Temperature characterisation of Brewer determined in the laboratory

Alberto Berjón, Alberto Redondas, Meelis-Mait Sildoja, Saulius Nevas, Virgilio Carreño, Daniel Santana, Sergio F. León-Luis, Bentorey Hernández, Javier López-Solano

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Objectives:

- Determine the effect of temperature on the Brewer measurements made through different ports: Direct and Global ports, and internal lamp.
- Determine the effect of PTFE diffuser on the instrument temperature dependence.
- Compare coefficients obtained in the laboratory and using field measurements.

Brewer TOC calculation

Beer-Lambert law: $TOC = \frac{R_6 - ETC - B}{A\mu}$

Intensity corrections:

- Dark counts
- Deadtime
- Temperature
- Filter transmittance

$$R_6 = \sum_{i=1}^{n} w_i F(\lambda_i)$$

$$F(\lambda_i) = 10^4 log(I(\lambda_i))$$

$$ETC = \sum_{i=1}^{n} w_i F_0(\lambda_i)$$

$$B = \nu \frac{p}{p_0} \sum_{i=1}^{n} w_i \beta(\lambda_i)$$

$$A = \sum_{i=1}^{n} w_i \alpha(\lambda_i)$$

Temperature correction

$$I = I_c - \tau_0(T - T_0) \qquad I_c = \frac{I}{1-\tau(T-T_0)} \qquad \tau = \tau_0/I_c$$

$$ln(I_c) = ln(I) + \tau(T - T_0)$$

Temperature correction

$$ln(I_c) = ln(I) + \tau (T - T_0)$$

$$10^4 log(I_c) = 10^4 log(I) + \tau_b T \qquad F_c = F + \tau_b T$$

$$\tau_b = 10^4 log(e)\tau$$

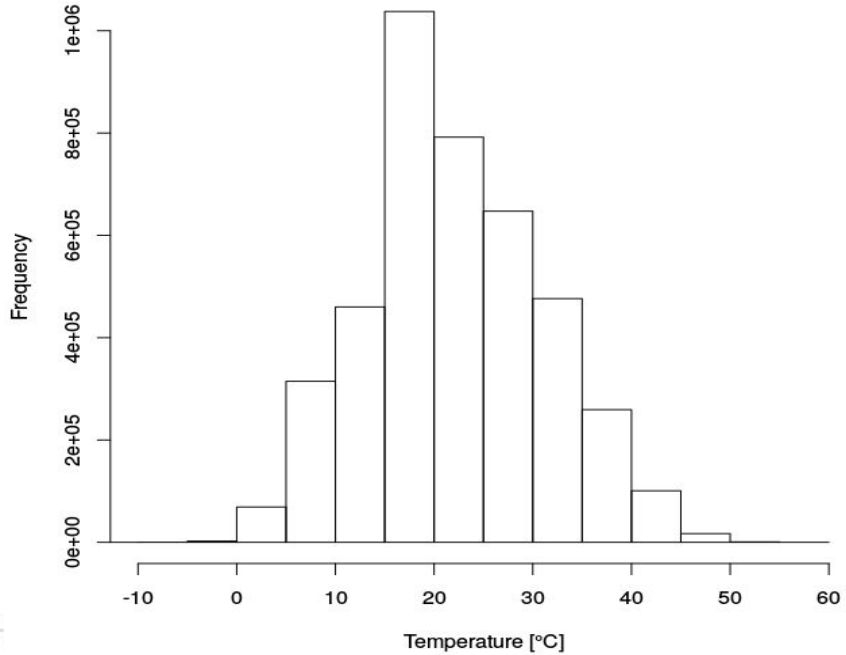
Temperature correction

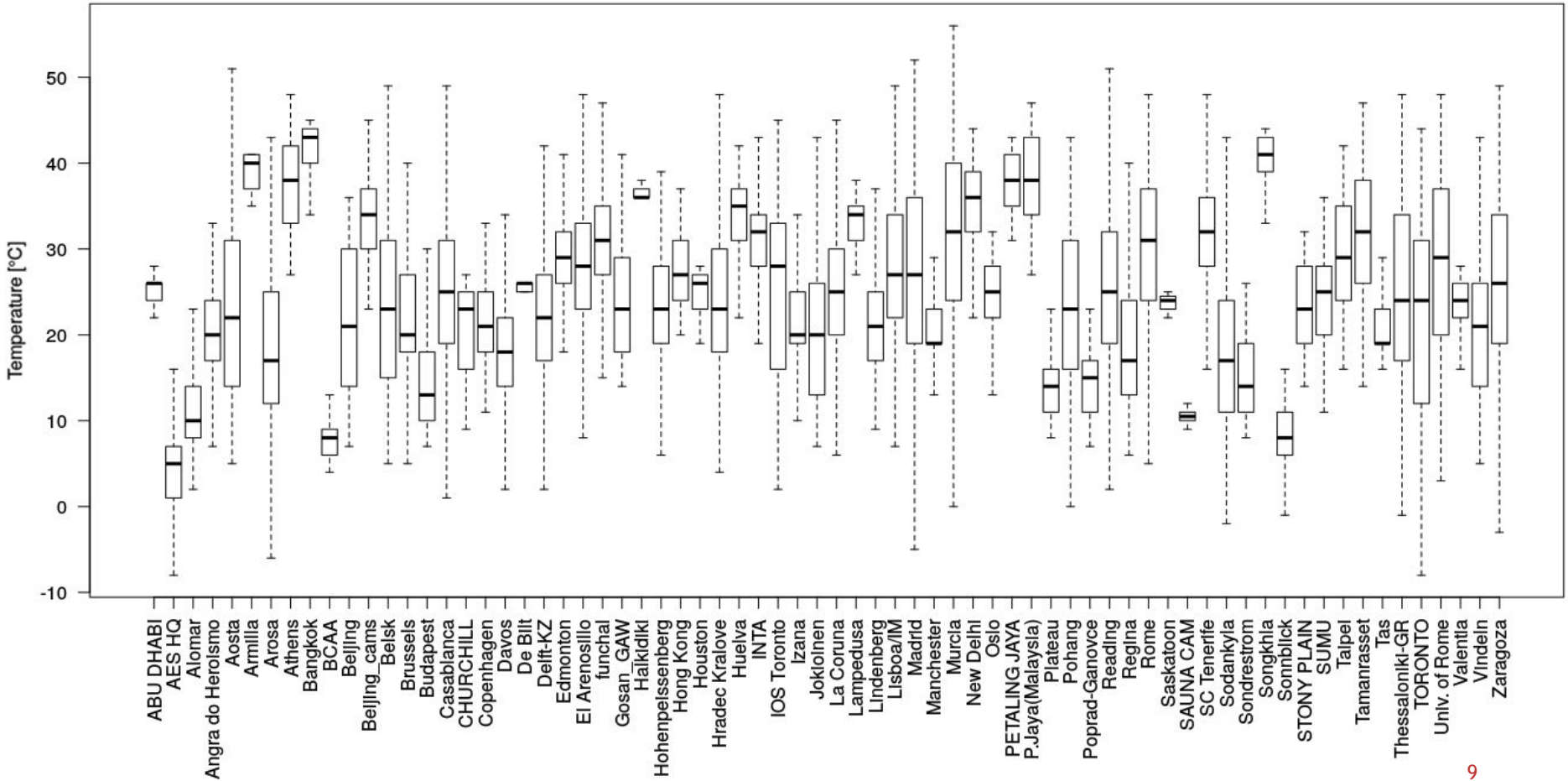
$$R_6 = \sum_{i=1}^{n} w_i F_c(\lambda_i) = \sum_{i=1}^{n} w_i F(\lambda_i) + \sum_{i=1}^{n} w_i \tau_b(\lambda_i) T$$

$$\sum_{i=1}^{n} w_i = 0$$

$$\tau'_b(\lambda_i) = \tau_b(\lambda_i) - \tau_b(\lambda_0)$$

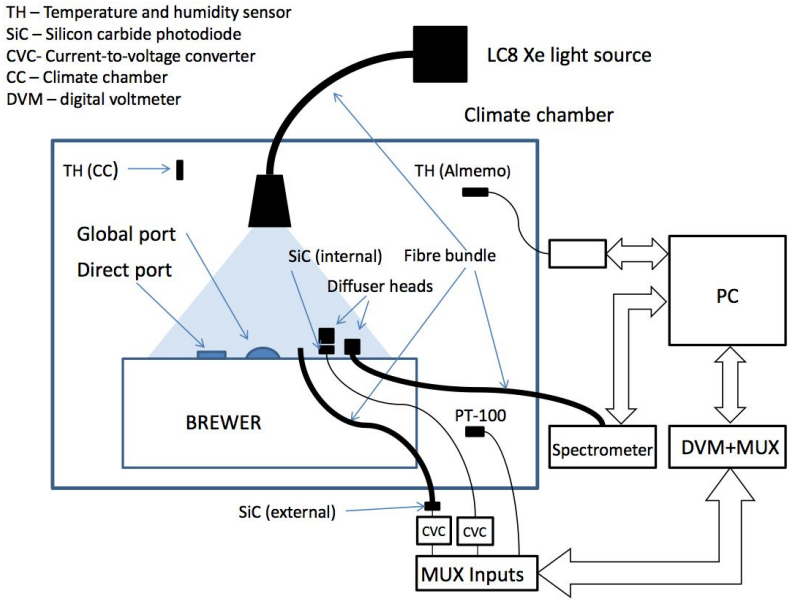
Statistics from The EUBREWNET DB

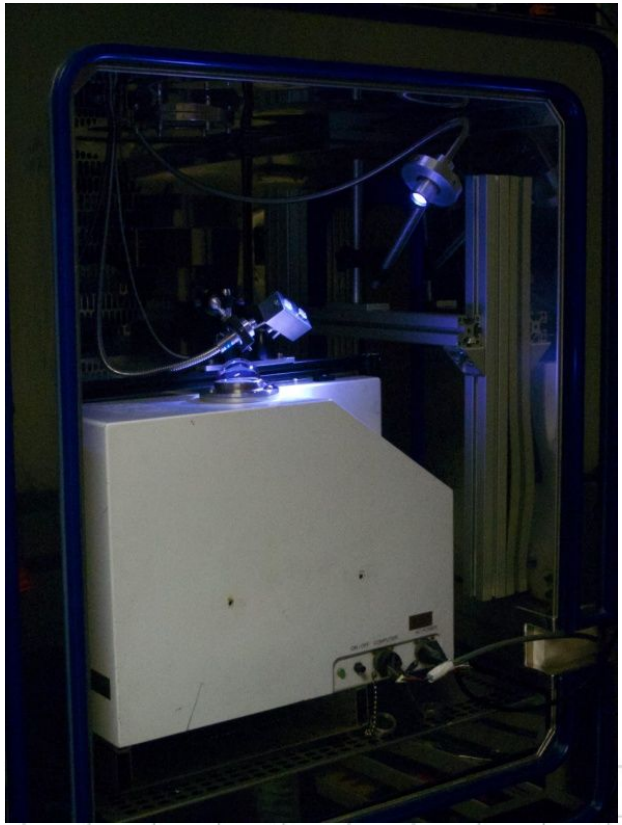



Temperature [°C]
50
40
30
20
10
0
-10
ABU DHABI
AES HQ
Alomar
Angra do Heroismo
Aosta
Armilla
Arosa
Athens
Bangkok
BCAA
Beijing
Beijing_cams
Belsk
Brussels
Budapest
Casablanca
CHURCHILL
Copenhagen
Davos
De Bilt
Delft-KZ
Edmonton
El Arenosillo
funchal
Gosan_GAW
Halkidki
Hohenpeissenberg
Hong Kong
Houston
Hradec Kralove
Huelva
INTA
IOS Toronto
Izana
Joklolinen
La Coruna
Lampedusa
Lindenberg
Lisboa/IM
Madrid
Manchester
Murcia
New Delhi
Oslo
PETALING JAYA
P.Jaya(Malaysia)
Plateau
Pohang
Poprad-Ganovce
Reading
Regina
Rome
Saskatoon
SAUNA CAM
SC Tenerife
Sodankyla
Sondrestrom
Songkhla
Sonnblick
STONY PLAIN
SUMU
Taipei
Tamanrasset
Tas
Thessaloniki-GR
TORONTO
Univ. of Rome
Valentia
Vindeln
Zaragoza

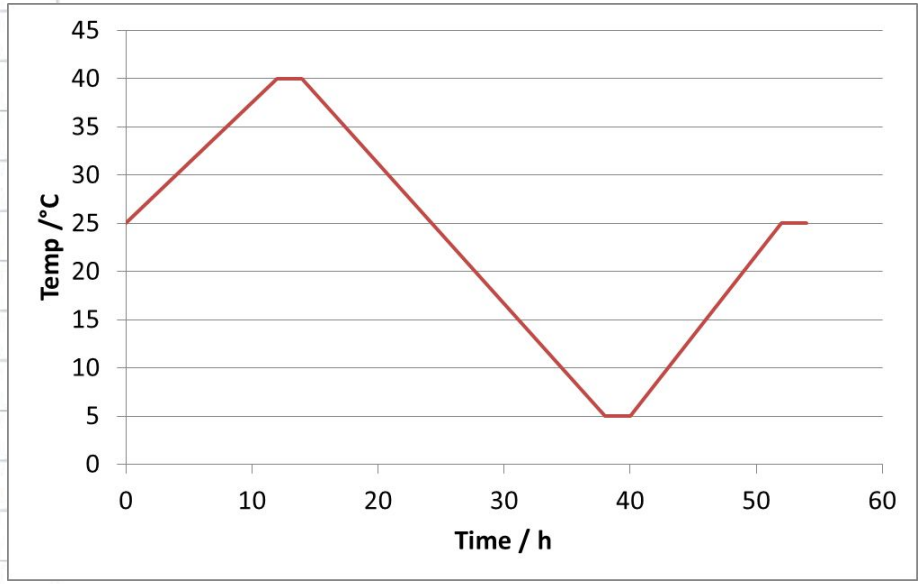
Description of the experiment

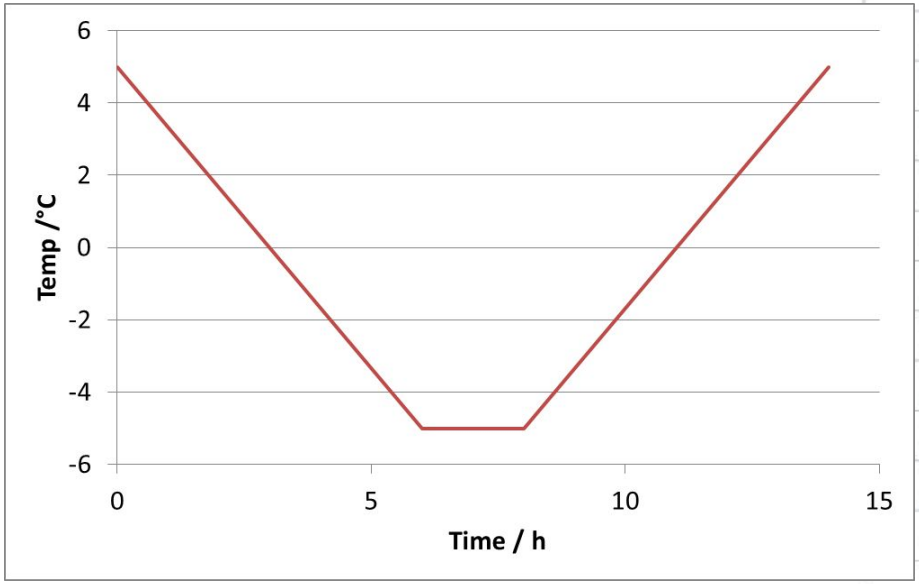
Measurements at the PTB

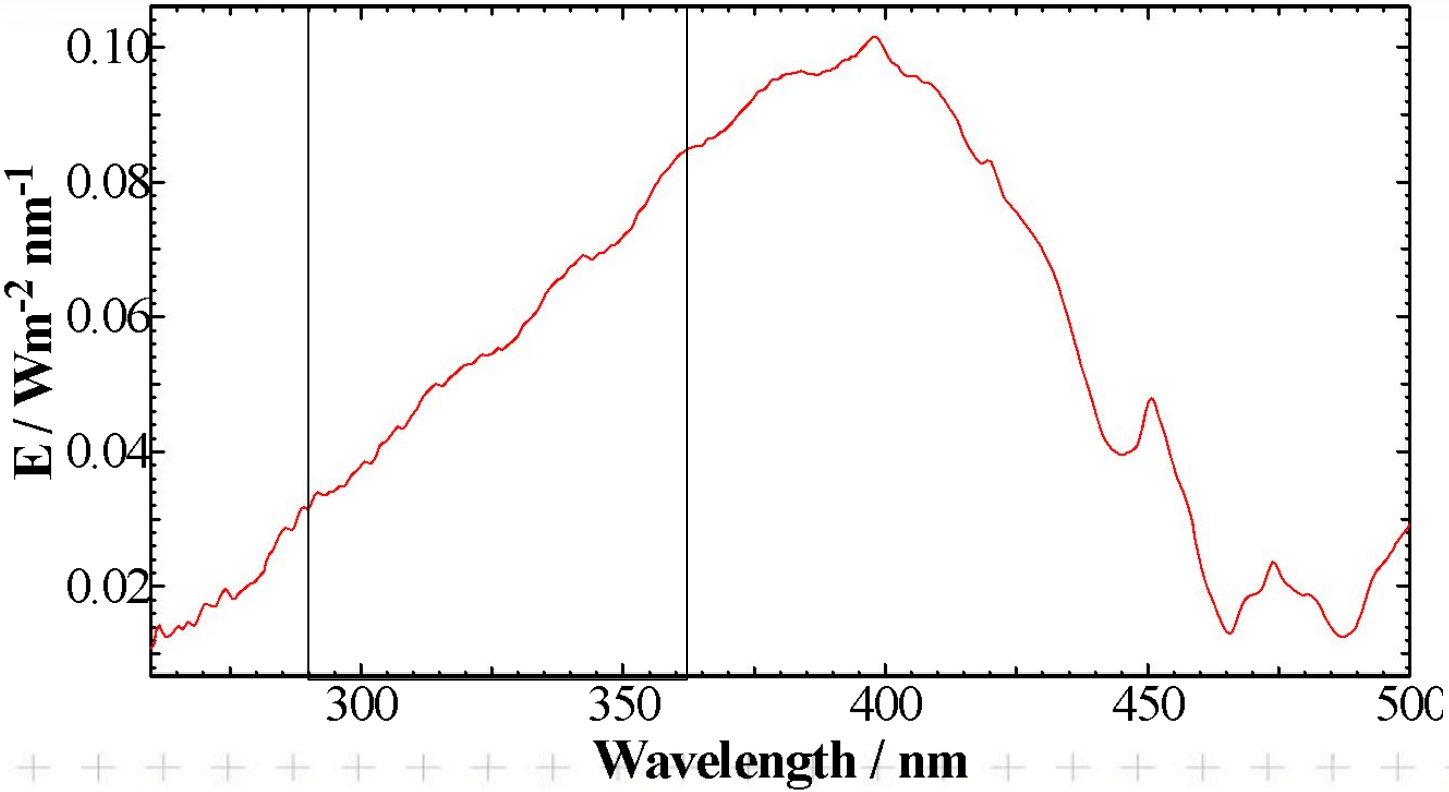


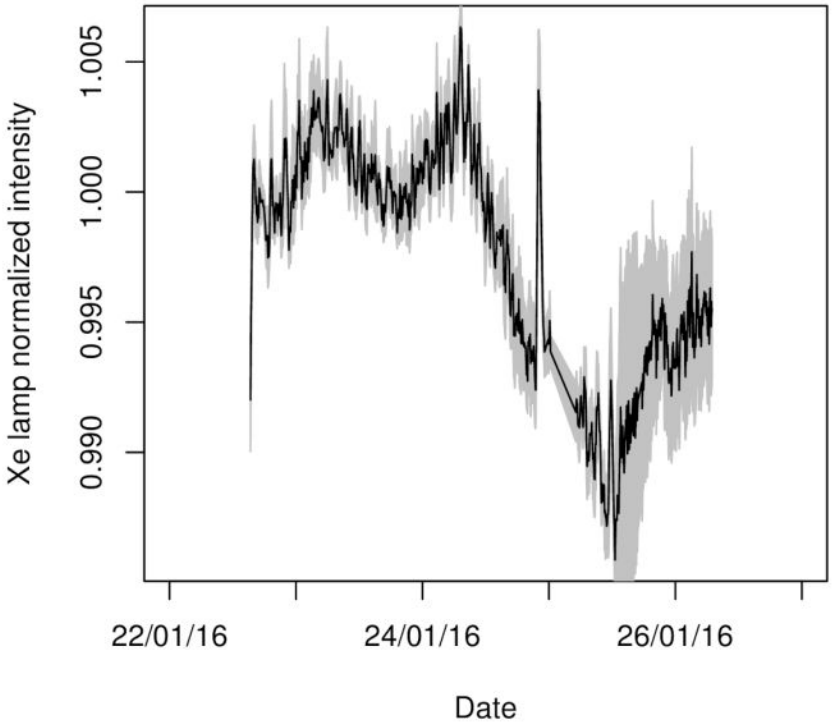


Measurements at the PTB



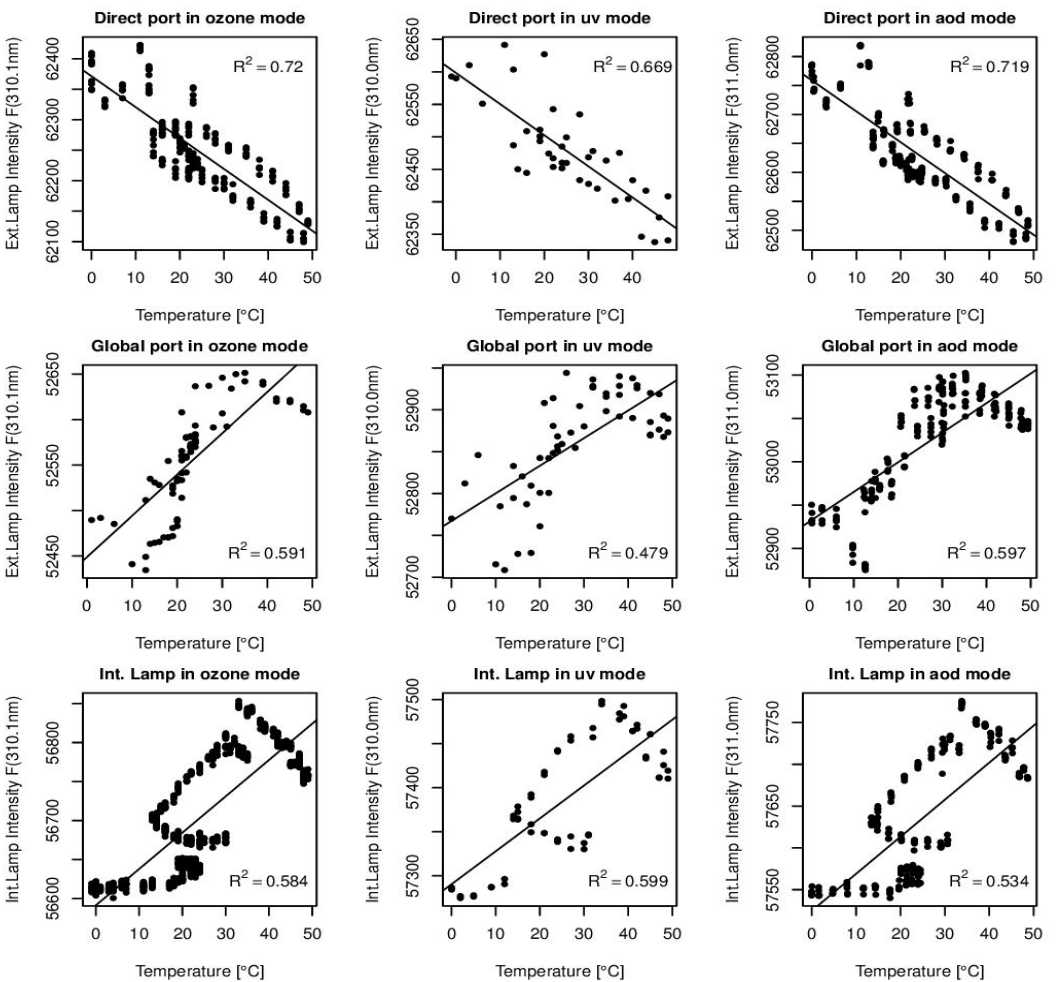



0.10
0.08
0.06
0.04
0.02
E / Wm-2 nm-1
300
350
400
450
500
Wavelength / nm

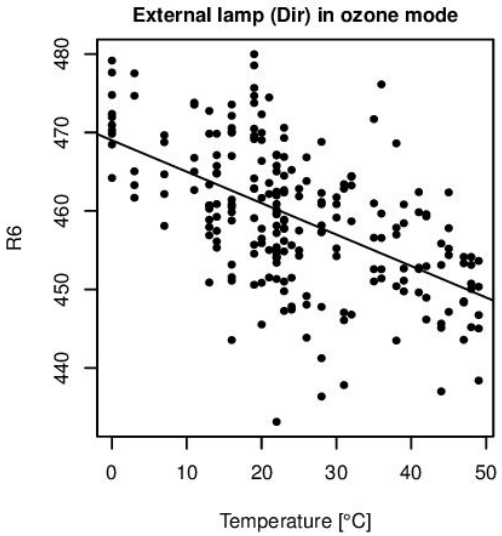

Xe lamp normalized intensity
0.990
0.995
1.000
1.005
22/01/16
24/01/16
26/01/16
Date

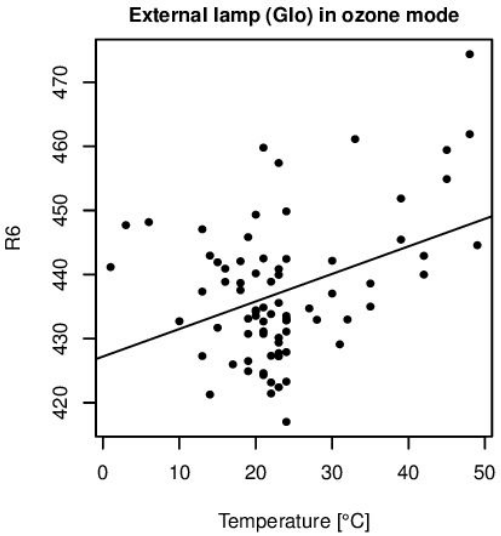
Mode	Input Port	Duration (min)	Cycles	Filter1	Filter2
ozone	Internal Lamp	10	20	256	0
aod	Internal Lamp	20	10	256	0/64
uv	Internal Lamp	15	4	256	0
ozone	Global Port	5	50	128	0
aod	Global Port	15	10	128	0
uv	Global Port	10	1	128	0
ozone	Direct Port	5	20	256	0/64
aod	Direct Port	15	10	256	0/64
uv	Direct Port	10	1	256	64

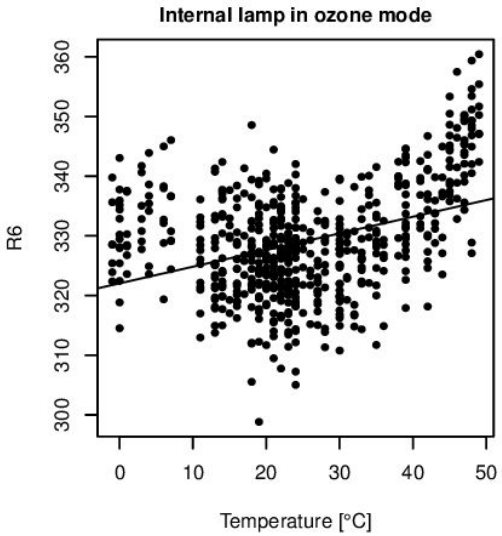
Temperature characterisation of Brewer determined in the laboratory



$$R_6 = \sum_{i=1}^{n} w_i F(\lambda_i)$$ (no temperature correction applied)







Temperature correction

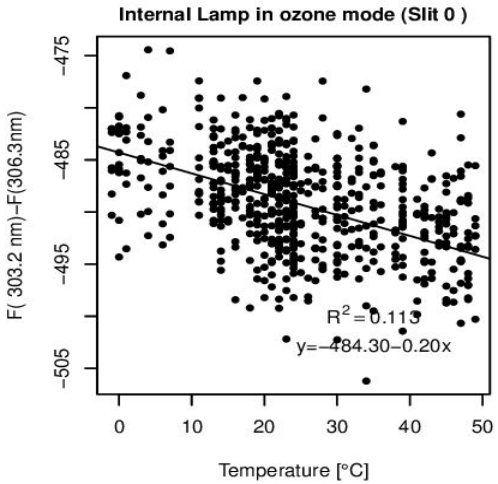
$$F(\lambda_i) = F_c(\lambda_i) - \tau_b(\lambda_i)T$$

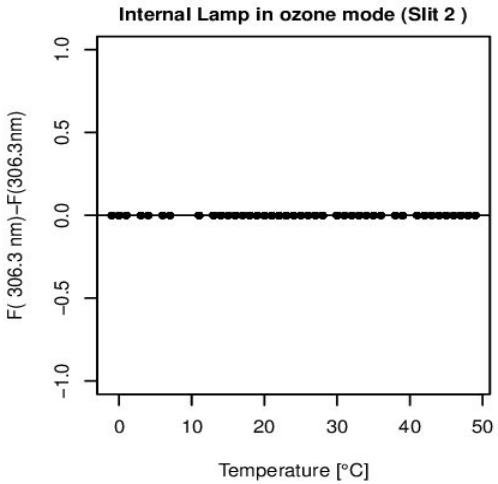
$$F(\lambda_i) - F(\lambda_0) = F(\lambda_i) - F(\lambda_0) - (\tau_b(\lambda_i) - \tau_b(\lambda_0))T$$

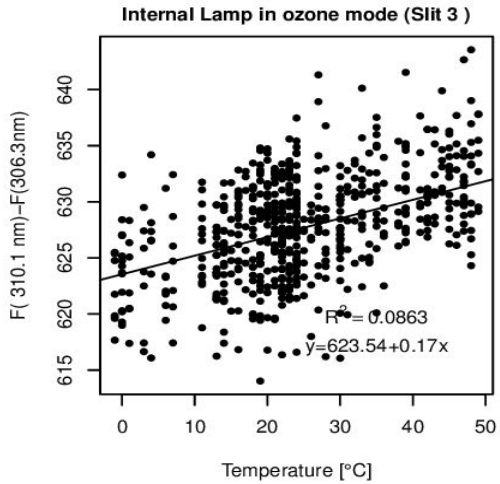
$$F(\lambda_i) - F(\lambda_0) = F(\lambda_i) - F(\lambda_0) - \tau'_b(\lambda_i)T$$

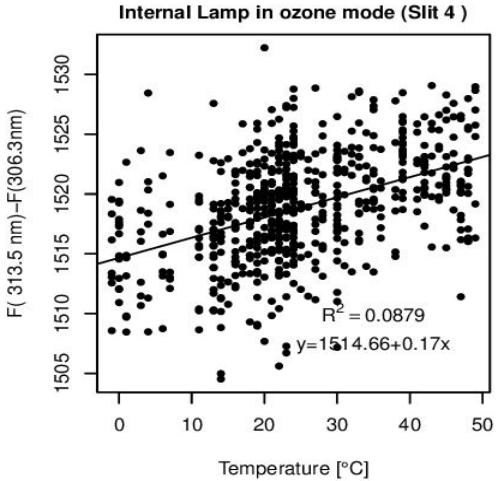
$$\tau'_b(\lambda_i) = \tau_b(\lambda_i) - \tau_b(\lambda_0)$$

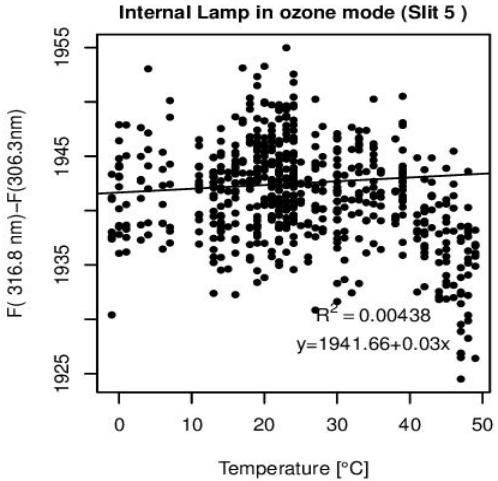
Temperature characterisation of Brewer determined in the laboratory

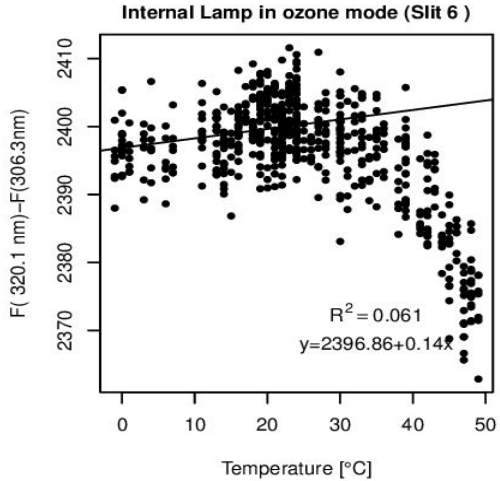












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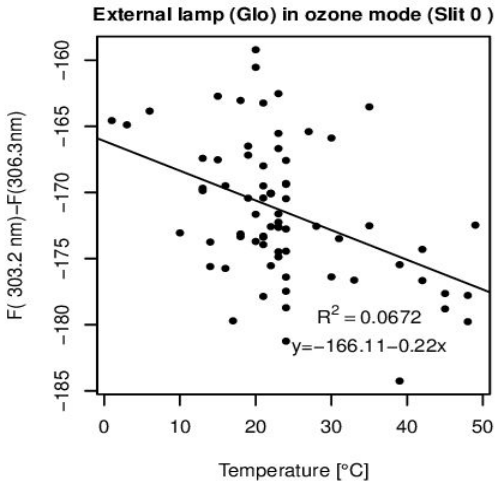

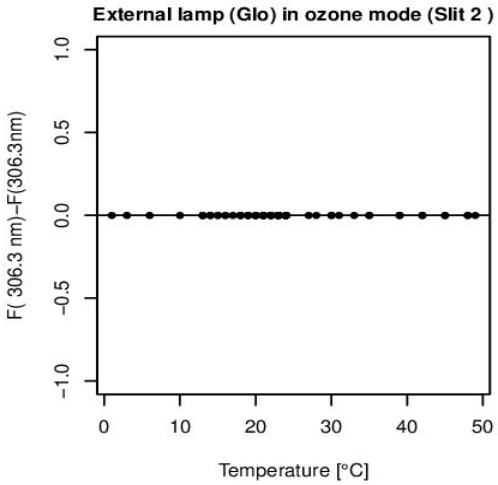

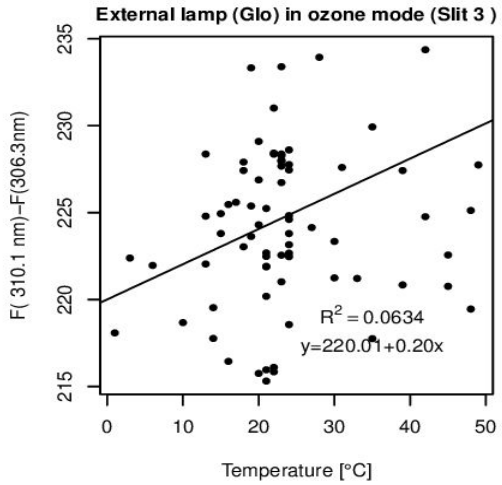

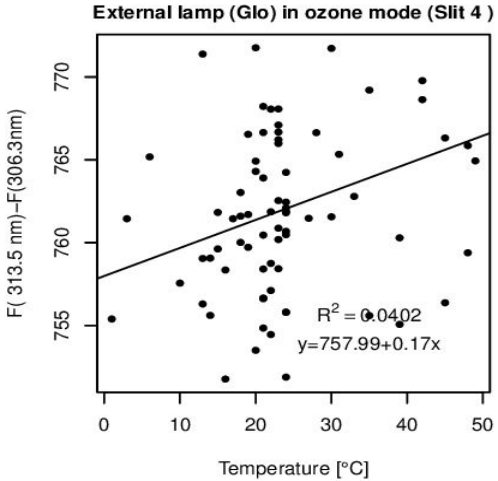

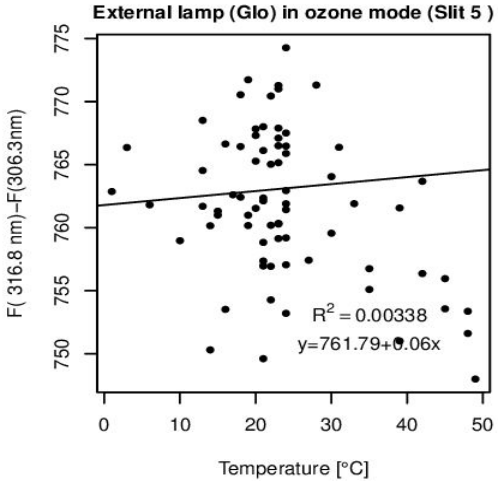

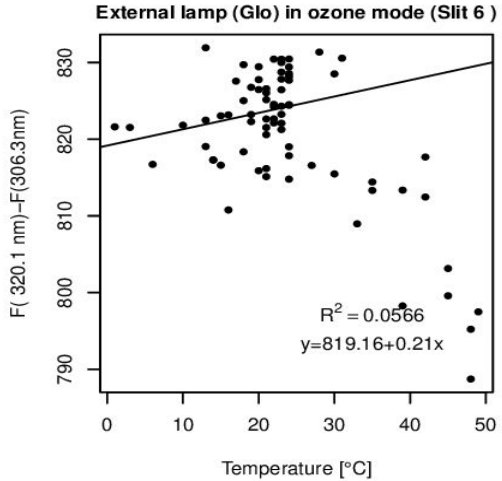

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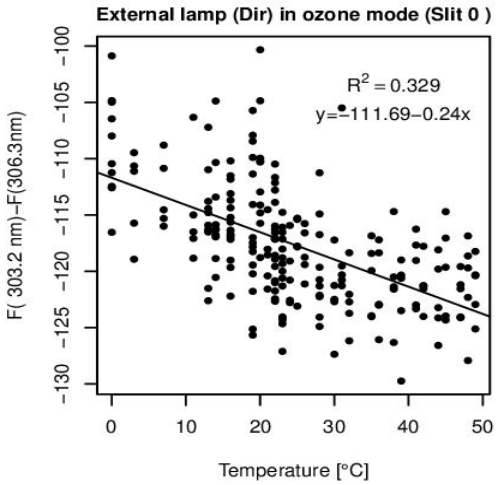
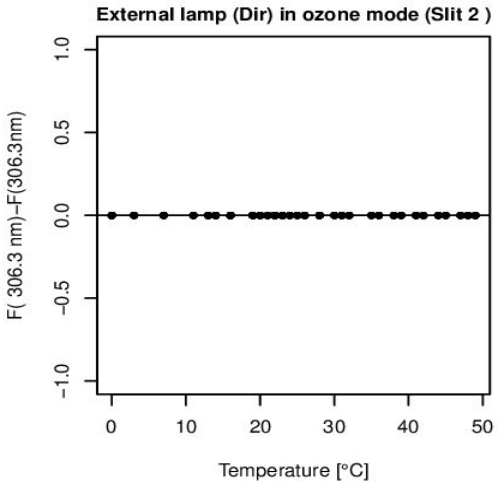
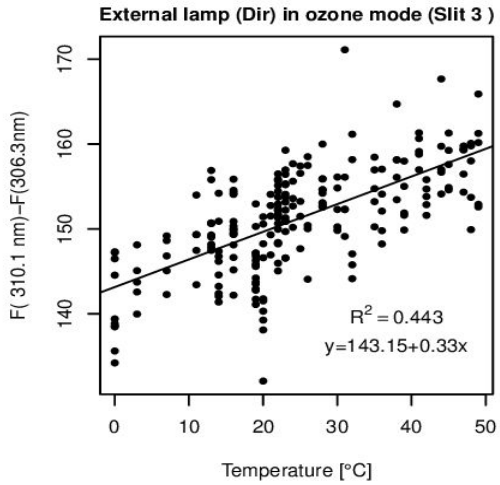
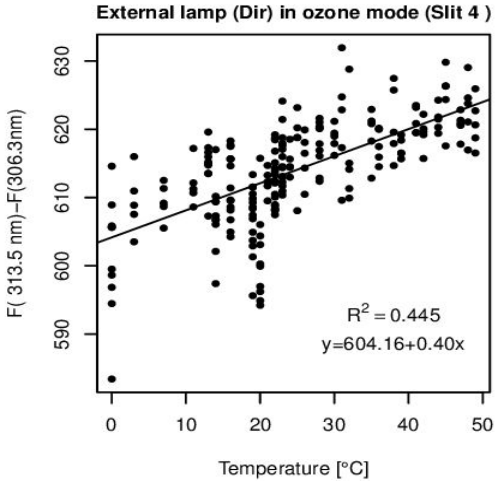
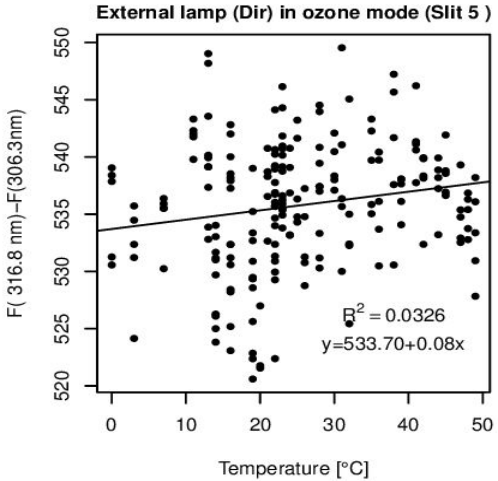
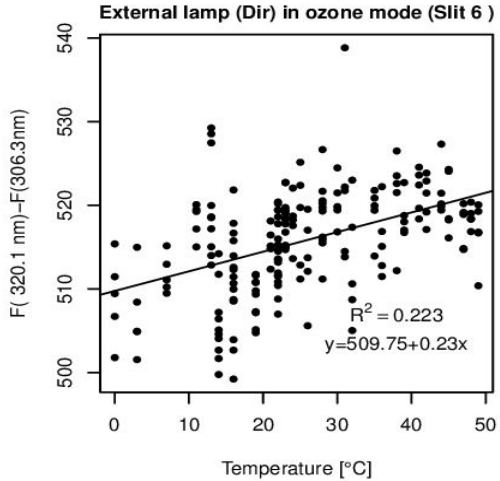


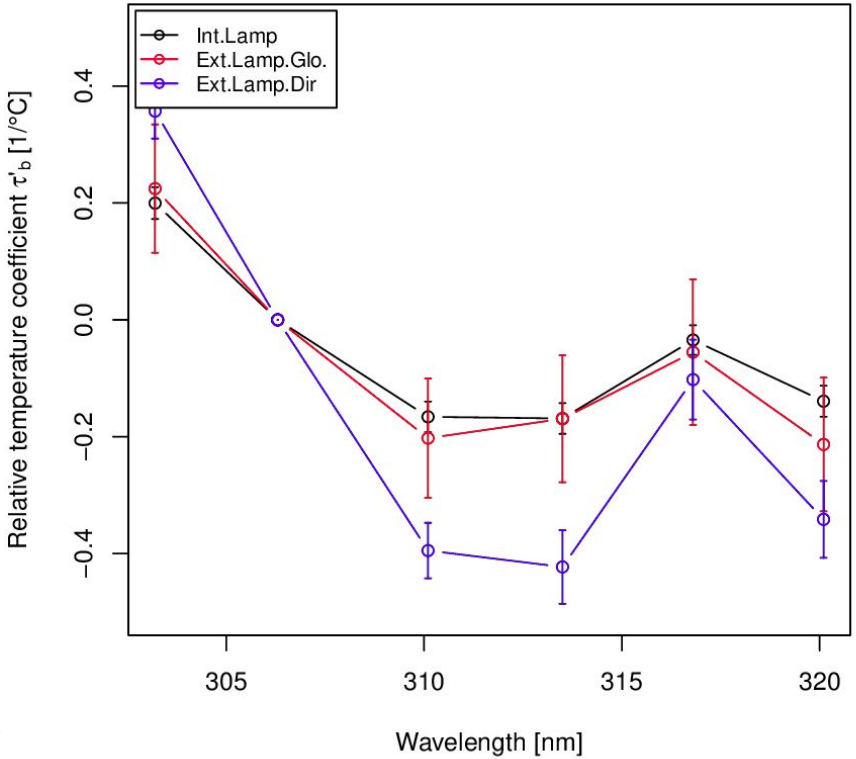




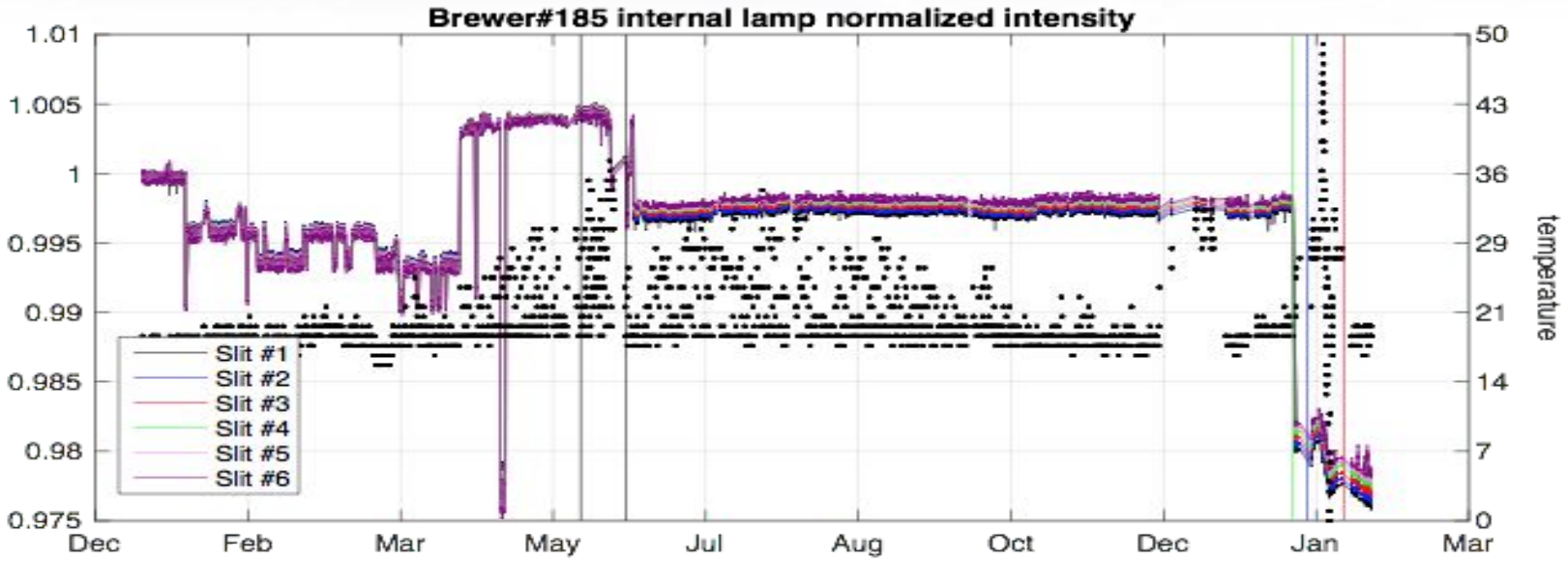




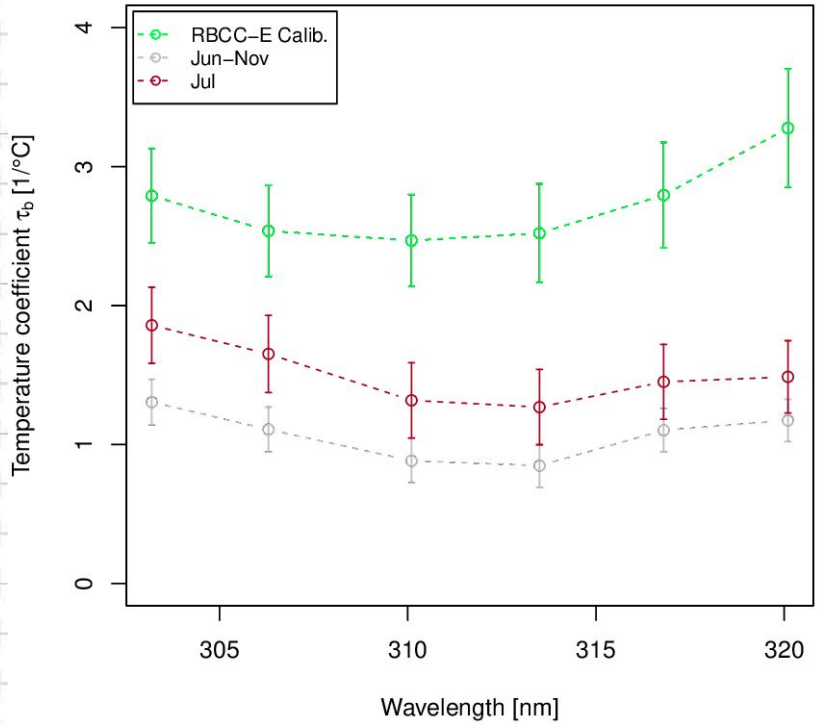


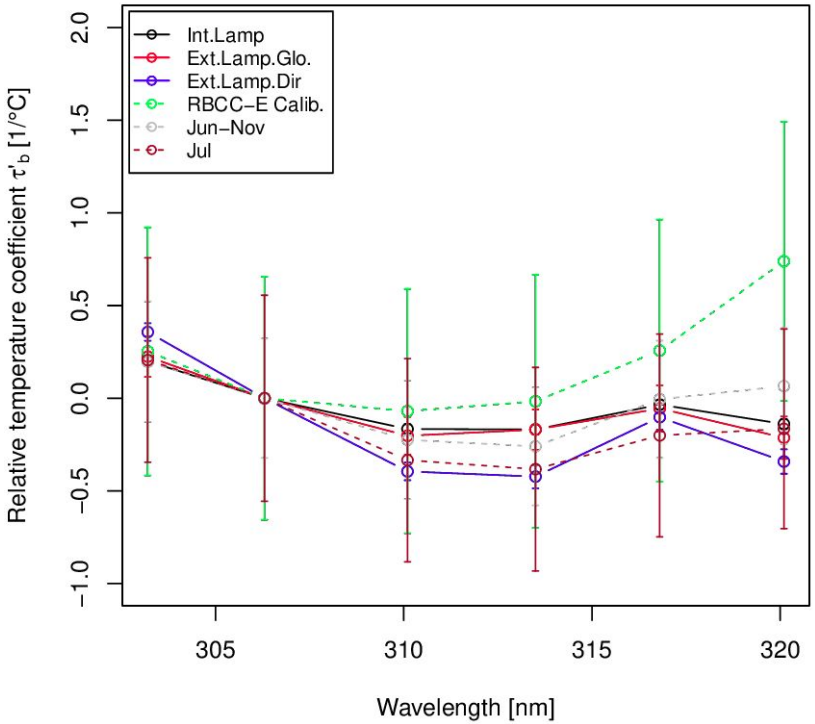

Int.Lamp
Ext.Lamp.Glo.
Ext.Lamp.Dir
Relative temperature coefficient τ'b [1/°C]
0.4
0.2
0.0
−0.2
−0.4
305
310
315
320
Wavelength [nm]

Comparison of Temperature coefficients obtained from laboratory measurements and field measurements

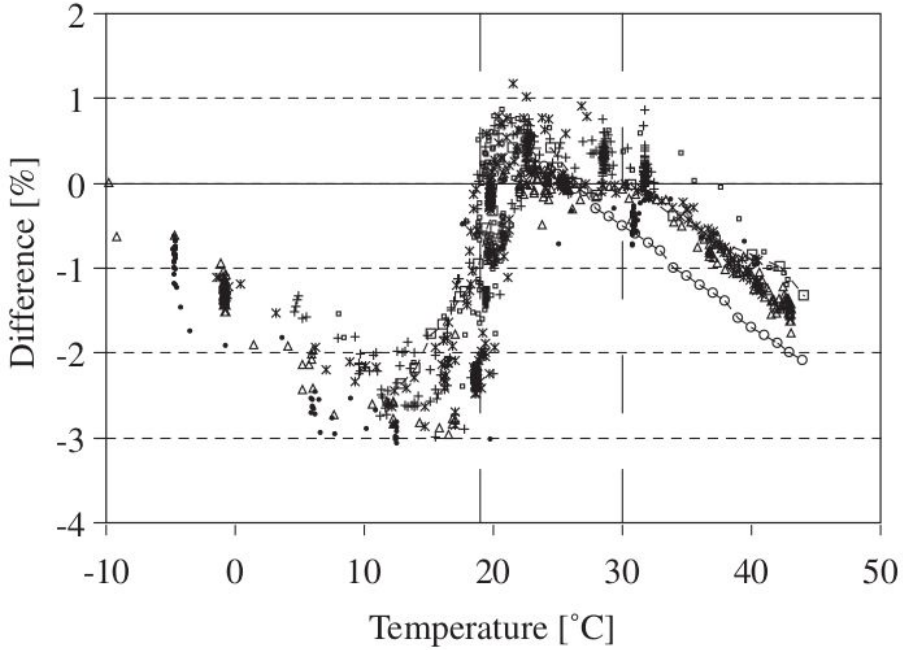


RBCC-E	Temperatures: 19 - 35	Dates: 2015-05-23 / 2015-06-02
Jun-Nov	Temperatures: 17 - 34	Dates: 2015-06-12 / 2015-11-30
Jul	Temperatures: 18 - 34	Dates: 2015-07-01 / 2015-07-31


RBCC–E Calib.
Jun–Nov
Jul
Temperature coefficient τ_b [1/°C]
0
1
2
3
4
305
310
315
320
Wavelength [nm]


Int.Lamp
Ext.Lamp.Glo.
Ext.Lamp.Dir
RBCC–E Calib.
Jun–Nov
Jul
Relative temperature coefficient τ'_b [1/°C]
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
305
310
315
320
Wavelength [nm]

Effect of PTFE diffuser on the instrument temperature dependence.



Ylianttila and Schreder [2005] “Temperature effects of PTFE diffusers”

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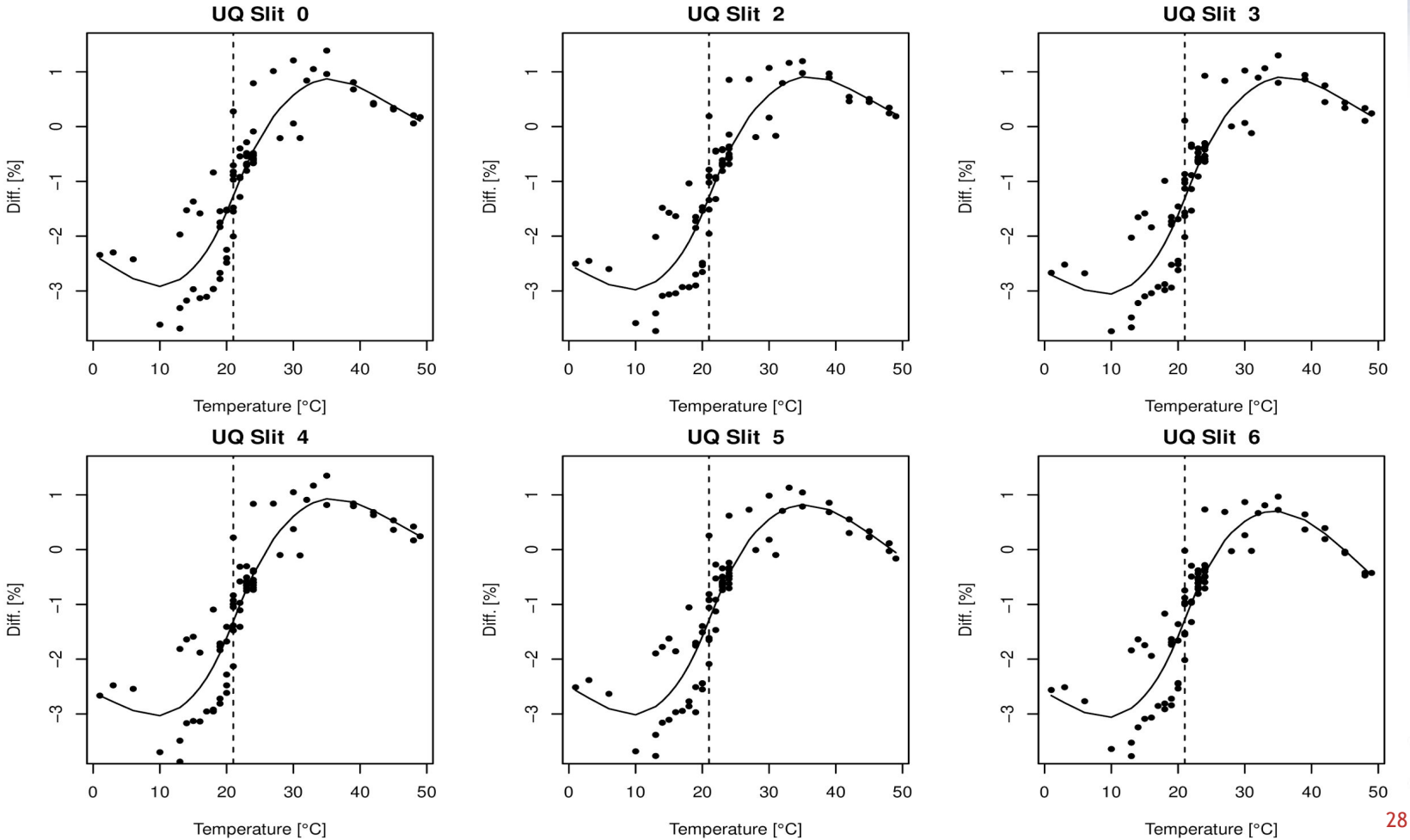
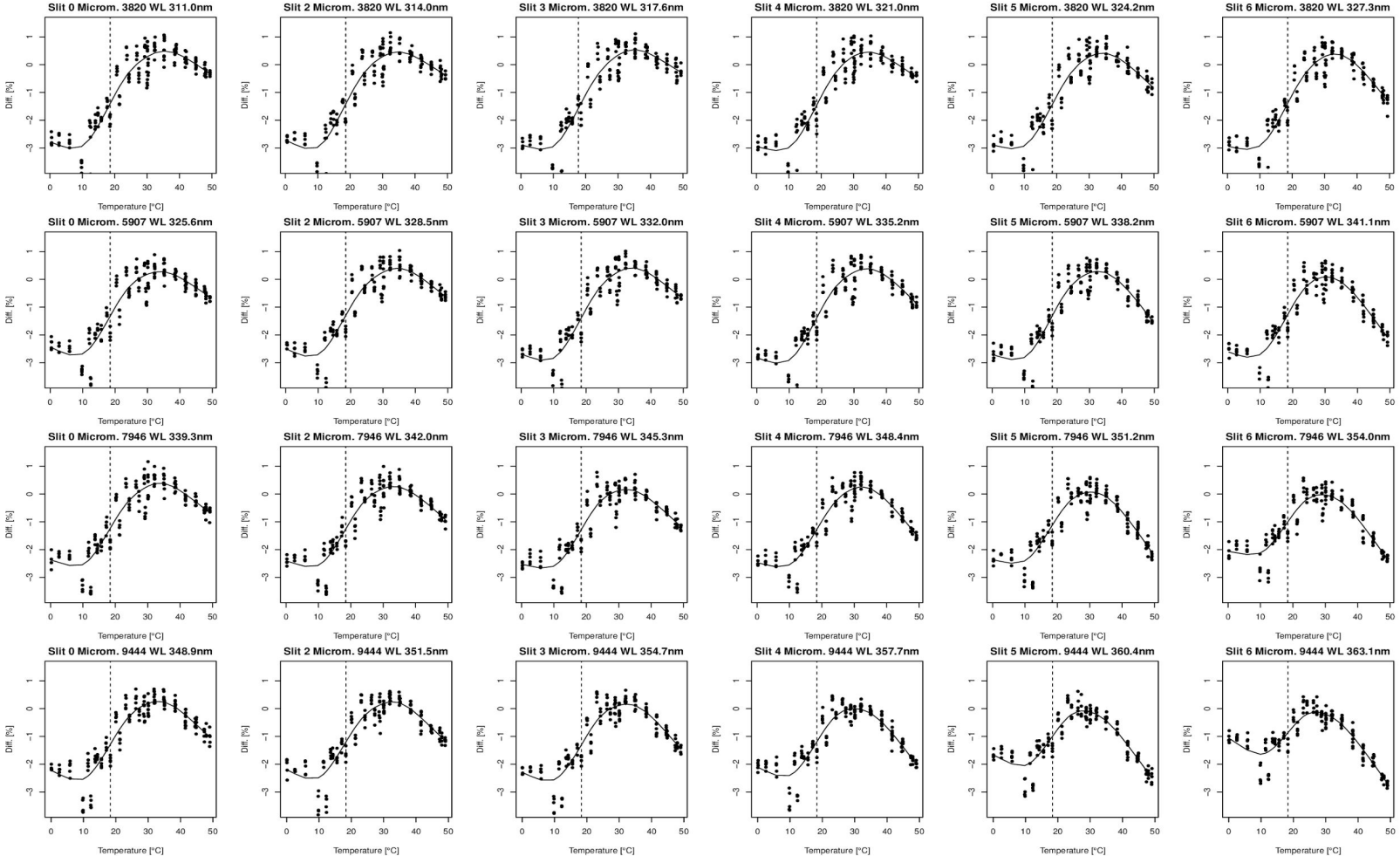
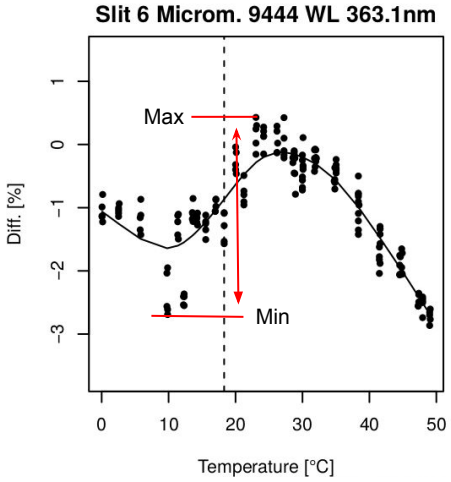
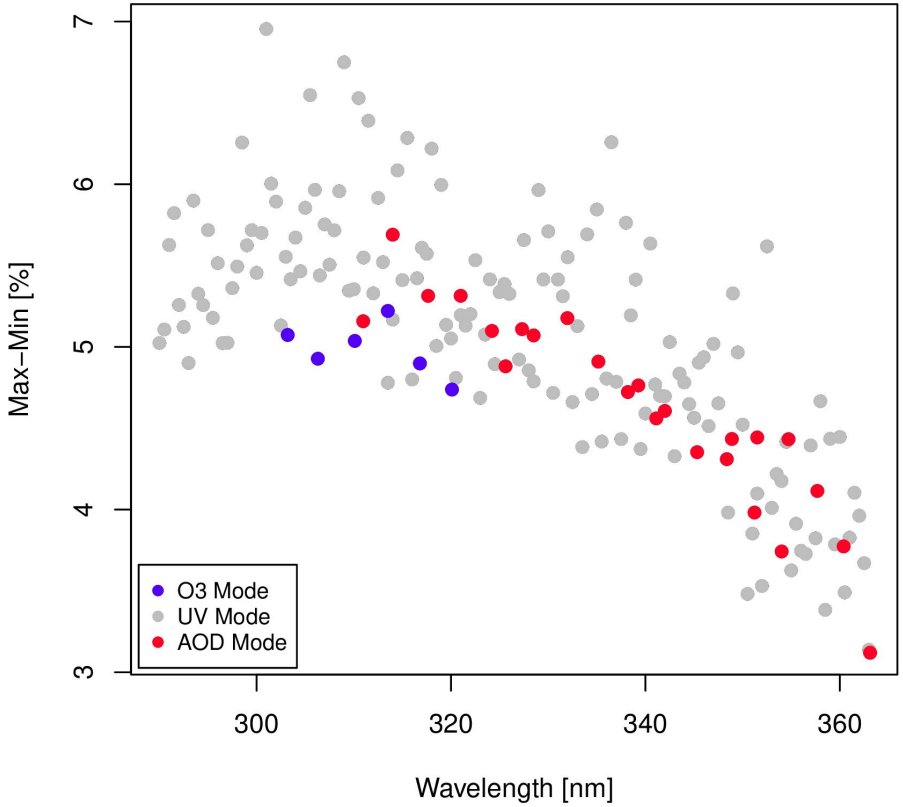


Temperature characterisation of Brewer determined in the laboratory




Slit 6 Microm. 9444 WL 363.1nm
Max
Min
Diff. [%]
1
0
−1
−2
−3
0
10
20
30
40
50
Temperature [°C]


Max−Min [%]
7
6
5
4
3
300
320
340
360
Wavelength [nm]
O3 Mode
UV Mode
AOD Mode

Conclusions

- The temperature sensitivity of Brewer spectrophotometer determined from internal lamp measurements and from external lamp measurements through the global port are in close agreement. Slits 5 and 6 present a non-linear dependence for temperature above 30°C.

- However, the temperature sensitivity determined from external lamp measurements through the direct port presents a linear behavior. This discrepancy with the other measurements may indicate a temperature dependence of the quartz window.

- Brewer global measurements are affected by a transmittance increase at about 20°C due to the PTFE diffuser. This effect is wavelength dependent, changing from 5% at 300nm to 3% at 360nm.

Thank you for your attention