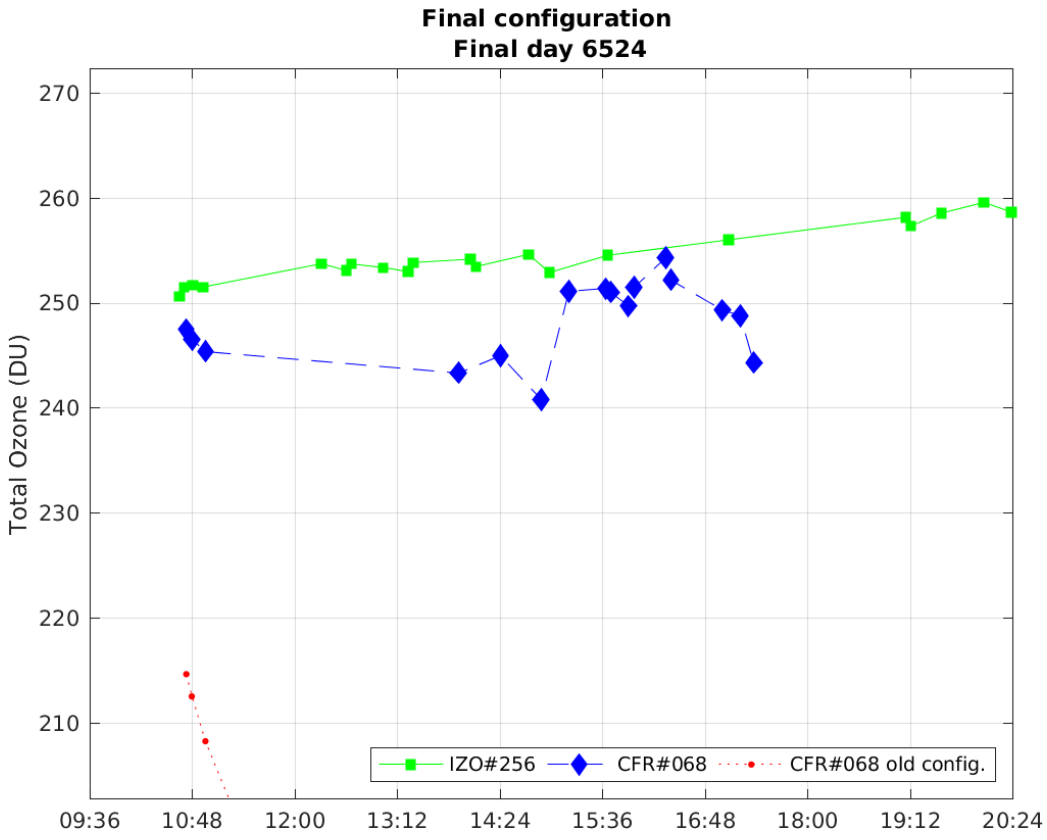
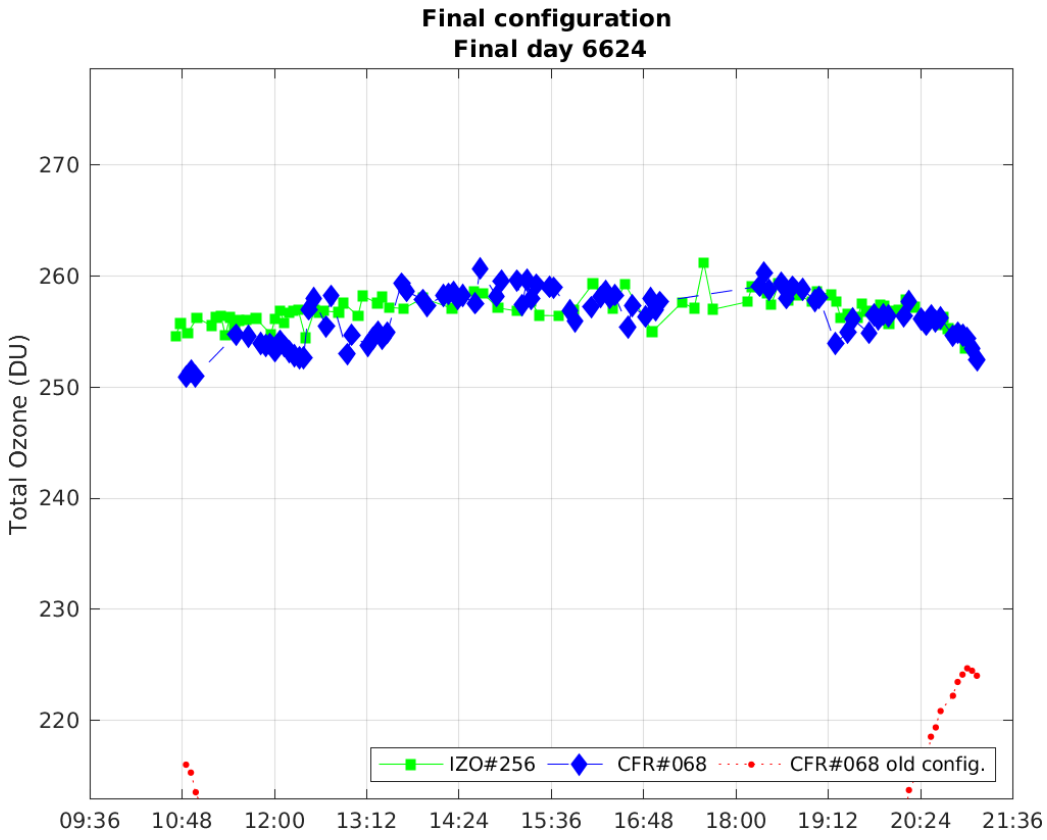


Figure 16-3 – Overview of the intercomparison. For the final days starting on day 65, Brewer CFR#068's data are evaluated using the final constants (blue circles) provided in the ICF05324.068 file.


Final configuration
Final day 6524
Total Ozone (DU)
270
260
250
240
230
220
210
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
IZO#256
CFR#068
CFR#068 old config.


Final configuration
Final day 6624
Total Ozone (DU)
270
260
250
240
230
220
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
21:36
IZO#256
CFR#068
CFR#068 old config.

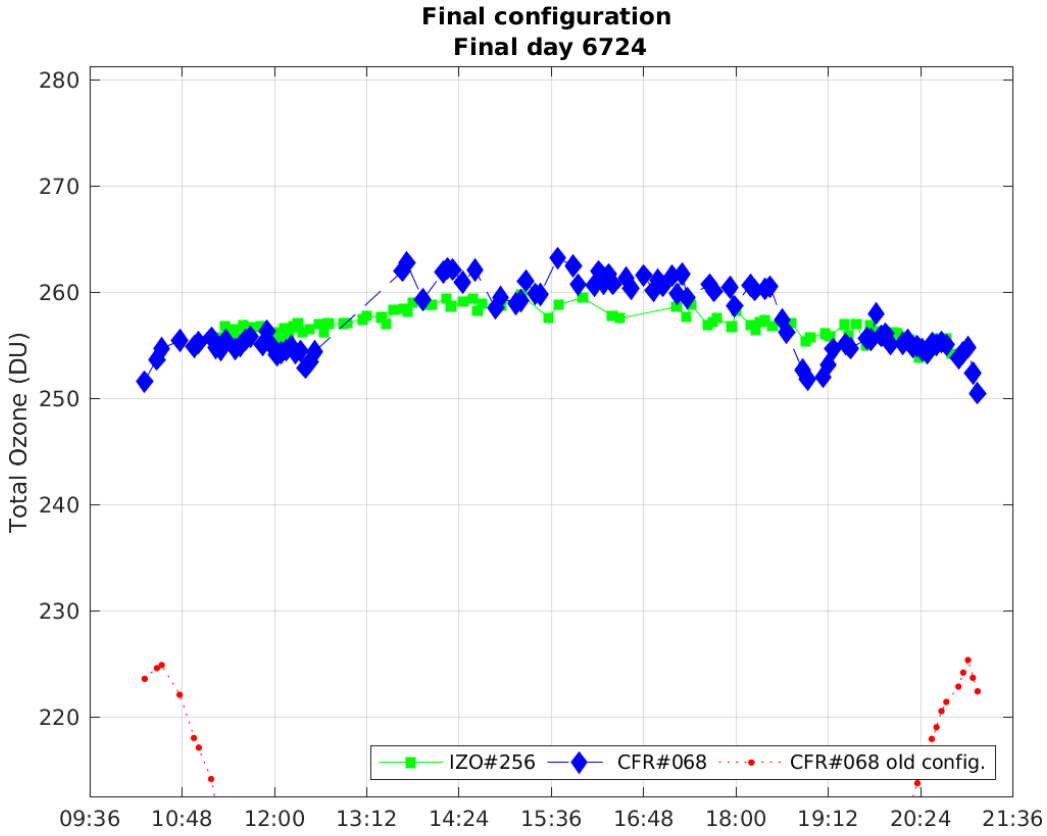


Figure 16-4 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF18316.068, red) and final (ICF05324.068, blue) configurations of Brewer CFR#068, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-5) and R5 (Fig. 16-6) ratios, and the intensity of slit 5 (Fig. 16-7), results of the Run/Stop (Fig. 16-8), Dead Time (Fig. 16-9), and analog voltages and intensity tests (Fig. 16-10), analysis of the temperature coefficient's performance (Figs. 16-11, 16-12, 16-13, and 16-14), evolution of the R6 ratio in the March–July 2024 period (Fig. 16-15), comparison of Brewers #062 and #167 in the March–July 2024 period (Fig. 16-16), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-17), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-18) tests.

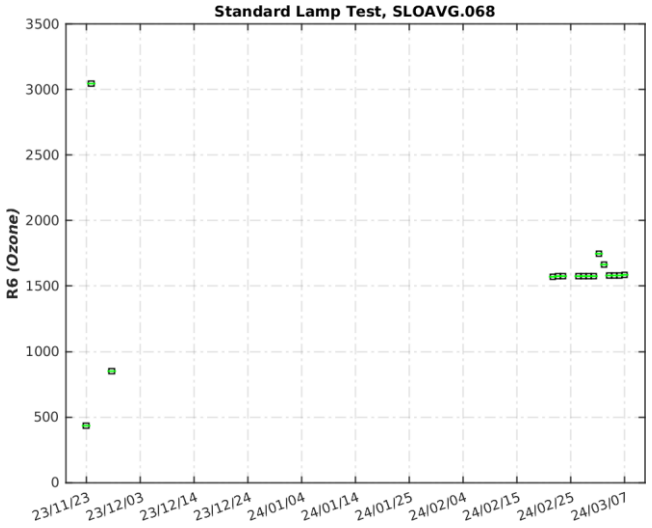


Figure 16-5 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

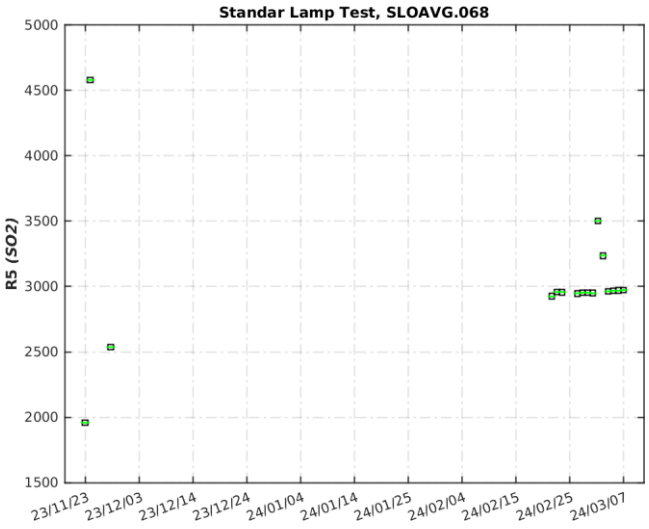


Figure 16-6 – Standard Lamp test R5 (SO_2) ratios

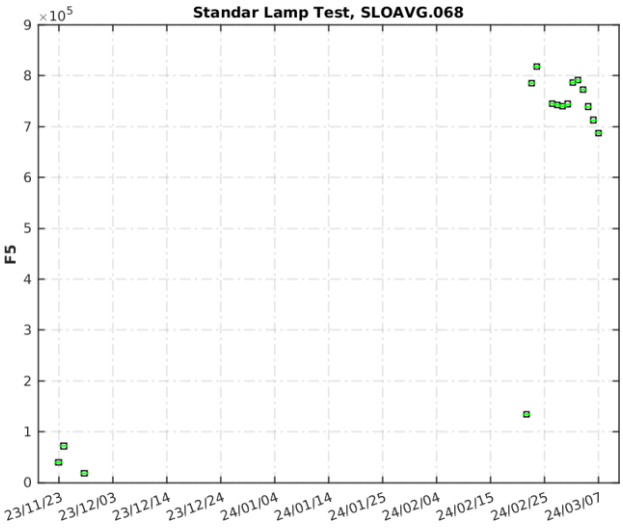


Figure 16-7 – SL intensity for slit five.

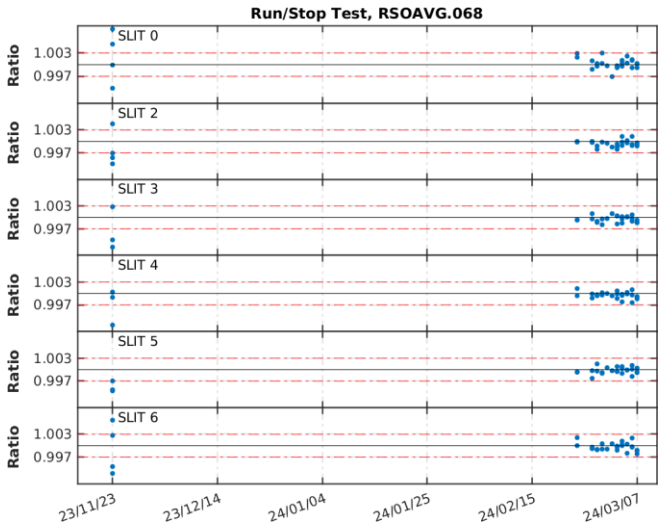


Figure 16-8 – Run/stop test

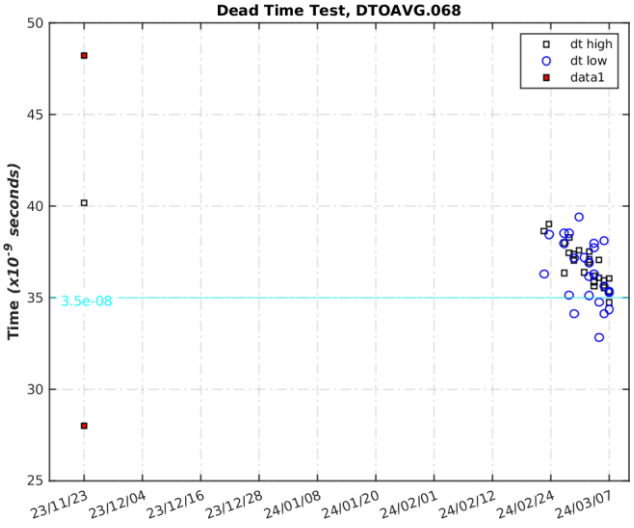


Figure 16-9 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

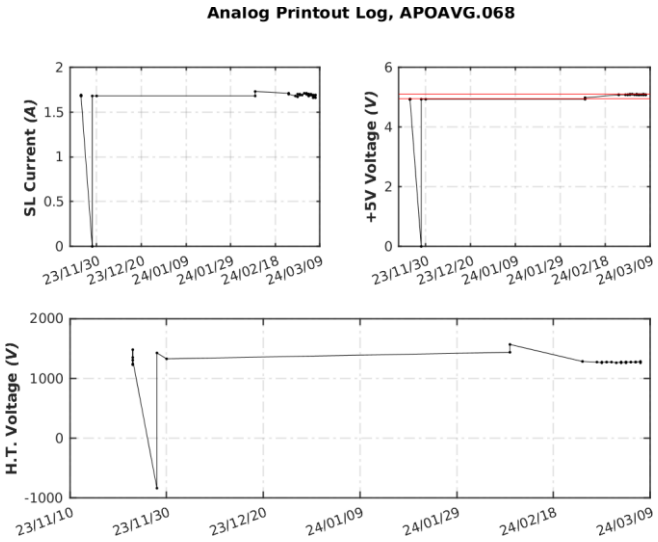


Figure 16-10 – Analog voltages and intensity.

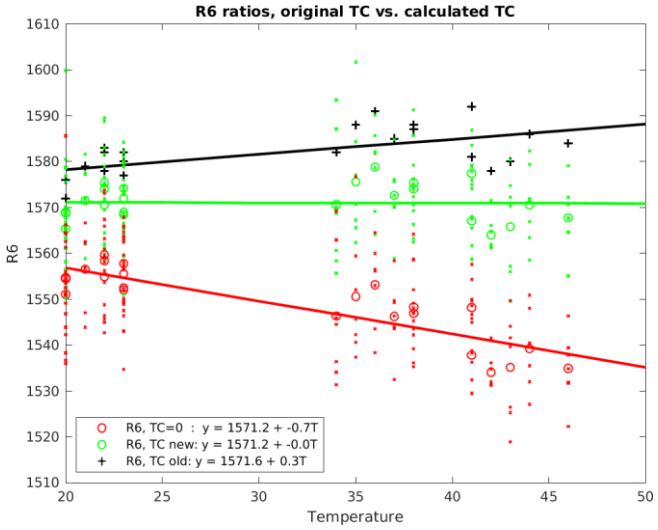


Figure 16-11 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the final days of the present campaign.

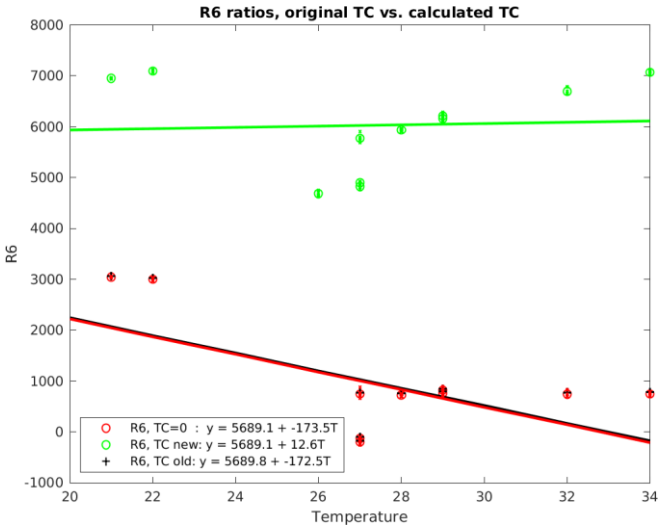


Figure 16-12 – Same as Fig. 16-11 but for all the data available.

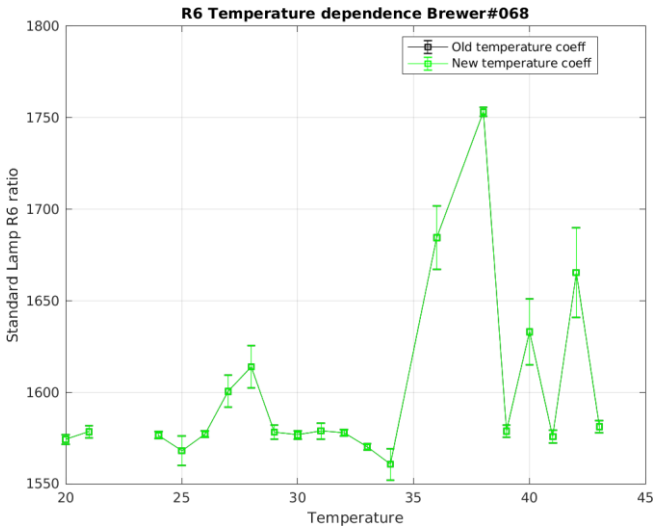


Figure 16-13 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

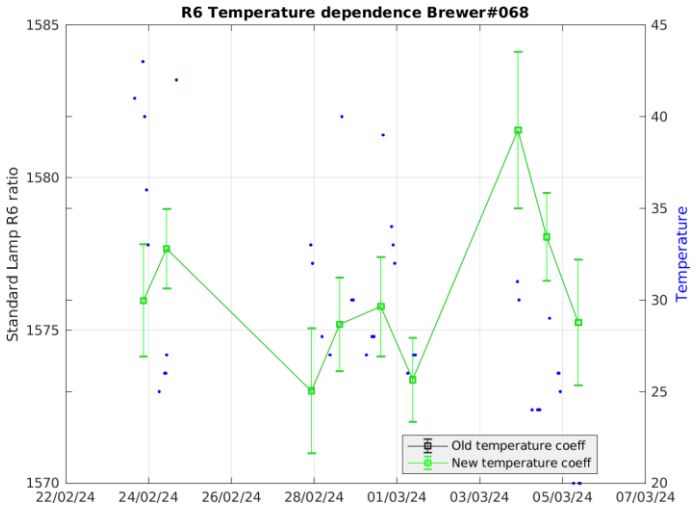


Figure 16-14 – Same as Fig. 16-13, but plotted as a function of the date.

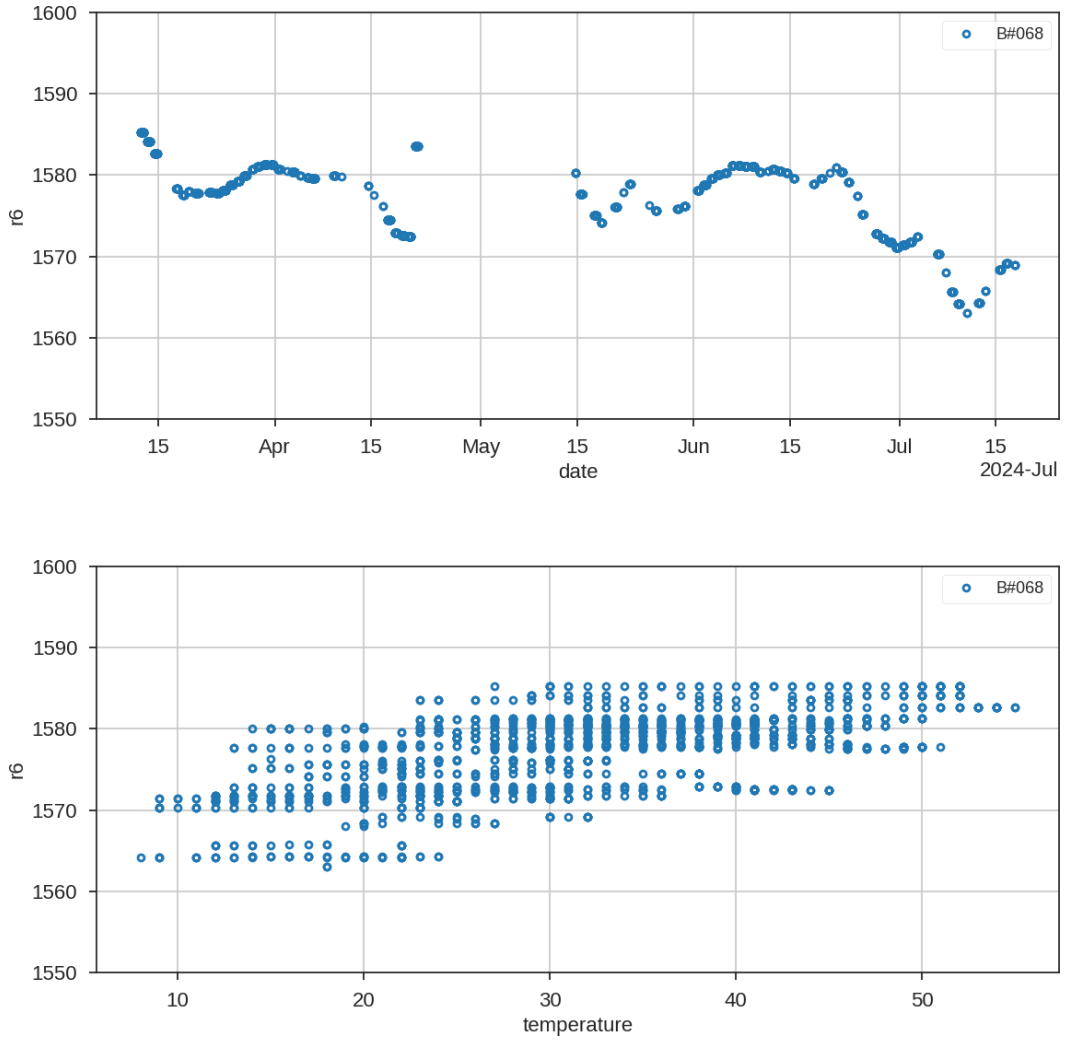


Figure 16-15 – Evolution of the R6 ratio in the after-campaign period from March 9th to July 17th.

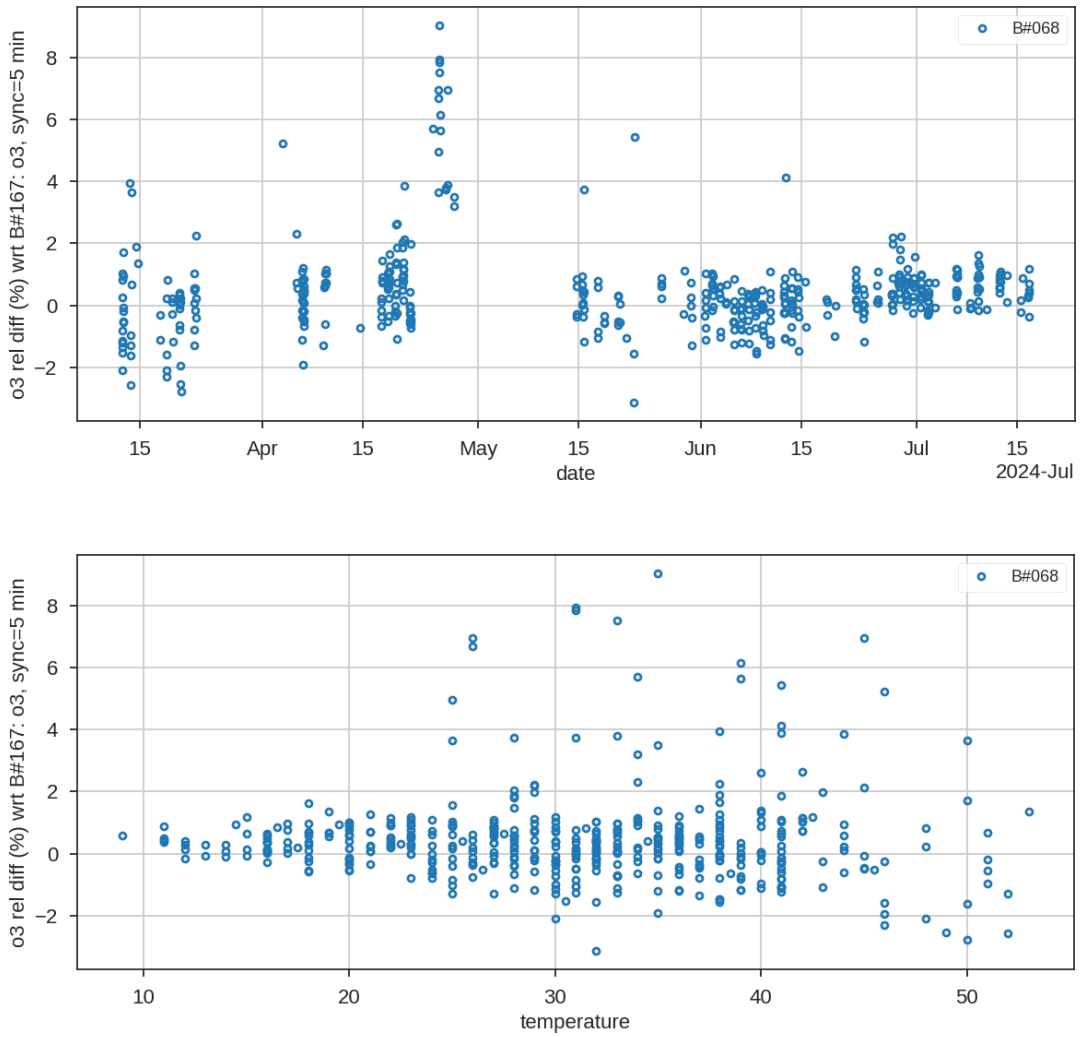


Figure 16-16 – Ozone relative difference between Brewers #068 and #167, in the after-campaign period from March 9th to July 17th.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	5	-7	22	-17	43
ETC Filt. Corr. (mean)	3.2	-2.3	-20.6	-18.2	70.3
ETC Filt. Corr. (mean 95% CI)	[-15 13.4]	[-21.8 13]	[-31.6 -12.7]	[-30.9 -3.8]	[-31.1 178.9]

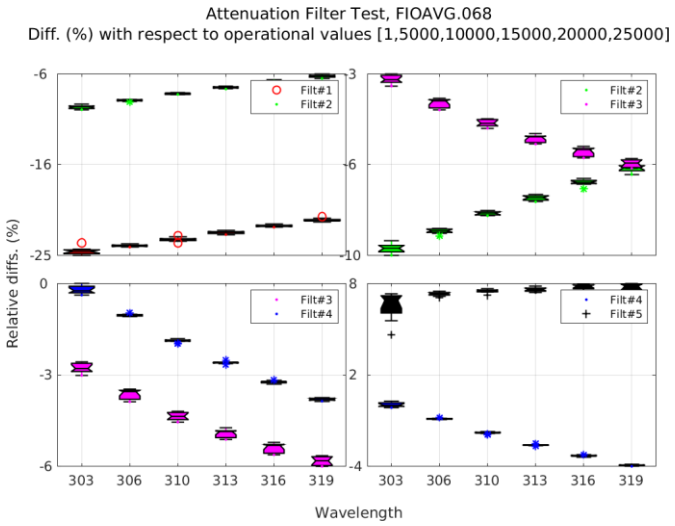


Figure 16-17 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	159	0.3315	2.3500	1.0970
25-Feb-2001	159	0.3400	2.7564	1.1443
26-Feb-2001	159	0.3400	2.7564	1.1443
05-Mar-2024	159	0.3398	2.7053	1.1464
10-Dec-1997	159	0.3417	2.7214	1.1505
11-Dec-1997	NaN	NaN	NaN	NaN
12-Dec-1997	159	0.3416	2.7133	1.1507
Final	159	0.3400	2.7600	1.1443

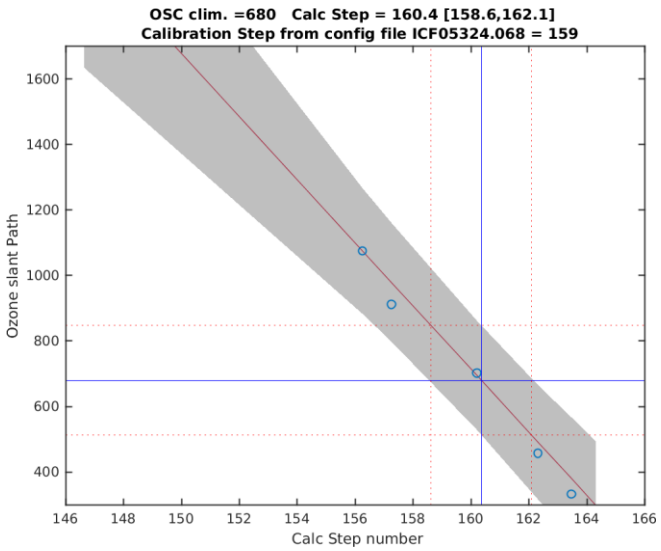


Figure 16-18 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16.5 References

[1] Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018.

16 Brewer NAT#073

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 19th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer NAT#073 participated in the campaign in the period from February 19th to March 8th, 2024. The campaign days of Brewer NAT#073 correspond to Julian days 50 to 68.

Close to it's date of arrival, on day 53, large maintenance operations were performed on Brewer NAT#073. There are no blind days no evaluate the initial status of this Brewer, which can be considered a new instrument. Problems after maintenance and bad weather leaves us with **122** simultaneous DS ozone measurements, taken from day **61** to **68**, to calibrate this instrument (Fig. 16-1)

16.1.1 Instrument's history and stability

There is no data from the last 2-3 years before this campaign, so we can't evaluate the status of Brewer NAT#073 in recent times.

16.1.2 Maintenance

IOS performed maintenance on the instrument on day 53. Maintenance work included the installation of new lid and entrance window gaskets, replacement of the entire UV dome, installation of a new UV filter, setting up new Hg and Standard lamps, new nylon wheel for filter wheels 1 and 3, installation of a new humidity sensor, and replacement of some ribbon cables and the sighting buttons.

16.1.3 Instrumental parameters during the campaign

After the maintenance by IOS, the instrument was found to be operating mostly within specifications. The RS tests show some values out of bounds, but the results are otherwise correct (Figure 16-8). DT tests show stable values, although at 43 ns the dt value is quite different from that of the previous calibration, 36 ns (Fig. 16-9). The analog tests on the power supplies are mostly correct (Fig. 16-10).

The Standard lamp was replaced during maintenance, but seems to have stabilized by the end of the campaign, the R6 and R5 ratios having values of approx. **1620** and **3160**, respectively (Figs. 16-5 and 16-6).

16.1.4 Temperature dependence and filters

Brewer NAT#073 shows a noticeable but acceptable temperature dependence (Fig. 16-11). More data will be necessary to recommend new temperature coefficients.

FIOAVG results show large changes when switching to filter #3 and #4 (Table 16-2). Although FIOAVG data is usually noisy and unreliable, the comparison with the reference Brewer improves appliying an ETC filter correction of 20 units for filter #3.

16.1.5 Sun scan and dispersion tests

Sun scan tests carried out during the campaign confirm the current cal step, nan(Fig. 16-15)

Dispersion tests during the campaign return quite a different ozone absorption coefficient, 0.3397, compared the one currenly in use, 0.3402. We recommend the adoption of the new coefficient.

16.1.6 ETC transfer

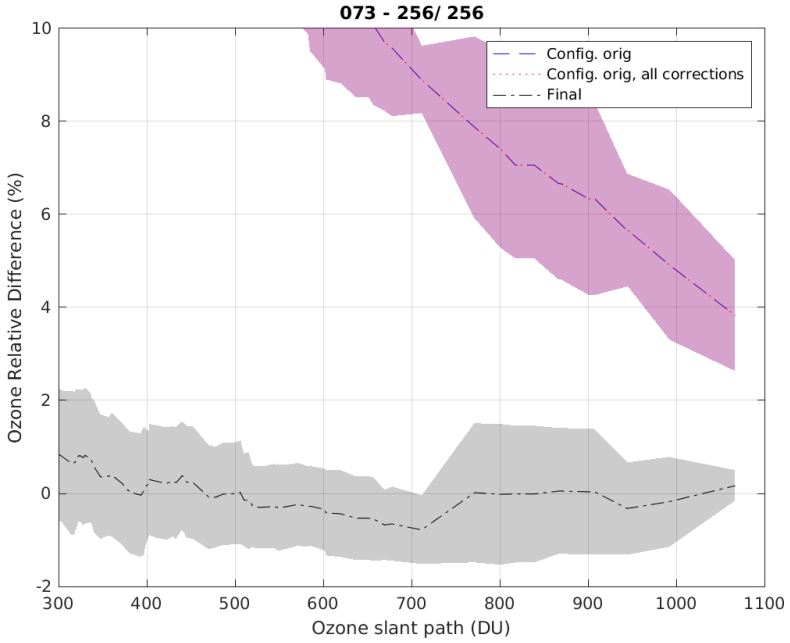


Figure 16-1 – Mean DS ozone column percentage difference between Brewer NAT#073 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

As shown in Fig. 16-1, after the maintenance and using the new calibration, Brewer NAT#073's ozone is within 0.2% with respect to reference Brewer IZO#256.

Being a Mk. IV model, Brewer NAT#073 measurements are affected by stray light. This produces the downward tail at large ozone slant path values shown in Fig. 16-1. However, as show in Fig. 16-2, the comparison with the Mk. III Brewer IZO#256 allows us to correct the effect of the stray light using the method described in [1].

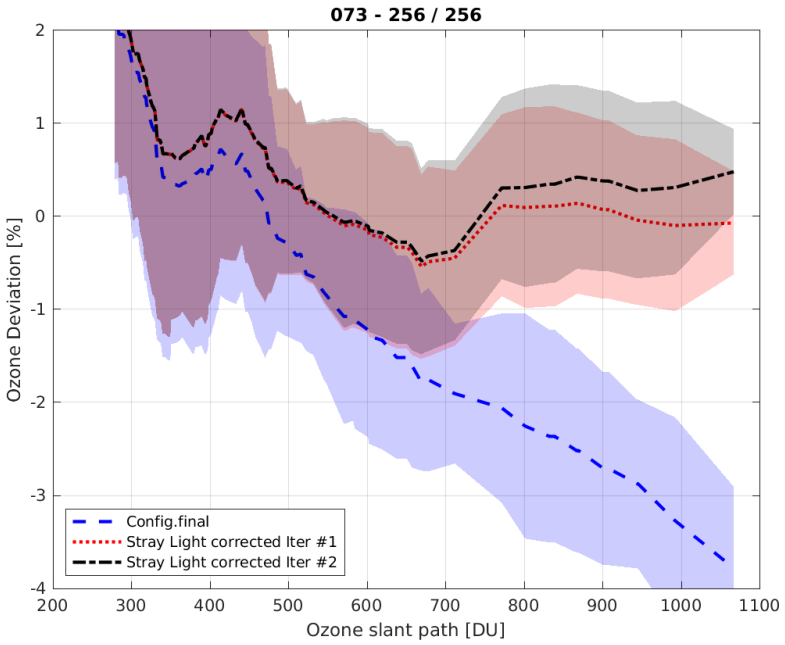


Figure 16-2 – Mean DS ozone column percentage difference between Brewer NAT#073 and Brewer IZO#256, plotted as a function of the ozone slant path. Results for the final (issued in this calibration campaign) configuration are show in blue; the red dotted line corresponds to the same configuration, but with the stray light correction obtained after 1 iteration; the black line corresponds to results obtained after 2 iterations. The shadow areas represent the standard deviation of the mean. The plot corresponds to the final days of the campaign.

16.1.7 Recommendations and Remarks

1. The R6 reference value shuld be updated to **1620**.
2. We suggest a new R5 reference value of **3160**.
3. We suggest updating the DT to **4.3·10**$^{-8}$ seconds, which is 7 units more than the value in the last calibration. This is a large change, so perodic DT checks are recommended.
4. We suggest the application of an ETC correction of **20 units for filter#3**.
5. For Brewer NAT#073, stray light has an important effect on measurements taken at large ozone slant paths. We suggest applying a stray light correction with parameters $k = a =$**-134**, and $s = b =$**4.77**.
6. Finally, we suggest updating the ETC value to **2705**.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/073/ICF06624.073

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=739701381#gid=739701381

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/073/html/cal_report_073a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/073/html/cal_report_073a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/073/html/cal_report_073b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/073/html/cal_report_073c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF33509.073)	Final (ICF06624.073)
o3 Temp coef 1	0	0
o3 Temp coef 2	0.8274	0.8274
o3 Temp coef 3	0.8908	0.8908
o3 Temp coef 4	1.1514	1.1514
o3 Temp coef 5	-0.1014	-0.1014
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3402	0.3397
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.1423	1.1423
ETC on O3 Ratio	2435	2705
ETC on SO2 Ratio	2000	2000
Dead time (sec)	3.6e-08	4.3e-08
WL cal step number	164	164
Slitmask motor delay	76	76
Umkehr Offset	1648	1648
ND filter 0	0	0
ND filter 1	5000	5000
ND filter 2	10000	10000
ND filter 3	15000	15000
ND filter 4	20000	20000
ND filter 5	25000	25000
Zenith steps/rev	2816	2816
Brewer Type	0	0
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	2120	2120
Mic #2 Offset	0	0
O3 FW #3 Offset	245	245
NO2 absn Coeff	-3	-3
NO2 ds etc	620	620
NO2 zs etc	640	640
NO2 Mic #1 Offset	4782	4782
NO2 FW #3 Offset	181	181
NO2/O3 Mode Change	2672	2672
Grating Slope	0	0
Grating Intercept	0	0
Micrometer Zero	3469	3469
Iris Open Steps	75	75
Buffer Delay (s)	0.5	0.5
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	64	64
Zenith Offset	40	40
Zenith UVB Position	2118	2118

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer NAT#073 using the final calibration (ICF06624.073), and by reference Brewer IZO#256. Fig. 16-4 shows the daily ozone data in detail.

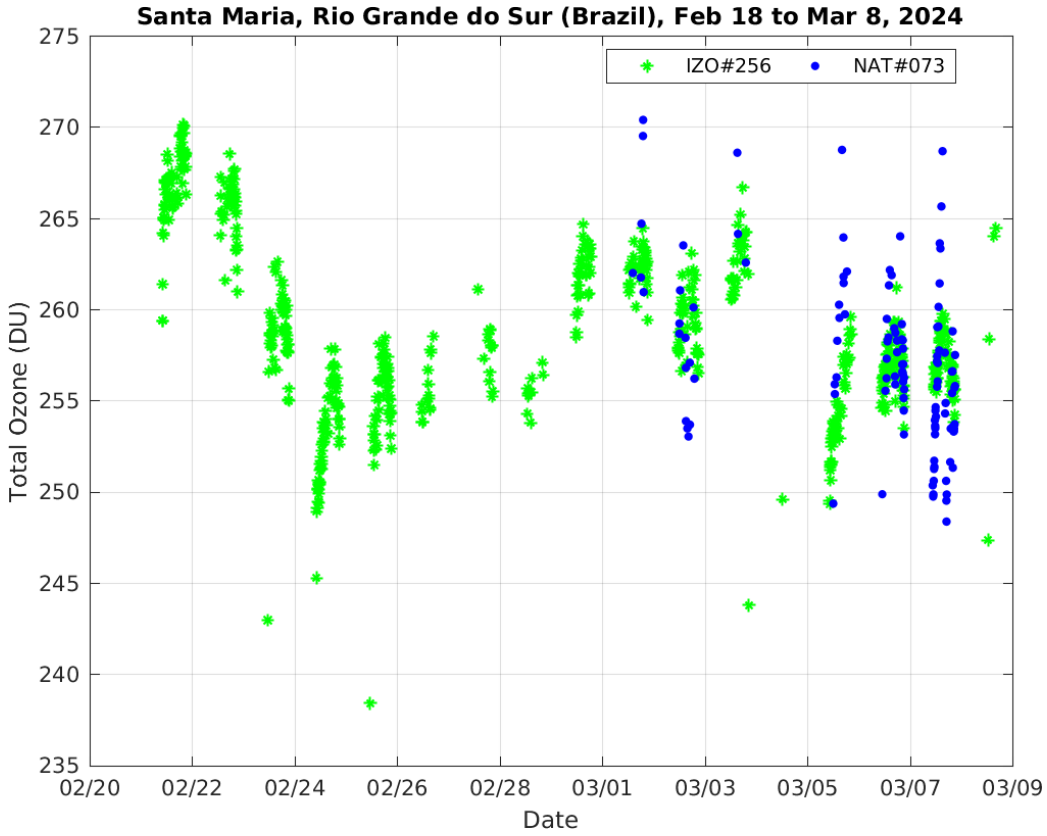
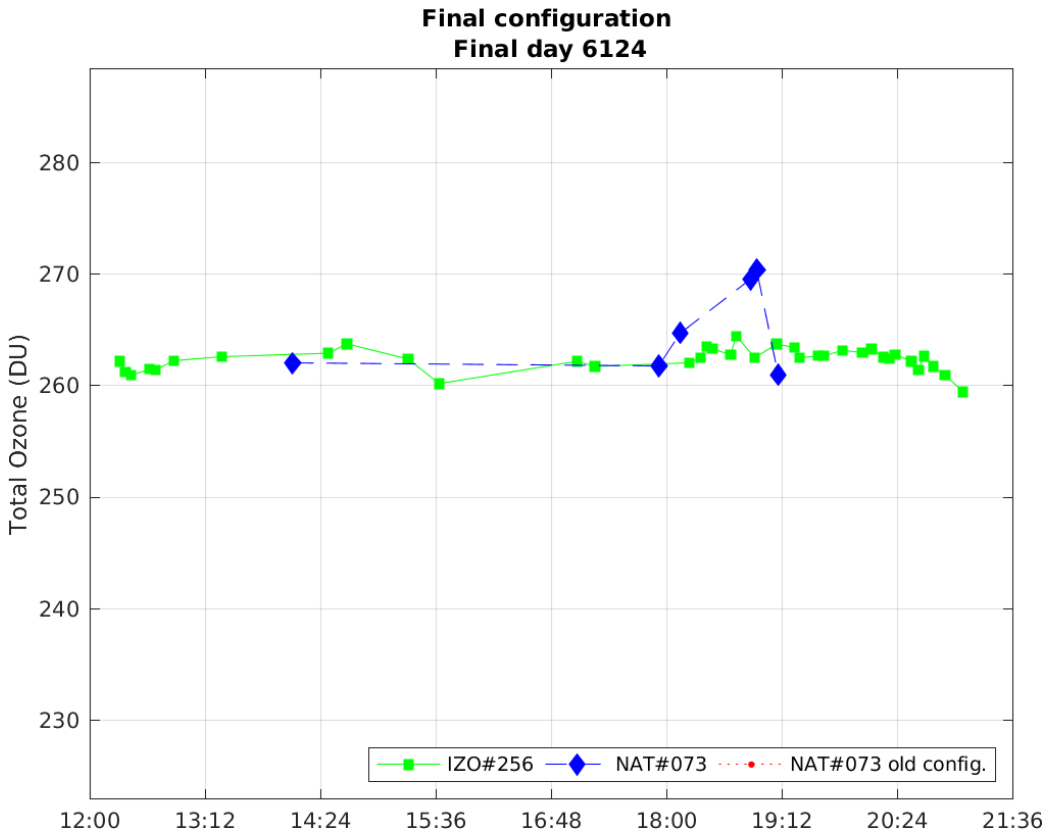
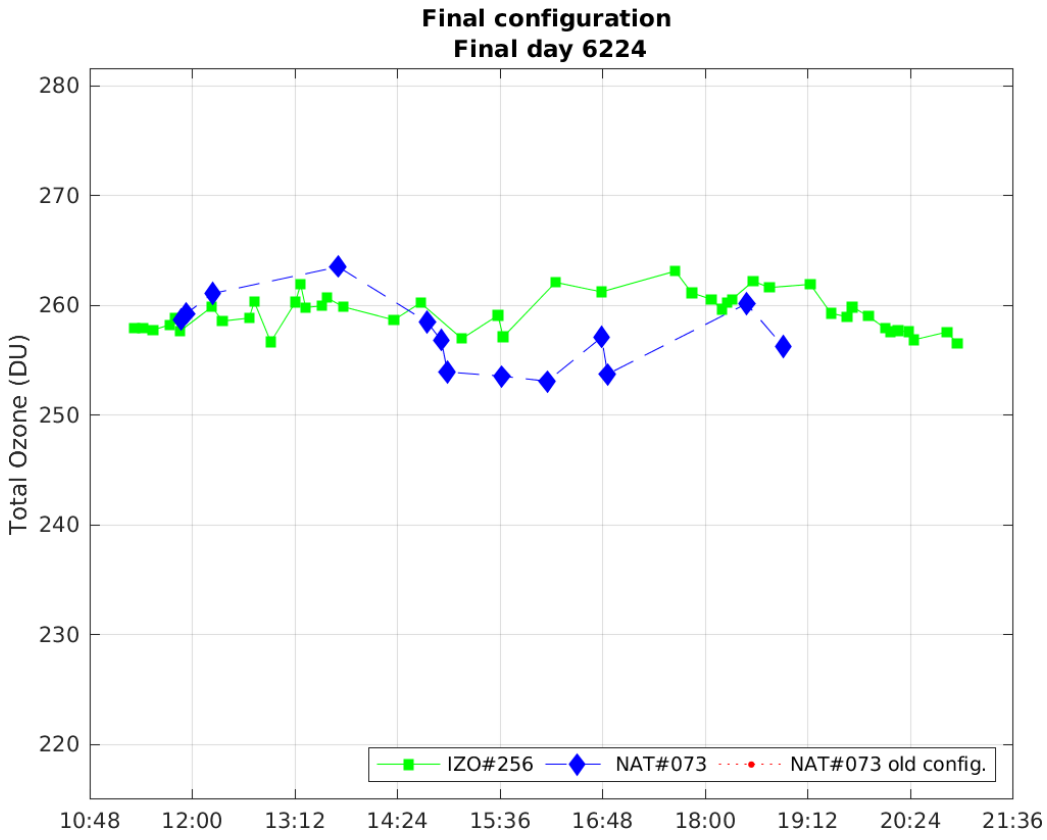
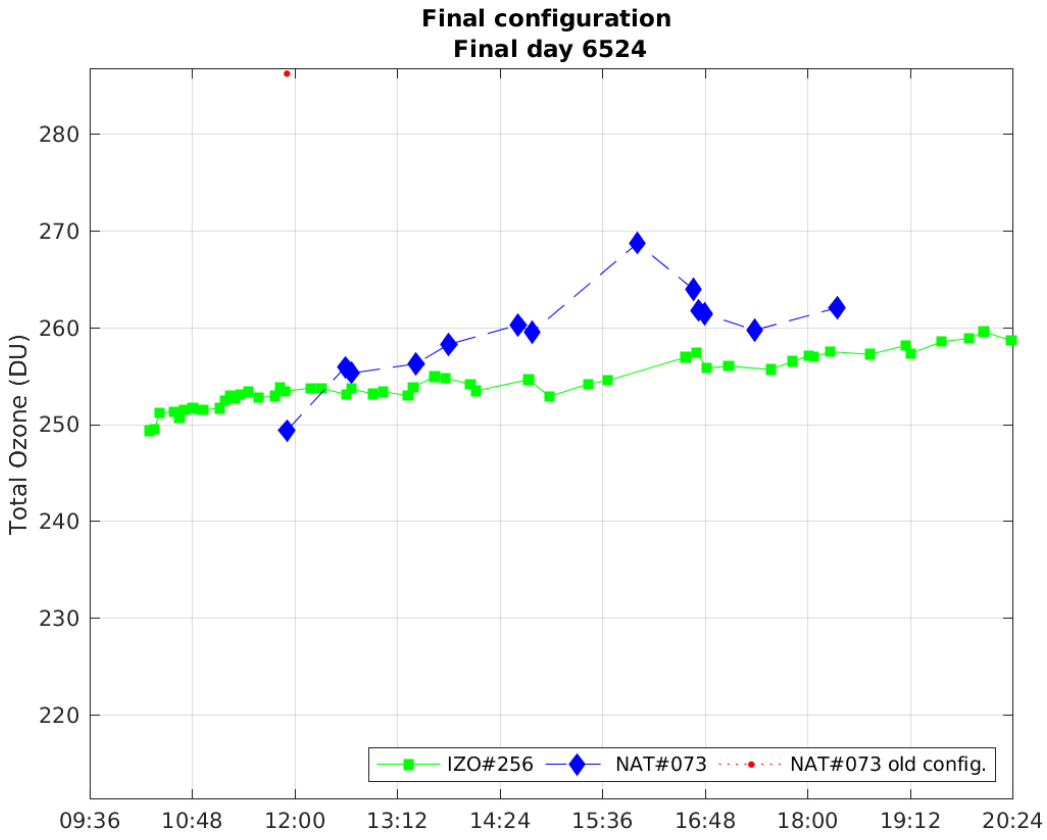
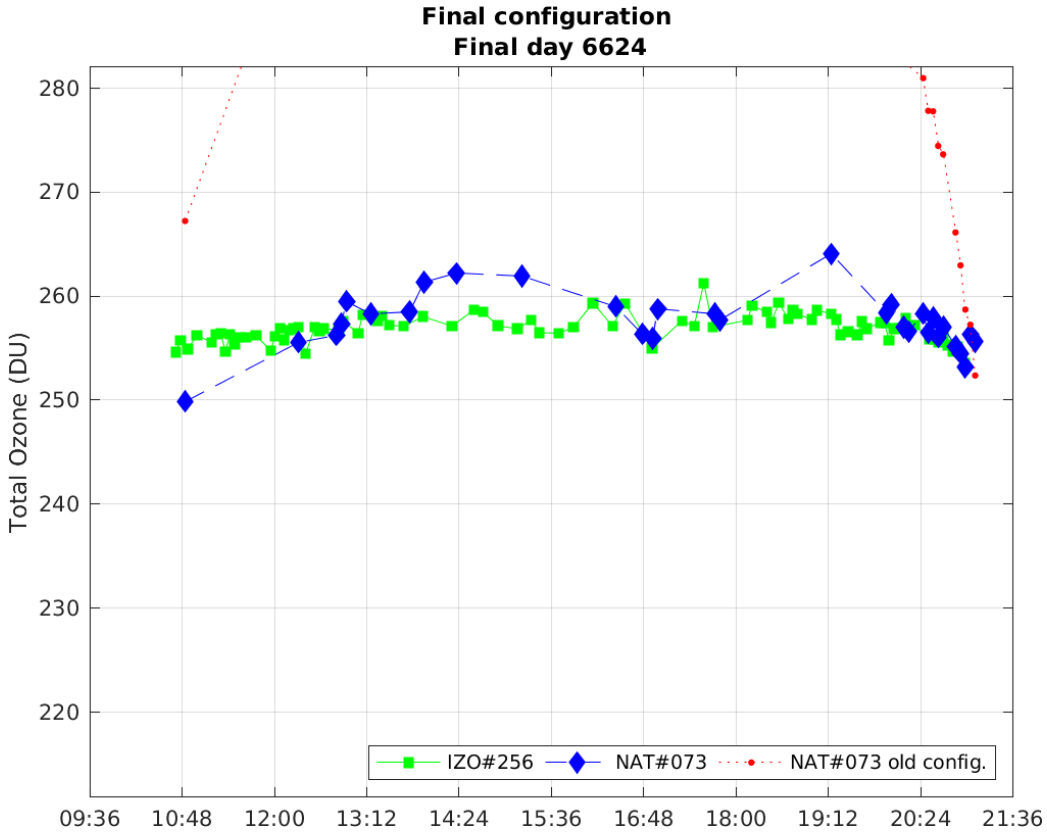


Figure 16-3 – Overview of the intercomparison. For the final days starting on day 61, Brewer NAT#073's data are evaluated using the final constants (blue circles) provided in the ICF06624.073 file.


Final configuration
Final day 6124
Total Ozone (DU)
280
270
260
250
240
230
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
21:36
IZO#256
NAT#073
NAT#073 old config.


Final configuration
Final day 6224
Total Ozone (DU)
280
270
260
250
240
230
220
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
21:36
IZO#256
NAT#073
NAT#073 old config.


Final configuration
Final day 6524
Total Ozone (DU)
280
270
260
250
240
230
220
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
IZO#256
NAT#073
NAT#073 old config.



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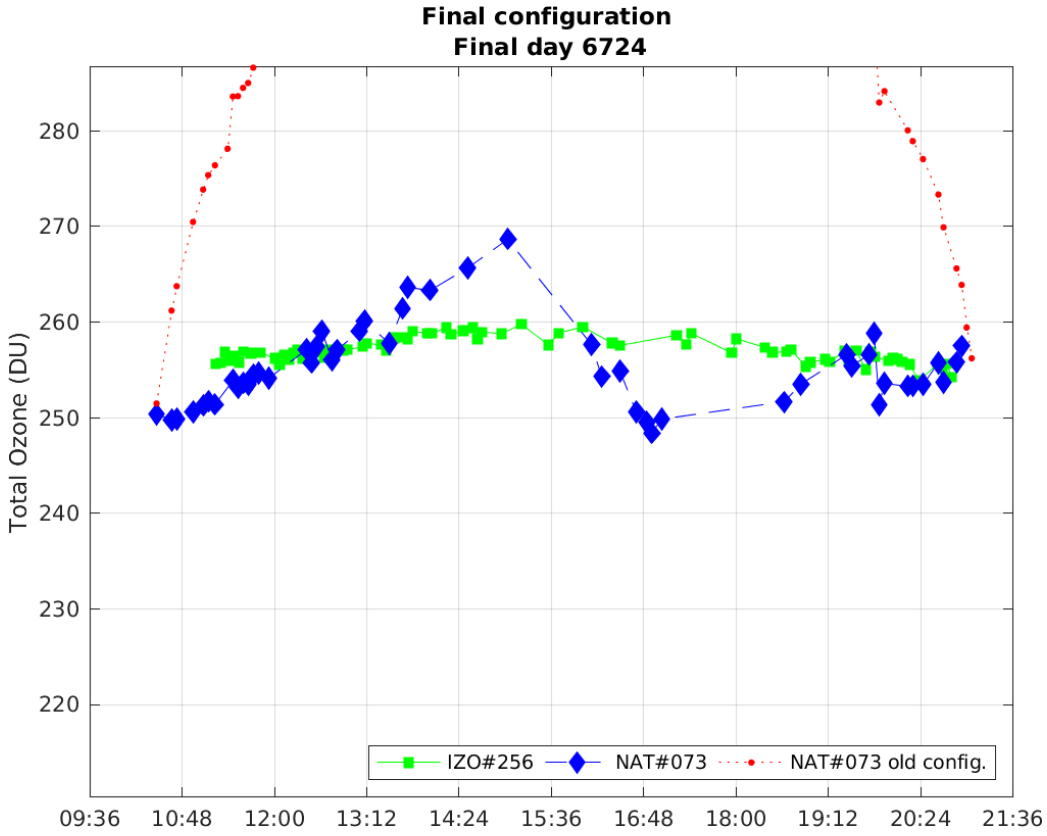


Figure 16-4 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF33509.073, red) and final (ICF06624.073, blue) configurations of Brewer NAT#073, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-5) and R5 (Fig. 16-6) ratios, and the intensity of slit 5 (Fig. 16-7), results of the Run/Stop (Fig. 16-8), Dead Time (Fig. 16-9), analog voltages and intensity tests (Fig. 16-10), analysis of the temperature coefficient's performance (Figs. 16-11, 16-12, and 16-13), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-14), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-15) tests.

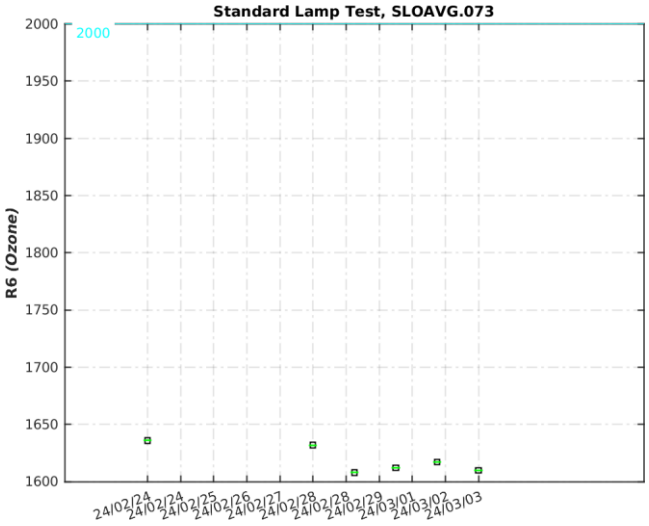


Figure 16-5 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

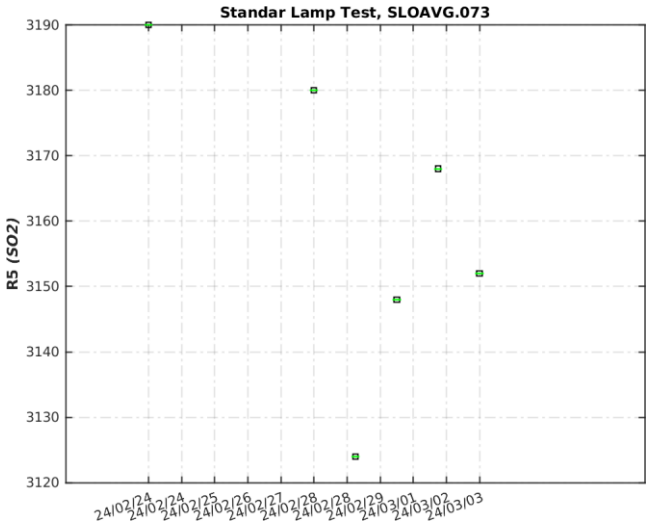


Figure 16-6 – Standard Lamp test R5 (SO_2) ratios

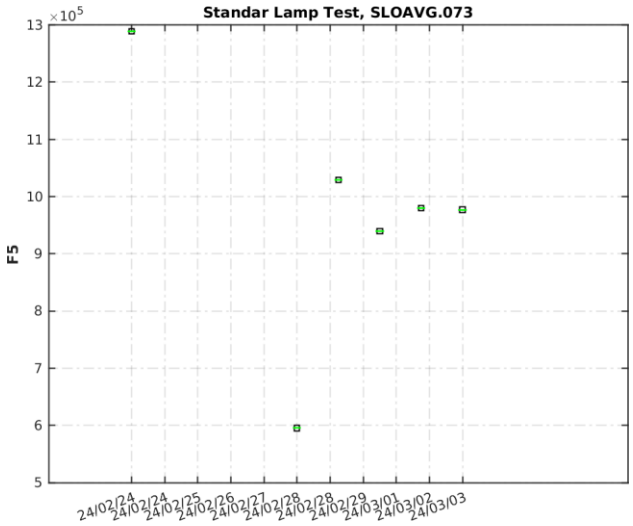


Figure 16-7 – SL intensity for slit five.

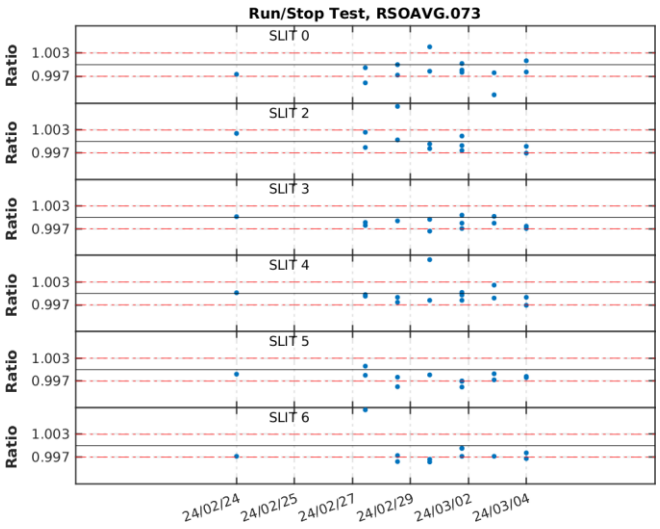


Figure 16-8 – Run/stop test

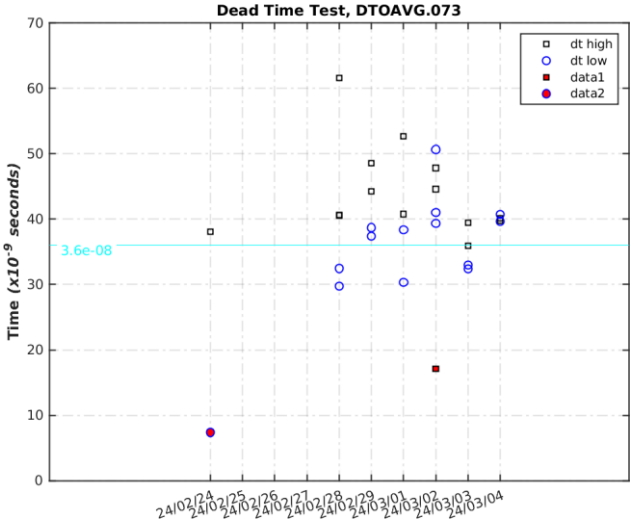


Figure 16-9 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

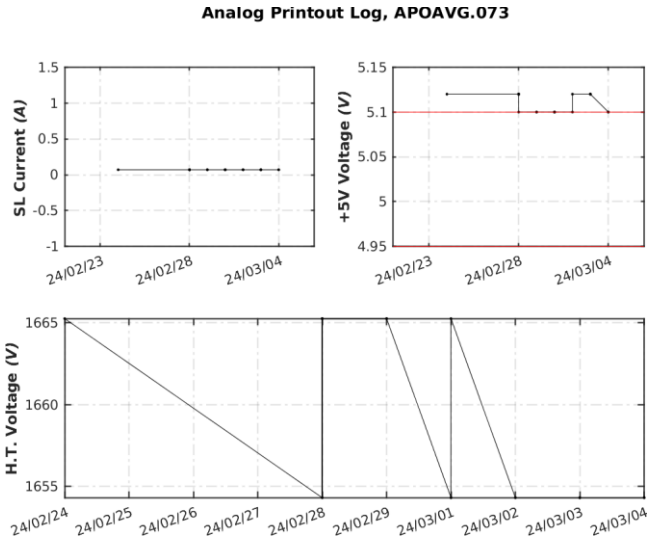


Figure 16-10 – Analog voltages and intensity.

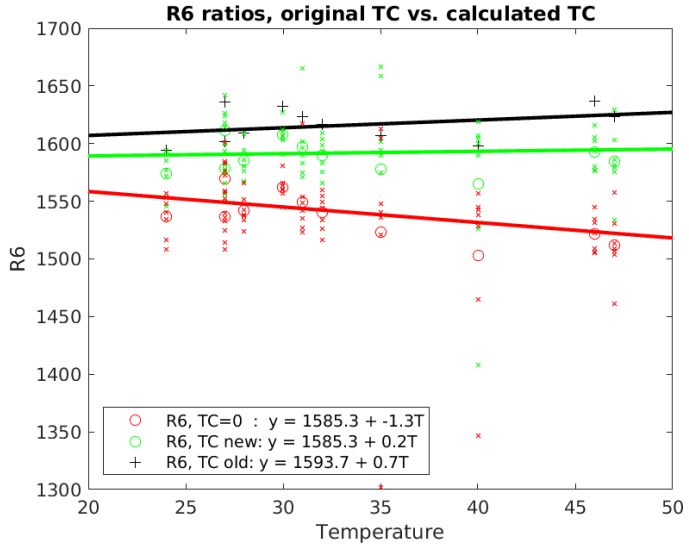


Figure 16-11 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

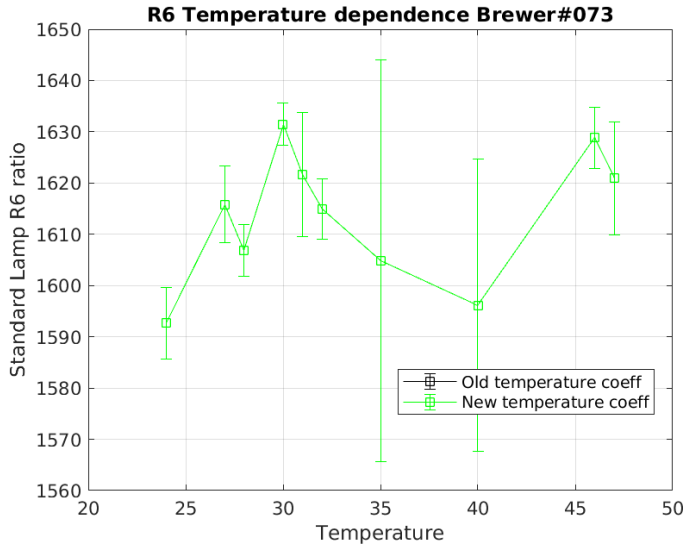


Figure 16-12 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

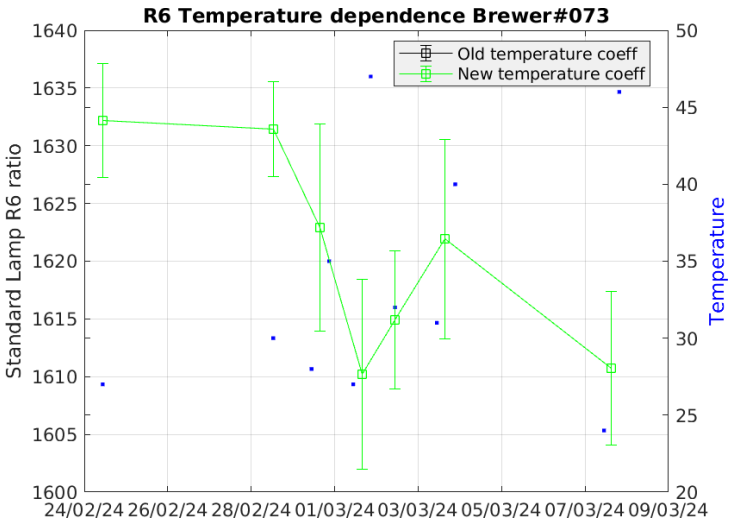


Figure 16-13 – Same as Fig. 16-12, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	-3	1	-48	-25	15
ETC Filt. Corr. (mean)	-1.9	-0.6	-32.9	-22.2	34.9
ETC Filt. Corr. (mean 95% CI)	[-17.4 19.8]	[-17.8 23.5]	[-125.8 0]	[-43.2 -4.3]	[-83.9 87.5]

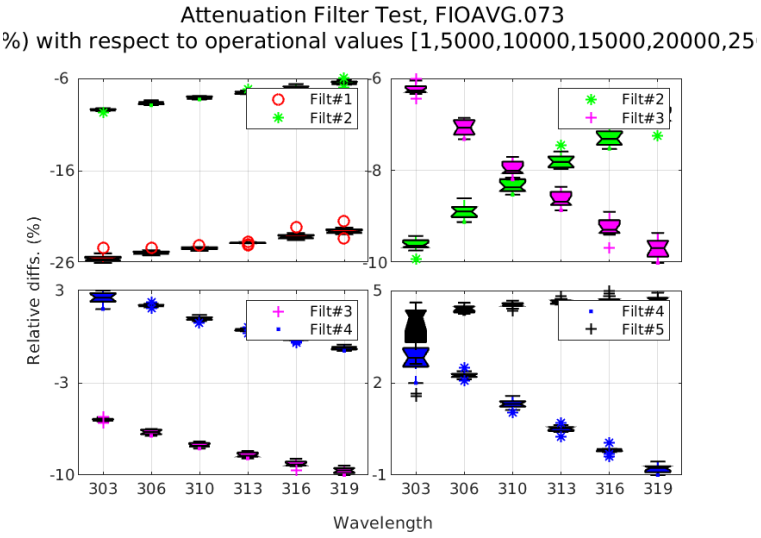


Figure 16-14 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	164	0.3402	2.3500	1.1423
27-Oct-2000	NaN	NaN	NaN	NaN
31-May-2004	164	0.3402	2.8164	1.1424
05-Dec-2007	164	0.3418	2.8151	1.1466
29-Feb-2024	164	0.3397	2.7866	1.1412
19-Dec-1996	164	0.3383	2.8754	1.1333
Final	164	0.3397	2.3500	1.1423

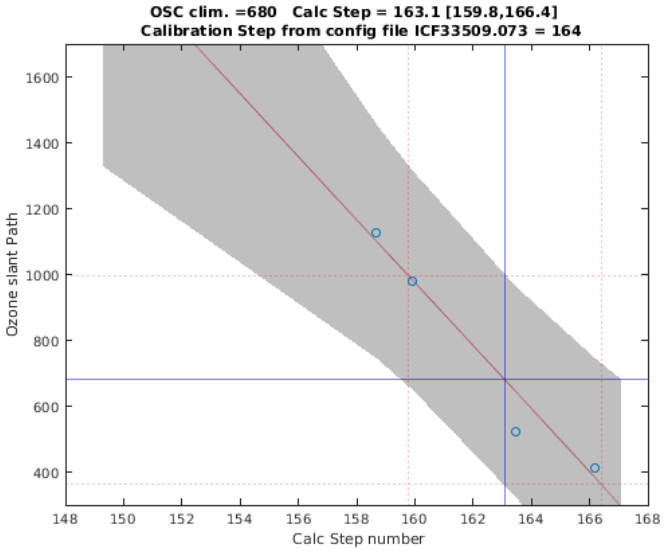


Figure 16-15 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16.5 References

[1] Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018.

16 Brewer SJC#081

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer SJC#081 participated in the regular campaign period from February 19th to March 8th. During this period, the instrument received extensive maintenance (see below) and that, together with the general bad weather conditions experienced during the campaign, left few days for the measurements needed to transfer the calibration from the reference instrument of the RBCC-E, Brewer #256. However, Brewer #081 stayed at Santa Mar´ıa after the campaign finished, and was operating normally from June 5th to June 27th together with Brewer #167. Since Brewer #167 was successfully calibrated during the regular campaign days, we have transferred its calibration to Brewer #081 using the data from June. The campaign days of Brewer SJC#081 thus extend from February 19th to June 27th, and we have used **119** simultaneous DS ozone measurements taken from day **157** to **179** to calibrate the instrument by transfer from Brewer #167 (Fig. 16-1)

16.1.1 Instrument's history and stability

Instrument's data in the years immediately before the present campaign are scarce. Brewer SJC#081 also received extensive maintenance during the campaign, so it can be considered a new instrument. This is highlighted by the comparison of the data during June using the pre-campaign configuration (blue and red lines in Fig. 16-1), which shows a large difference with Brewer #167, not matter the SL correction is applied (red line) or not (blue).

16.1.2 Maintenance

Extensive maintenance was carried out by IOS on February 23rd, and included the replacement of the lid and entrance window gaskets, new Hg and Standard (Quartz) lamps, a new UV filter, maintenance to the filter wheel motor and micrometers, new counter and clock boards, and the installation of a new humidity sensor.

16.1.3 Instrumental parameters during the campaign

After the maintenance, the standard lamp data is not stable, with noticeable drops in R6 and R5 by early June (Figs. 16-5 and 16-6). The intensity of the SL also shows some changes (Fig. 16-7), so the changes might be related to the lamp rather than to the instrument. The RS and, specially, the DT tests, which also use the standard lamp, show some noise (Figs. 16-8 and 16-9), so the problem might indeed be the lamp. Nevertheless, the SL ratios stabilized around values **1630** and **3100** for R6 and R5 respectively.

Another possible source of unstability is the power supply: as shown in Fig. 16-10, the HT voltage is noisy, and the +5V is slightly above the upper tolerance limit.

The behaviour of the filter wheel is also suspect: in June, all the measurements were taken at the same filter position (#0), something that was not happening before and that does not happen to the co-located Brewer #167 (Fig. 16-15)

16.1.4 Temperature dependence and filters

Brewer SJC#081 seems to feature a noticeable temperature dependence, see Fig. 16-11. However, since the SL data is in doubt, we have elected not change the temperature coefficients at this time.

The data from the FIOAVG tests during the campaign shows a noticeable non-linearity. However, FIOAVG data are usually noisy and, as mentioned above, all the data from Brewer #081 in June was measured with the filter wheel in position 0, so we can't check the effect of the filter changes on the ozone. Regardless, the behaviour of the filter wheel is highly unusual.

16.1.5 Sun scan and dispersion tests

Data from the sun-scan tests (SC) is scarce, but seems to confirm the current cal step, nan.

Likewise, the dispersion tests during the campaign confirm the ozone absorption coefficient to within 0.001 of the current value, 0.3416.

16.1.6 ETC transfer

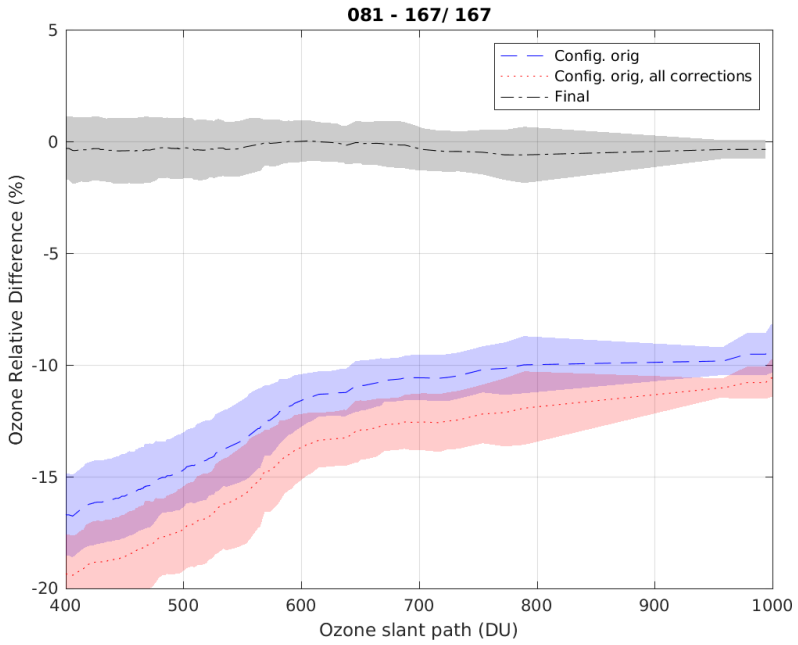


Figure 16-1 – Mean DS ozone column percentage difference between Brewer SJC#081 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

As shown in Fig. 16-1, after the maintenance and using the new calibration, Brewer SJC#081's ozone is within −0.3% with respect to reference Brewer IZO#256.

Being a Mk. IV model, Brewer SJC#081 measurements are affected by stray light. This produces the downward tail at large ozone slant path values (blue line in Fig. 16-2). However, the comparison with the Mk. III Brewer #167 allows us to correct the effect of the stray light using the method described in [1] (black line in Fig. 16-2)

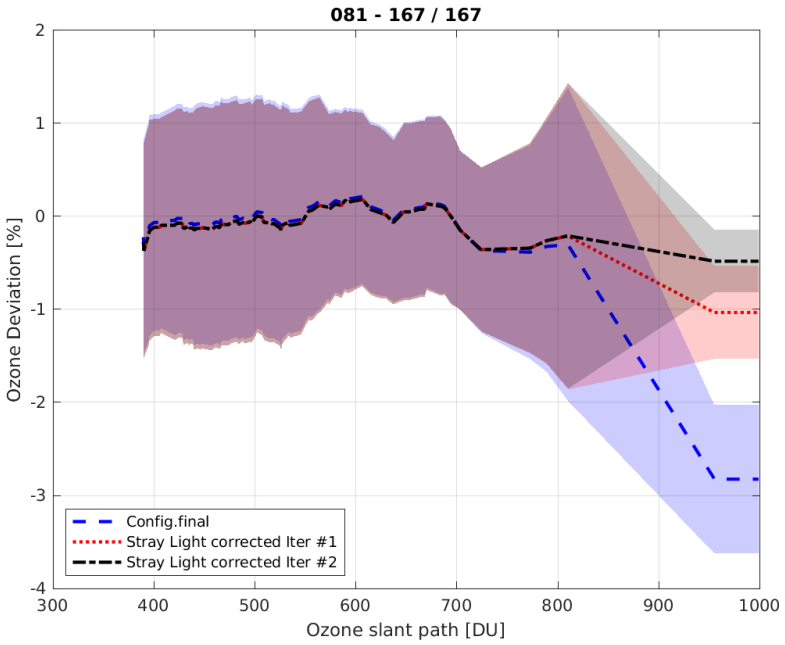


Figure 16-2 – Mean DS ozone column percentage difference between Brewer SJC#081 and Brewer #167, plotted as a function of the ozone slant path. Results for the final (issued in this calibration campaign) configuration are show in blue; the red dotted line corresponds to the same configuration, but with the stray light correction obtained after 1 iteration; the black line corresponds to results obtained after 2 iterations. The shadow areas represent the standard deviation of the mean. The plot corresponds to the final days of the campaign.

16.1.7 Recommendations and Remarks

1. It's not clear whether the standard lamp is stable or not, so we can't recommend the application of the SL correction at this time. However, by the end of June the R6 reference seems to have stabilized to **1630**.
2. Likewise, the R5 reference value seems to have stabilized to a value of **3100**.
3. For Brewer SJC#081, stray light has an important effect on measurements taken at large ozone slant paths. We suggest applying a stray light correction with parameters $k = a = -\mathbf{117}$, and $s = b = \mathbf{14}$.

4. Finally, we suggest updating the ETC value to **2727**.
5. With this configuration, we obtain a good comparison with Brewer #167 in June, but the stability of instrument is suspect, as outlined next.
6. The RS data is quite noisy, but this might be related to the unstability of the SL.
7. Likewise, the DT data is also quite noisy. We have retained a deadtime value close to the original one, 37 ns, corresponding to the early days of the campaign. However, a much smaller value, approx. 15 ns, is derived from more recent tests.
8. We have not adopted new temperature coefficients because we're not sure of the SL stability.
9. The power supply does not seem to be completely stable, the HT voltage showing some noise.
10. The filter wheel does not seem to be operating correctly since early June – all the data measured corresponds to filter position #0.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/081/ICF15724.081

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=1893434543#gid=1893434543

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/081/html/cal_report_081a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/081/html/cal_report_081a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/081/html/cal_report_081b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/081/html/cal_report_081c2.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF15304.081)	Final (ICF15724.081)
o3 Temp coef 1	0	0
o3 Temp coef 2	2.5385	2.5385
o3 Temp coef 3	2.0308	2.0308
o3 Temp coef 4	0.5374	0.5374
o3 Temp coef 5	-0.3125	-0.3125
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3416	0.3416
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.1445	1.1445
ETC on O3 Ratio	2960	2727
ETC on SO2 Ratio	2750	2750
Dead time (sec)	3.5e-08	3.7e-08
WL cal step number	296	296
Slitmask motor delay	84	84
Umkehr Offset	1781	1781
ND filter 0	0	0
ND filter 1	5000	5000
ND filter 2	10000	10000
ND filter 3	15000	15000
ND filter 4	20000	20000
ND filter 5	25000	25000
Zenith steps/rev	2816	2816
Brewer Type	0	0
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	2120	2120
Mic #2 Offset	0	0
O3 FW #3 Offset	240	240
NO2 absn Coeff	-3	-3
NO2 ds etc	795	795
NO2 zs etc	790	790
NO2 Mic #1 Offset	4788	4788
NO2 FW #3 Offset	176	176
NO2/O3 Mode Change	2659	2659
Grating Slope	0	0
Grating Intercept	0	0
Micrometer Zero	3469	3469
Iris Open Steps	75	75
Buffer Delay (s)	0	0
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	64	64
Zenith Offset	53	53
Zenith UVB Position	2118	2118

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer SJC#081 using the final calibration (ICF15724.081), and by reference Brewer IZO#256. Fig. 16-4 shows the daily ozone data in detail.

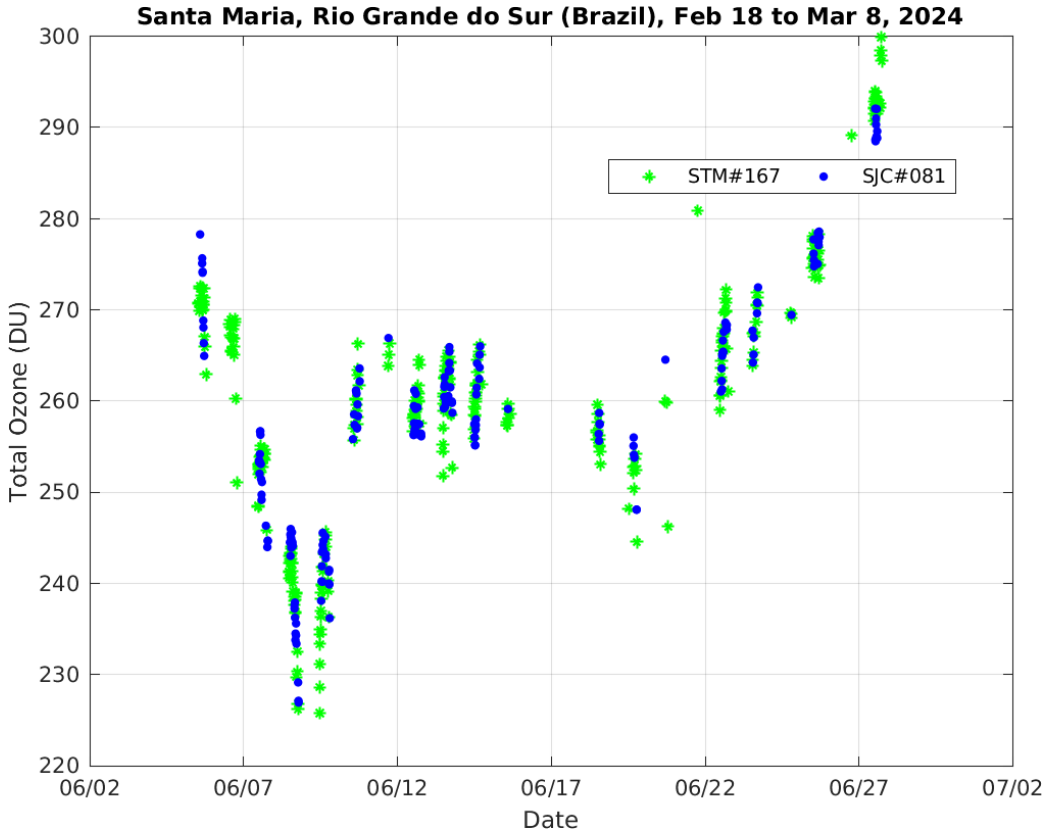
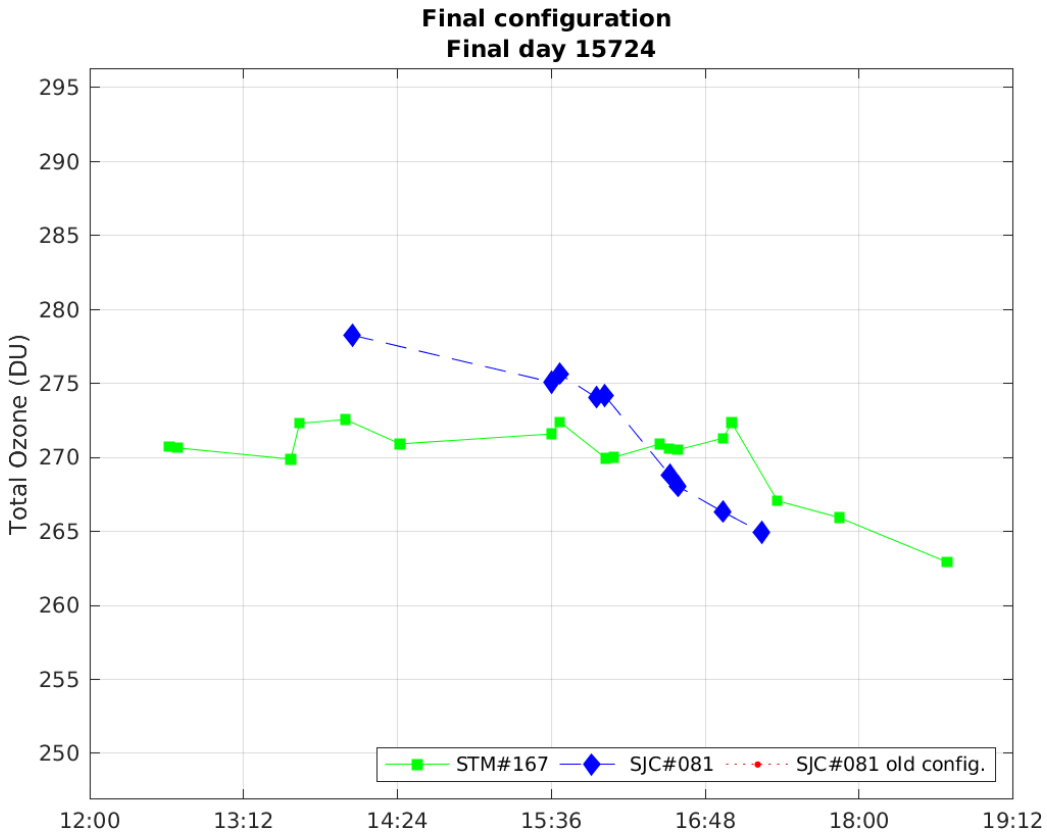
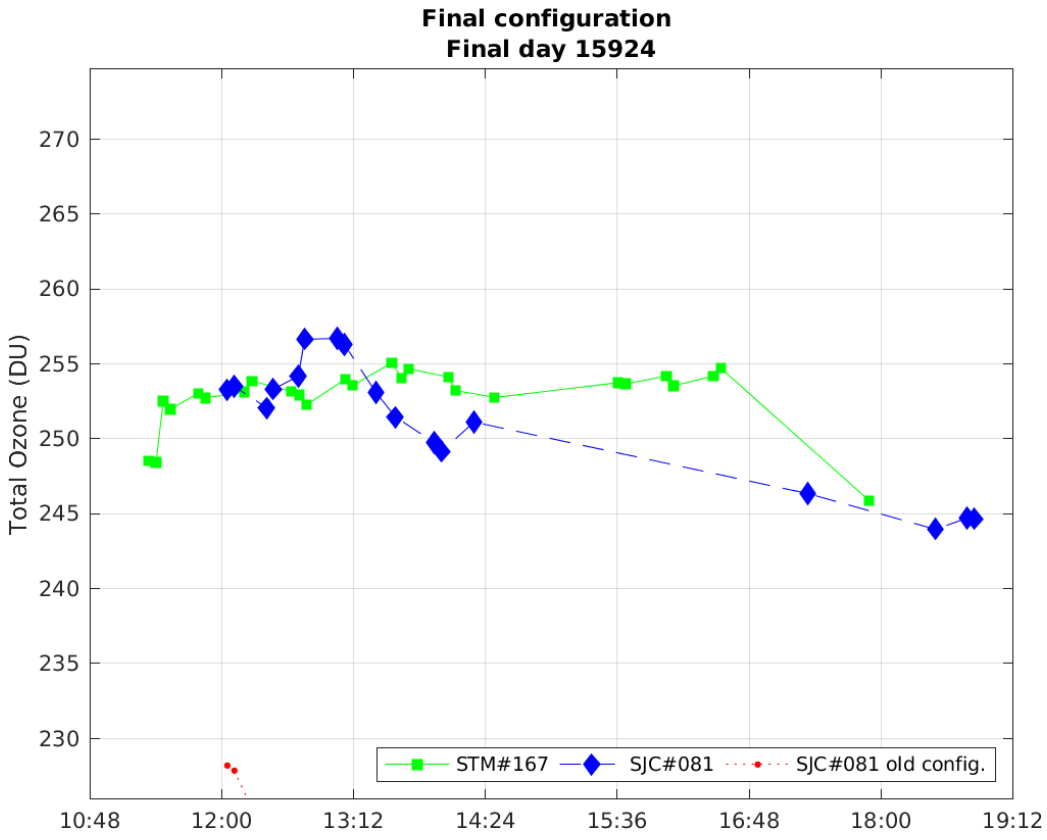
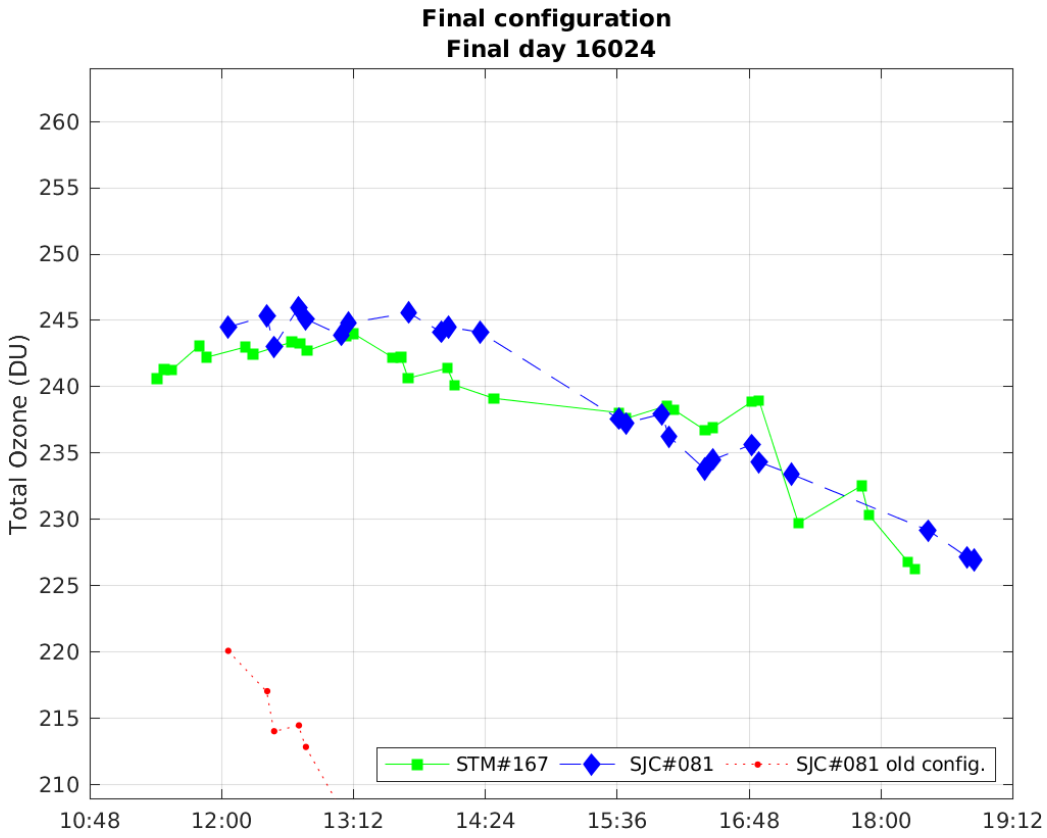


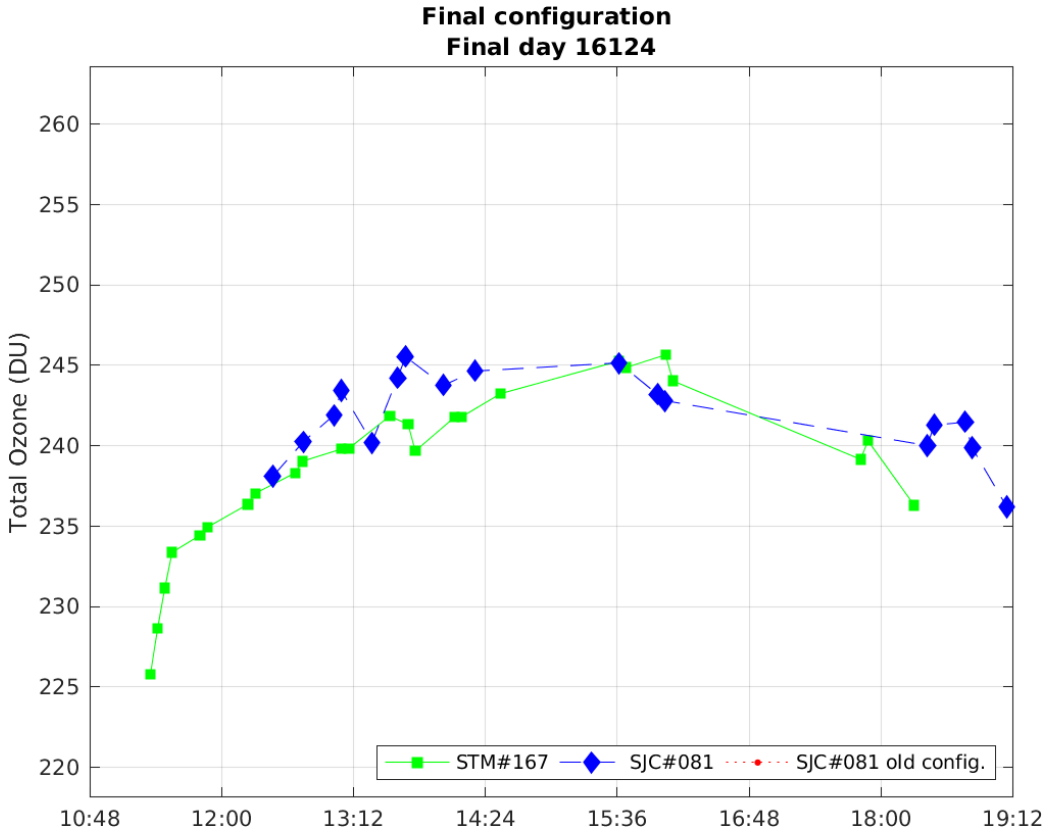
Figure 16-3 – Overview of the intercomparison. For the final days starting on day 65, Brewer SJC#081's data are evaluated using the final constants (blue circles) provided in the ICF15724.081 file.


Final configuration
Final day 15724
Total Ozone (DU)
295
290
285
280
275
270
265
260
255
250
12:00
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.

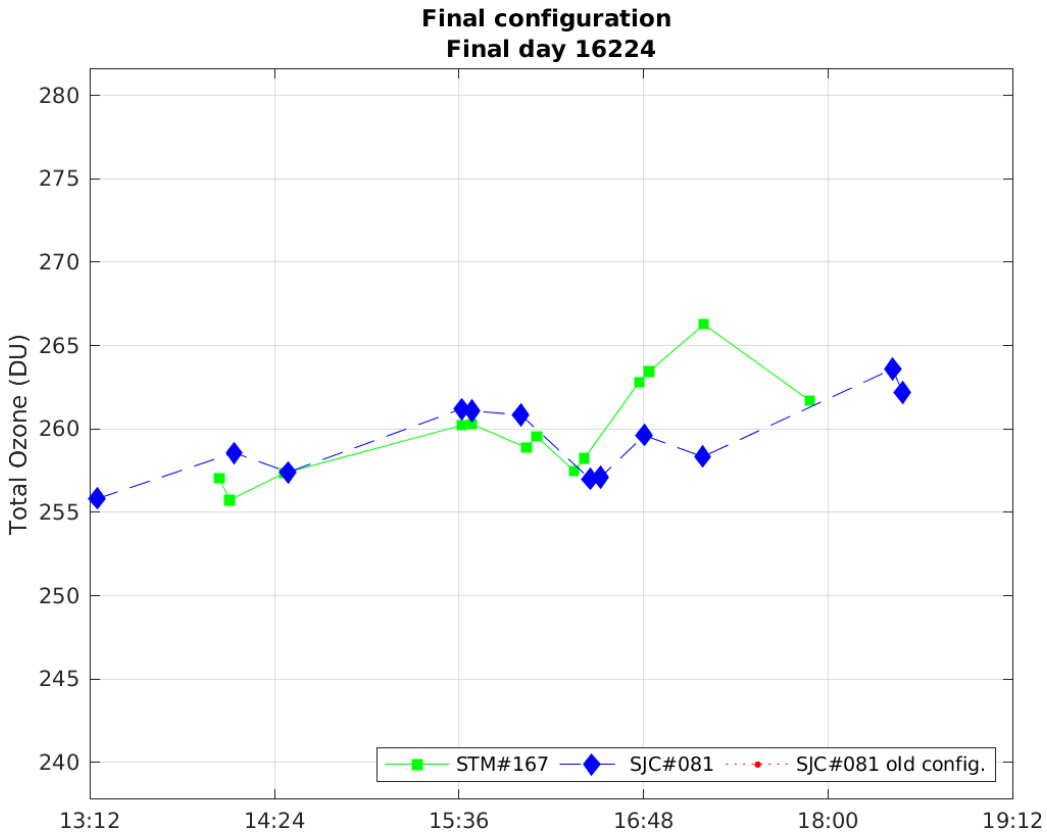

Final configuration
Final day 15924
Total Ozone (DU)
270
265
260
255
250
245
240
235
230
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.

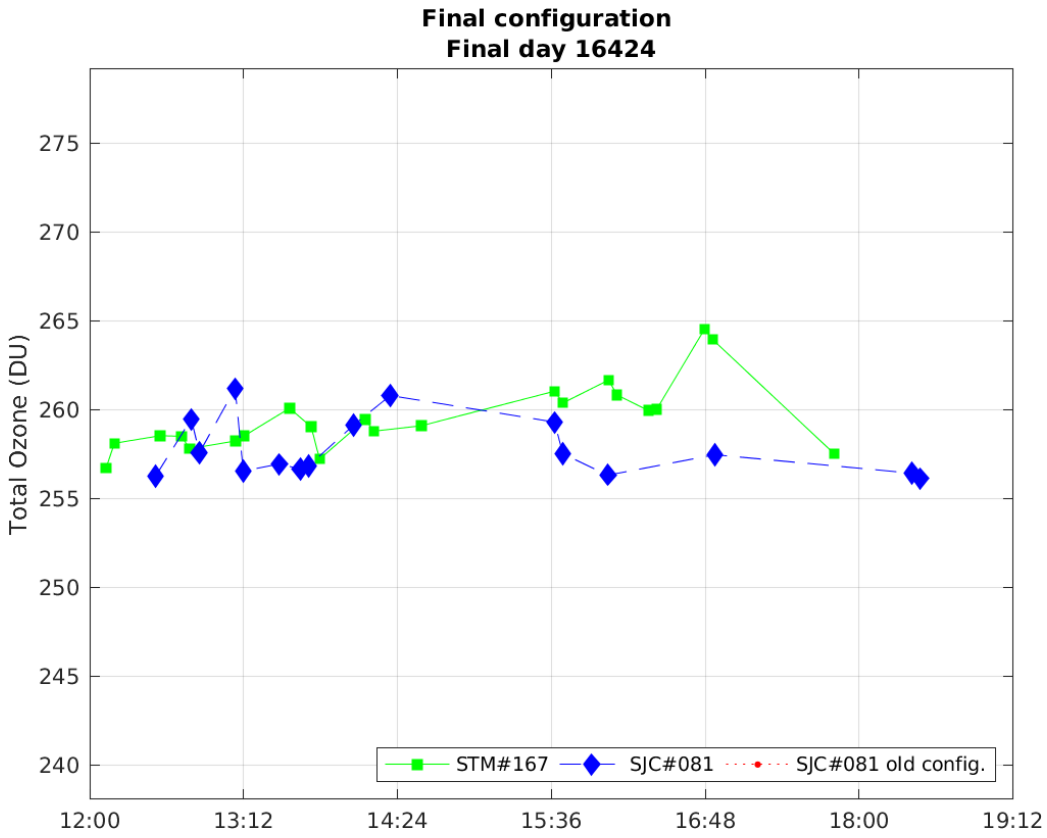


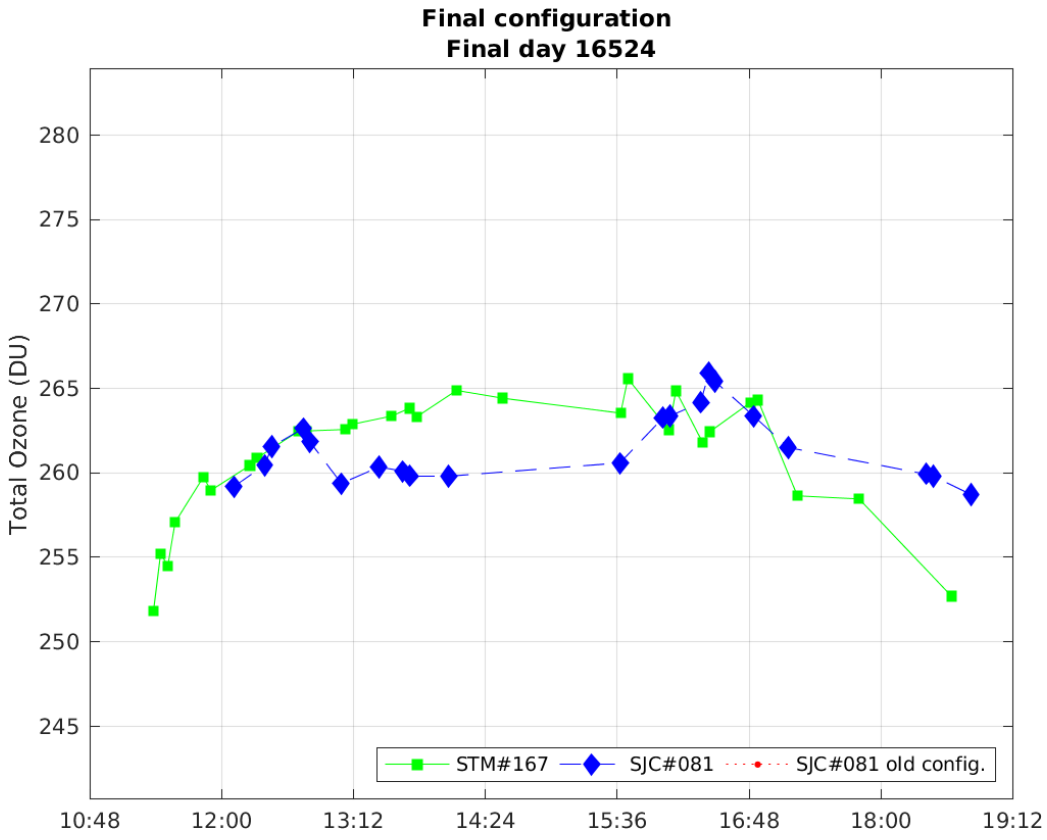
Izaña Atmospheric Research Center
La Marina 20, 38071 S/C de Tenerife, Spain
Tf: +34922151718/Fax: +3492274475



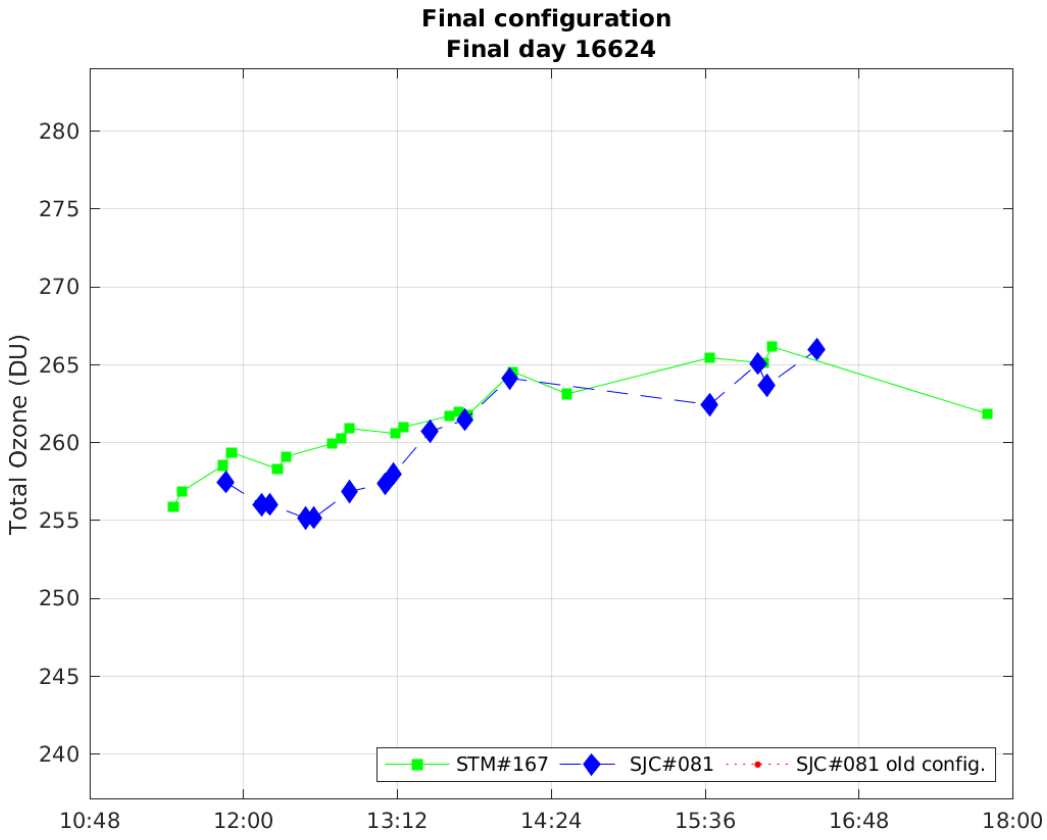
Izaña Atmospheric Research Center
La Marina 20, 38071 S/C de Tenerife, Spain
Tf: +34922151718/Fax: +3492274475

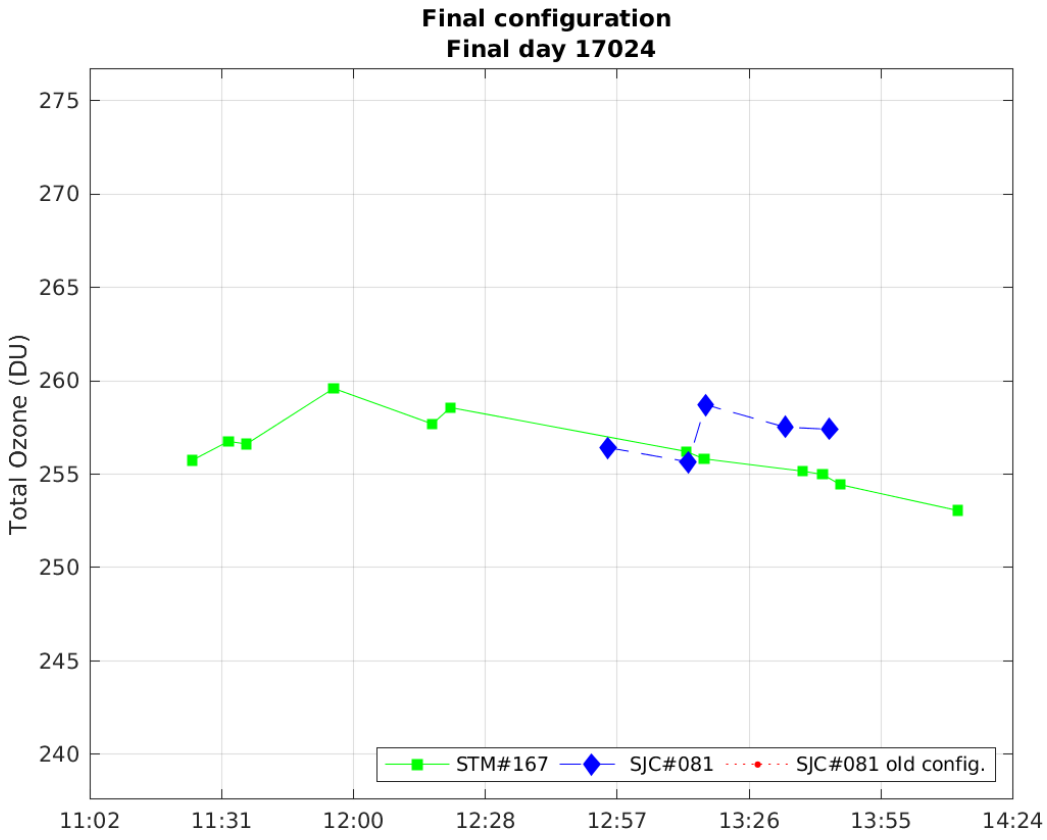

Final configuration
Final day 16224
Total Ozone (DU)
280
275
270
265
260
255
250
245
240
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.

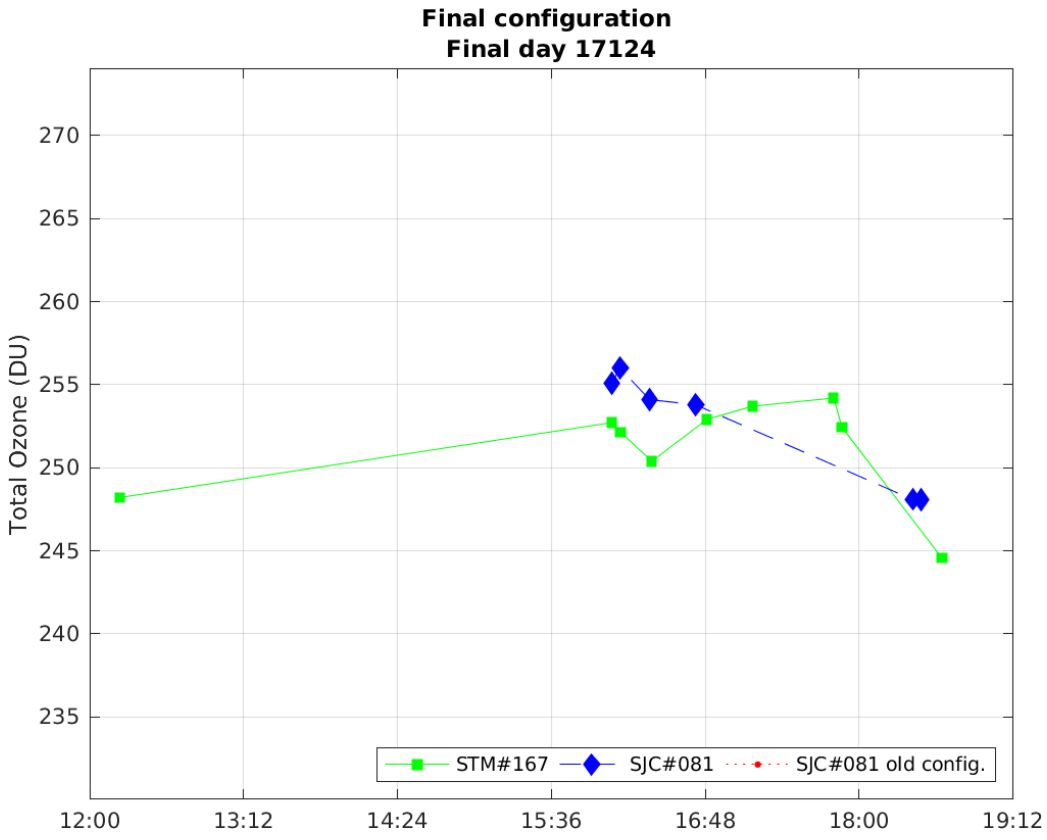

Final configuration
Final day 16424
Total Ozone (DU)
275
270
265
260
255
250
245
240
12:00
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.

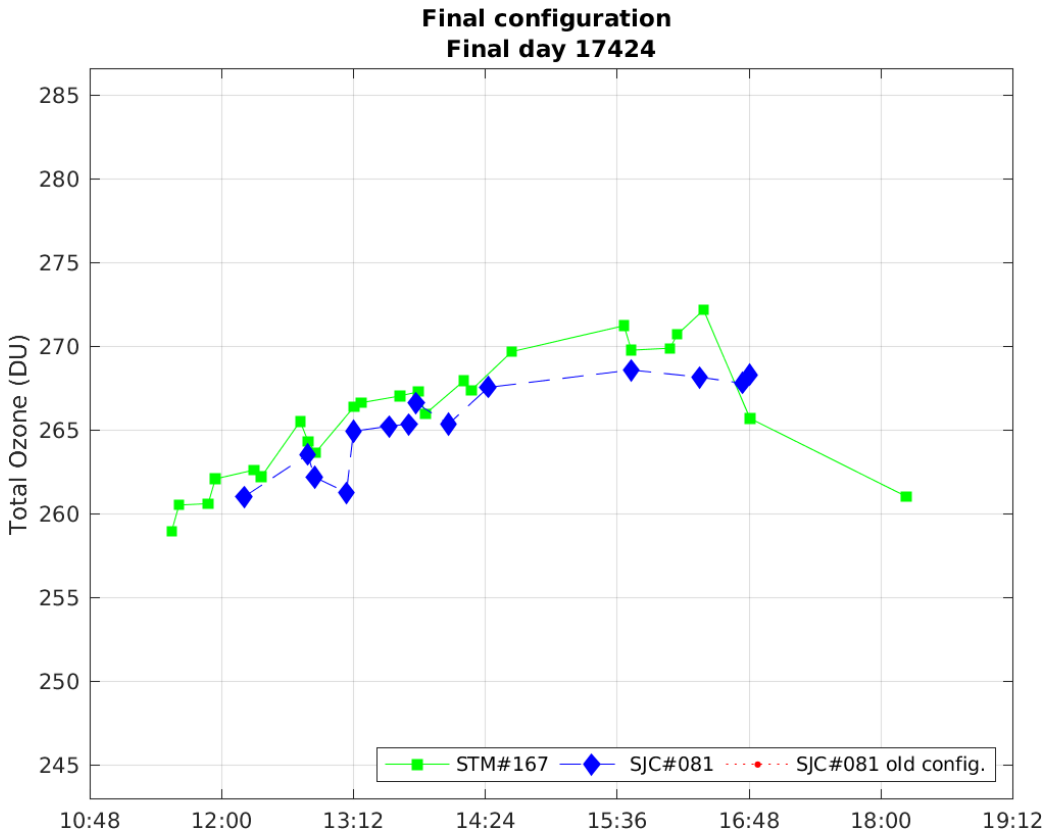


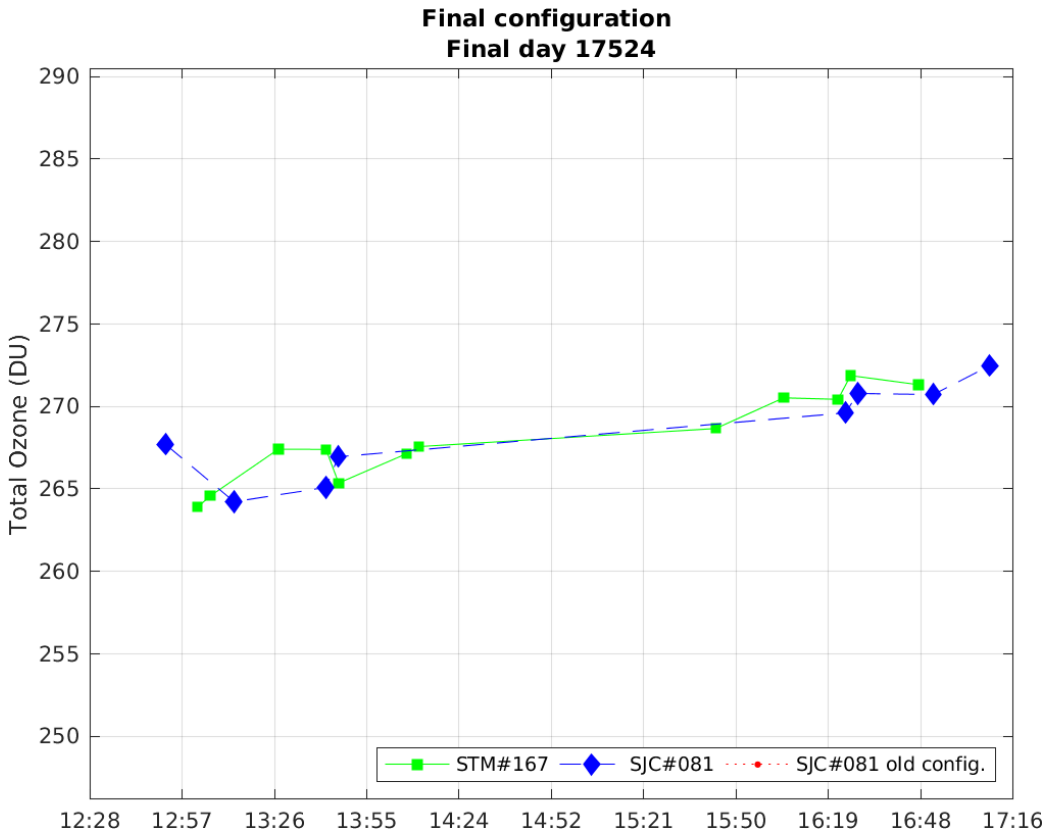
Izaña Atmospheric Research Center
La Marina 20, 38071 S/C de Tenerife, Spain
Tf: +34922151718/Fax: +3492274475


Final configuration
Final day 16624
Total Ozone (DU)
280
275
270
265
260
255
250
245
240
10:48
12:00
13:12
14:24
15:36
16:48
18:00
STM#167
SJC#081
SJC#081 old config.

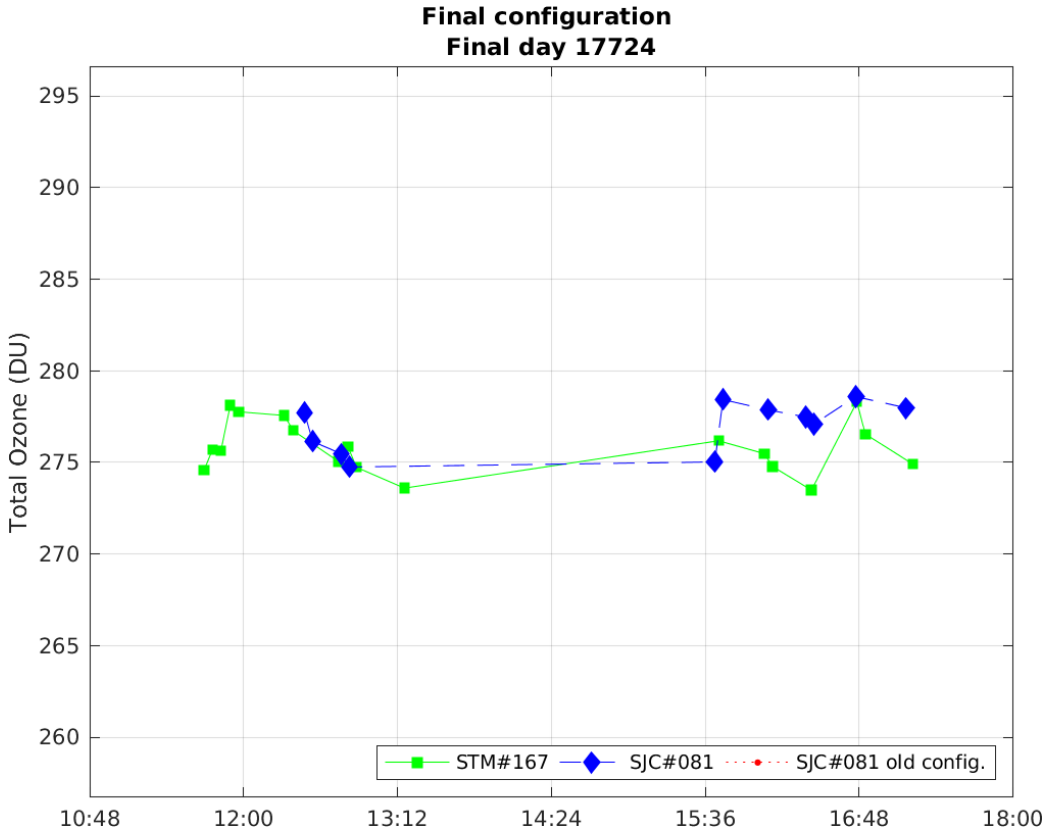

Final configuration
Final day 17024
Total Ozone (DU)
275
270
265
260
255
250
245
240
11:02
11:31
12:00
12:28
12:57
13:26
13:55
14:24
STM#167
SJC#081
SJC#081 old config.


Final configuration
Final day 17124
Total Ozone (DU)
270
265
260
255
250
245
240
235
12:00
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.


Final configuration
Final day 17424
Total Ozone (DU)
285
280
275
270
265
260
255
250
245
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
STM#167
SJC#081
SJC#081 old config.



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Final configuration
Final day 17724
Total Ozone (DU)
295
290
285
280
275
270
265
260
10:48
12:00
13:12
14:24
15:36
16:48
18:00
STM#167
SJC#081
SJC#081 old config.

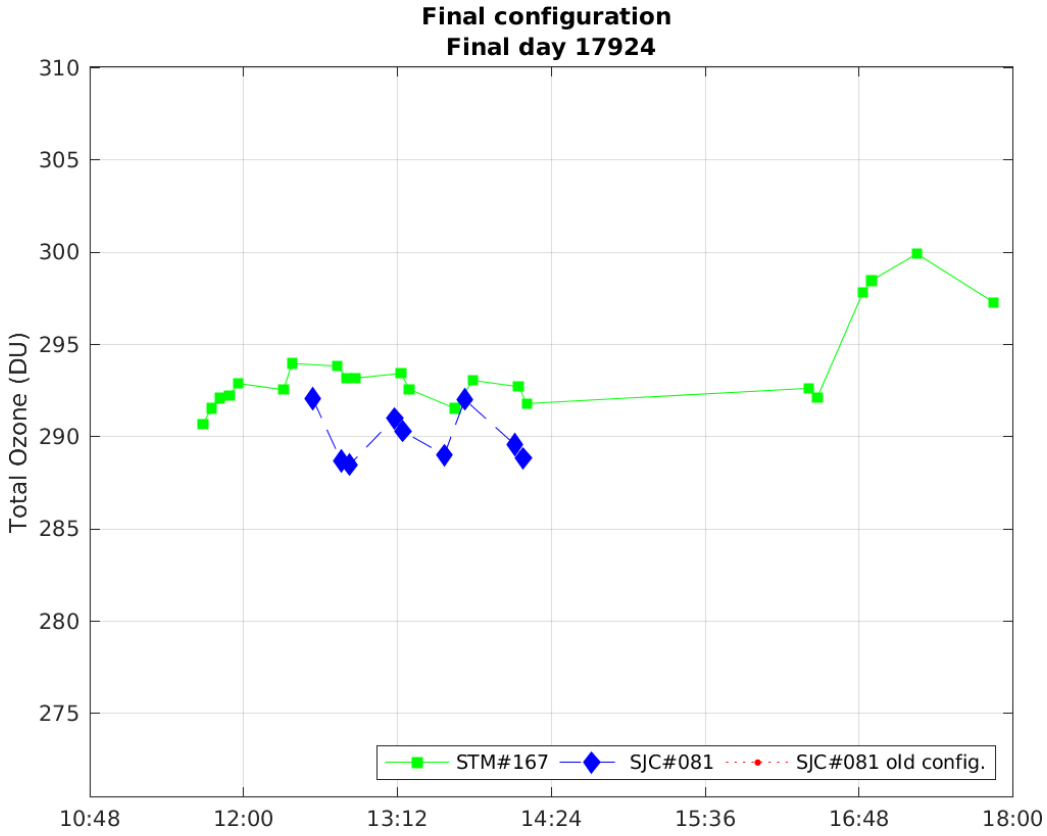


Figure 16-4 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF15304.081, red) and final (ICF15724.081, blue) configurations of Brewer SJC#081, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-5) and R5 (Fig. 16-6) ratios, and the intensity of slit 5 (Fig. 16-7), results of the Run/Stop (Fig. 16-8), Dead Time (Fig. 16-9), and analog voltages and intensity (Fig. 16-10) tests, analysis of the temperature coefficient's performance (Figs. 16-11, 16-12, and 16-13), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-14), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-16) tests.

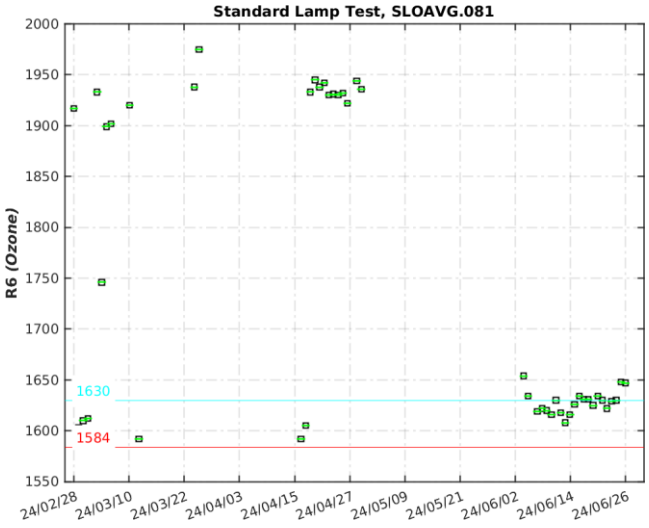


Figure 16-5 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

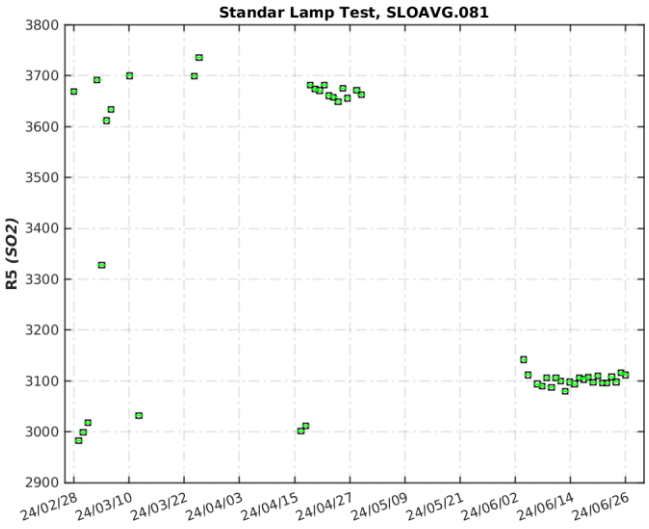


Figure 16-6 – Standard Lamp test R5 (SO_2) ratios

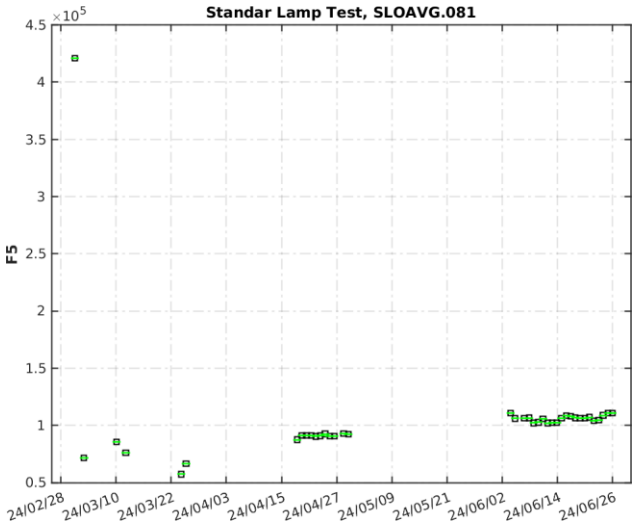


Figure 16-7 – SL intensity for slit five.

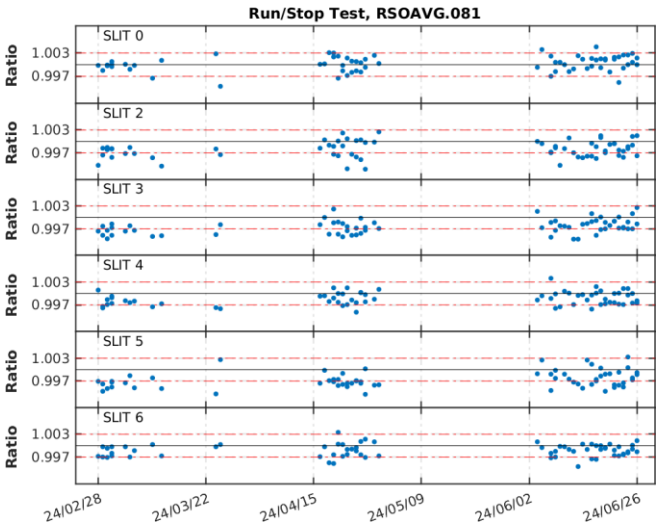


Figure 16-8 – Run/stop test

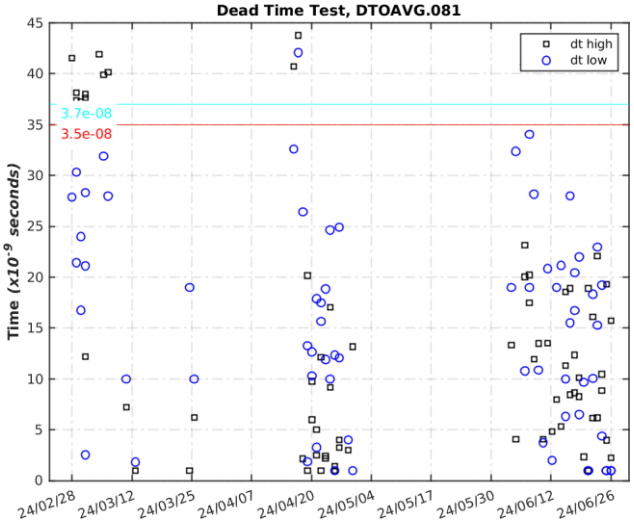


Figure 16-9 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

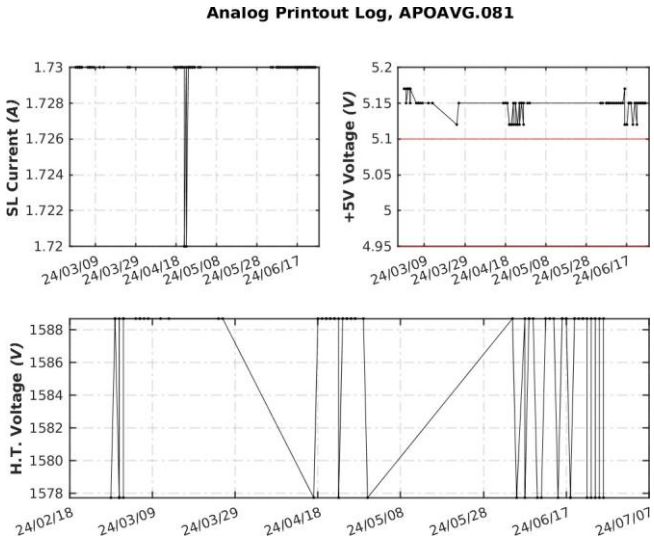


Figure 16-10 – Analog voltages and intensity.

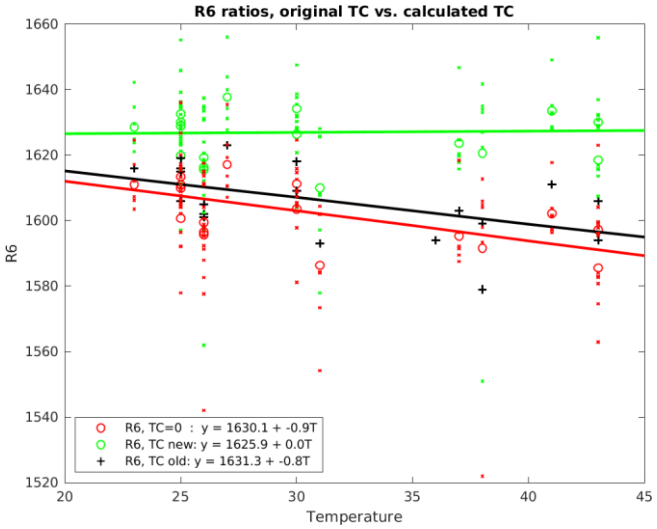


Figure 16-11 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

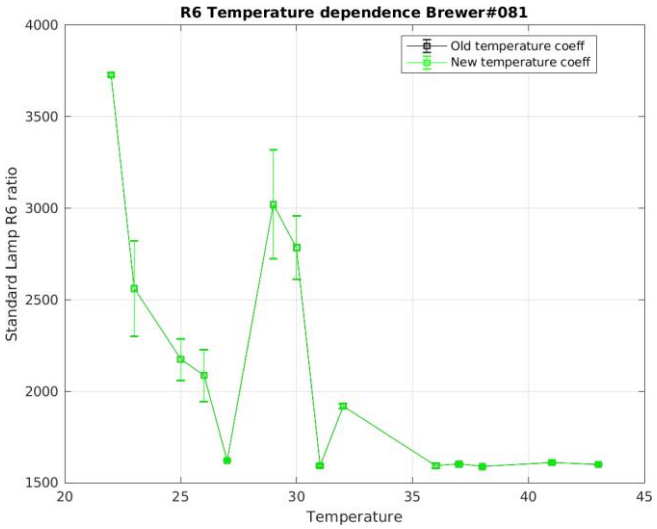


Figure 16-12 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

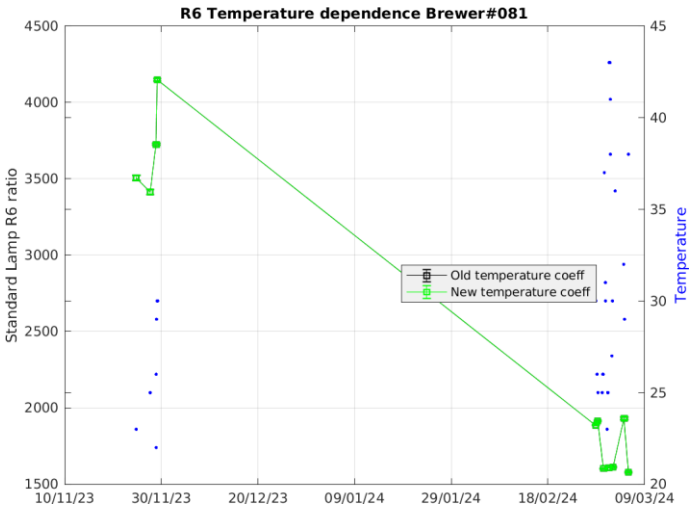


Figure 16-13 – Same as Fig. 16-12, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	7	-7	-31	-11	-56
ETC Filt. Corr. (mean)	2.3	8.3	-28.7	-7.2	-55.5
ETC Filt. Corr. (mean 95% CI)	[-12.9 13]	[-30.8 50.9]	[-47 3]	[-29.7 26.9]	[-110.8 -2]

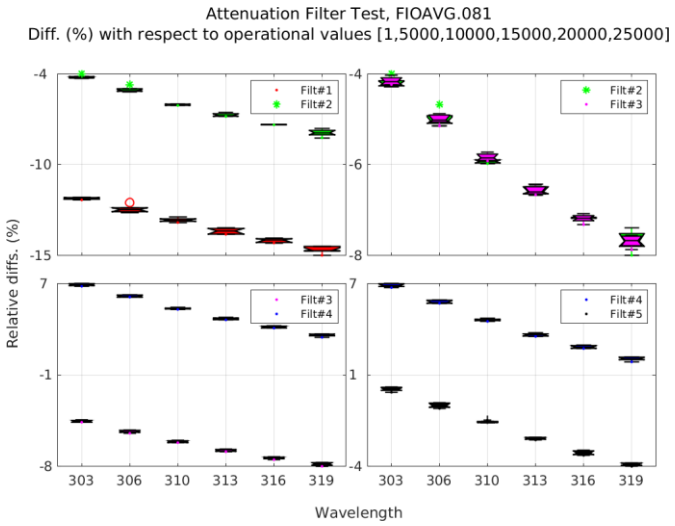


Figure 16-14 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

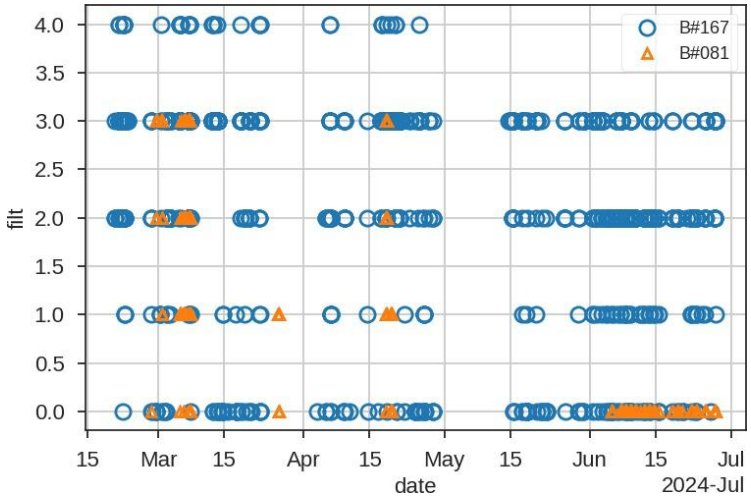


Figure 16-15 – Filter position used during measurements from early February to the end of June

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	296	0.3416	2.3500	1.1445
27-Oct-2000	296	0.3437	2.7452	1.1532
25-Feb-2001	NaN	NaN	NaN	NaN
01-Jun-2004	296	0.3391	2.8208	1.1384
29-Feb-2024	296	0.3421	2.7762	1.1518
21-Dec-1996	296	0.3336	2.8903	1.1230
11-Mar-1999	296	0.3362	2.7960	1.1340
Final	296	0.3416	2.3500	1.1445

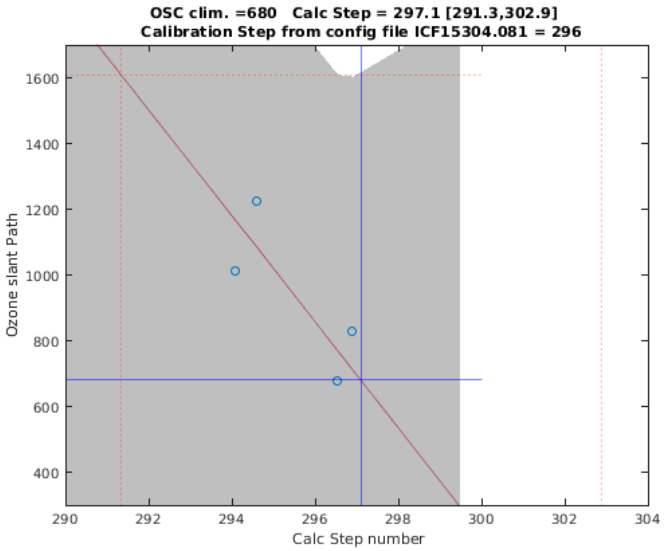


Figure 16-16 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16.5 References

[1] Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018.

16 Brewer SMA#162

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer SMA#162 participated in the campaign in the period from February 23th to March 8th. The campaign days of Brewer SMA#162 correspond to Julian days 54 – 68.

The instrument received maintenance since its arrival up to day 62. In particular, the humidity sensor was replaced on day 61. Large drops in R6 were registered both before and after maintenance, on days 61, 62, and 63, so the instrument was not considered stable until day 64. We have used **176** simultaneous DS ozone measurements taken from day **64** to **68** to calibrate the instrument (Fig. 16-2)

16.1.1 Instrument's history and stability

Over the last two years, the R6 standard lamp measurements have not been completely stable (Fig. 16-6). The SL intensity however does not show large changes (Fig. 16-8), which points to the changes in R6 being real changes of Brewer SMA#162. The comparison with the reference Brewer also improves when the standard lamp correction is applied to the original calibration (Fig. 16-2), so indeed the standard lamp seems to be operating correctly.

Regarding other instrumental parameters, the deadtime tests show a large difference between the high and low values which is not usual (Fig. 16-10). In the run/stop tests, most slits are close to the lower tolerance limits (Fig. 16-9. Finally, although the results of the AP tests show some noise (Fig. 16-11), its values are mostly between tolerance limits.

To further check the stability of the instrument, we have compared EUBREWNET's level 1.5 ozone product with the ERA5 data for the station of Brewer SMA#162, for the two years before the present campaign. The relative difference between both datasets is plotted in Fig. 16-1 and shows a reasonable agreement, with some periodicity (see the downward trend in the data for March 2022 and 2023). Note the data from Brewer SMA#162 includes the Standard Lamp correction.

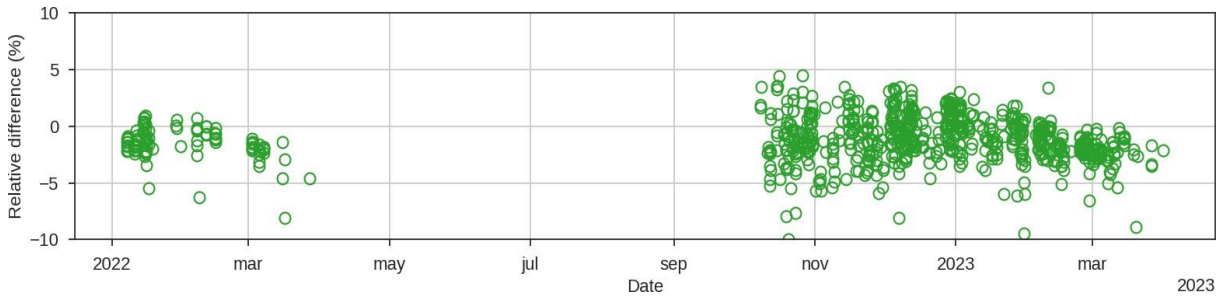


Figure 16-1 – Relative difference of EUBREWNET's level 1.5 ozone product with respect to the ERA5 data for the station of Brewer SMA#162

16.1.2 Maintenance

Maintenance was carried out from day 54 to 62, and it included the replacement of the humidity sensor. After maintenance, most of the instrumental parameters were operating between acceptable values. The instrument was considered stable on day 64, after some large drops in R6 were observed on days 61, 62, and 63.

16.1.3 Instrumental parameters during the campaign

During the final days, the standard lamp ratios stabilized around values **2152** and **4081** for R6 and R5 respectively(Figures 16-6 and 16-7, respectively).

Analysis of the dead time tests return a value of 37 ns for this parameter. However, using this value in the configuration resulted in a worse comparison with the reference at low ozone slant path values, so the present value, 40 ns, has been retained in the new configuration.

16.1.4 Temperature dependence and filters

Using its present temperature coefficients, Brewer SMA#162 shows a very small temperature dependence during the campaign (Fig. 16-12). Data before the campaign shows a noticeable dependence, but futher analysis would be required to remove possible bad data. Overall, the performance of the instrument before the campaign seems within reasonable limits and we have decided to retain the current temperature coefficients.

Concerning the filters, analysis of the FIOAVG data indicates that filter #4 is operating outside the tolerance limits (Table 16-2 and Fig. 16-16), and the comparison with the reference confirms it – see in particular the zig-zag of the data with the original configuration (without any filter correction) at noon of day 66, red line in Fig. 16-5. To correct the bad behaviour of filter #4, we have added an ETC filter correction of -25 units to the data measured with this filter.

16.1.5 Sun scan and dispersion tests

No sun scans were carried out at the instrument's station before the campaign. The tests during the campaign shows two steps less than the current value, 280.2 vs 282. This is a noticeable difference, but we decided not change the cal step value until more data is available.

The dispersion tests during the campaign provide a small but noticeable change in the ozone absorption coefficient, so we have decided to update its value from 0.336 to 0.3375.

16.1.6 ETC transfer

As shown in Fig. 16-2, after the maintenance and using the new calibration, Brewer SMA#162's ozone is within 0.5% with respect to reference Brewer IZO#256. Note the standard lamp correction improves noticeably the data using the original (pre-campaign) configuration.

Being a Mk. IV model, Brewer SMA#162 measurements are affected by stray light. This produces the downward tail at large ozone slant path values shown in Fig. 16-2. However, as show in Fig. 16-3, the comparison with the Mk. III Brewer IZO#256 allows us to correct the effect of the stray light using the method described in Ref. [1].

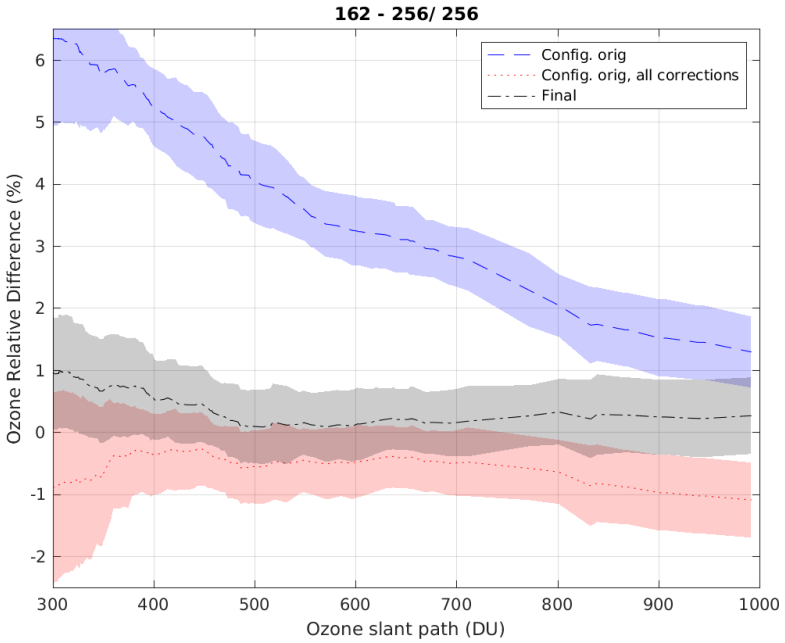


Figure 16-2 – Mean DS ozone column percentage difference between Brewer SMA#162 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

16.1.7 Recommendations and Remarks

1. The R6 reference value shuld be updated to **2152**.
2. We suggest a new R5 reference value of **4081**.
3. Although DT tests provide a deadtime of 37 ns, this value seems to produce a worse comparison with the reference, so we have retained the current value, **40 ns**. Running DT tests regularly is recommended.
4. We suggest the application of an ETC correction of **-25** units to data from filter#4. We recommend to perform FI tests regularly, to gather more data to improve the characterization of the filters.
5. We have not adopted new temperature coefficients at this time, but recommend tracking the evolution of the standard lamp R6 value with temperature.
6. The sun scan tests during the campaign show a noticeable difference of two steps with the current cal step value. We have not updated the cal step number at this time, but recommend running sun scan tests regularly.

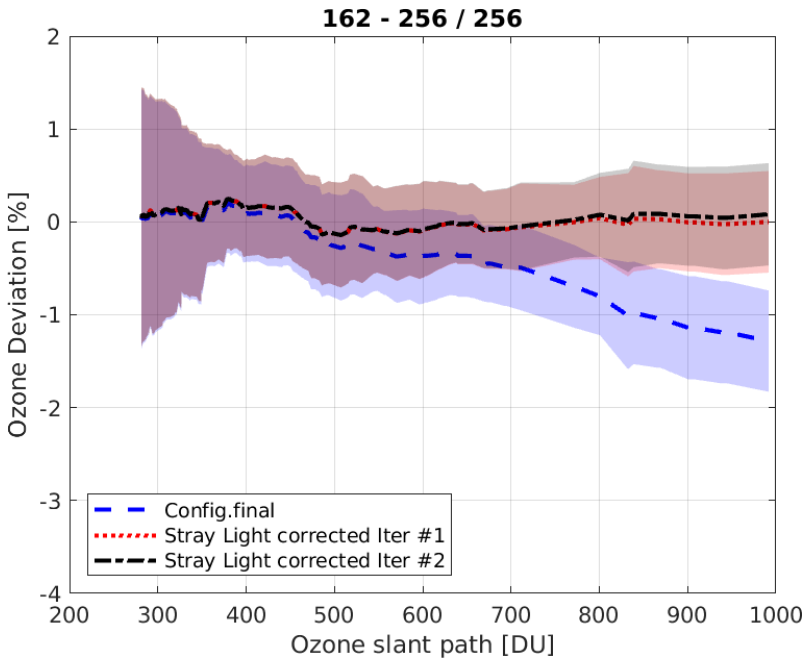


Figure 16-3 – Mean DS ozone column percentage difference between Brewer SMA#162 and Brewer IZO#256, plotted as a function of the ozone slant path. Results for the final (issued in this calibration campaign) configuration are show in blue; the red dotted line corresponds to the same configuration, but with the stray light correction obtained after 1 iteration; the black line corresponds to results obtained after 2 iterations. The shadow areas represent the standard deviation of the mean. The plot corresponds to the final days of the campaign.

7. For Brewer SMA#162, stray light has an important effect on measurements taken at large ozone slant paths. We suggest applying a stray light correction with parameters $k = a = \mathbf{-60.9}$, and $s = b = \mathbf{4.7}$.
8. We suggest updating the ETC value to **3305**.
9. Data before the present campaigns seems to improve with the standard lamp correction, so we recommend it's application, although further checks on the historical data are recommended.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/162/ICF06624.162

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=65427977#gid=65427977

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/162/html/cal_report_162a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/162/html/cal_report_162a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/162/html/cal_report_162b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/162/html/cal_report_162c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF08614.162)	Final (ICF06624.162)
o3 Temp coef 1	0	0
o3 Temp coef 2	-0.5072	-0.5072
o3 Temp coef 3	-1.2542	-1.2542
o3 Temp coef 4	-2.3363	-2.3363
o3 Temp coef 5	-4.311	-4.311
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.336	0.3375
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.1324	1.1324
ETC on O3 Ratio	3214	3305
ETC on SO2 Ratio	3449	3449
Dead time (sec)	4e-08	4e-08
WL cal step number	282	282
Slitmask motor delay	44	44
Umkehr Offset	1694	1694
ND filter 0	0	0
ND filter 1	5000	5000
ND filter 2	10000	10000
ND filter 3	15000	15000
ND filter 4	20000	20000
ND filter 5	25000	25000
Zenith steps/rev	2972	2972
Brewer Type	0	0
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	6550	6550
Mic #2 Offset	0	0
O3 FW #3 Offset	242	242
NO2 absn Coeff	-3	-3
NO2 ds etc	705	705
NO2 zs etc	685	685
NO2 Mic #1 Offset	9050	9050
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2510	2510
Grating Slope	0	0
Grating Intercept	0	0
Micrometer Zero	2669	2669
Iris Open Steps	250	250
Buffer Delay (s)	1	1
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	64	64
Zenith Offset	34	34
Zenith UVB Position	2212	2212

16.3 Appendix: Summary Plots

Figure 16-4 in this appendix shows the ozone during the campaign as determined by Brewer SMA#162 using the final calibration (ICF06624.162), and by reference Brewer IZO#256. Fig. 16-5 shows the daily ozone data in detail.

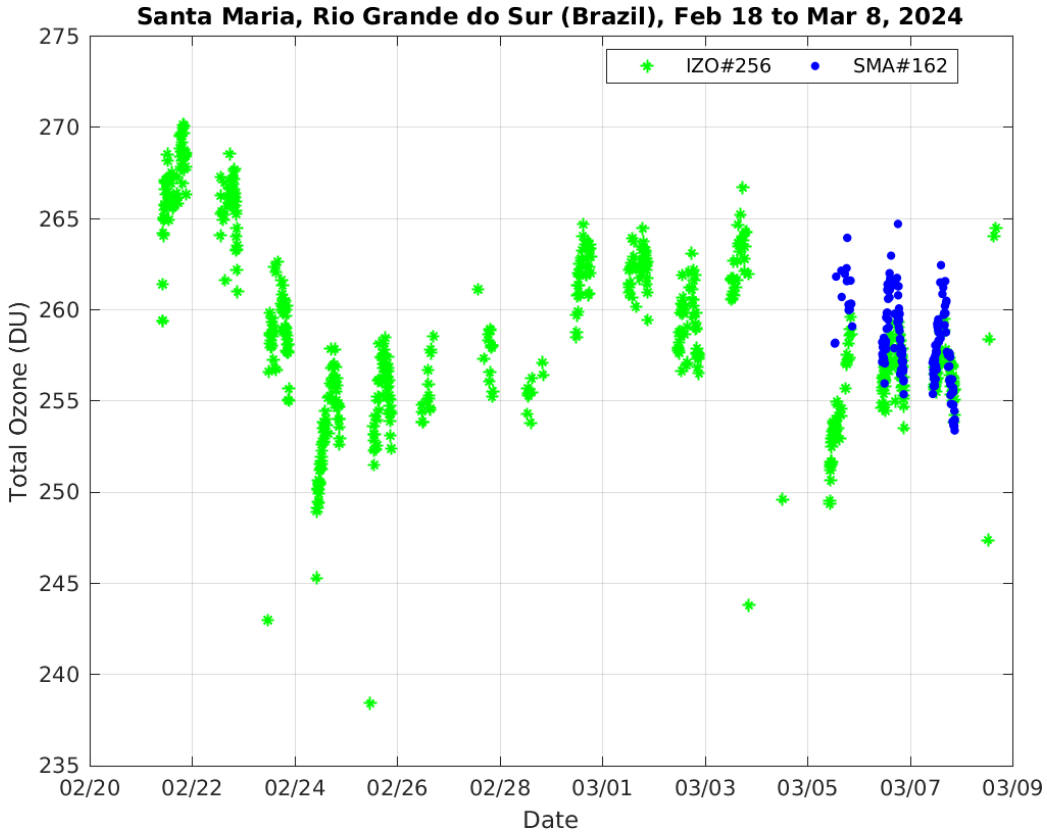
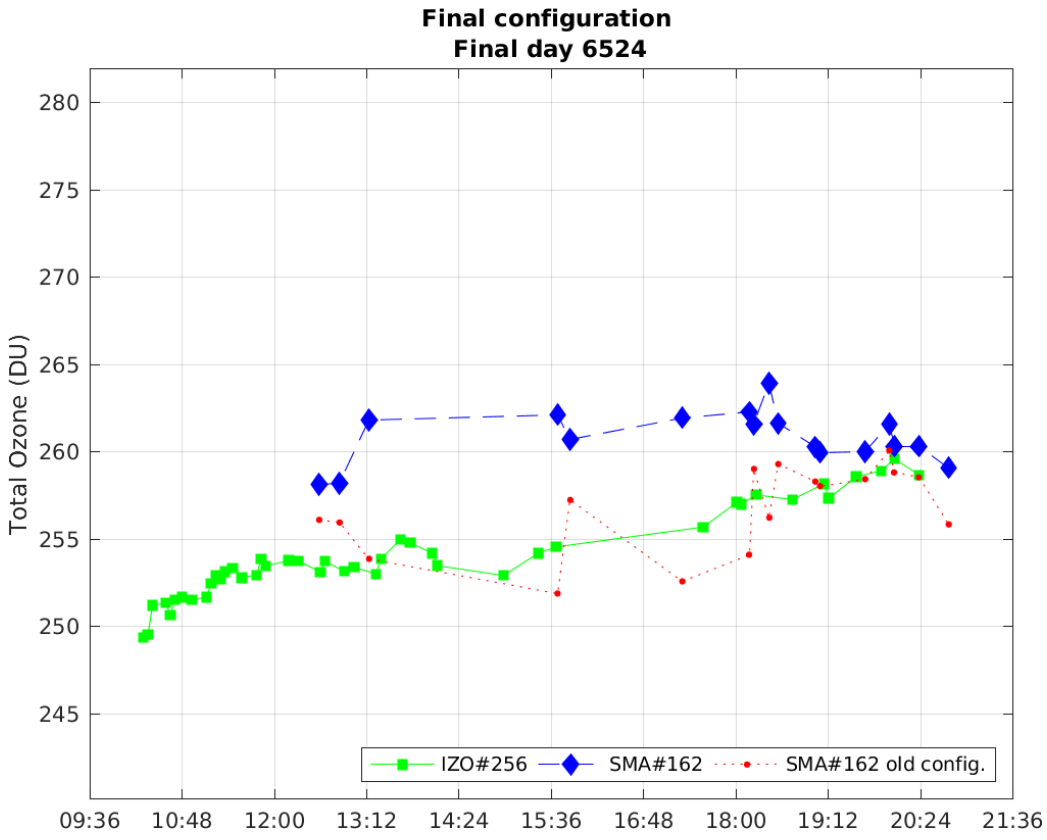
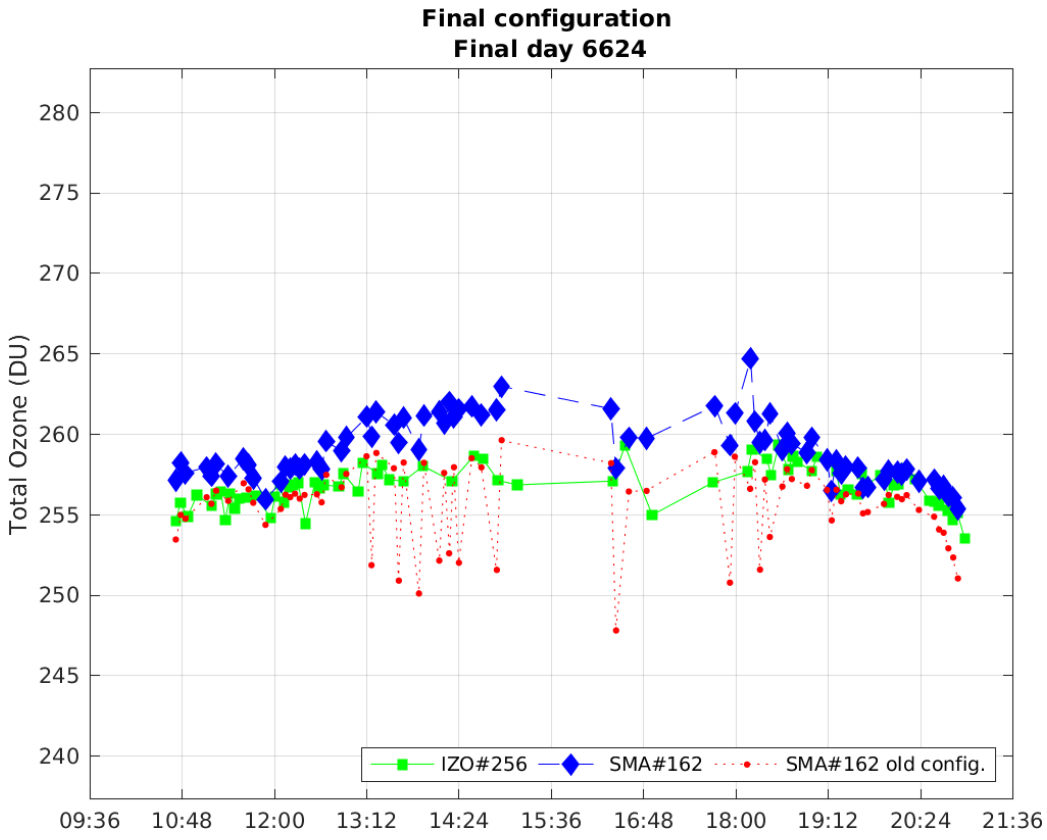


Figure 16-4 – Overview of the intercomparison. For the final days starting on day 64, Brewer SMA#162's data are evaluated using the final constants (blue circles) provided in the ICF06624.162 file.


Final configuration
Final day 6524
Total Ozone (DU)
280
275
270
265
260
255
250
245
09:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
19:12
20:24
21:36
IZO#256
SMA#162
SMA#162 old config.



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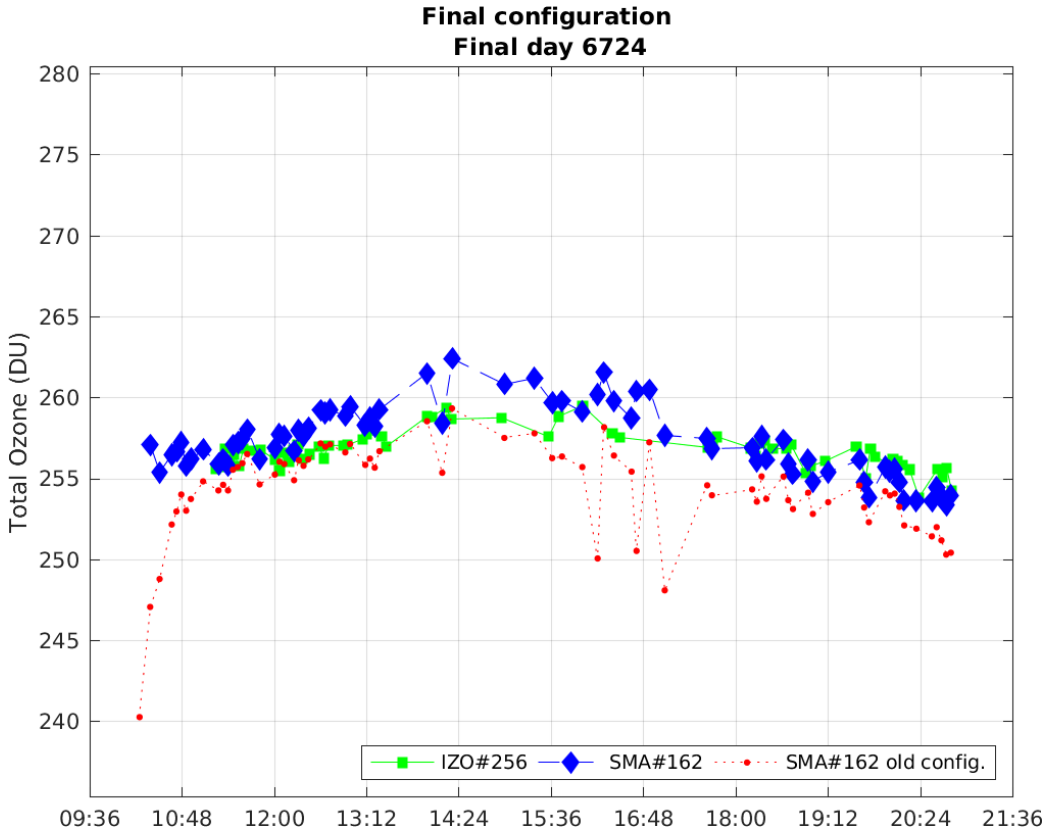


Figure 16-5 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF08614.162, red) and final (ICF06624.162, blue) configurations of Brewer SMA#162, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-6) and R5 (Fig. 16-7) ratios, and the intensity of slit 5 (Fig. 16-8), results of the Run/Stop (Fig. 16-9), Dead Time (Fig. 16-10), and analog voltages and intensity tests (Fig. 16-11),analysis of the temperature coefficient's performance (Figs. 16-12, 16-13, 16-14, and 16-15), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-16), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-17) tests.

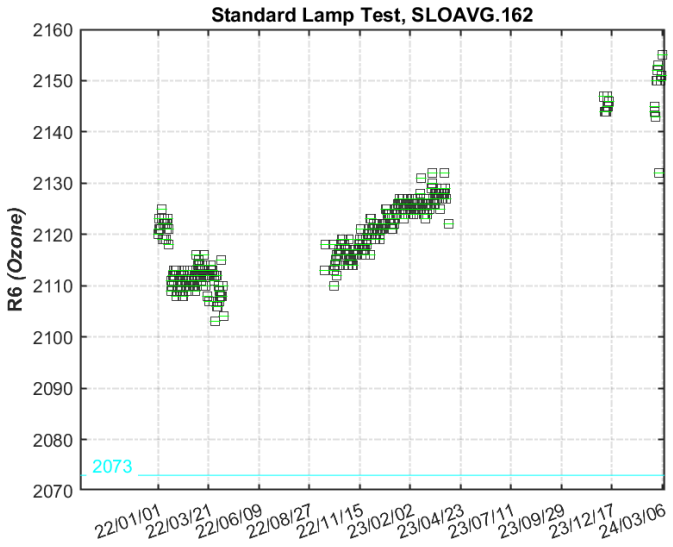


Figure 16-6 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

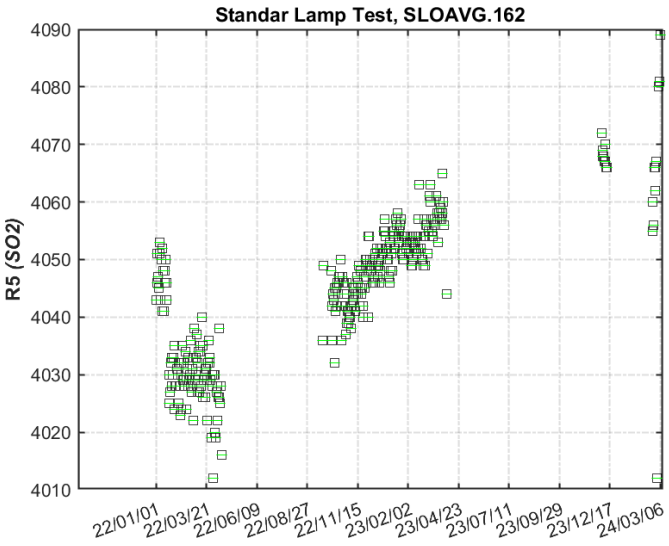


Figure 16-7 – Standard Lamp test R5 (SO_2) ratios

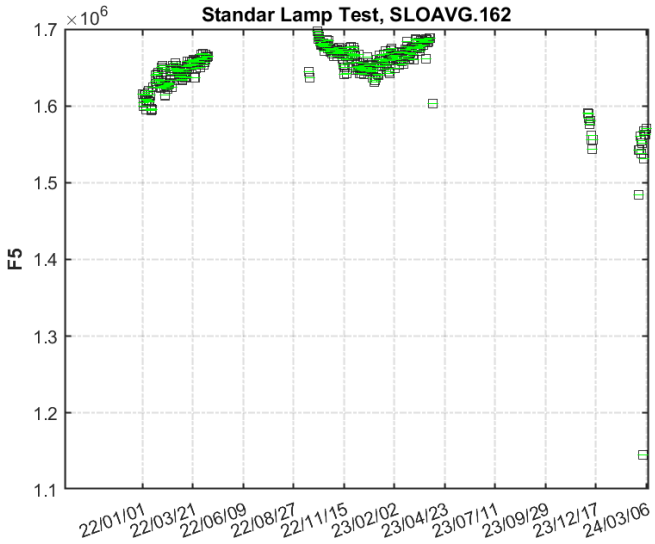


Figure 16-8 – SL intensity for slit five.

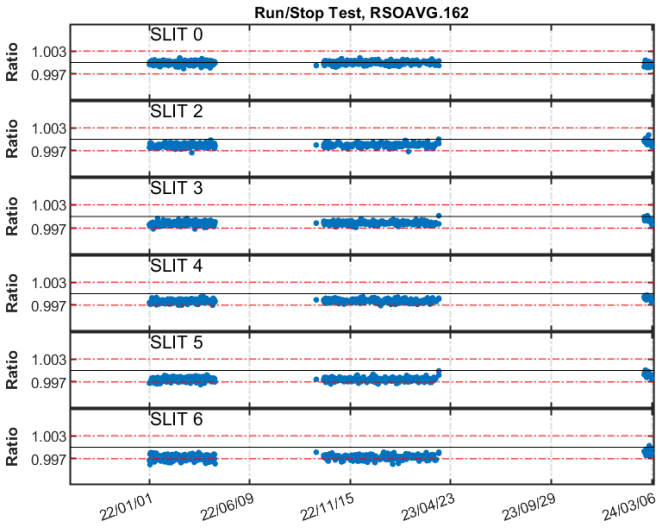


Figure 16-9 – Run/stop test

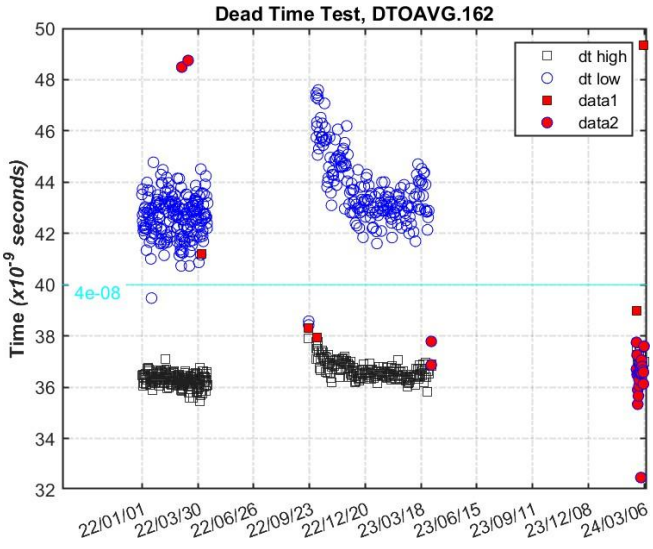


Figure 16-10 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

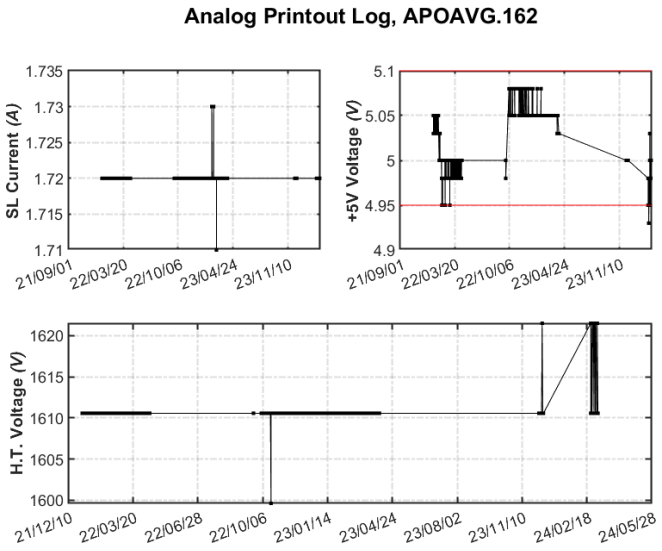


Figure 16-11 – Analog voltages and intensity.

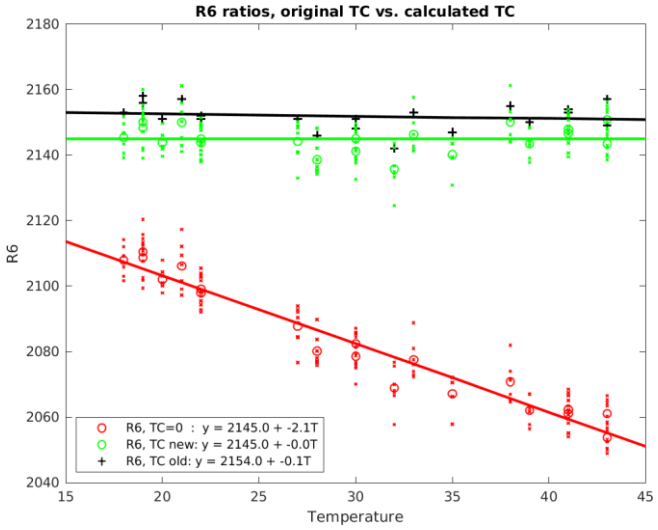


Figure 16-12 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

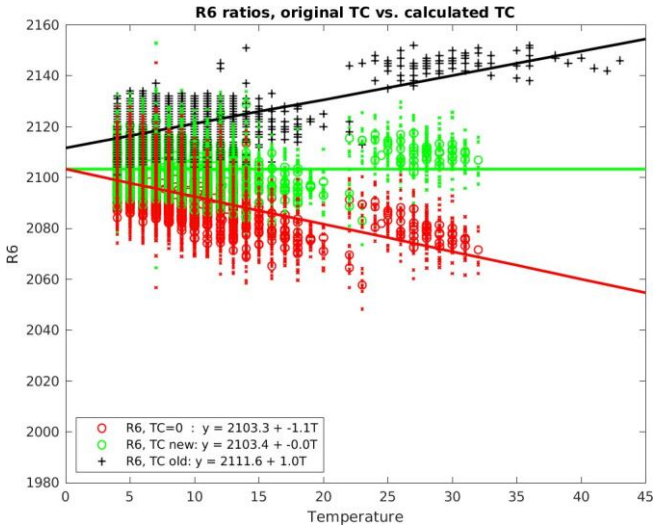


Figure 16-13 – Same as Fig. 16-12 but for the whole period between calibration campaigns.

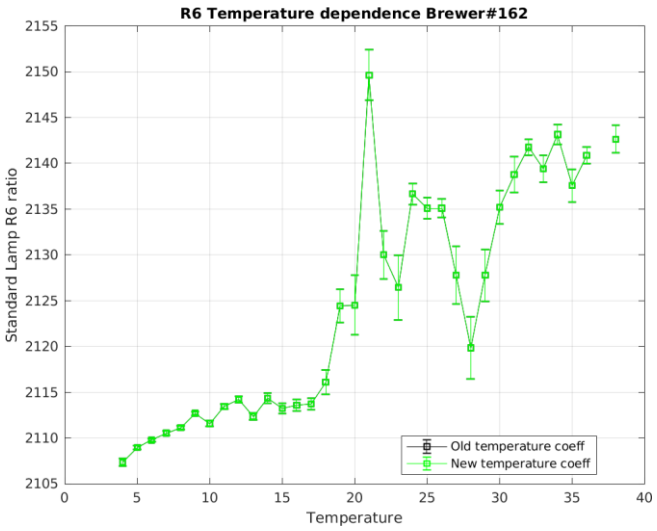


Figure 16-14 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

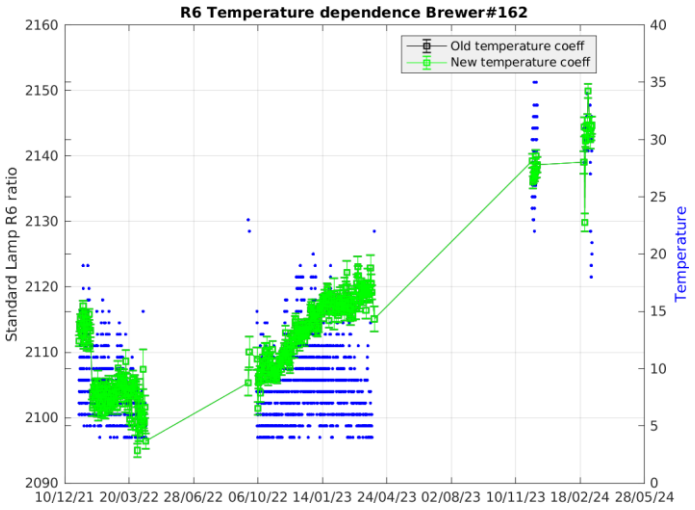


Figure 16-15 – Same as Fig. 16-14, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	10	0	-8	3	1
ETC Filt. Corr. (mean)	9.1	-5.7	-11.4	0.1	-3
ETC Filt. Corr. (mean 95% CI)	[6.3 11.8]	[-8.8 -2.8]	[-13.8 -8.9]	[-2.7 2.9]	[-5.9 0.1]

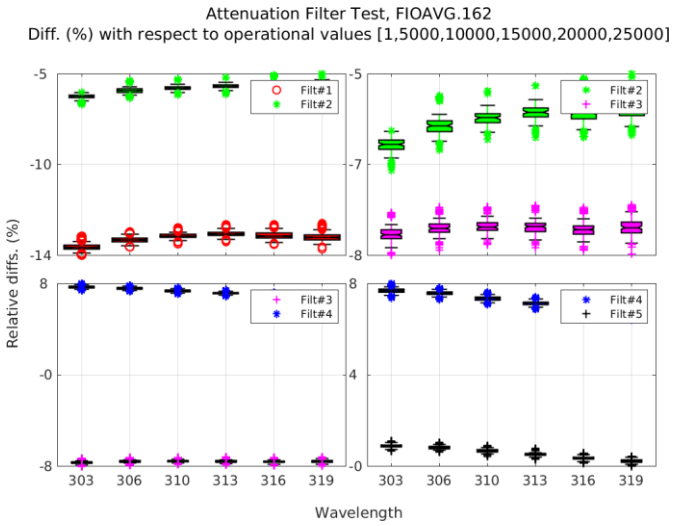


Figure 16-16 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	282	0.3360	2.3500	1.1324
03-Mar-2024	282	0.3375	2.7610	1.1369
Final	282	0.3375	2.3500	1.1324

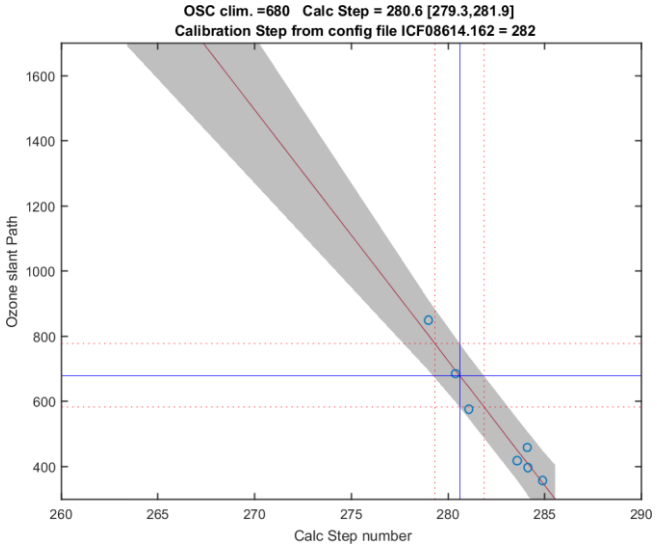


Figure 16-17 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16.5 References

[1] Alberto Redondas, Virgilio Carreño, Sergio F. León-Luis, Bentorey Hernández-Cruz, Javier López-Solano, Juan J. Rodriguez-Franco, Jos´e M. Vilaplana, Julian Gröbner, John Rimmer, Alkiviadis F. Bais, Vladimir Savastiouk, Juan R. Moreta, Lamine Boulkelia, Nis Jepsen, Keith M. Wilson, Vadim Shirotov, and Tomi Karppinen. EUBREWNET RBCC-E Huelva 2015 Ozone Brewer Intercomparison. *Atmospheric Chemistry and Physics*, 18(13):9441–9455, July 2018.

16 Brewer STM#167

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer STM#167 participated in the campaign in the period from February 19th to March 8th. The campaign days of Brewer STM#167 correspond to Julian days 50 to 68.

The instrument received some maintenance during the campaign, including the replacement of the micrometer connector and of the communications' chip. The cal step was updated on day 66. For the final calibration, We have used **105** simultaneous DS ozone measurements taken from day **66** to **69** (Fig. 16-1)

16.1.1 Instrument's history and stability

There is little data from the two years before the current campaign, most of it corresponding to November 2023. Looking at these data, the standard lamp has been quite stable (Fig. 16-4), although the current R6 value, 320, is quite far from the reference one provided in the previous calibration, 200.

Some noise can be observed in the run/stop, dead time, and AP tests (Figs. 16-7, 16-8, and 16-9, respectively), but overall these parameters presented correct values.

Because of the lack of historical data before the campaign, we can't provide a full evaluation of the last operative configuration. However, looking at the data of the campaign, it should be noted that the SL correction seems to improve noticeably the ozone data (16-1)

16.1.2 Maintenance

As already mentioned, the instrument's micrometer connector and communication chip were replaced during the campaign, on days 50 and 58 respectively. Data from days 55 to 58 was lost due to communication problems. Finally, the cal step was updated on day 66.

16.1.3 Instrumental parameters during the campaign

No noticeable changes were observed in the instrumental RS, DT, and AP tests during the campaign, see Figs. 16-7, 16-8, and 16-9.

The standard lamp ratios stabilized around values **320** and **730** for R6 and R5 respectively, see Figures 16-4 and 16-5, respectively.

16.1.4 Temperature dependence and filters

Brewer STM#167 shows some temperature dependence (Fig. 16-10), but the slope of the R6 vs T fit is below the 5 units per 10 degrees threshold.

Concerning the filters, the analysis of the data in the FIOAVG file (Table 16-2) and Fig. 16-14) shows some filter changes out of acceptable limits. However, FIOAVG data is usually very noisy and few

measurents are available. The ozone also does not show any noticeable discontinuity on filter changes, so we don't recommend any ETC filter correction at this time.

16.1.5 Sun scan and dispersion tests

No sun-scan data is available at the instrument's home station. Data during the campaign produces a rather different cal step, 283, compared to the one currently in operation, 287. As mentioned above, the cal step was updated on day 66.

Dispersion tests carried during the campaign provide a value of 0.3445 for the ozone absorption coefficient with the new cal step.

16.1.6 ETC transfer

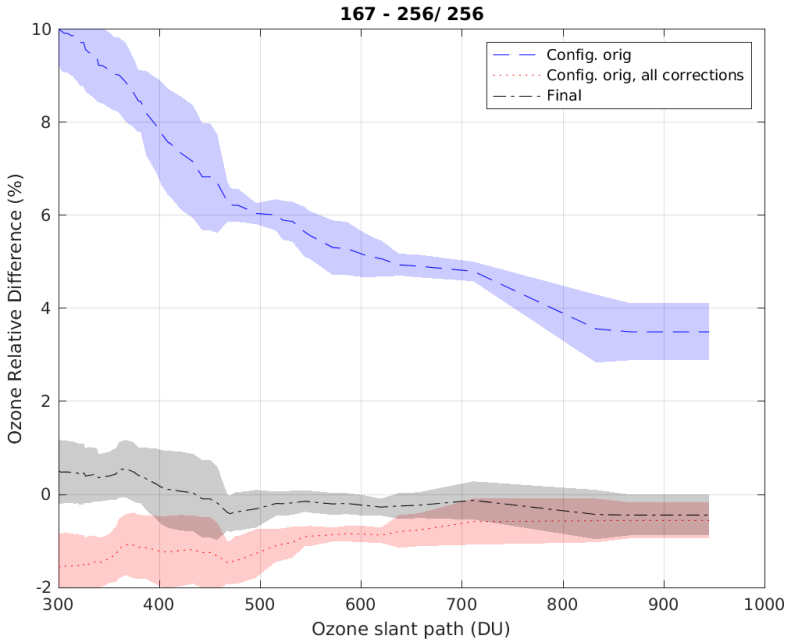


Figure 16-1 – Mean DS ozone column percentage difference between Brewer STM#167 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

As shown in Fig. 16-1, after the maintenance and using the new calibration, Brewer STM#167's ozone is within 0.1% with respect to reference Brewer IZO#256. This is a noticeable improvement of the result with the old configuration, even taking into account the effect of the SL correction.

16.1.7 Recommendations and Remarks

1. The R6 reference value shuld be updated to **320**.
2. We suggest a new R5 reference value of **730**.
3. We suggest updating the ETC value to **1540**.
4. We have updated the cal step number to 283, but we recommend running sun scan tests at the station to confirm this new value. The ozone absorption coefficient was also updated to 0.3445.
5. We recommend running the FI tests periodically so that the filters can be properly characterized
6. During the first days of the campaign, the SL correction improves the comparison with the reference Brewer. We thus recommend the application of the SL correction for the data before the campaign, although it should be noted that a detailed analysis has not been possible due to the lack of data.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/167/ICF06624.167

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=732937541#gid=732937541

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/167/html/cal_report_167a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/167/html/cal_report_167a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/167/html/cal_report_167b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/167/html/cal_report_167c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF33323.167)	Final (ICF06624.167)
o3 Temp coef 1	0	0
o3 Temp coef 2	-0.2795	-0.2795
o3 Temp coef 3	-0.4238	-0.4238
o3 Temp coef 4	-0.7682	-0.7682
o3 Temp coef 5	-1.0904	-1.0904
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3413	0.3445
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.146	1.146
ETC on O3 Ratio	1450	1540
ETC on SO2 Ratio	180	180
Dead time (sec)	2.6e-08	2.6e-08
WL cal step number	287	283
Slitmask motor delay	16	16
Umkehr Offset	1710	1710
ND filter 0	0	0
ND filter 1	4350	4350
ND filter 2	10100	10100
ND filter 3	14140	14140
ND filter 4	21200	21200
ND filter 5	25790	25790
Zenith steps/rev	2972	2972
Brewer Type	3	3
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	0	0
Mic #2 Offset	0	0
O3 FW #3 Offset	242	242
NO2 absn Coeff	-3	-3
NO2 ds etc	770	770
NO2 zs etc	740	740
NO2 Mic #1 Offset	8028	8028
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2518	2518
Grating Slope	0.998	0.998
Grating Intercept	0	0
Micrometer Zero	2469	2469
Iris Open Steps	250	250
Buffer Delay (s)	0.2	0.2
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	0	0
Zenith Offset	0	0
Zenith UVB Position	2210	2210

16.3 Appendix: Summary Plots

Figure 16-2 in this appendix shows the ozone during the campaign as determined by Brewer STM#167 using the final calibration (ICF06624.167), and by reference Brewer IZO#256. Fig. 16-3 shows the daily ozone data in detail.

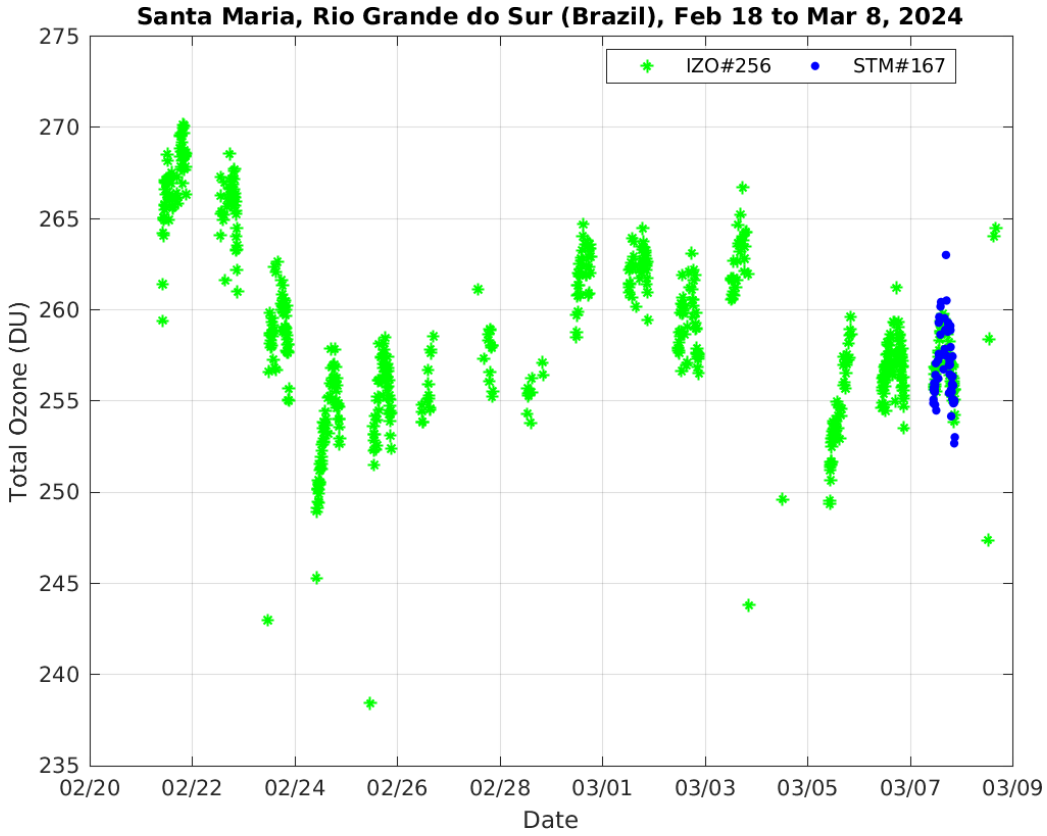


Figure 16-2 – Overview of the intercomparison. For the final days starting on day 66, Brewer STM#167's data are evaluated using the final constants (blue circles) provided in the ICF06624.167 file.

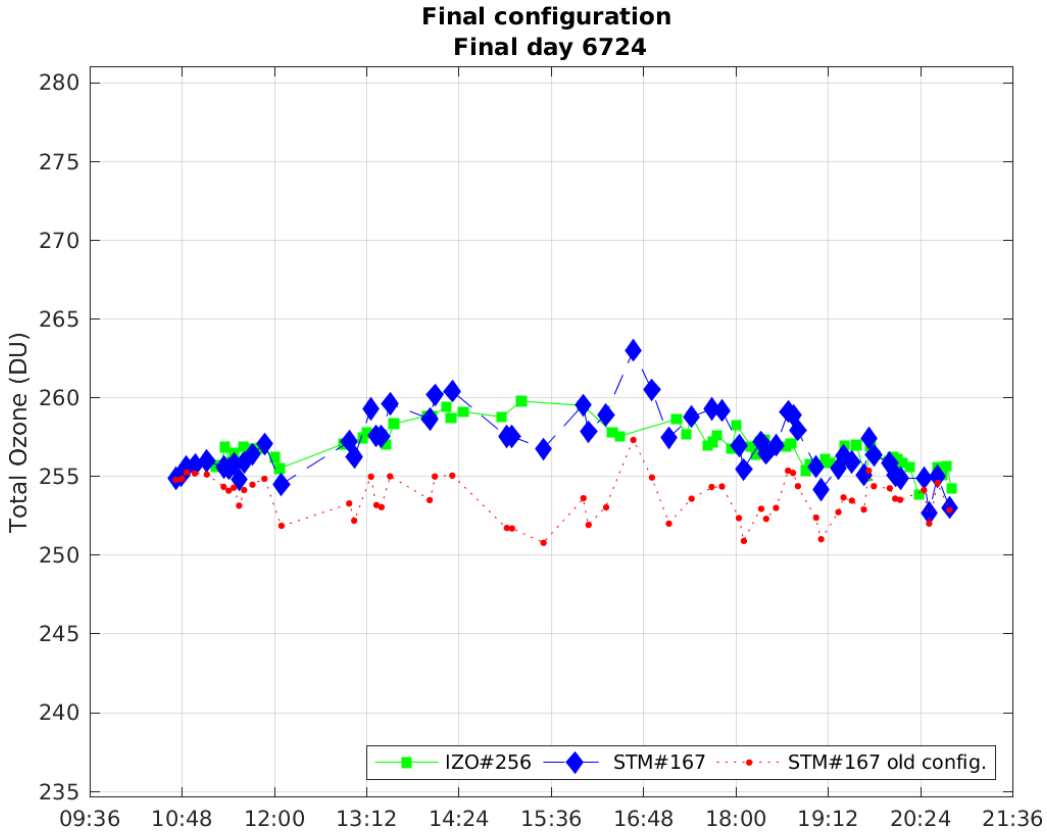


Figure 16-3 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF33323.167, red) and final (ICF06624.167, blue) configurations of Brewer STM#167, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-4) and R5 (Fig. 16-5) ratios, and the intensity of slit 5 (Fig. 16-6), results of the Run/Stop (Fig. 16-7), Dead Time (Fig. 16-8), and analog voltages and intensity (Fig. 16-9) tests, analysis of the temperature coefficient's performance (Figs. 16-10, 16-11, 16-12, and 16-13), check of the neutral density filter's linearity (Table 16-2), and Fig. 16-14), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-15) tests.

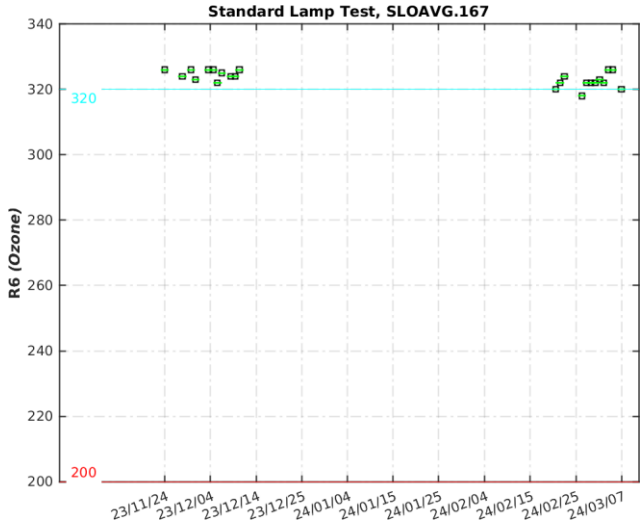


Figure 16-4 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

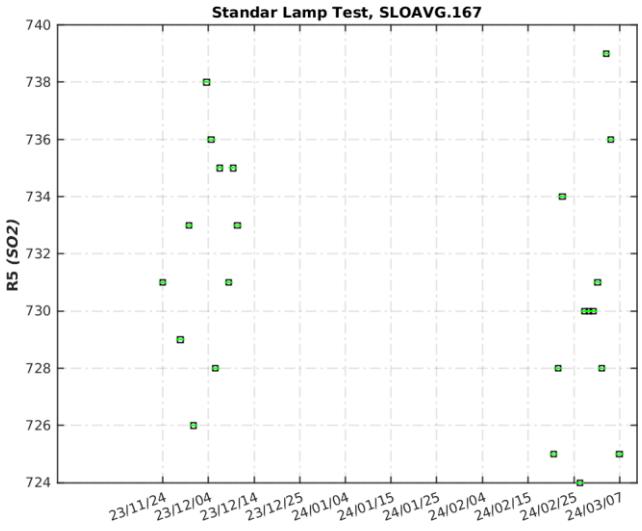


Figure 16-5 – Standard Lamp test R5 (SO_2) ratios

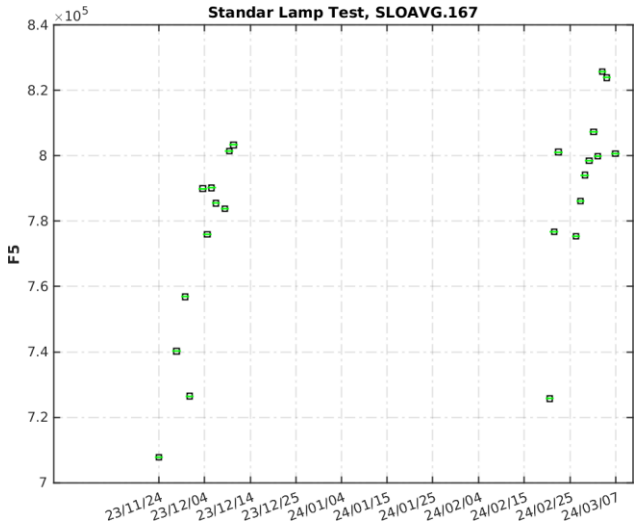


Figure 16-6 – SL intensity for slit five.

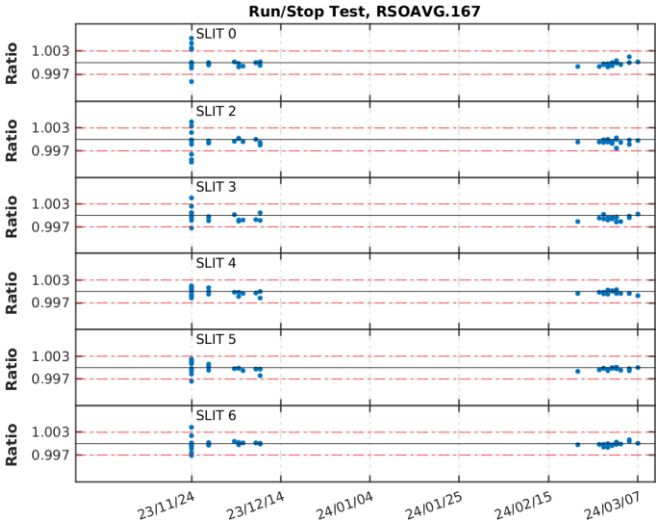


Figure 16-7 – Run/stop test

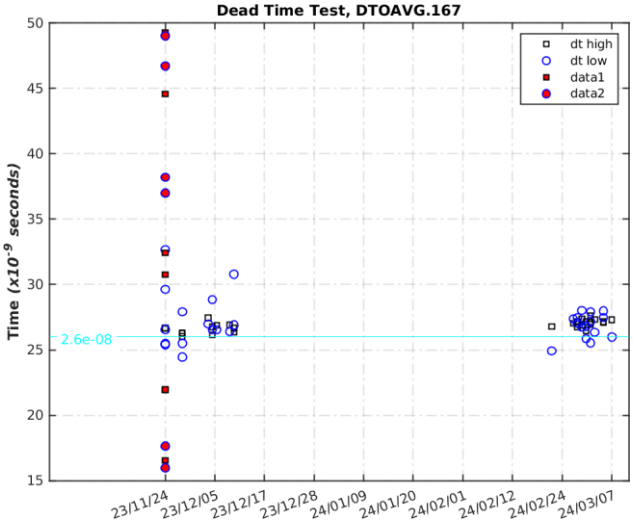


Figure 16-8 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

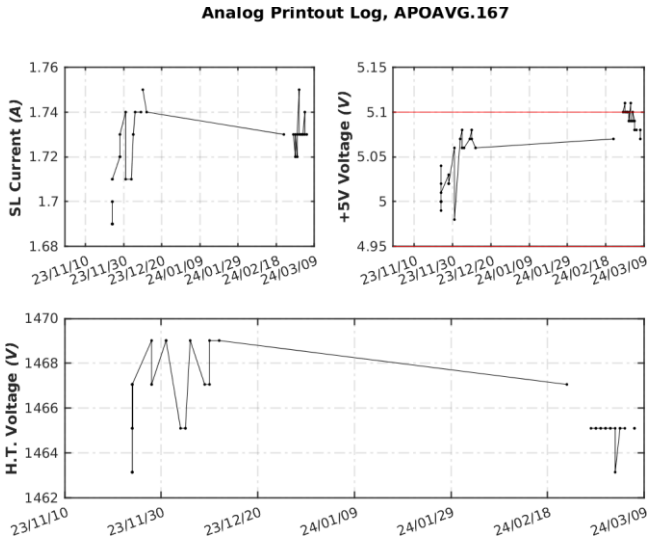


Figure 16-9 – Analog voltages and intensity.

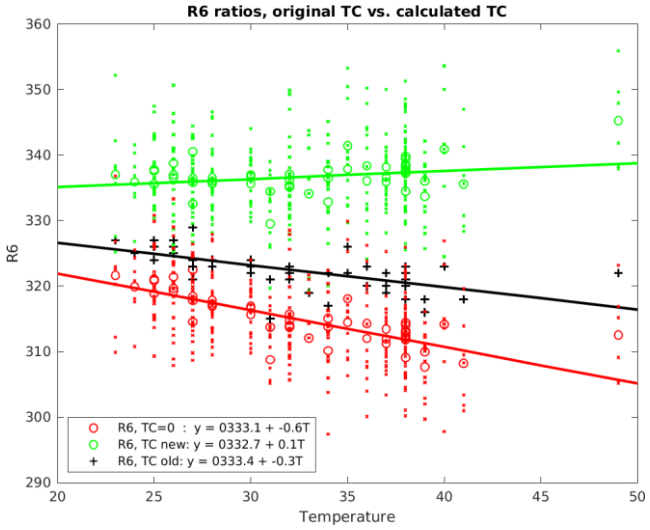


Figure 16-10 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

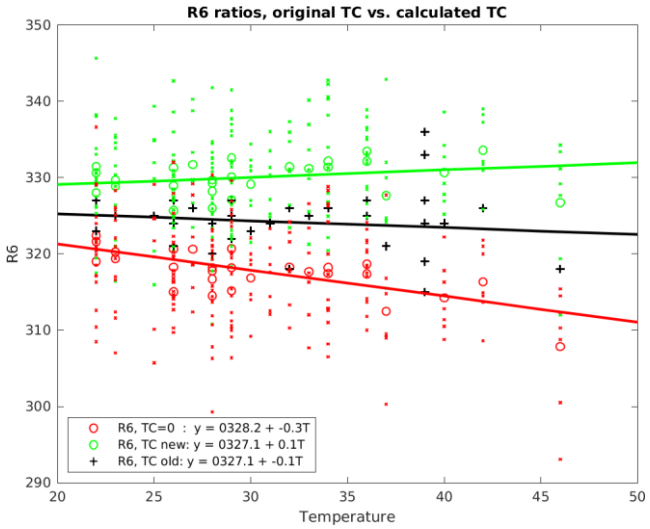


Figure 16-11 – Same as Fig. 16-10 but for the whole period between calibration campaigns.

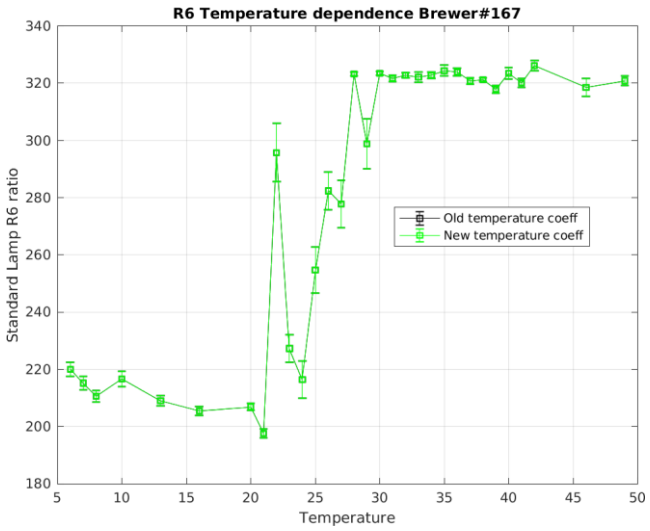


Figure 16-12 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

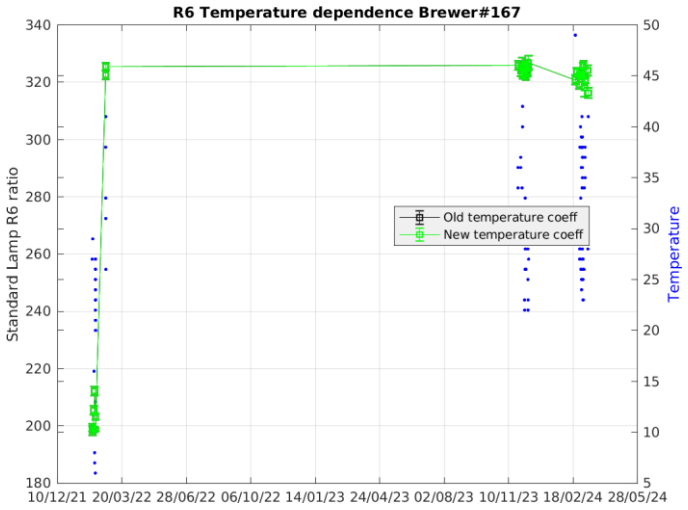


Figure 16-13 – Same as Fig. 16-12, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	9	-13	-6	-12	6
ETC Filt. Corr. (mean)	1	-8	-7.8	-12.1	-0.1
ETC Filt. Corr. (mean 95% CI)	[-7.9 10.5]	[-17.7 3.8]	[-17.6 3.4]	[-19.8 -3.8]	[-6.9 13]

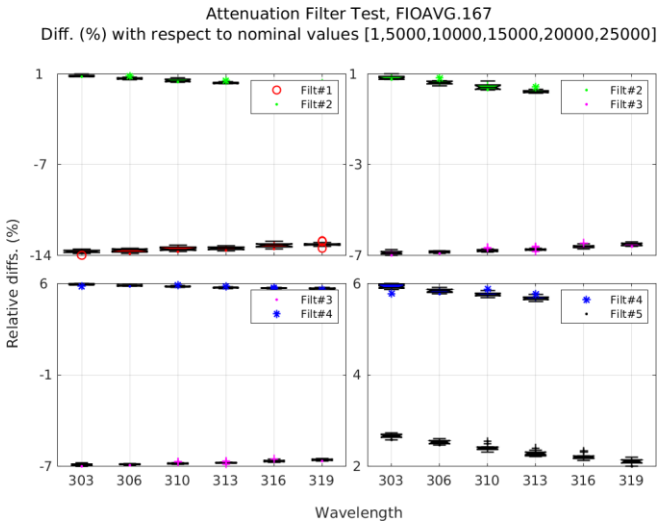


Figure 16-14 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

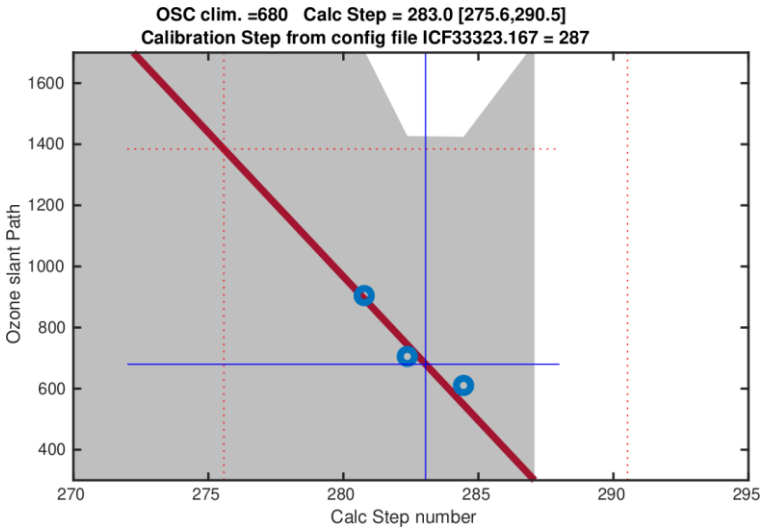


Figure 16-15 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16 Brewer PUQ#180

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer PUQ#180 participated in the campaign in the period from 22th of February to 8th of March. The campaign days of Brewer PUQ#180 correspond to Julian days 53– 68.

On its arrival on day 53, do not work properly during the first days on the campaing with ananomalous readings of Standard Lamp ratios, Dead Time and High Voltage. The instrument received extensive maintenance by IOS since day 060, including the mirror adjustment and HV voltage on day 63. After that severall issues with the tracker do not allow the proper operation of the instrument. Finally we manage to have observations with the automatic sitting provided by the FV routine.

Due this there are thus no blind days no evaluate the status of the instrument.

We used **87** simultaneous DS ozone measurements taken from day **66** to **68** to calibrate the instrument after the maintenance (Fig. 16-2)

16.1.1 Instrument's history and stability

Over the last years, the R6 standard lamp measurements were very stable, only showing slighly noisy behavior after the lamp replacement in March 2023. see Fig. 16-4. The run/stop test aswell Dead Time test shows simmilar behavior with more noticeable noisy results (Fig. 16-7, Fig. 16-8). The results of the AP tests in Fig. 16-9 do not show the noisy resutls, only the adjusted values during the campaing.

To further check the stability of the instrument, we have compared EUBREWNET's level 1.5 ozone product with the ERA5 data for the station of Brewer PUQ#180, for the two years between intercomparison campaigns. The relative difference between both datasets is shown in Fig. 16-1. The relative difference shows a noticeable offset about -5% and seasonality but otherwise the ozone has quite a stable behaviour.

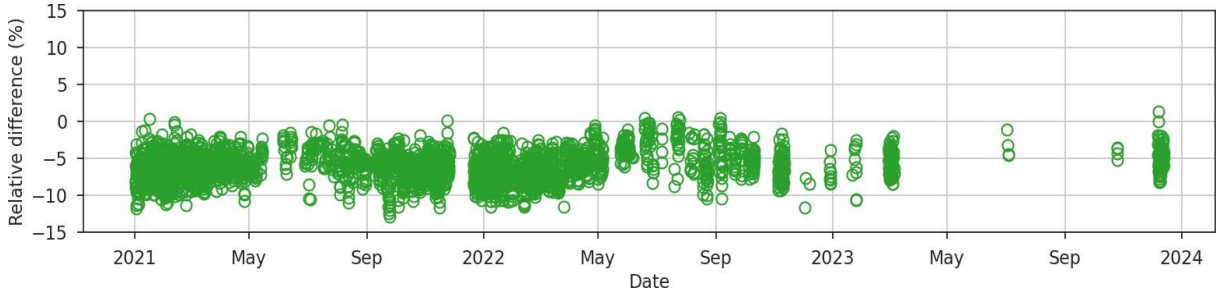


Figure 16-1 – Relative difference of EUBREWNET's level 1.5 ozone product with respect to the ERA5 data for the station of Brewer PUQ#180

16.1.2 Maintenance

As mentioned before, the instrument were maintained by IOS and the RBCC-E team. Maintenance work included adjustments to the mirror and high voltage.

16.1.3 Instrumental parameters during the campaign

After maintenance, the RS and DT tests show correct values, see Figs. 16-7 and 16-8, respectively. Some changes in the results of the AP tests were observed during the campaign, likely caused by the maintenance work.

During last campaign days the standard lamp ratios stabilized around values **250** and **400** for R6 and R5 respectively, see Figures 16-4 and 16-5, respectively. Due the few days used for the calibration the confidence of these values is limited.

16.1.4 Temperature dependence and filters

Temperature coefficients perform very well using the observations in Punta Arenas. The calculated temperature coefficients perform very similar to the existing ones (see Fig. 16-11). We thus do not suggest changing the temperature coefficients.

The nonlinearity corrections for the filtes are very similar for all of them arround 5 ETC units but no significance, we dont apply any correction. This also confirmed analizing simultaneous measurments that use different filter.

16.1.5 Sun scan and dispersion tests

Data from the sun-scan tests (SC) at the instrument's station before the campaign were not performed, but the SC tests carried out during the campaign confirm the current cal step, nan.

The ozone absorption coefficient in use (0.343) is slightly different to the value derived from dispersion tests performed in 2015. A new value 0.3396 was adopted in final configuration,about 3 mic step different from the setting 0.343and two steps from the last dispersion.

16.1.6 ETC transfer

As shown in Fig. 16-2, after the maintenance and using the new calibration, Brewer PUQ#180's ozone is within with respect to reference Brewer IZO#256.

16.1.7 Recommendations and Remarks

1. The R6 reference value shuld be updated to **250** and new R5 reference value of **400**. This values has to be evaluated when the instrument comeback to the home station as where derived from a few observations days.
2. Regular test of responsivity and wavelength aligment (CI, HL,HS) are advisable to perform every week using the apropiate ED routine
3. Finally, we suggest updating the ETC value to **1515**.

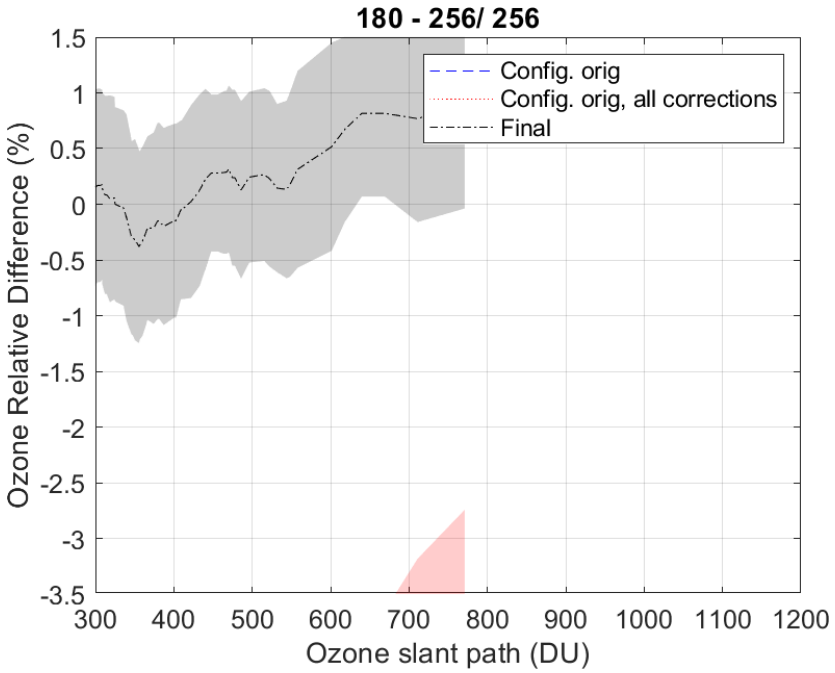


Figure 16-2 – Mean DS ozone column percentage difference between Brewer PUQ#180 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/180/ICF06424.180

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=754835468#gid=754835468

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/180/html/cal_report_180a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/180/html/cal_report_180a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/180/html/cal_report_180b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/180/html/cal_report_180c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF06015.180)	Final (ICF06424.180)
o3 Temp coef 1	6.9213	6.9213
o3 Temp coef 2	7.0381	7.0381
o3 Temp coef 3	7.1294	7.1294
o3 Temp coef 4	7.2462	7.2462
o3 Temp coef 5	7.3423	7.3423
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.343	0.3396
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.147	1.147
ETC on O3 Ratio	1640	1515
ETC on SO2 Ratio	430	430
Dead time (sec)	2.6e-08	3.1e-08
WL cal step number	286	286
Slitmask motor delay	14	14
Umkehr Offset	1691	1691
ND filter 0	0	0
ND filter 1	4400	4400
ND filter 2	10250	10250
ND filter 3	14000	14000
ND filter 4	21200	21200
ND filter 5	25900	25900
Zenith steps/rev	2972	2972
Brewer Type	3	3
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	-7	-7
Mic #2 Offset	-8	-8
O3 FW #3 Offset	242	242
NO2 absn Coeff	-3	-3
NO2 ds etc	770	770
NO2 zs etc	740	740
NO2 Mic #1 Offset	8028	8028
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2500	2500
Grating Slope	0.998	0.998
Grating Intercept	-5	-5
Micrometer Zero	2469	2469
Iris Open Steps	250	250
Buffer Delay (s)	0.8	0.8
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	0	0
Zenith Offset	0	0
Zenith UVB Position	2225	2225

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer PUQ#180 using the final calibration (ICF06424.180), and by reference Brewer IZO#256. Fig. **??** shows the daily ozone data in detail.

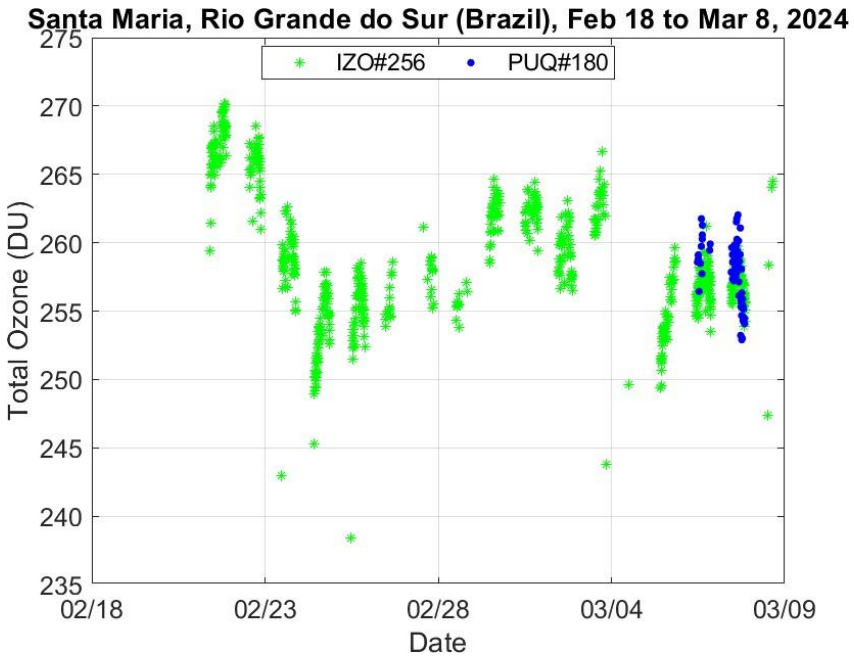
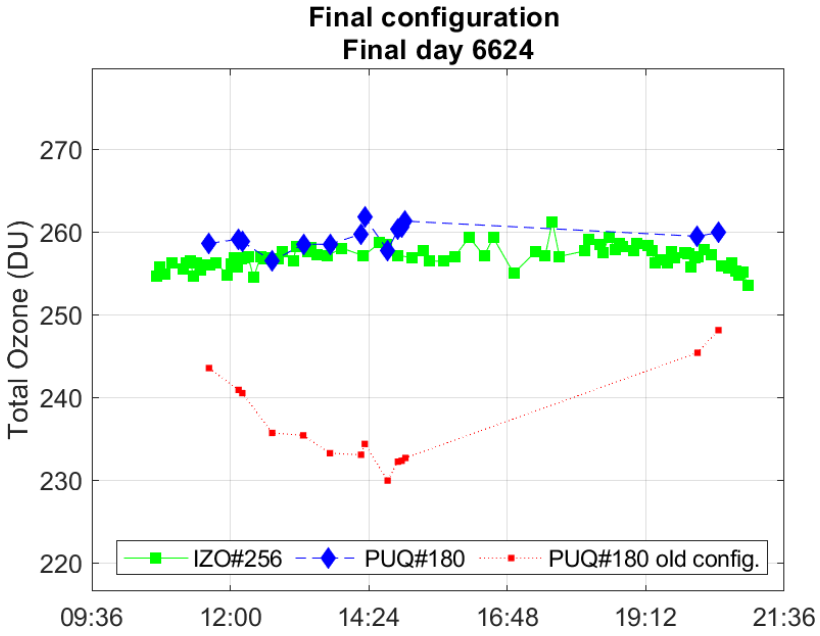
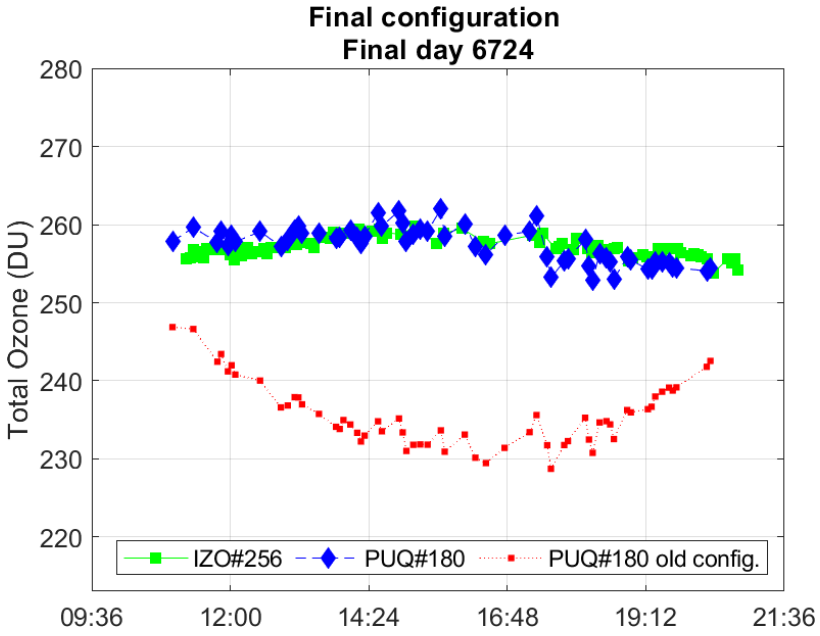


Figure 16-3 – Overview of the intercomparison. For the final days starting on day 66, Brewer PUQ#180's data are evaluated using the final constants (blue circles) provided in the ICF06424.180 file.


Final configuration
Final day 6624
Total Ozone (DU)
270
260
250
240
230
220
09:36
12:00
14:24
16:48
19:12
21:36
IZO#256
PUQ#180
PUQ#180 old config.


Final configuration
Final day 6724
Total Ozone (DU)
280
270
260
250
240
230
220
09:36
12:00
14:24
16:48
19:12
21:36
IZO#256
PUQ#180
PUQ#180 old config.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-4) and R5 (Fig. 16-5) ratios, and the intensity of slit 5 (Fig. 16-6), results of the Run/Stop (Fig. 16-7), Dead Time (Fig. 16-8), analog voltages and intensity (Fig. 16-9), and CI (Fig. **??**) tests, analysis of the temperature coefficient's performance (Figs. 16-10, 16-11, 16-12, and 16-13), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-14), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-15) tests.

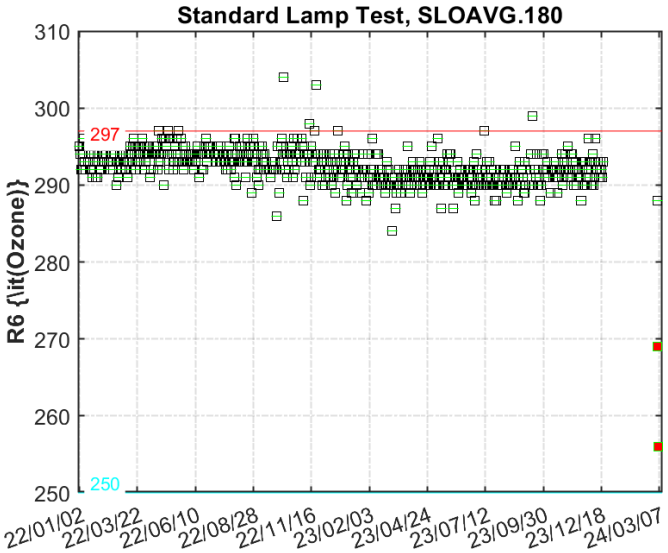


Figure 16-4 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

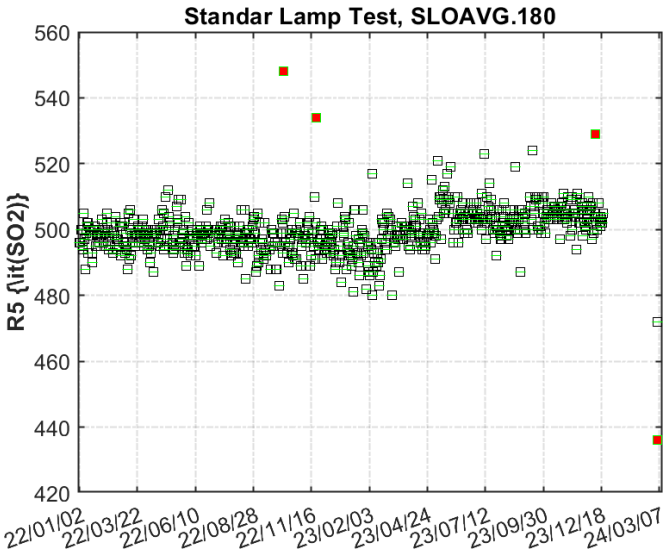


Figure 16-5 – Standard Lamp test R5 (SO_2) ratios

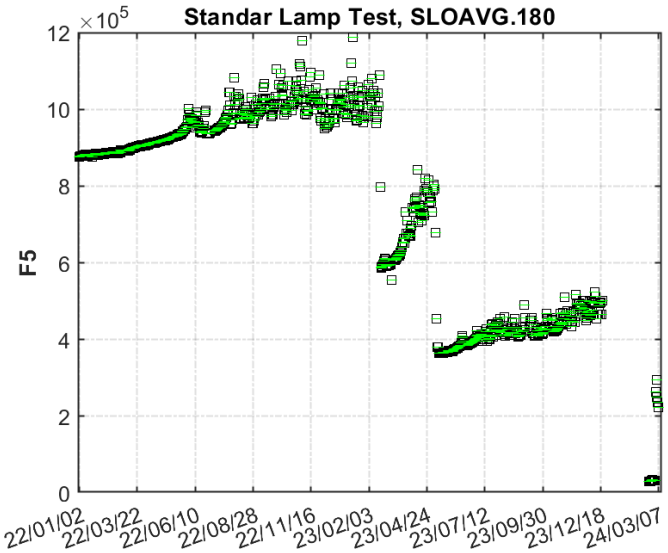


Figure 16-6 – SL intensity for slit five.

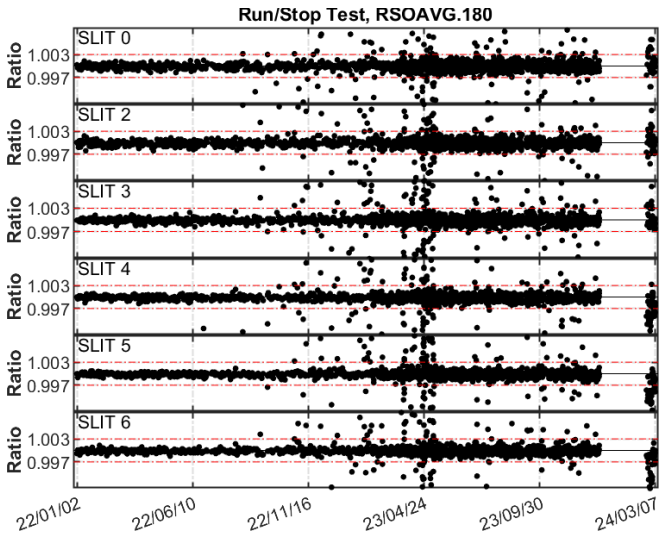


Figure 16-7 – Run/stop test

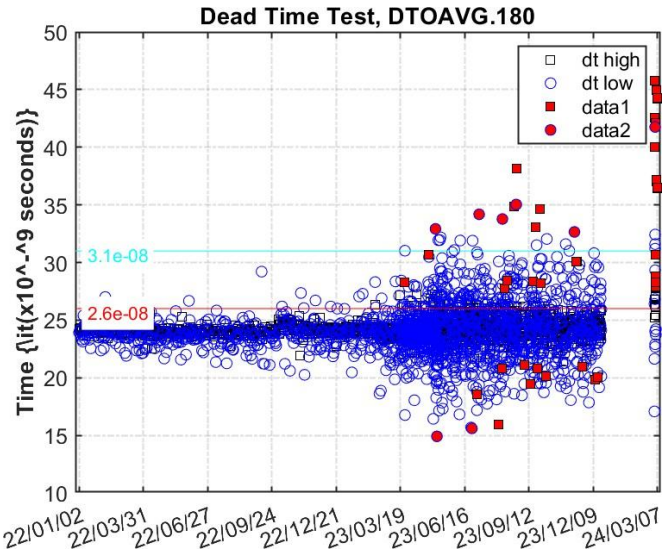


Figure 16-8 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

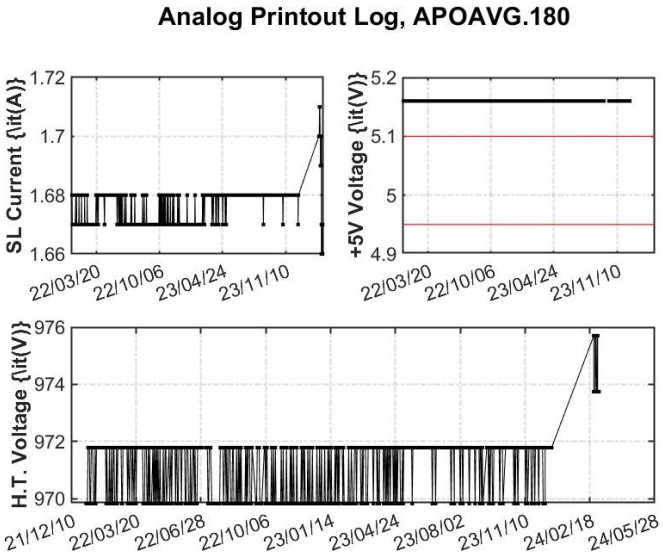


Figure 16-9 – Analog voltages and intensity.

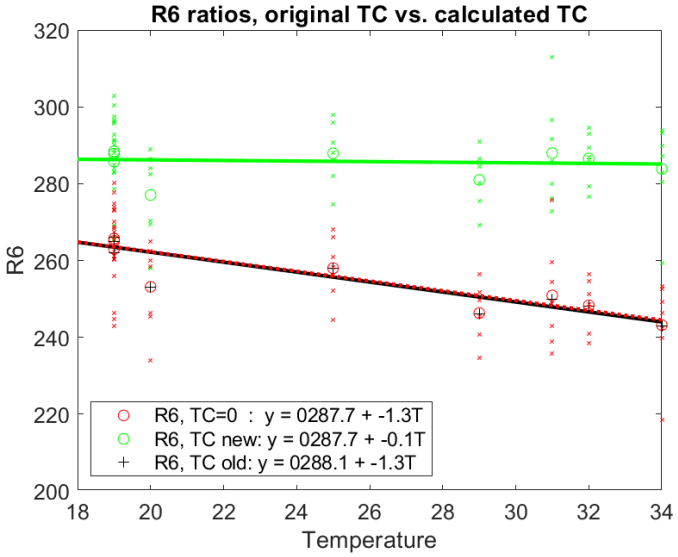


Figure 16-10 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

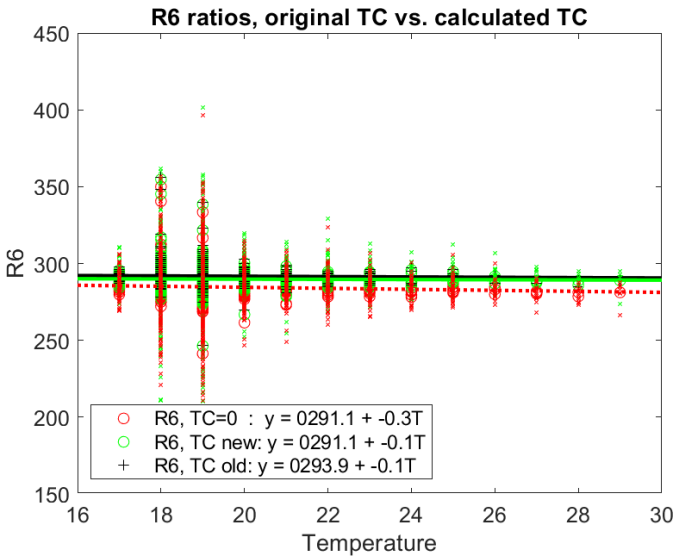


Figure 16-11 – Same as Fig. 16-10 but for the whole period between calibration campaigns.

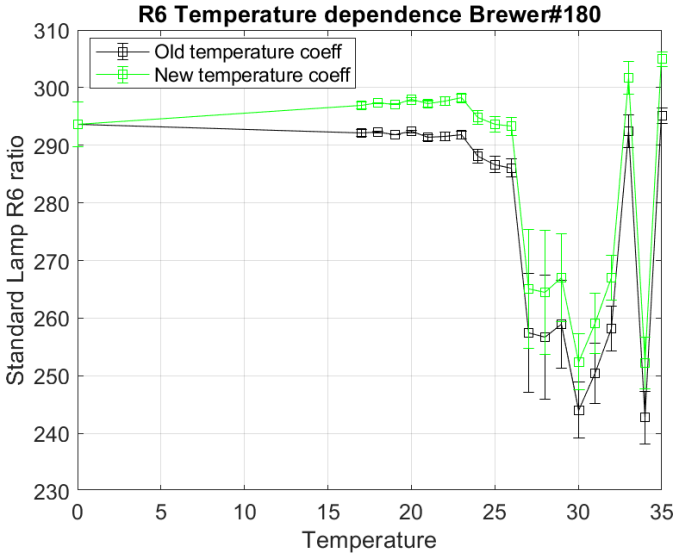


Figure 16-12 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

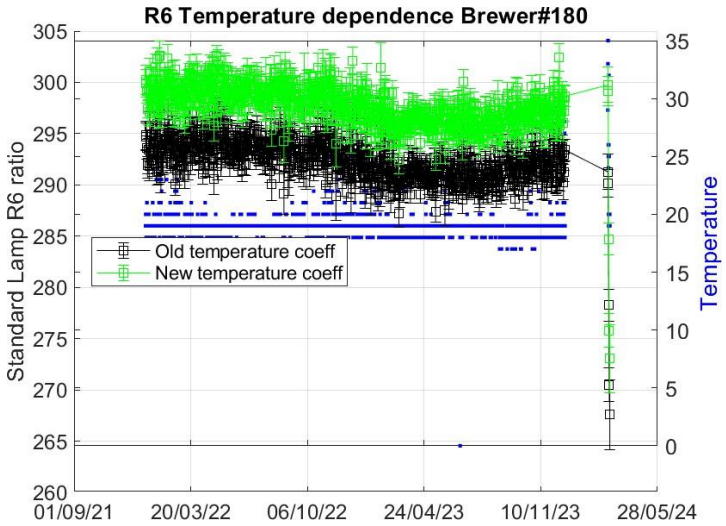


Figure 16-13 – Same as Fig. 16-12, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	2	-6	-5	-6	-4
ETC Filt. Corr. (mean)	-2.2	-3.1	-4	-5.9	-3.1
ETC Filt. Corr. (mean 95% CI)	[-5 0.5]	[-6 -0.2]	[-7.1 -0.7]	[-10.3 -1.8]	[-9.2 3.5]

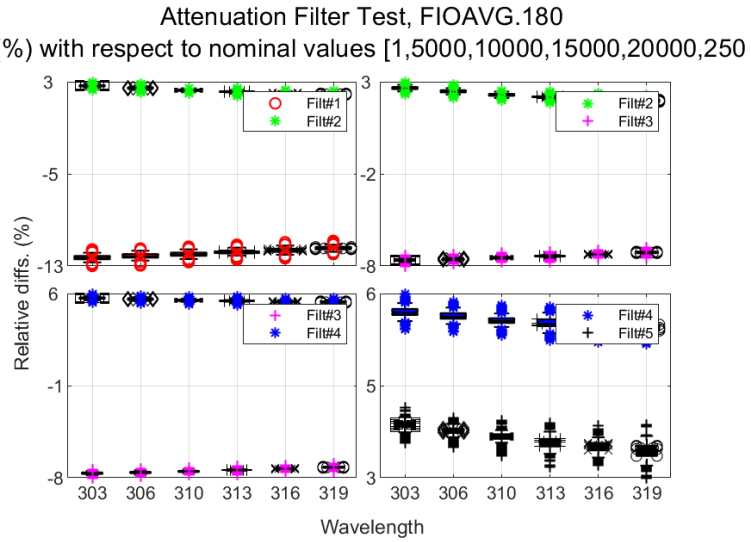


Figure 16-14 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	286	0.3430	2.3500	1.1470
01-Mar-2015	286	0.3415	2.7621	1.1465
04-Mar-2024	286	0.3396	2.7773	1.1403
Final	286	0.3396	2.3500	1.1470

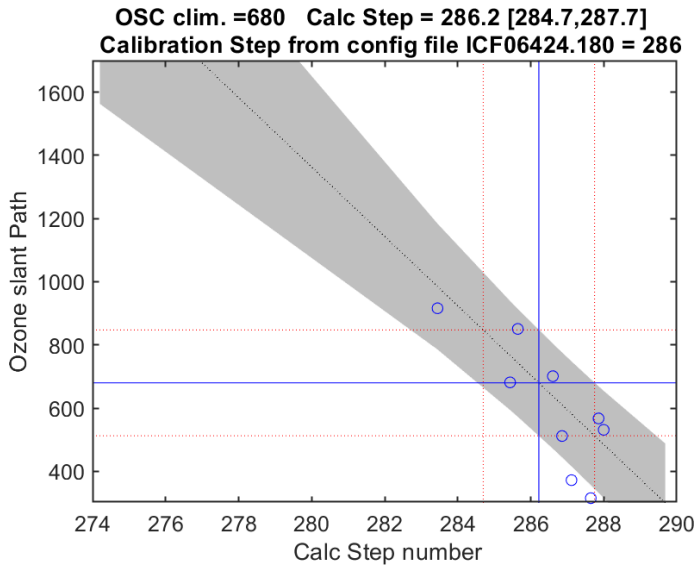


Figure 16-15 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16 Brewer QTO#218

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 10th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer QTO#218 participated in the campaign from February 24th to March 8th. The campaign days of Brewer QTO#218 thus correspond to Julian days 55 – 68.

The instrument received minor maintenance during the campaign, including the replacement of the standard lamp on day 63. We have used **118** simultaneous DS ozone measurements taken from day **64** to **68** to calibrate the instrument (Fig. 16-2)

16.1.1 Instrument's history and stability

Over the last two years, the R6 standard lamp measurements have not been stable, showing a continuous zig-zag pattern with an amplitude of 20 units in R6, see Fig. 16-5. This behaviour seems to feature some periodicity and might be related to weather conditions at the station. The results of the AP tests in Fig. 16-12 are quite stable, showing little changes until the SL was replaced at the present campaign. No data from run/stop and dead time tests seems to be available before the campaign.

Using the data from the blind days of the present campaign, we obtain an ETC of 1665, fairly close to the ETC in the current configuration, 1668. Note the R6 reference ratio has almost not changed, retaining an average value of approx. 420 units.

To further check the stability of the instrument, we have compared EUBREWNET's level 1.5 ozone product with the ERA5 data for the station of Brewer QTO#218, for the two years before the present campaigns. The relative difference between both datasets is shown in Fig. 16-1. Note the Brewer data includes de standard lamp correction, which was found to improve slightly the comparison with the ERA5, although further analysis is required. The relative difference shows a noticeable increase in noise in summer 2022. Otherwise, the ozone has quite a stable behaviour.

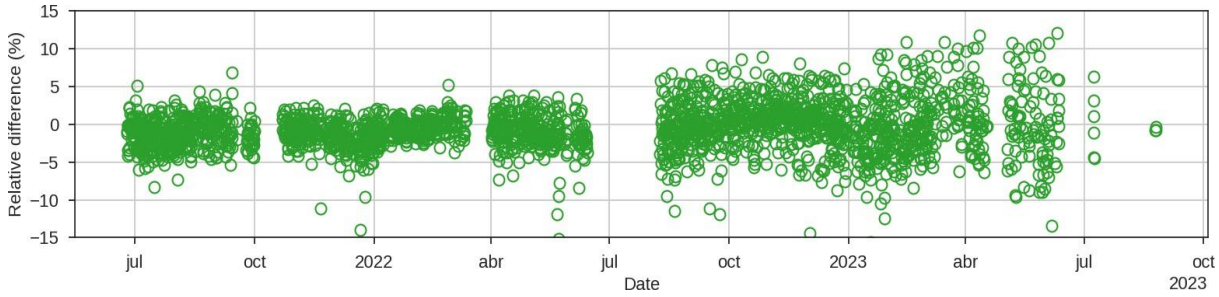


Figure 16-1 – Relative difference of EUBREWNET's level 1.5 ozone product with respect to the ERA5 data for the station of Brewer QTO#218

16.1.2 Maintenance

After the standard lamp was replaced, the noise in the R6 ratio was reduced, see Fig. 16-6.

16.1.3 Instrumental parameters during the campaign

The standard lamp ratios stabilized at values of approx. **419** and **575** for R6 and R5, respectively. Note the R6 reference value remains practically the same after the lamp replacement.

From the dead time tests performed during the campaign, Fig. 16-11, a new value of $2.2 \cdot 10^{-8}$seconds should be used instead of the present one, $2.7 \cdot 10^{-8}$s. The RS tests show correct values, see Fig. 16-10.

16.1.4 Temperature dependence and filters

Brewer QTO#218 does not shows a noticeable temperature dependence, neither during the present campaign (Fig. 16-14) nor during the last two years (Fig. 16-15). We thus do not suggest changing the temperature coefficients.

Concerning the performance of the filters, the ozone does not seem to present any large discontinuity at filter changes, so no ETC filter correction is suggested.

16.1.5 Sun scan and dispersion tests

No sun-scan tests were conducted before the campaign, and the data acquired during the campaign does not seem correct. We thus can not suggest any change to the current cal step, nan.

Compared to present value of 0.3463, dispersion tests during the campaign produce a slightly lower value of the ozone absorption coefficient, 0.3441, and we recommend adopting this new value.

16.1.6 ETC transfer

As shown in Fig. 16-2, the new calibration produces a small but noticeable improvement in the comparison with reference Brewer IZO#256, with Brewer QTO#218's ozone now within 0.3% with respect to reference instrument.

16.1.7 Recommendations and Remarks

1. After the standard lamp replacement, the R6 reference value remains almost unchanged at an average value of **419**.
2. We suggest a new R5 reference value of **575**.
3. We suggest updating the DT to $\mathbf{2.2 \cdot 10^{-8}}$ seconds.
4. We suggest updating the ETC value to **1660**.
5. We have not been able to check the current cal step number due to missing sun scan data. We recommend performing this test at the home station (although any update to the cal step will have to wait for the next intercomparison)
6. We recommend performing the RS and DT tests regularly at the station.

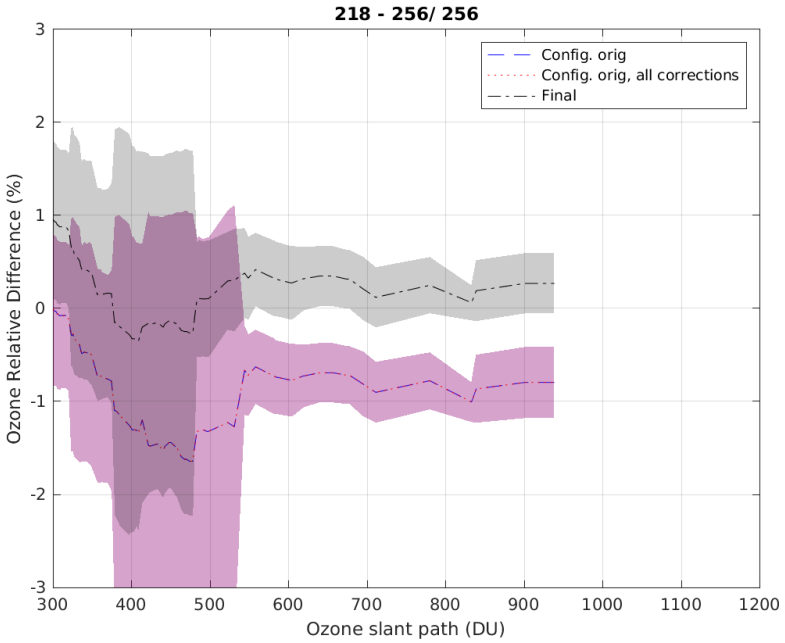


Figure 16-2 – Mean DS ozone column percentage difference between Brewer QTO#218 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

7. In our brief check of the stability of the instrument before the campaign, we found that the standard lamp correction with an R6 reference value of 420 units, improves the comparison with the ERA5 data. We thus recommend the application of the standard lamp correction to previous data, although further analysis of these data should be performed.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/218/ICF06424.218

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=68223524#gid=68223524

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/218/html/cal_report_218a1.html

Temperature & Filter

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/218/html/cal_report_218a2.html

Wavelength

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/218/html/cal_report_218b.html

ETC transfer

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/218/html/cal_report_218c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF01514.218)	Final (ICF06424.218)
o3 Temp coef 1	0	0
o3 Temp coef 2	0.05156	0.05156
o3 Temp coef 3	0.07756	0.07756
o3 Temp coef 4	0.1046	0.1046
o3 Temp coef 5	-0.0455	-0.0455
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3463	0.3441
SO2 on SO2 Ratio	2.35	2.35
O3 on SO2 Ratio	1.1369	1.1369
ETC on O3 Ratio	1668	1660
ETC on SO2 Ratio	72	72
Dead time (sec)	2.7e-08	2.2e-08
WL cal step number	286	286
Slitmask motor delay	14	14
Umkehr Offset	1682	1682
ND filter 0	0	0
ND filter 1	4756	4756
ND filter 2	10572	10572
ND filter 3	13382	13382
ND filter 4	22576	22576
ND filter 5	26587	26587
Zenith steps/rev	2972	2972
Brewer Type	3	3
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	0	0
Mic #2 Offset	0	0
O3 FW #3 Offset	242	242
NO2 absn Coeff	-3	-3
NO2 ds etc	770	770
NO2 zs etc	740	740
NO2 Mic #1 Offset	8028	8028
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2515	2515
Grating Slope	1.0018	1.0018
Grating Intercept	-14.77	-14.77
Micrometer Zero	2469	2469
Iris Open Steps	250	250
Buffer Delay (s)	0	0
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	0	0
Zenith Offset	0	0
Zenith UVB Position	2210	2210

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer QTO#218 using the final calibration (ICF06424.218), and by reference Brewer IZO#256. Fig. 16-4 shows the daily ozone data in detail.

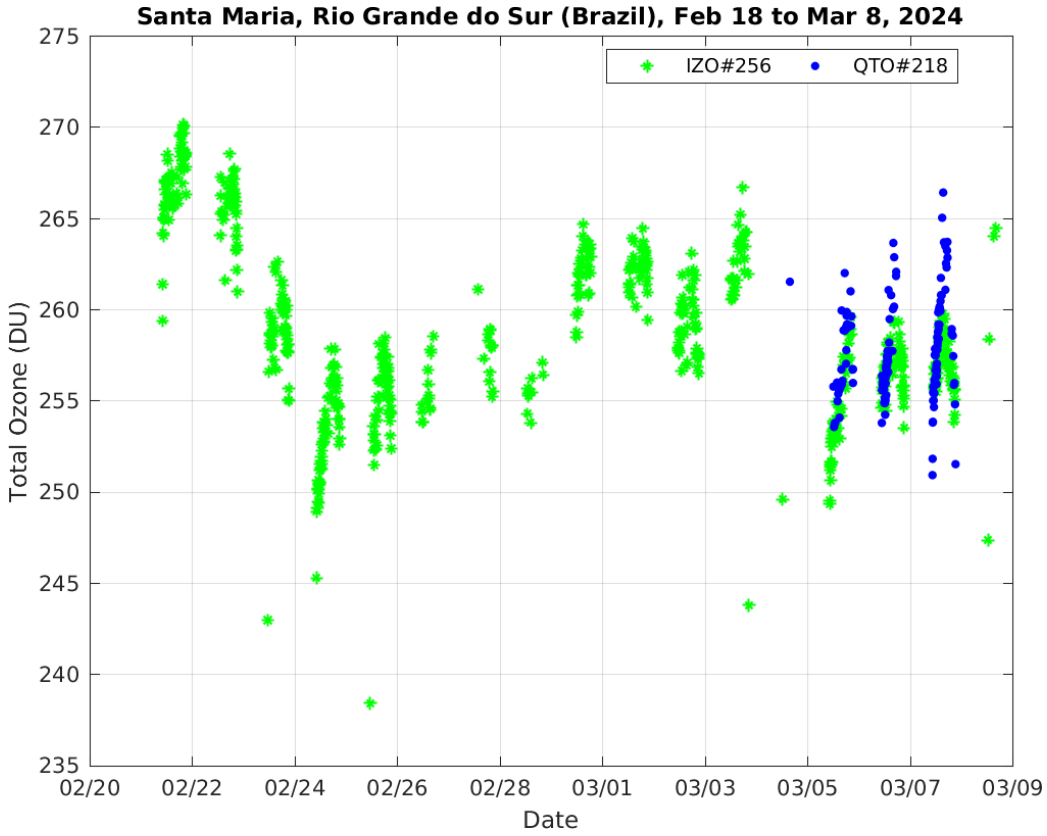
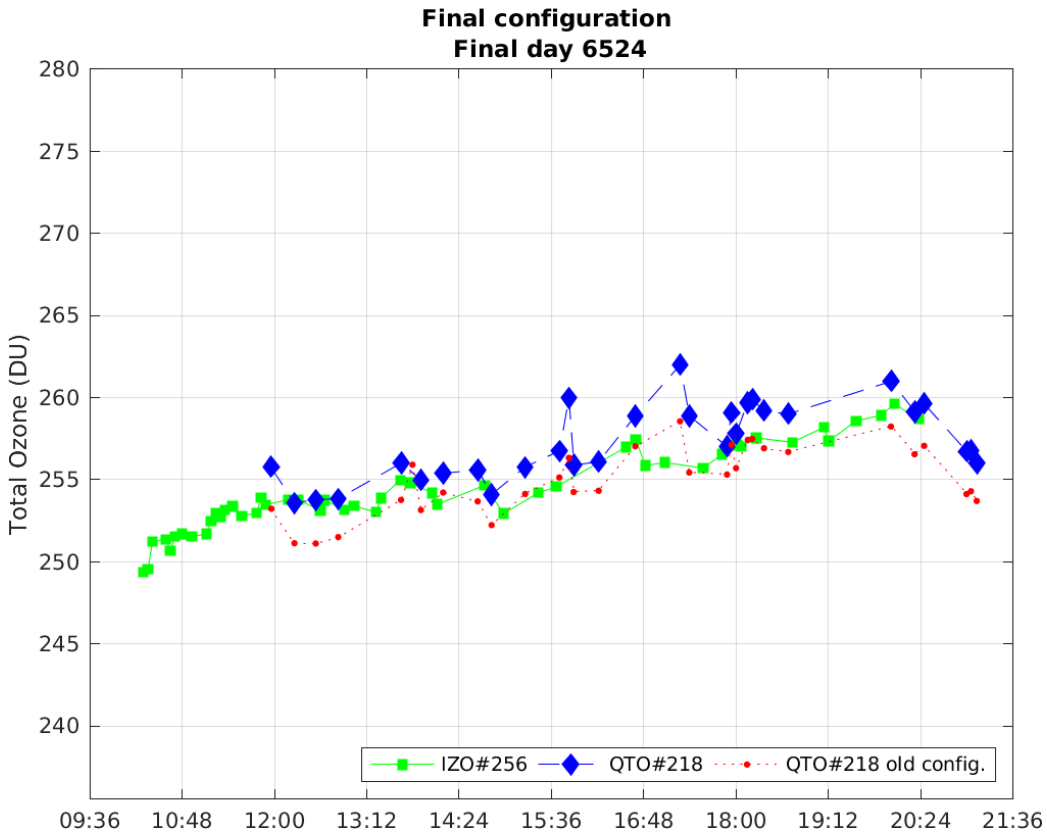
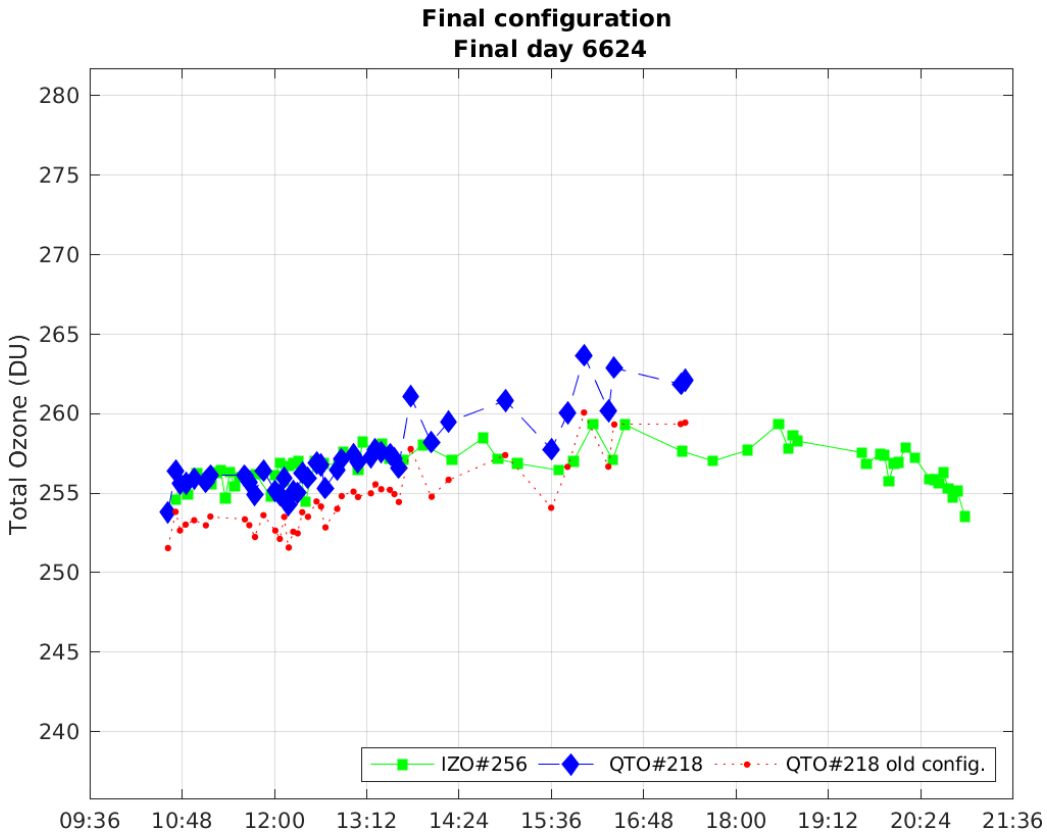


Figure 16-3 – Overview of the intercomparison. For the final days starting on day 64, Brewer QTO#218's data are evaluated using the final constants (blue circles) provided in the ICF06424.218 file.



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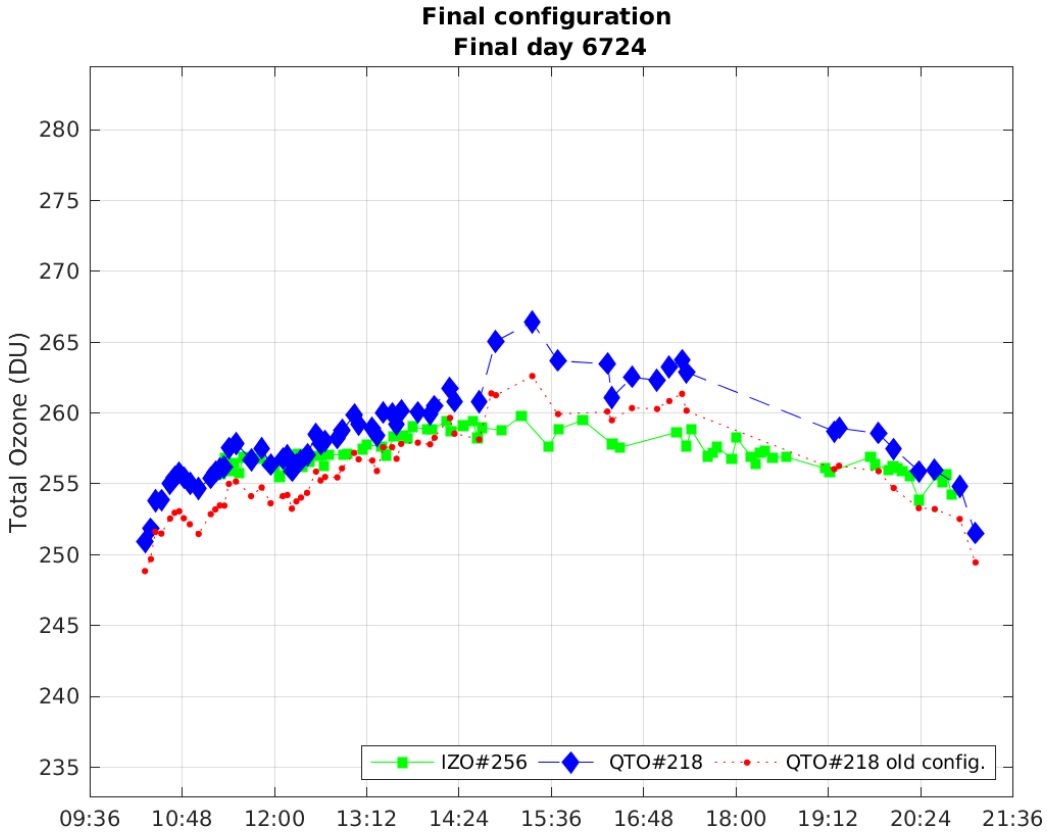


Figure 16-4 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF01514.218, red) and final (ICF06424.218, blue) configurations of Brewer QTO#218, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-6) and R5 (Fig. 16-8) ratios, and the intensity of slit 5 (Fig. 16-9), results of the Run/Stop (Fig. 16-10), Dead Time (Fig. 16-11), analog voltages and intensity (Fig. 16-13) tests, analysis of the temperature coefficient's performance (Figs. 16-14, 16-15, 16-16, and 16-17), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-18), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-19) tests.

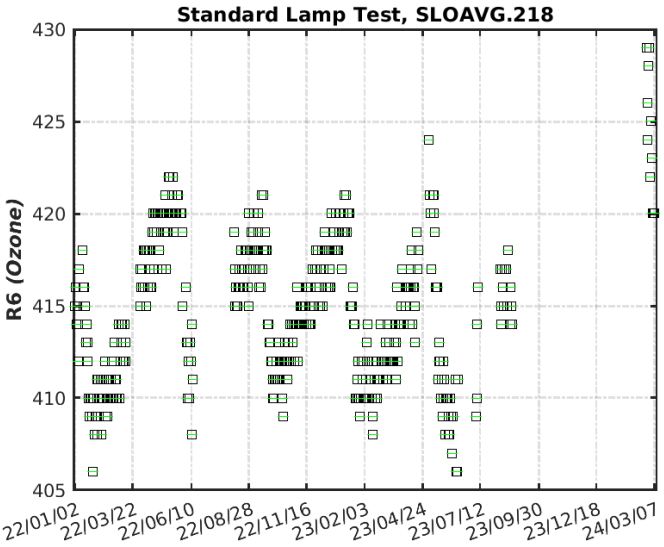


Figure 16-5 – Historical record of standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

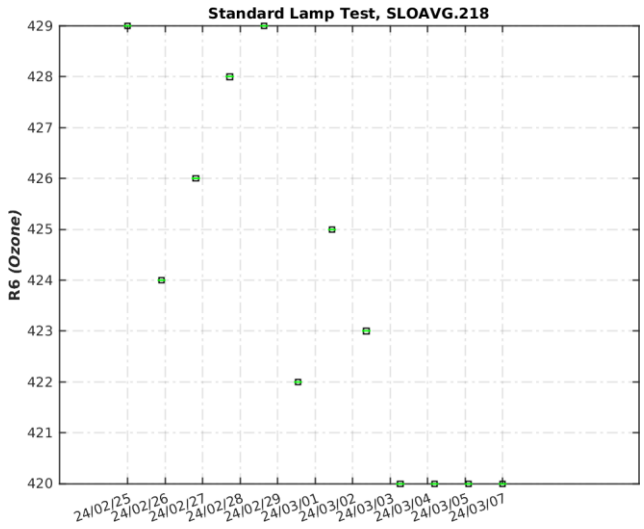


Figure 16-6 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

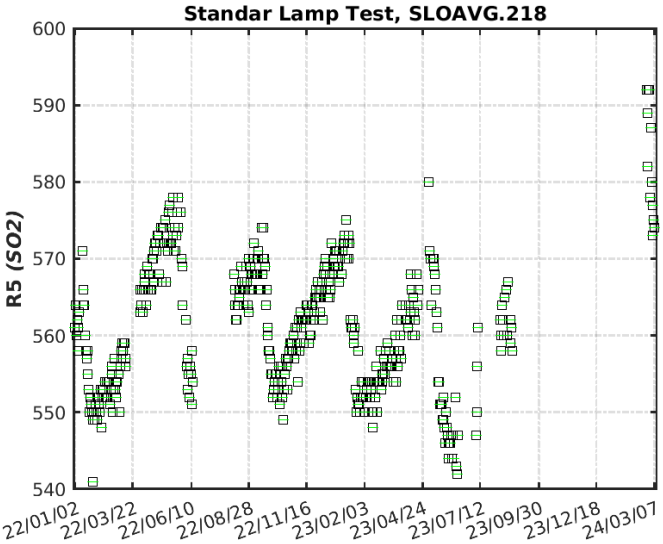


Figure 16-7 – Historical record of standard Lamp test R5 (SO_2) ratios

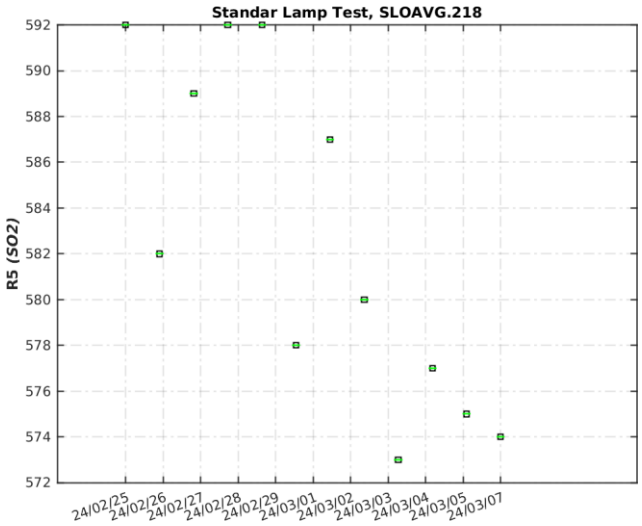


Figure 16-8 – Standard Lamp test R5 (SO_2) ratios

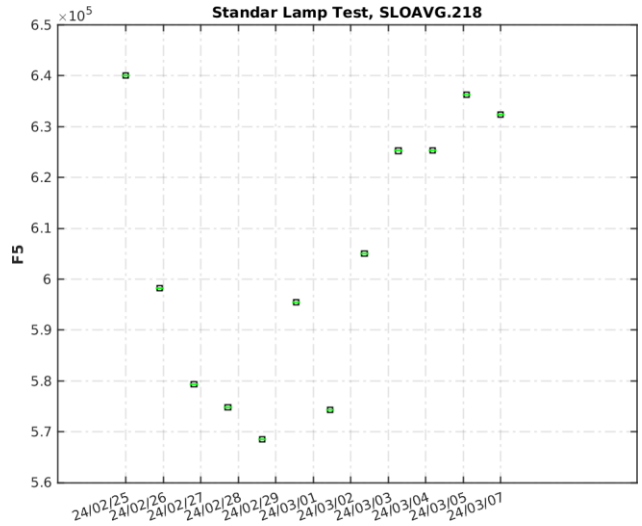


Figure 16-9 – SL intensity for slit five.

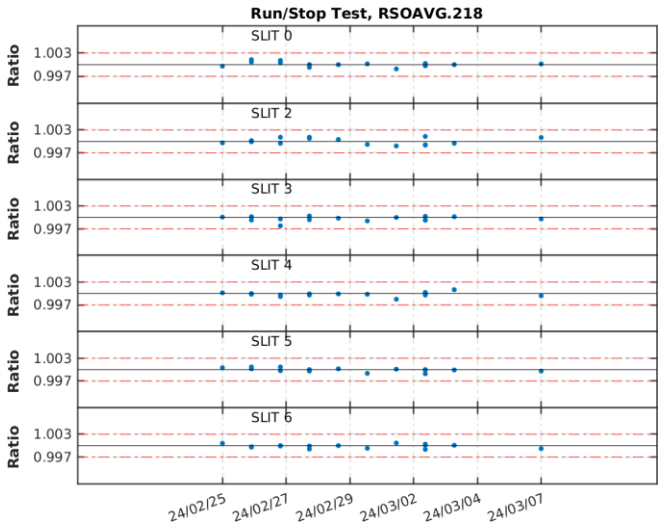


Figure 16-10 – Run/stop test

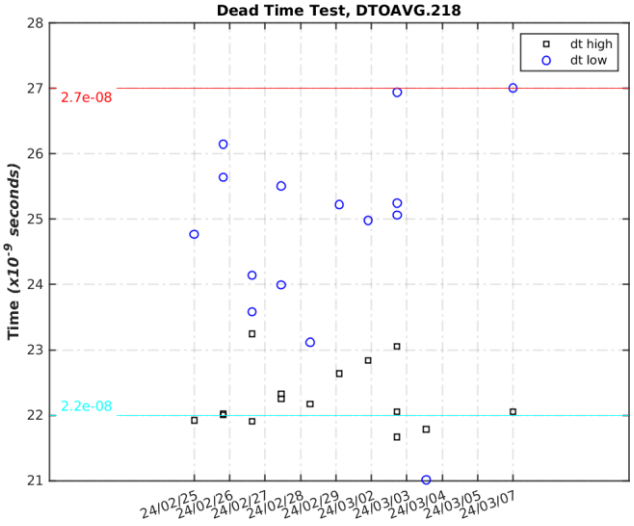


Figure 16-11 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

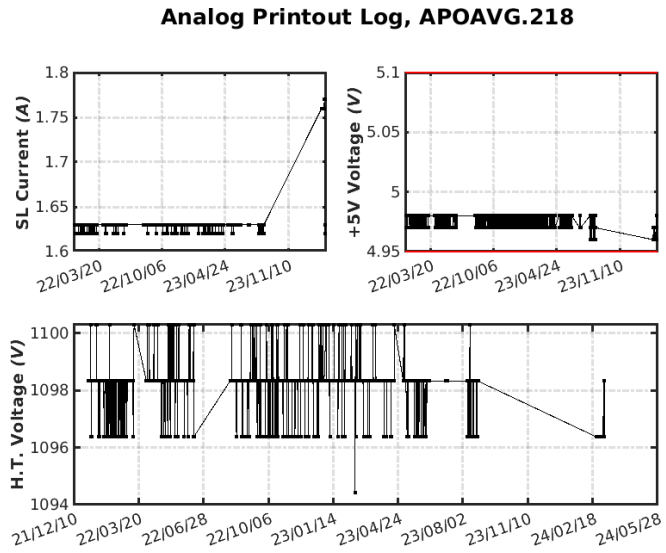


Figure 16-12 – Historical record of analog voltages and intensity.

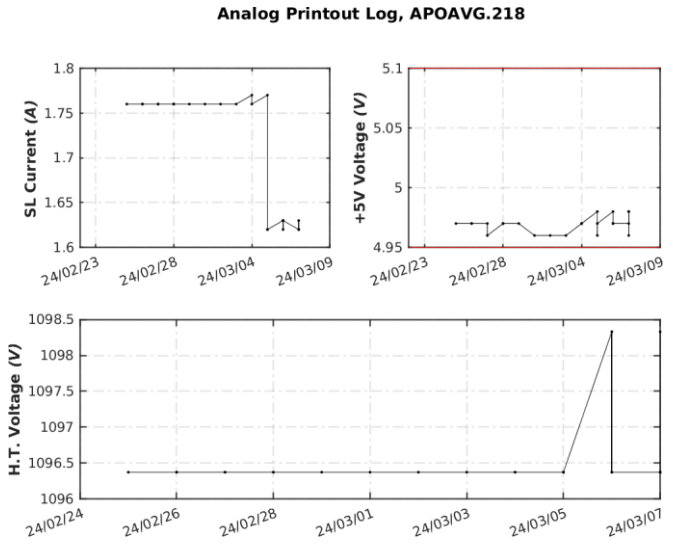


Figure 16-13 – Analog voltages and intensity.

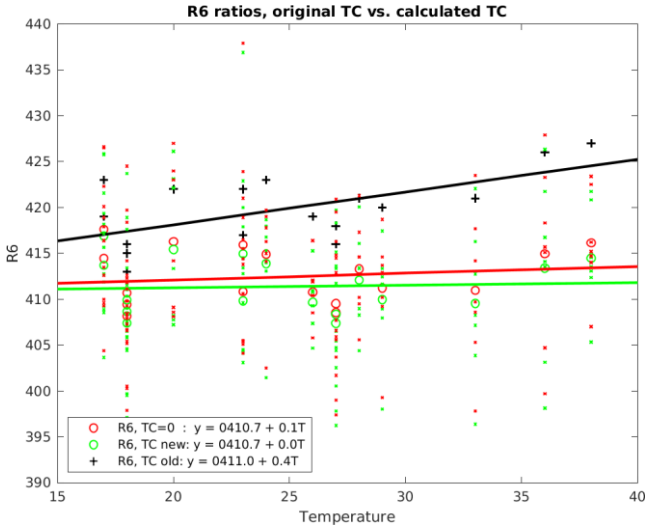


Figure 16-14 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

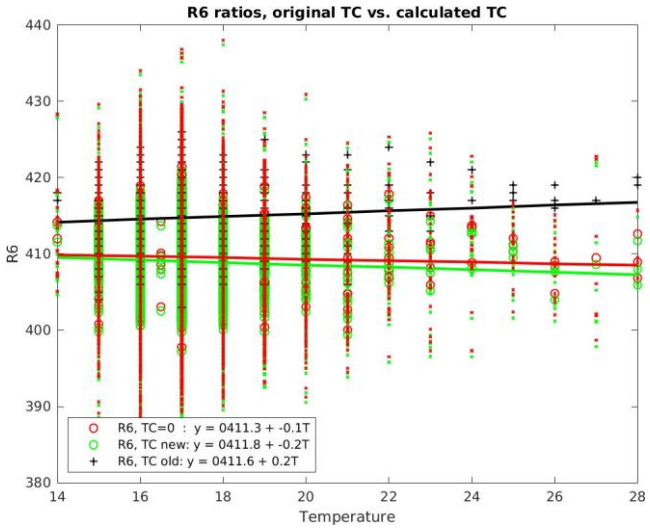


Figure 16-15 – Same as Fig. 16-14 but for data before the present campaigns.

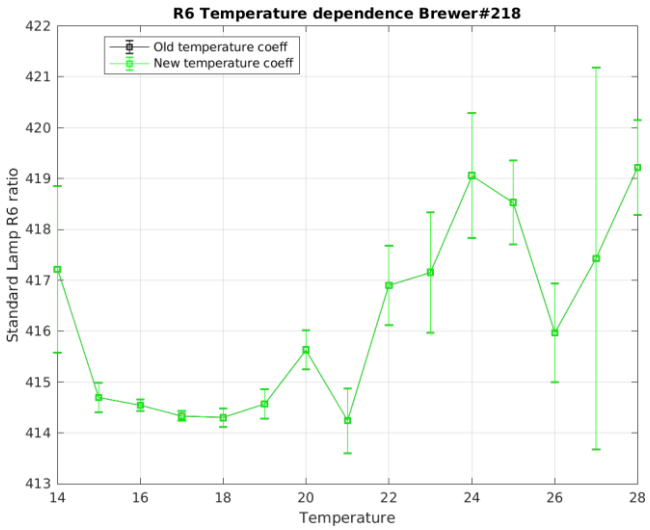


Figure 16-16 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

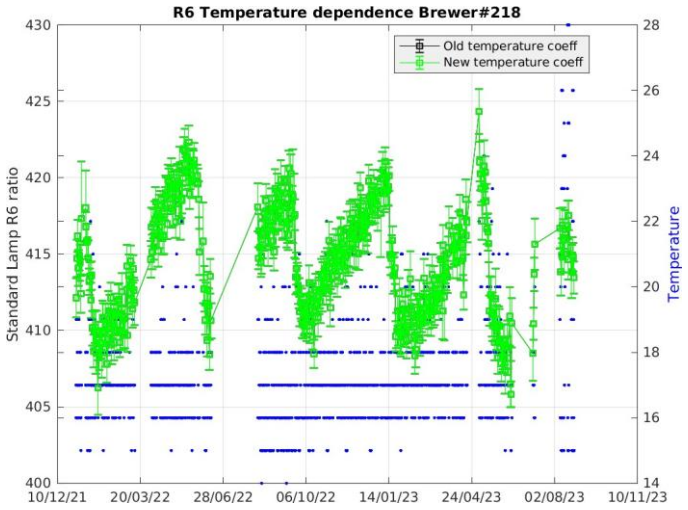


Figure 16-17 – Same as Fig. 16-16, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	-1	5	-16	-12	-15
ETC Filt. Corr. (mean)	-3	-1.3	-8.4	-15.8	-14.4
ETC Filt. Corr. (mean 95% CI)	[-13 4.3]	[-15.5 10.2]	[-21.5 3.8]	[-40.3 -4.3]	[-22.6 -7.1]

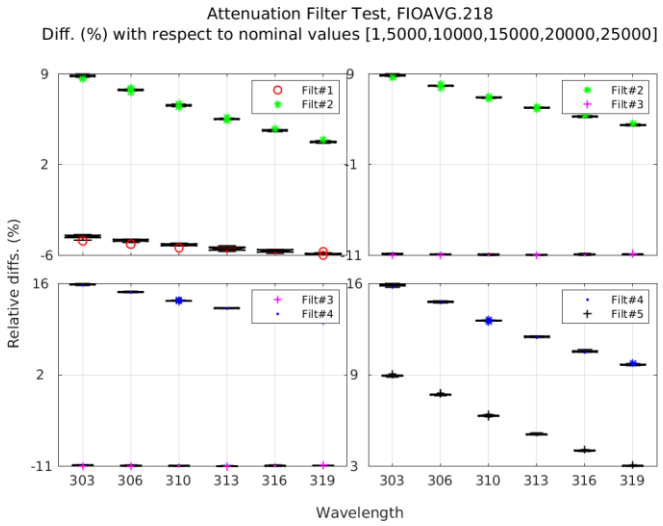


Figure 16-18 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	286	0.3463	2.3500	1.1369
05-Mar-2024	286	0.3442	2.8323	1.1508
Final	286	0.3441	2.3500	1.1369

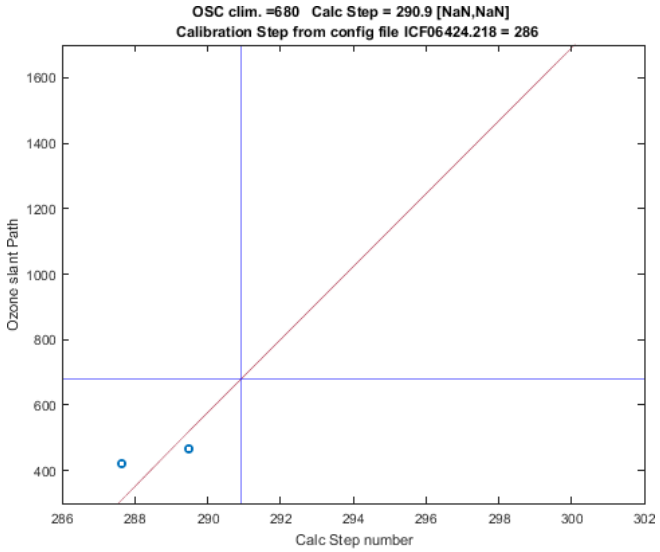


Figure 16-19 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

16 Brewer RGA#229

16.1 Calibration Summary

The First Ibero-American Brewer Ozone Spectrophotometer Intercomparison Campaign of the Regional Brewer Calibration Center Europe (RBCC-E) was held from February 19th to March 8th, 2024, at the *Santa Mar´ıa* Station of the *Universidade Federal de Santa Mar´ıa* (UFSM), Brazil.

Brewer RGA#229 participated in the campaign in the period from February 22nd to March 8th. The campaign days of Brewer RGA#229 correspond to Julian days 53 – 68.

The instrument received extensive maintenance during the campaign, including the replacement of filter #3 on day 67. There are thus very few measurements to perform the final calibration: we used **87** simultaneous DS ozone measurements taken on day **67** (Fig. 16-2)

16.1.1 Instrument's history and stability

Over the last two years, the R6 standard lamp measurements have not been completely stable (Fig. 16-5). The SL intensity also shows some changes (Fig. 16-7), so the R6 changes could be related to the lamp and not the instrument.

To further check the stability of the instrument, we have compared EUBREWNET's level 1.5 ozone product with the ERA5 data for the station of Brewer RGA#229, for the two years between intercomparison campaigns. The relative difference between both datasets is shown in Fig. 16-1. The relative difference shows a noticeable shift, but otherwise the ozone has quite a stable behaviour. Since the Brewer data uses the SL correction, it looks like the Standard Lamp has been indeed operating correctly and the R6 changes are real changes in the instrument.

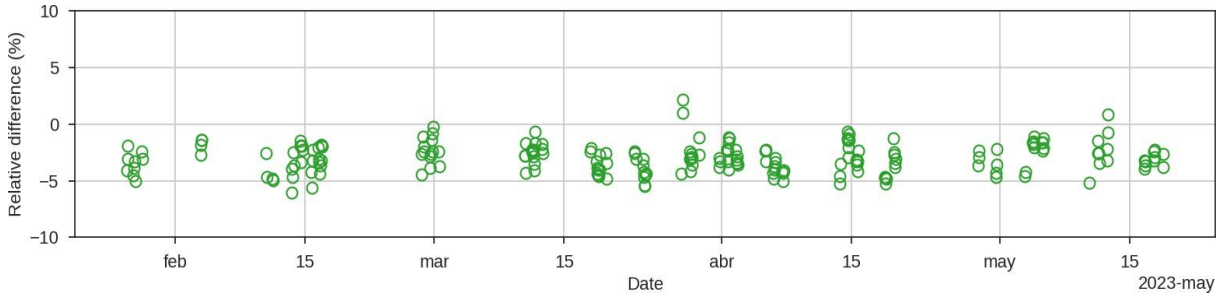


Figure 16-1 – Relative difference of EUBREWNET's level 1.5 ozone product with respect to the ERA5 data for the station of Brewer RGA#229

Regarding other parameters, the run/stops tests show some values below the lower tolerance limit for slits 4, 5, and 6 (Fig. 16-8). The results of the dead time tests show a large difference with the value of the previous calibration (Fig. 16-9).

16.1.2 Maintenance

IOS performed maintenance on the instrument from day 59 to 67:

- day 59: cleaning of the micrometers
- day 61: SL replacement
- day 63: mirrors' check
- day 67: filter #3 replacement, filter wheel adjusted

16.1.3 Instrumental parameters during the campaign

After the maintenance, the SL R6 and R5 ratios stabilized to approx. **403** and **632**, respectively.

The dt value found in the campaign is 23 ns, 4 ns lower than the one from the previous calibration (Fig. 16-9)

16.1.4 Temperature dependence and filters

Brewer RGA#229 current temperature coefficients seem to perform correctly (Fig. 16-13), so we don't recommend any updates at this time.

Concerning the performance of the filters, the data we have was measured before filter #3 was replaced. It thus shows large differences when switching to filter #3, but is otherwise not useful. We recommend running filter tests regularly at the station, specially to characterize the new filter.

16.1.5 Sun scan and dispersion tests

Data from the sun-scan tests (SC) at the instrument's station and during the campaign are in agreement, and confirm the current cal step number, 1016.

Dispersion tests during the campaign result in 0.3452for the ozone absorption coefficient. This is approx. 2 steps larger than the current value, and we recommend the adoption of the new value.

16.1.6 ETC transfer

As shown in Fig. 16-2, after the maintenance and using the new calibration, Brewer RGA#229's ozone is within −0.3% with respect to reference Brewer IZO#256. Note the previous calibration also produce a reasonable comparison once the SL correction is applied.

16.1.7 Recommendations and Remarks

1. The R6 reference value shuld be updated to **403**.
2. We suggest a new R5 reference value of **632**.
3. We suggest updating the DT to $\mathbf{2.3 \cdot 10^{-8}}$ seconds, which is 4 units less than the value in the calibration.
4. According to the dispersion tests carried during the campaign, the ozone absorption coefficient should be updated to 0.3452.
5. Finally, we suggest updating the ETC value to **1622**.

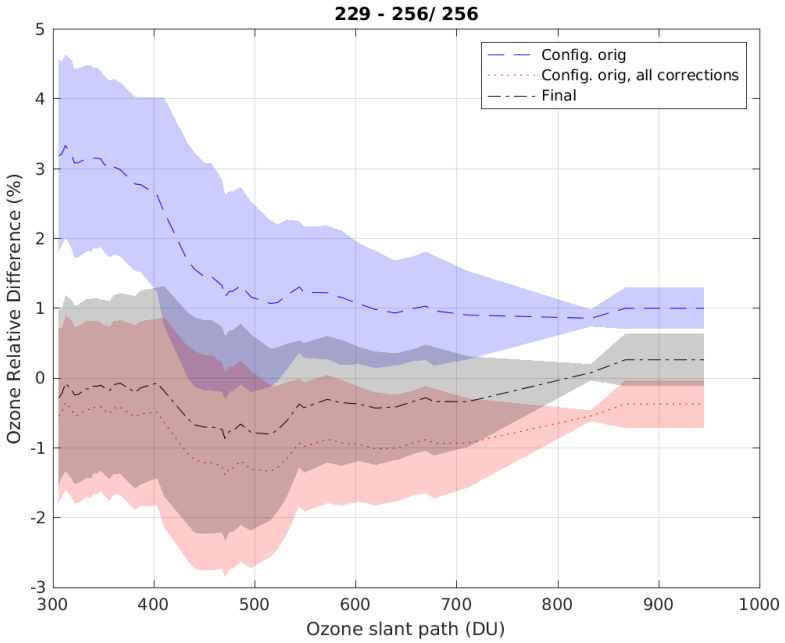


Figure 16-2 – Mean DS ozone column percentage difference between Brewer RGA#229 and Brewer IZO#256, plotted as a function of the ozone slant path. The blue line shows the results for the current configuration; the red dotted line corresponds to the same configuration, but with the SL, straylight and ETC filter corrections applied; and the black line corresponds to the final configuration of the present campaign, again with all corrections applied. The plot corresponds to the final days. Data has been calculated with EUBREWNET's server.

6. It should be stressed that, because of the replacement of filter #3 in the last day of the campaign, very little data is available to perform the calibration of this Brewer. Thus, the above calibration should be used with caution.

7. We recommend performing regular filter tests to characterize the new filter #3. We also recommend performing run/stop tests to follow carefully the evolution of slits 4, 5, and 6.

16.1.8 External links

Configuration File

http://rbcce.aemet.es/svn/campaigns/stm2024/bfiles/229/ICF06624.229

Calibration Report

https://docs.google.com/spreadsheets/d/1R_6gafm2Ff2ZZ9QX_2lrbRlBrOWD7EF9CfTx0PFe9Eg/edit?gid=754835468#gid=754835468

Calibration Reports Detailed

Historic and instrumental

http://rbcce.aemet.es/svn/campaigns/stm2024/latex/229/html/cal_report_229a1.html
Temperature & Filter
http://rbcce.aemet.es/svn/campaigns/stm2024/latex/229/html/cal_report_229a2.html
Wavelength
http://rbcce.aemet.es/svn/campaigns/stm2024/latex/229/html/cal_report_229b.html
ETC transfer
http://rbcce.aemet.es/svn/campaigns/stm2024/latex/229/html/cal_report_229c.html

16.2 Configuration

16.2.1 Instrument constant file

	Initial (ICF27915.229)	Final (ICF06624.229)
o3 Temp coef 1	0	0
o3 Temp coef 2	-0.1891	-0.1891
o3 Temp coef 3	-0.2661	-0.2661
o3 Temp coef 4	-0.3413	-0.3413
o3 Temp coef 5	-0.1504	-0.1504
Micrometer steps/deg	0	0
O3 on O3 Ratio	0.3471	0.3452
SO2 on SO2 Ratio	2.35	2.78
O3 on SO2 Ratio	1.1584	1.1548
ETC on O3 Ratio	1574	1622
ETC on SO2 Ratio	-67	-67
Dead time (sec)	2.7e-08	2.3e-08
WL cal step number	1016	1016
Slitmask motor delay	14	14
Umkehr Offset	2416	2418
ND filter 0	0	0
ND filter 1	4737	4737
ND filter 2	10316	10316
ND filter 3	18562	18562
ND filter 4	23425	23425
ND filter 5	26004	26004
Zenith steps/rev	2972	2972
Brewer Type	3	3
COM Port #	1	1
o3 Temp coef hg	0	0
n2 Temp coef hg	0	0
n2 Temp coef 1	0	0
n2 Temp coef 2	0	0
n2 Temp coef 3	0	0
n2 Temp coef 4	0	0
n2 Temp coef 5	0	0
O3 Mic #1 Offset	0	0
Mic #2 Offset	0	0
O3 FW #3 Offset	242	242
NO2 absn Coeff	-3	-3
NO2 ds etc	770	770
NO2 zs etc	740	740
NO2 Mic #1 Offset	8028	8028
NO2 FW #3 Offset	178	178
NO2/O3 Mode Change	2515	2515
Grating Slope	1.0003	1.0003
Grating Intercept	-15.39	-15.39
Micrometer Zero	1744	1744
Iris Open Steps	250	250
Buffer Delay (s)	0	0
NO2 FW#1 Pos	64	64
O3 FW#1 Pos	256	256
FW#2 Pos	0	0
uv FW#2 Pos	0	0
Zenith Offset	0	0
Zenith UVB Position	2201	2201

16.3 Appendix: Summary Plots

Figure 16-3 in this appendix shows the ozone during the campaign as determined by Brewer RGA#229 using the final calibration (ICF06624.229), and by reference Brewer IZO#256. Fig. 16-4 shows the daily ozone data in detail.

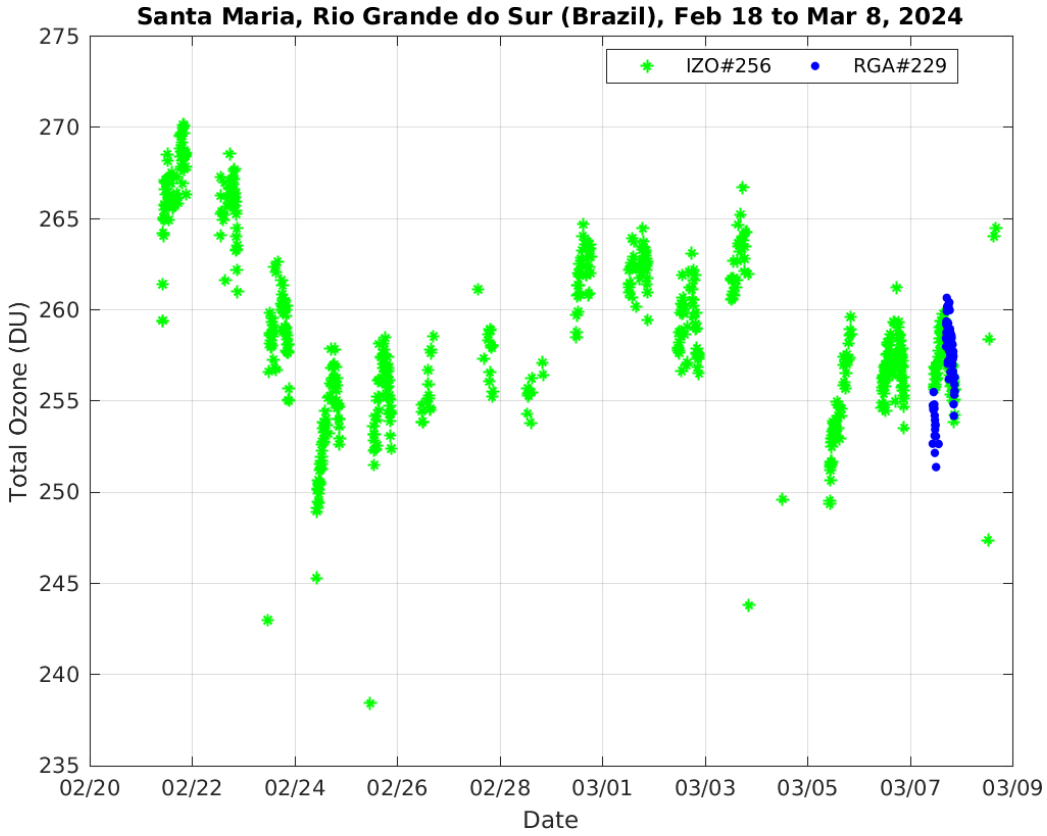


Figure 16-3 – Overview of the intercomparison. For the final days starting on day 67, Brewer RGA#229's data are evaluated using the final constants (blue circles) provided in the ICF06624.229 file.

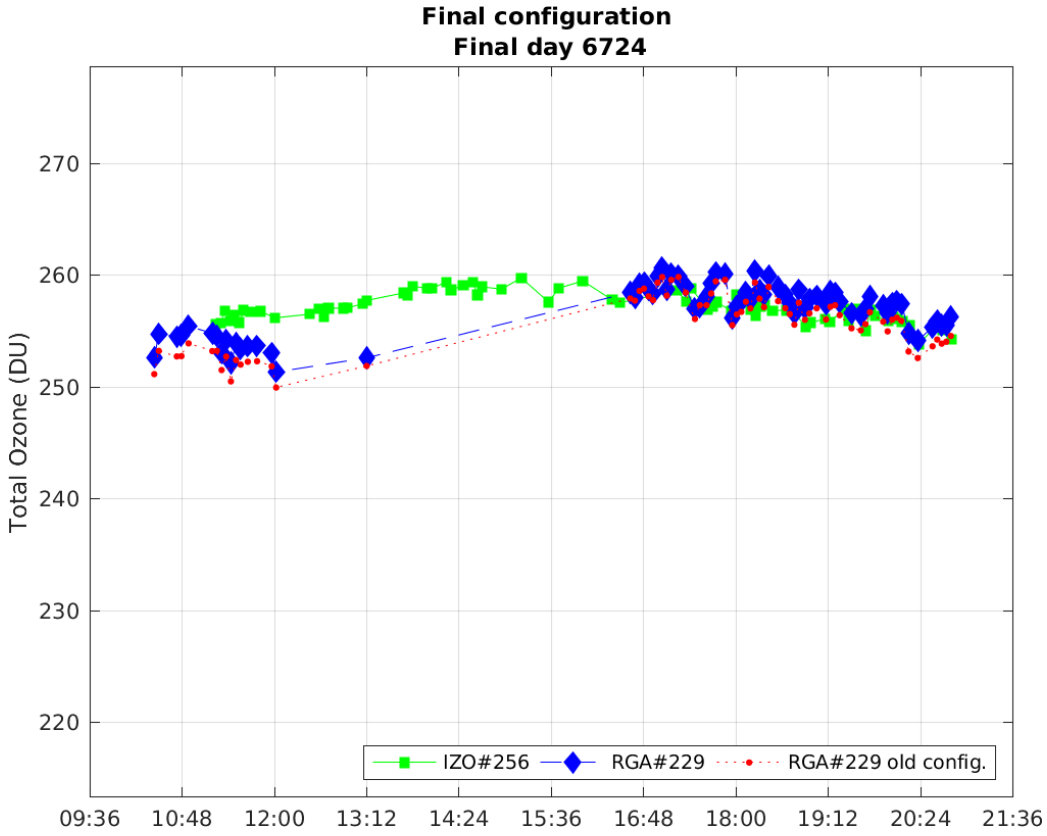


Figure 16-4 – Daily ozone plots for the final days of the campaign. We show the ozone determined using both the current (ICF27915.229, red) and final (ICF06624.229, blue) configurations of Brewer RGA#229, and also Brewer IZO#256 data. Data corresponds to EUBREWNET's L1.5 product.

16.4 Appendix: Main instrumental parameters

In this appendix we show plots and tables of some of the main Brewer instrumental parameters. This includes parameters of the Standard Lamp such as the R6 (Fig. 16-5) and R5 (Fig. 16-6) ratios, and the intensity of slit 5 (Fig. 16-7), results of the Run/Stop (Fig. 16-8), Dead Time (Fig. 16-9), analog voltages and intensity (Fig. 16-10), and CI (Fig. 16-11) tests, analysis of the temperature coefficient's performance (Figs. 16-12, 16-13, 16-14, and 16-15), check of the neutral density filter's linearity (Table 16-2 and Fig. 16-16), and results of the dispersion (Table 16-3) and Sun Scan (Fig. 16-17) tests.

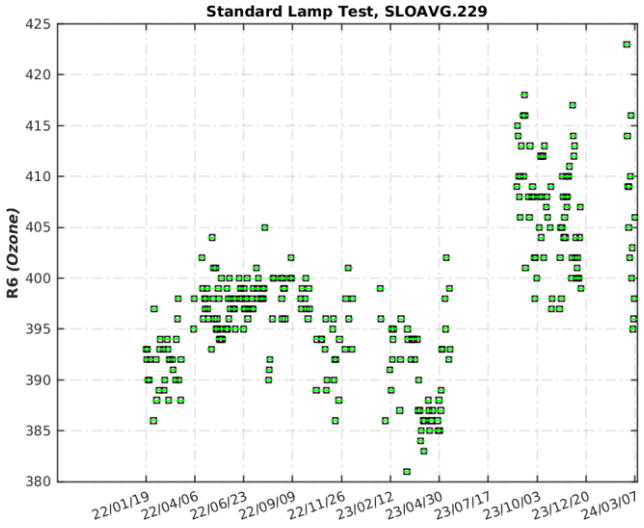


Figure 16-5 – Standard Lamp test R6 (Ozone) ratios. Horizontal lines are labeled with the original and final reference values (red and blue lines, respectively)

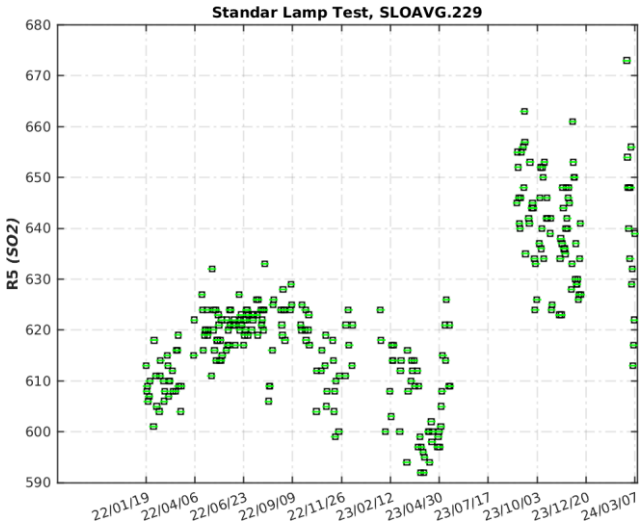


Figure 16-6 – Standard Lamp test R5 (SO_2) ratios

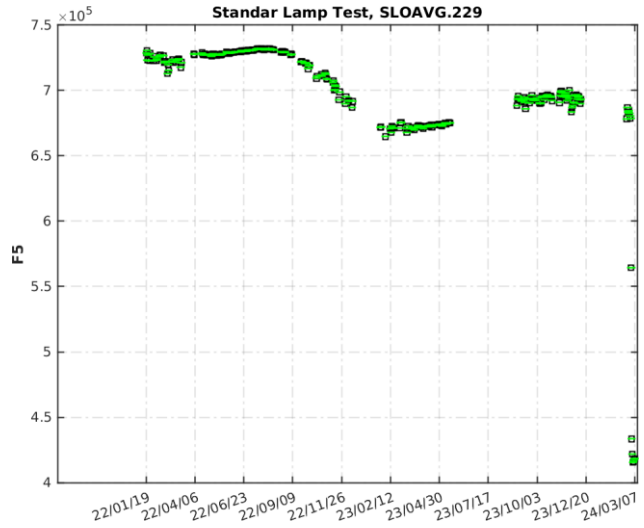


Figure 16-7 – SL intensity for slit five.

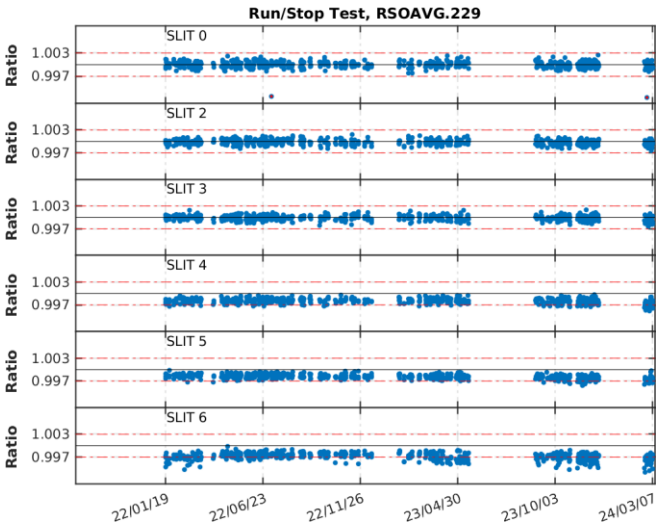


Figure 16-8 – Run/stop test

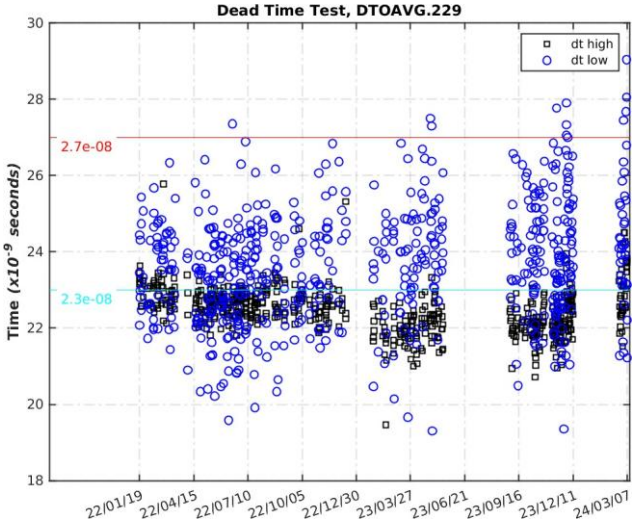


Figure 16-9 – Dead Time test. Horizontal lines are labelled with the current (red) and final (blue) values.

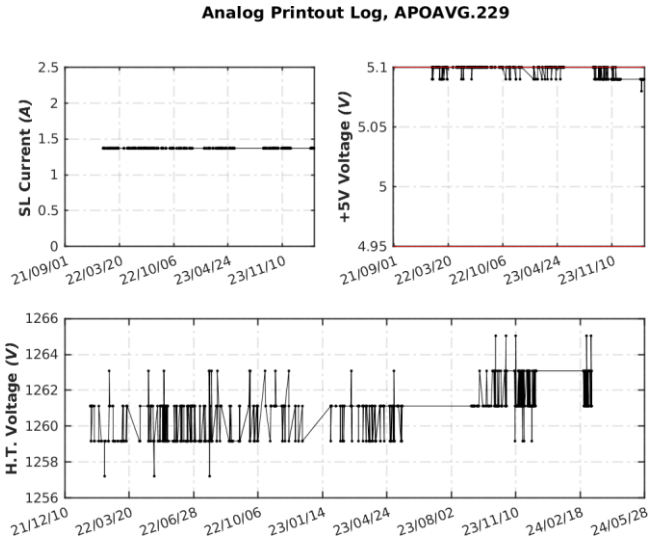


Figure 16-10 – Analog voltages and intensity.

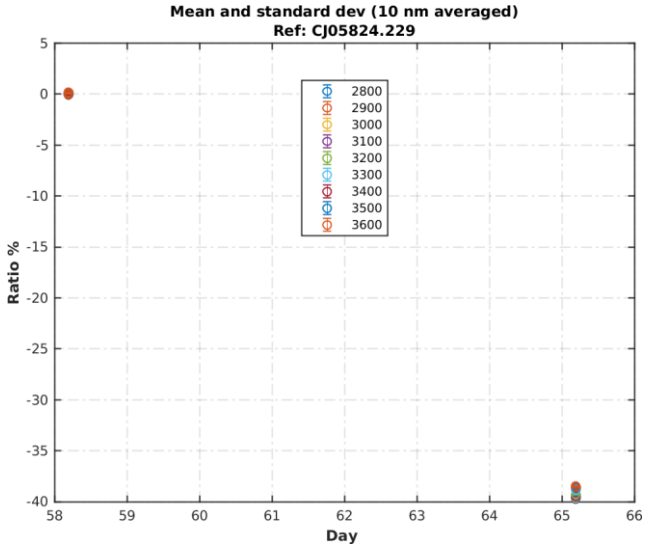


Figure 16-11 – CI scan of Standard Lamp performed during the campaign days: relative differences with respect to a selected reference scan

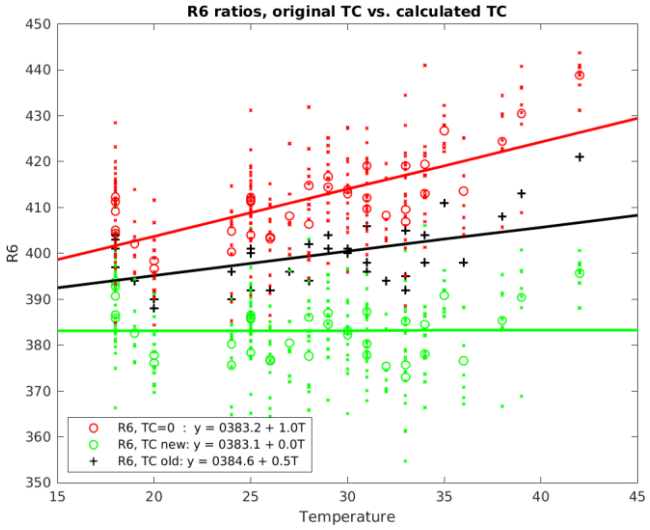


Figure 16-12 – Temperature coefficients' performance. Red circles represent standard lamp R6 ratios calculated from raw counts without temperature correction (temperature coefficients set to 0). Black crosses and green circles represent standard lamp R6 ratios corrected with original and calculated temperature coefficients, respectively. Data corresponds to the present campaign.

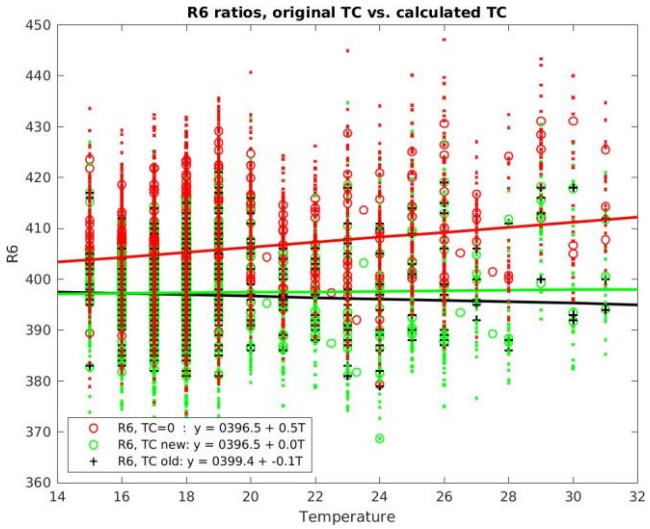


Figure 16-13 – Same as Fig. 16-12 but for the whole period between calibration campaigns.

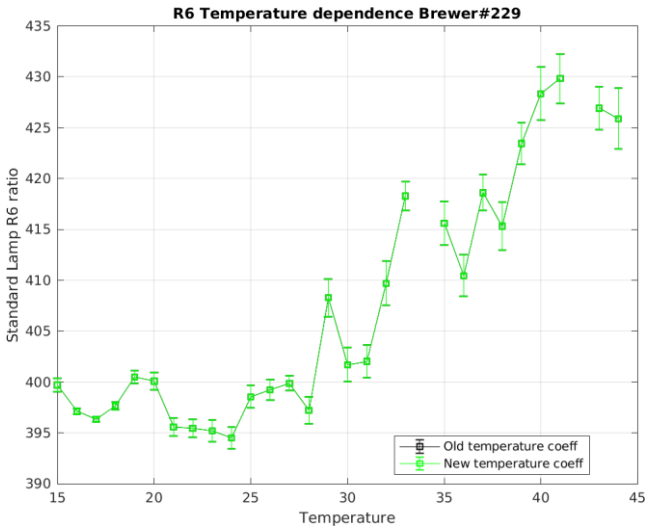


Figure 16-14 – Standard lamp R6 (MS9) ratio as a function of temperature. We plotted R6 ratio recalculated with the original (black) and the new (green) temperature coefficients

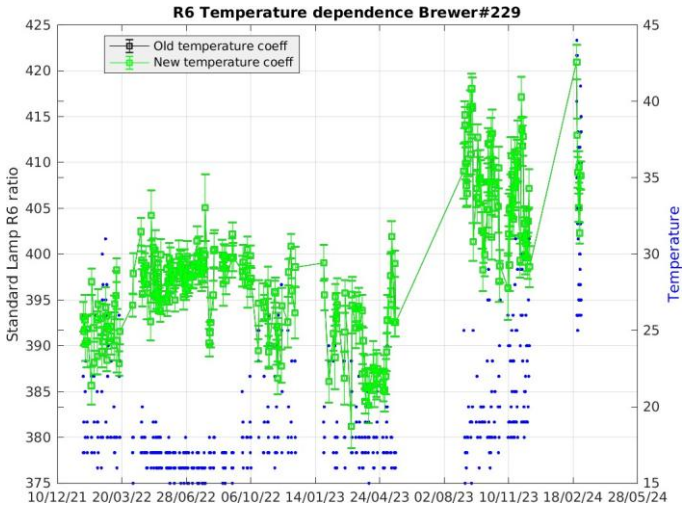


Figure 16-15 – Same as Fig. 16-14, but plotted as a function of the date.

Table 16-2 – ETC correction due to Filter non-linearity. Median value, mean values and, 95% confidence intervals are calculated using bootstrap technique

	filter#1	**filter#2**	**filter#3**	**filter#4**	**filter#5**
ETC Filt. Corr. (median)	1	1	-10	3	-9
ETC Filt. Corr. (mean)	3.5	-0.4	-4.6	-1.7	-13.3
ETC Filt. Corr. (mean 95% CI)	[-3.9 11.4]	[-8.6 10.5]	[-11.7 3.2]	[-12.3 9.7]	[-19.9 -3.8]

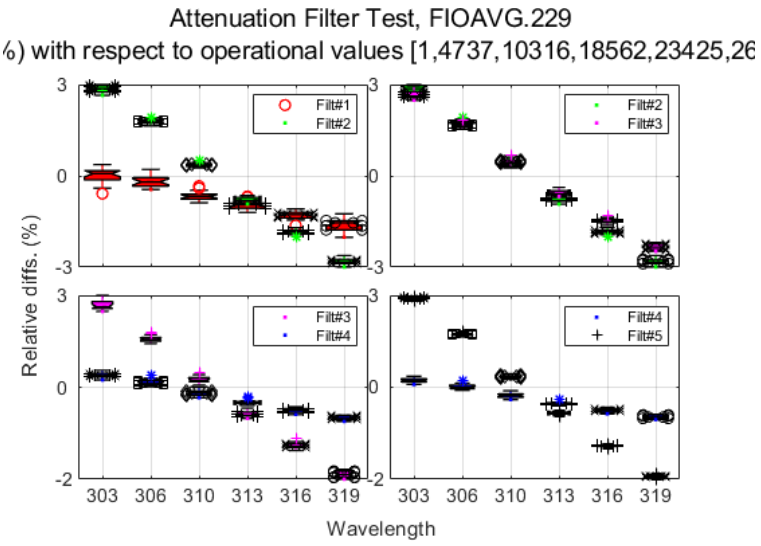


Figure 16-16 – Notched box-plot for the calculated attenuation relative differences of neutral density filters with respect to operational values. We show for each subplot relative differences correspond- ing to correlative filters (color box-plots). Solid lines and boxes mark the median, upper and lower quartiles. The point whose distance from the upper or lower quartile is 1 times larger than the interquartile range is defined as outlier.

Table 16-3 – Dispersion derived constants

	Cal step	A1	A2	A3
Current	1016	0.3471	2.3500	1.1584
21-Jul-2015	1016	0.3454	2.8249	1.1523
31-Jul-2015	1016	0.3472	2.7797	1.1591
02-Mar-2024	1016	0.3452	2.7824	1.1548
Final	1016	0.3452	2.7800	1.1548

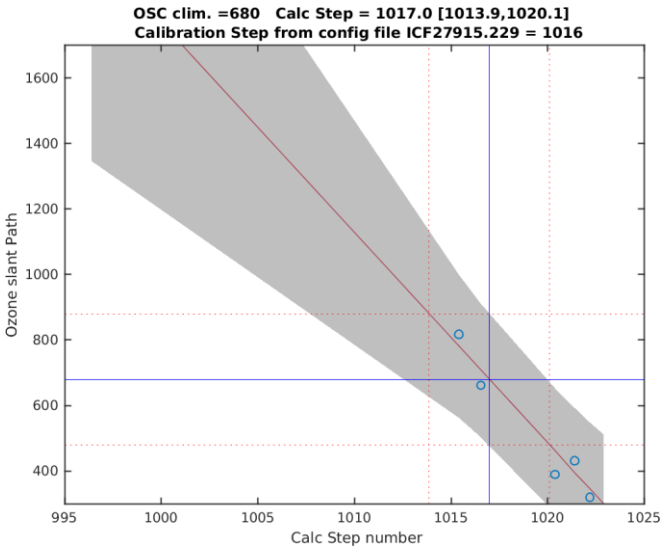
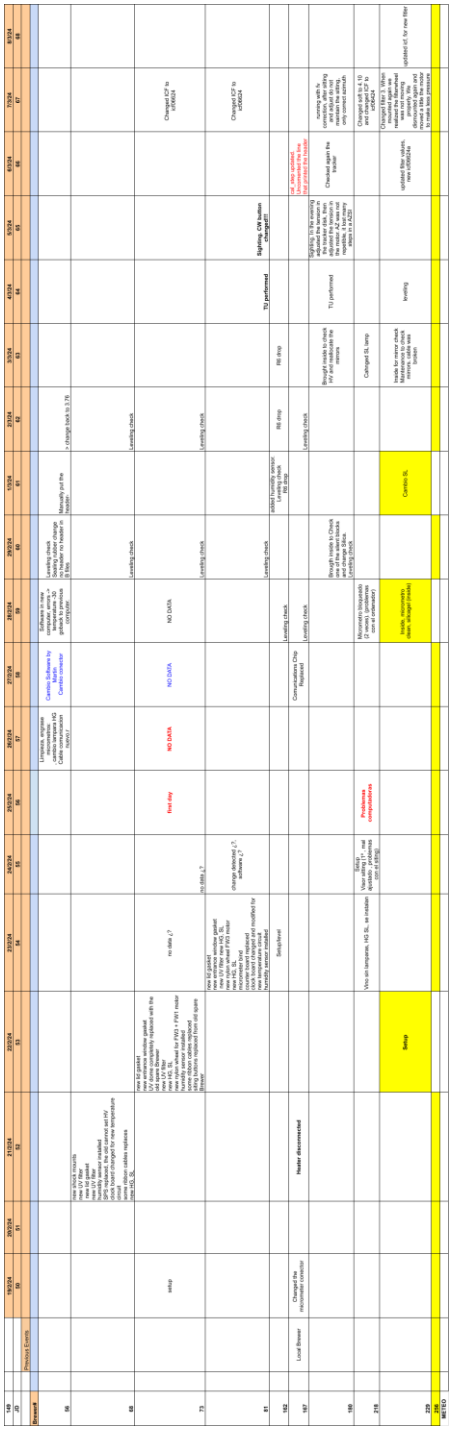


Figure 16-17 – Ozone Slant Path *vs* Calc – Step number. Vertical solid line marks the calculated *Cal Step Number* for a climatological OSC equal to **680** (horizontal solid line). Blue area represents a 95% confidence interval

13 Maintenance Table



14 Glossary

CI	Scan to the internal Standard Lamp
CSN	Cal step number
CZ	Custom Scan generally to the internal lamps
DSP	Dispersion File
DT	Dead Time
Hg	Internal Mercury Line
HL	Scan to the Internal Mercury Line of 295.nm
HS	Scan to the Internal Mercury Line of 345.nm
ICF	Instrument Constant File
OSC	Ozone Slant Column
R6	Ratio 6, Standard Lamp Ozone Ratio
R5	Ratio 5, Standard Lamp SO2 Ratio
SL	Standard Lamp
RS	Run Stop test
TC	Temperature Coefficients

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