P234
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EUBREWNET RBCC-E Huelva 2015
Ozone Brewer Intercomparison

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Brewer Ozone Calibration

The ozone retrieved for the brewer can be summarized: $X = \frac{F - ETC}{\alpha\mu}$

The calibration process can be divided in three steps:

· The **Instrumental calibration** includes all the parameters that affect the measured counts (F): in particular Dead Time, Temperature coefficients and Filter attenuation.

· The **wavelength calibration** determines the ozone absorption coefficient (α), or differential absorption coefficient. This procedure is called the dispersion test and is used to obtain the wavelength calibration and slit function of the instrument.

· Finally the **ETC transfer** is performed by comparison with the reference.

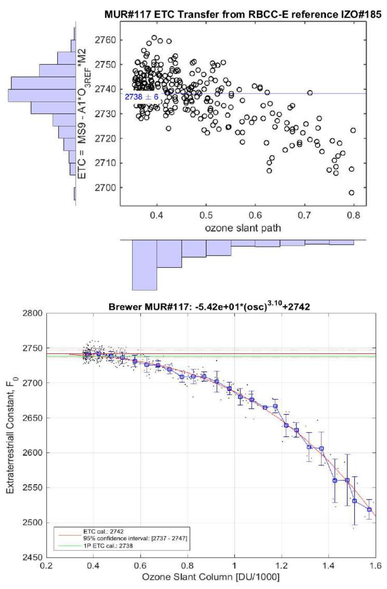
$$ETC = O_3(reference) * \alpha * m - F$$

For a well-characterized instrument the ETC values shows a Gaussian distribution and the mean value is used as instrument constant.

One exception to this rule is the single monochromator brewer models (MK-II, and MK-IV) that are affected by stray light, and the distribution shows a tail to the lower ETC. For these type of brewer only stray-light free region is used to determine the ETC (from 600 DU to 900 DU OSC)

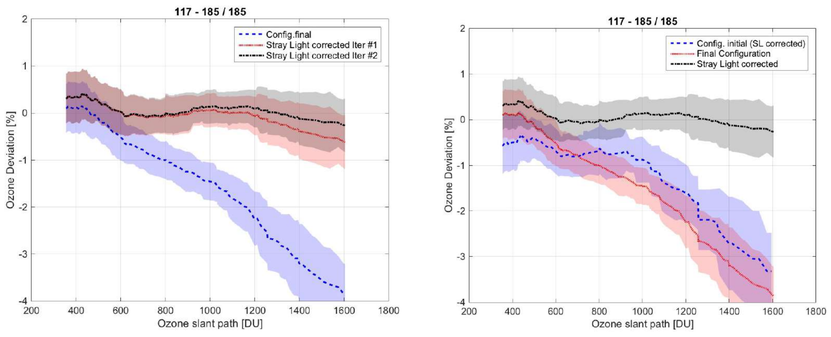
The calibration is performed assuming that the stray light can be characterized following a power law of the ozone slant column (O_3*m) thus

$$F = F_0 - K * (O_3 * m)^S$$



The stray light parameters k and s are determined by a nonlinear fit using the ETC determined from the stray-light free region as first guess parameters.

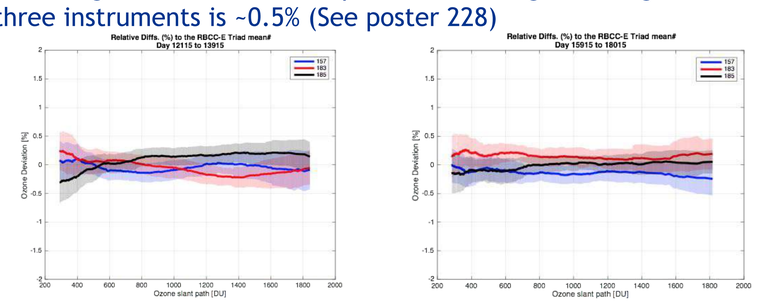
Where F_0 is the ETC for the stray light free osc region and K and S are retrieved from the reference comparison. As the counts (F) from the single brewer are affected by straylight, the ozone is calculated using an iterative process.



Only one iteration is needed for the conditions of the intercomparison (up to 1500 DU) for further ozone slant path measurements 1500 DU – 2000 DU two iterations are enough to correct the ozone.

The Reference

The RBCC-E triad is calibrated monthly. The three instruments are independently Langley Calibrated. Before and after the campaign the travelling instrument is compared. The long term agreement of the three instruments is ~0.5% (See poster 228)



Smooth average in OSC, in +/- 50 DU, of the ratio of the simultaneous measurements before (left) and after the travel (right) of the Izaña Triad.

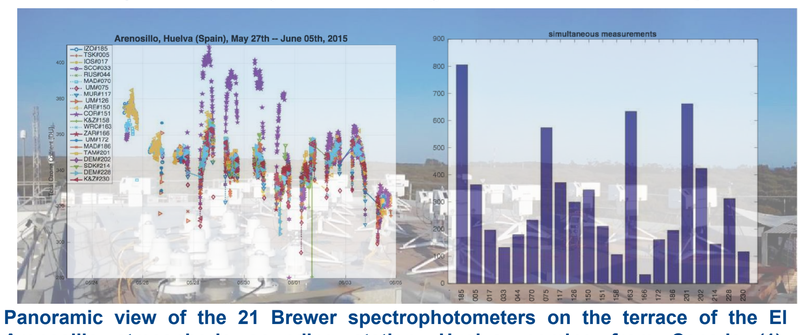
RBCC-E X Intercomparison

The X Regional Brewer Calibration Center for Europe (RBCC-E) intercomparison was held at El Arenosillo Atmospheric Sounding Station of the "Instituto Nacional de Técnica Aeroespacial" (INTA) during the period of May 25th - June 5th, 2015. This X campaign was a joint EUBREWNET campaign in collaboration with the Area of Instrumentation and Atmospheric Research of INTA, with the support of the COST ACTION 1207. Twenty-one Brewer instruments from eleven countries participated at the Arenosillo campaign. In addition, the solar UV irradiance calibration was performed by the traveling reference standard QASUME of the World Calibration Center for UV (WCC-UV).

The calibration campaigns is scheduled into three stages:

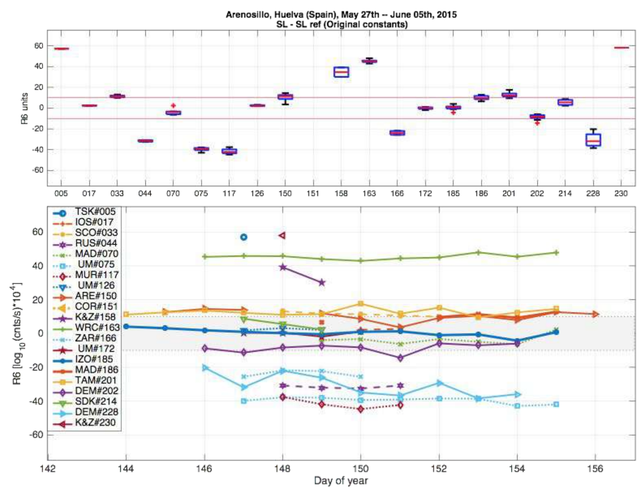
1. Initial calibration to assess the current calibration
2. Servicing, adjustments and maintenance work.
3. Final calibration.

During the initial calibration (**blind intercomparison**) modifications of the instrument were not allowed. The next days are dedicated to **characterize the instrument**. At the end of the maintenance period the instruments will be ready for the ETC transfer or 'Final intercomparisons'.



Panoramic view of the 21 Brewer spectrophotometers on the terrace of the El Arenosillo atmospheric sounding station, Huelva, coming from Canada (1), Netherlands (2), United Kingdom (3), Switzerland (1), Finland (1), Greece (1), Denmark (2), Russia (1), Algeria (1) and Spain(7).

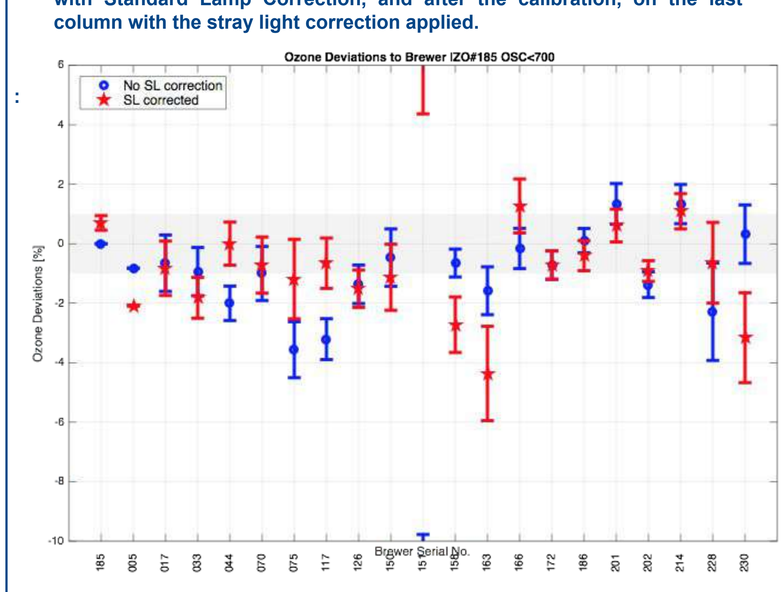
Blind Intercomparison



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

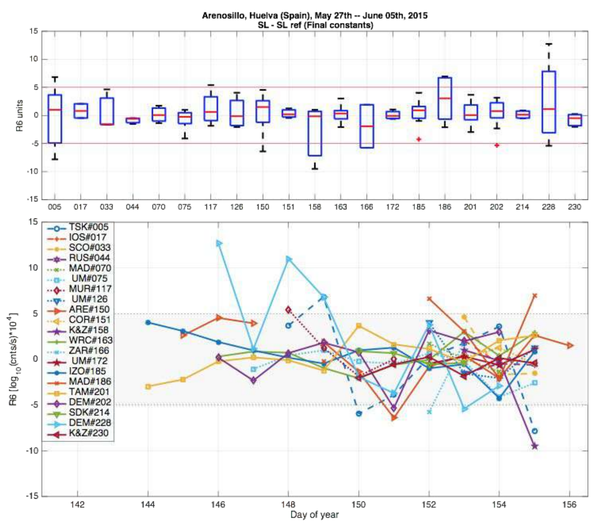
	TSK#005	IOS#017	SCO#033	RUS#044	MAD#070	UM#075	MUR#117	UM#126	ARE#150	COR#151
No SL corr.		-0.3	-0.8	-2.0	-0.7	-3.4	-3.4	-1.2	-0.4	-17
SL corr.		-0.5	-1.8	0.1	-0.4	-0.7	-0.4	-1.4	-1.1	9.9
Full Osc.	-1.9	-1.0	-1.1	-0.2	-0.7	-1.2	-0.7	-1.4	-0.4	8.0
	K&Z#158	WRC#163	ZAR#166	UM#172	MAD#186	TAM#201	DEM#202	SDK#214	DEM#228	K&Z#230
No SL corr.	-0.5	-1.5	-0.2	-0.7	0.1	1.2	-1.4	1.4	-1.9	-0.2
SL corr.	-2.4	-4.2	1.5	-0.7	-0.3	0.5	-0.9	1.2	-0.4	-3.5
Full Osc.	-0.5	-1.5	-0.2	-0.7	0.1	0.5	-0.9	1.2	-0.4	-0.2

Summary of mean percentage difference before calibration, without and with Standard Lamp Correction, and after the calibration, on the last column with the stray light correction applied.



Percentage mean difference for the simultaneous direct sun measurements with the reference for all the participating instruments, with and without the standard lamp correction, on the stray-light free OSC region (OSC<700).

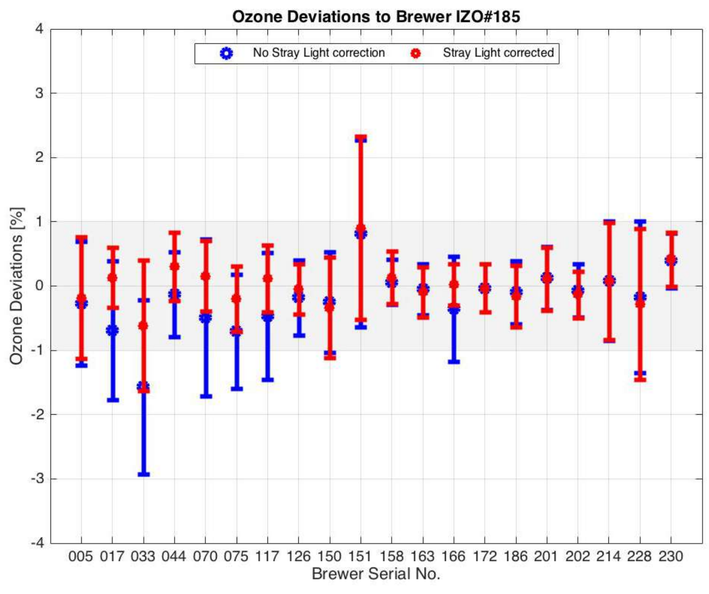
Final Intercomparison



Differences between the daily standard lamp R6 ratio and the proposed R6 reference value during the final days.

	TSK#005	IOS#017	SCO#033	RUS#044	MAD#070	UM#075	MUR#117	UM#126	ARE#150	COR#151
No SL corr.	-0.2	-1.0	-1.8	-0.3	-0.5	-0.8	-0.6	-0.3	-0.3	0.7
SL corr.	-0.3	-1.0	-1.8	-0.2	-0.5	-0.8	-0.7	-0.3	-0.3	0.7
Stray Light	-0.1	0.1	-0.5	0.2	0.2	-0.2	0.0	-0.1	-0.3	0.8
	K&Z#158	WRC#163	ZAR#166	UM#172	MAD#186	TAM#201	DEM#202	SDK#214	DEM#228	K&Z#230
No SL corr.	0.0	-0.1	-0.6	-0.0	-0.0	0.1	-0.1	-0.0	-0.1	0.4
SL corr.	0.1	-0.1	-0.7	-0.0	-0.1	0.1	-0.1	-0.0	-0.2	0.4
Stray Light	0.1	-0.1	-0.1	-0.0	-0.1	0.1	-0.1	-0.0	-0.2	0.4

Summary of mean percentage difference after the calibration, on the last row with the stray light correction applied.



Final days percentage mean difference for the simultaneous direct sun measurements with the reference for all the participating instruments, in blue without the stray light correction and in red with the correction applied to single Brewer spectrophotometers.

Summary

Blind days Before the X RBCC-E campaign, using a two-years old calibration :

- 16 Brewer spectrophotometers (~75% of the participating instruments) are inside the 1% agreement range.
- 10 Brewer spectrophotometers (~50%) are inside the ±0.5% range, i.e., show a perfect agreement.
- The max average error was 1.5% for operational Brewer instruments within stray-light free conditions (OSC <700 DU).

Final days After the new calibration was issued at the end of the X RBCC-E campaign:

- Large errors of up to 4% can be expected for single-monochromator Brewer instruments operating at OSC larger than 1000 DU.
- The implementation of the stray light correction in the calibration of single Brewer instruments improved their performance.
- All participating Brewer spectrophotometers are within the ±0.5% agreement range.

Acknowledgments

All this work would not be possible without all the Brewer operators who participate in the campaigns. This poster is based upon work from COST Action 1207 "EUBREWNET", supported by COST (European Cooperation in Science and Technology). This work has been supported by the European Metrology Research Programme (EMRP) within the joint research project ENV59 "Traceability for atmospheric total column ozone" (ATMOZ). The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union. We acknowledge further support by the Fundación General de la Universidad de La Laguna.

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