Temperature characterisation of Brewer determined in the laboratory

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Objectives:

- Validation of the standard method of thermal characterization of the Brewer spectroradiometer: Comparison of the thermal sensitivity of the measurements made through the direct port and measurements to the internal lamp.
- Determine the effect of PTFE diffuser on the instrument temperature dependence.

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

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

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

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

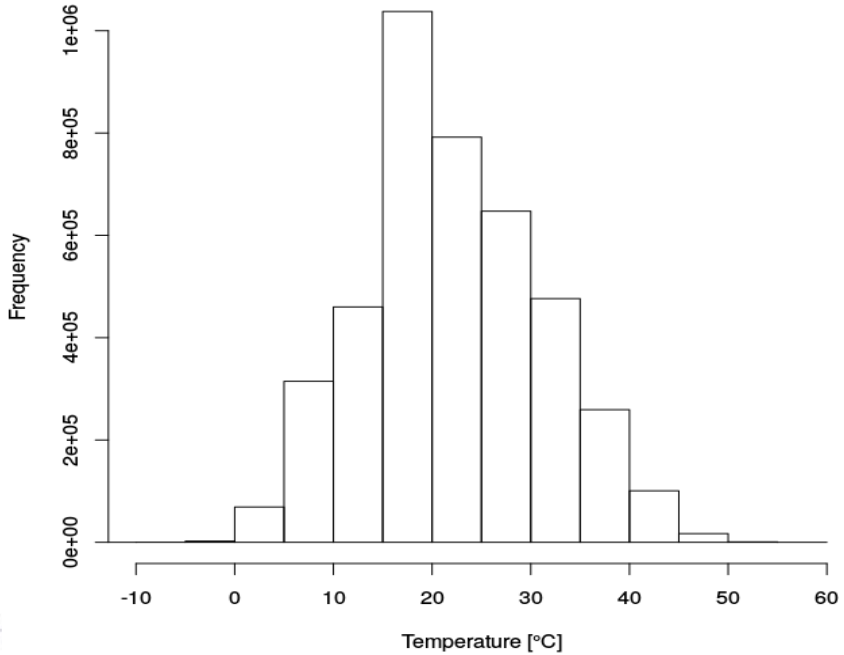
Temperature correction

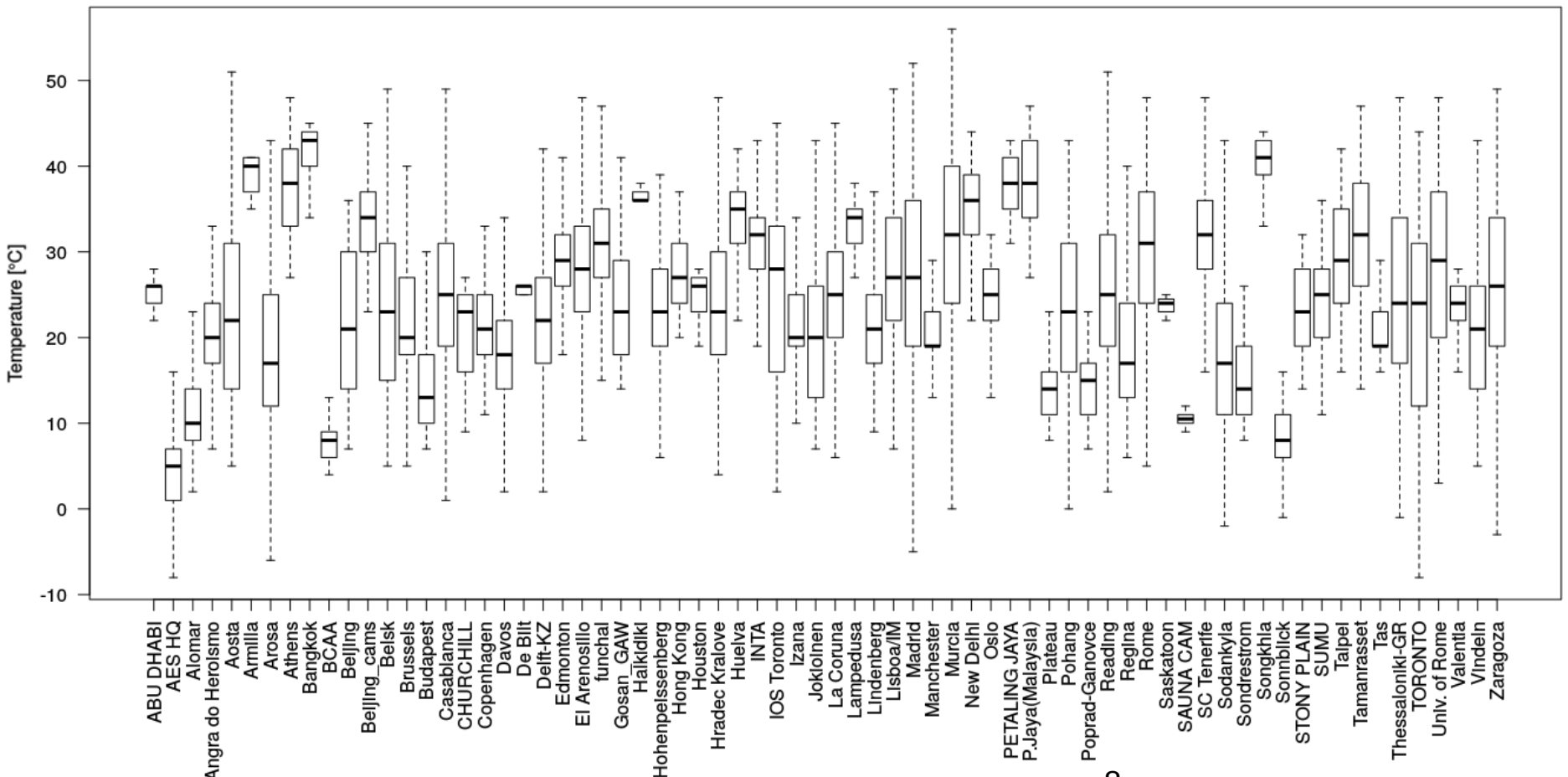
$$R_6 = \sum_{i=1}^{n} w_i F_c(\lambda_i) = \sum_{i=1}^{n} w_i F(\lambda_i) + \sum_{i=1}^{n} w_i \tau_b(\lambda_i) T$$

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

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

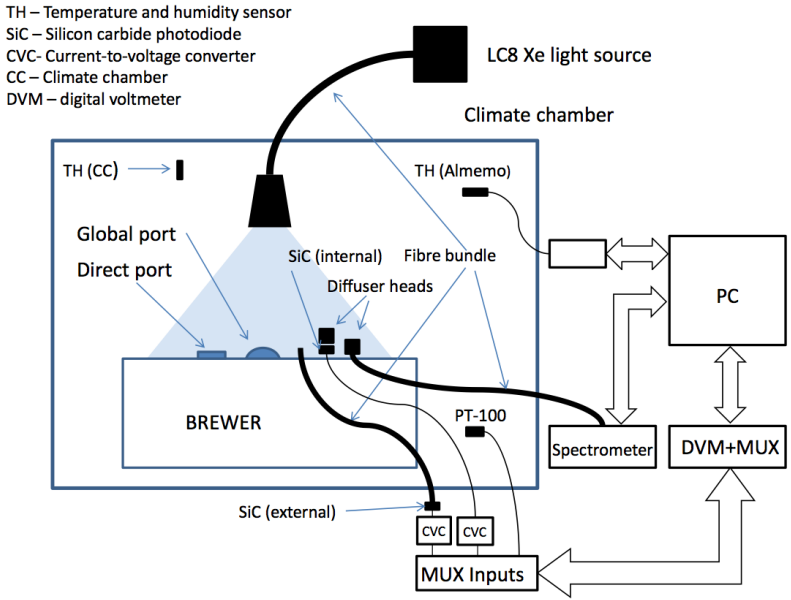
Statistics from The EUBREWNET DB

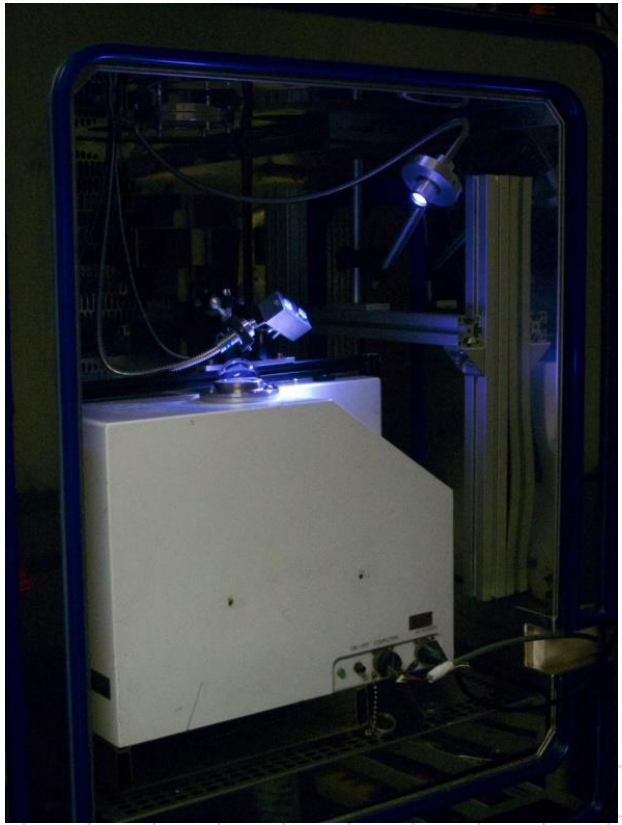



Temperature [°C]
50
40
30
20
10
0
-10
ABU DHABI
AES HQ
Alomar
Angra do Heroismo
Aosta
Armilla
Arosa
Athens
Bangkok
BCAA
Beijing
Beijing_cams
Belsk
Brussels
Budapest
Casablanca
CHURCHILL
Copenhagen
Davos
De Bilt
Delft-KZ
Edmonton
El Arenosillo
funchal
Gosan_GAW
Halkidki
Hohenpeissenberg
Hong Kong
Houston
Hradec Kralove
Huelva
INTA
IOS Toronto
Izana
Joklolnen
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

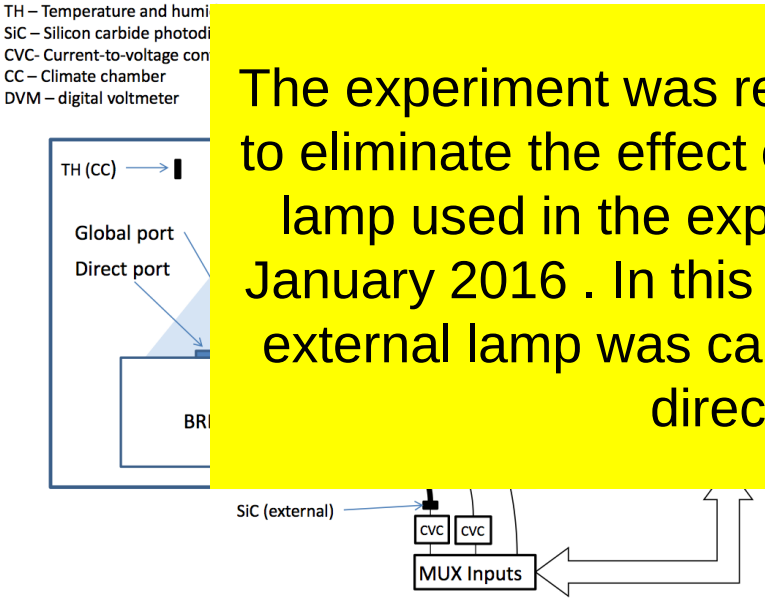
Description of the experiment

Measurements at the PTB (Jan2016)



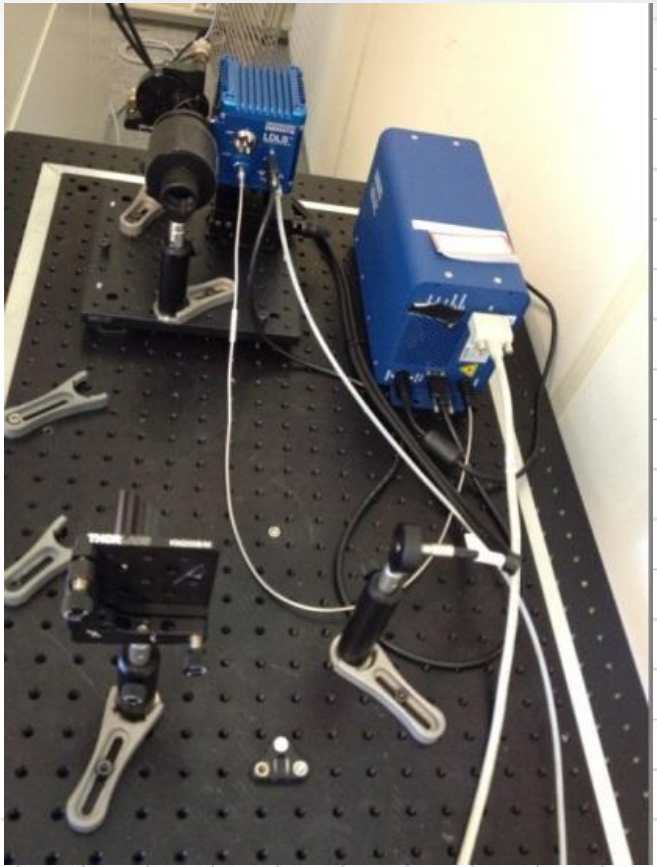


Measurements at the PTB (Jan2016)



The experiment was repeated on March 2017 to eliminate the effect of the defective internal lamp used in the experiment carried out in January 2016 . In this second experiment the external lamp was carefully aligned with the direct port.

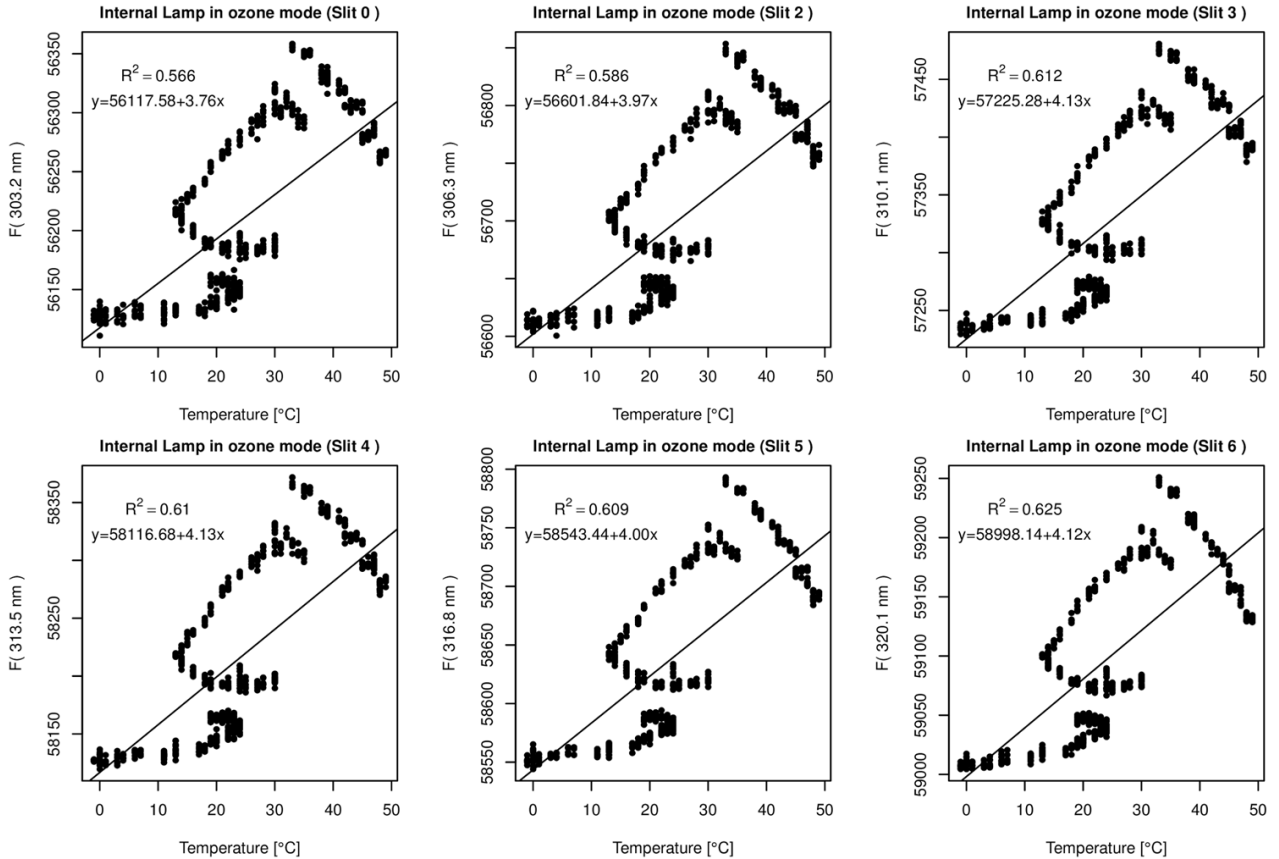
Measurements at Kipp&Zonen



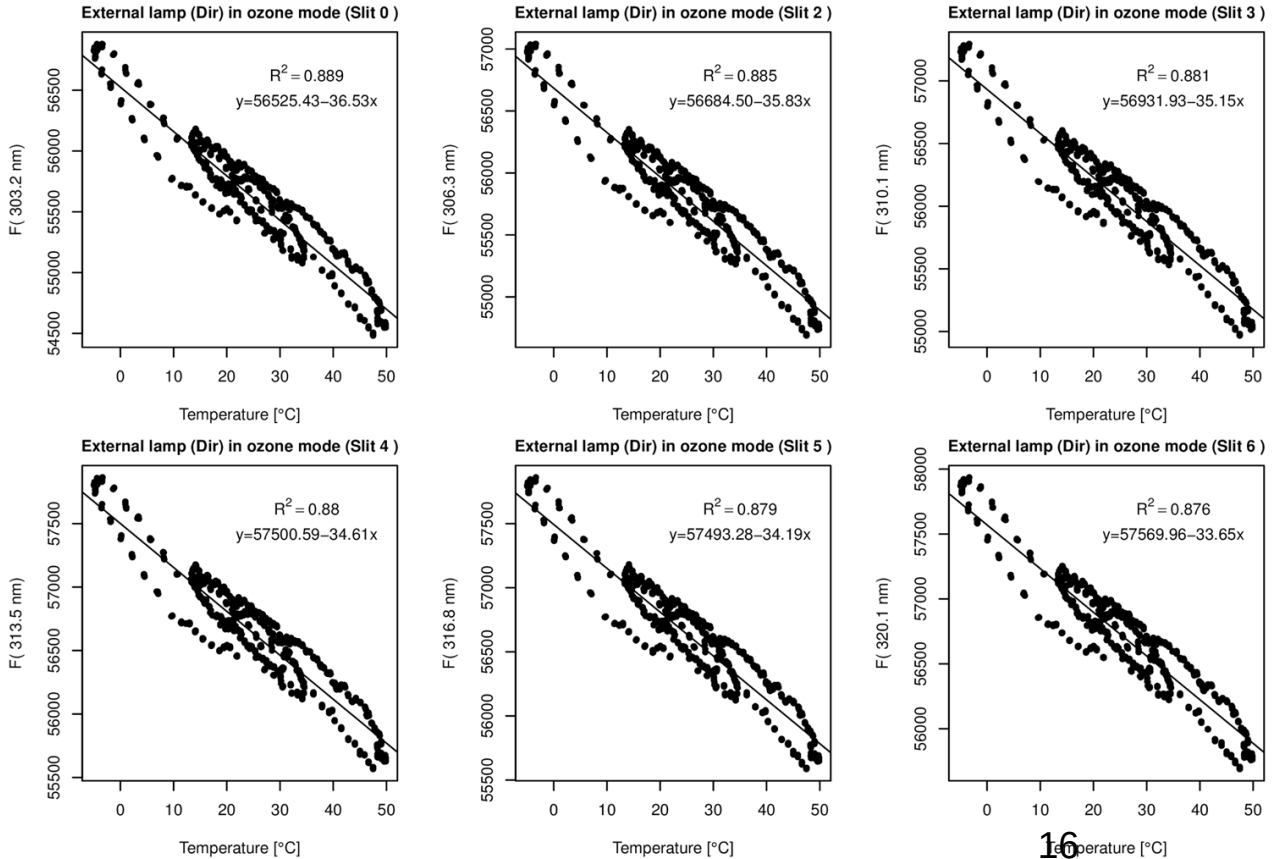
Comparison of the thermal sensitivity of the measurements made through the direct port and measurements to the internal lamp.

Measurements vs. Temperature

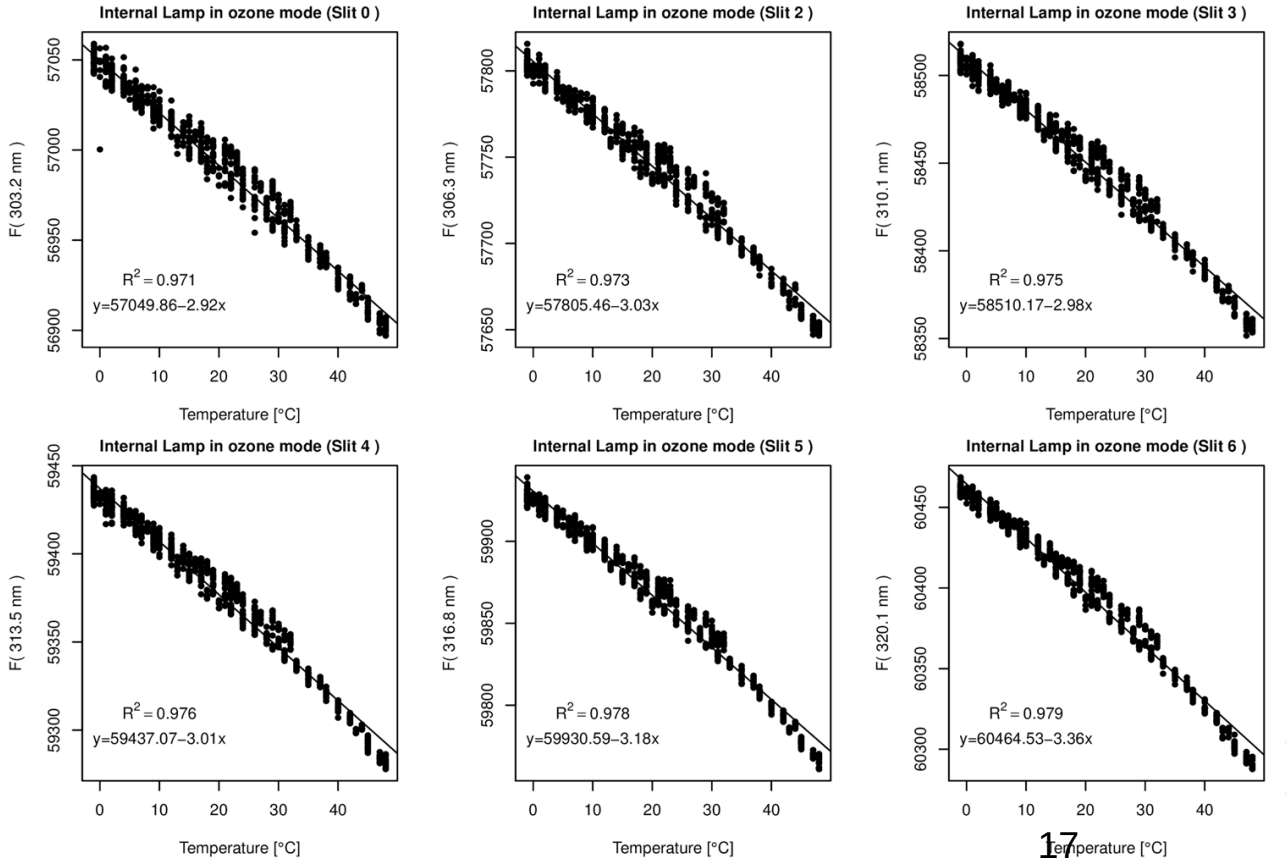
PTB Jan2016 #185



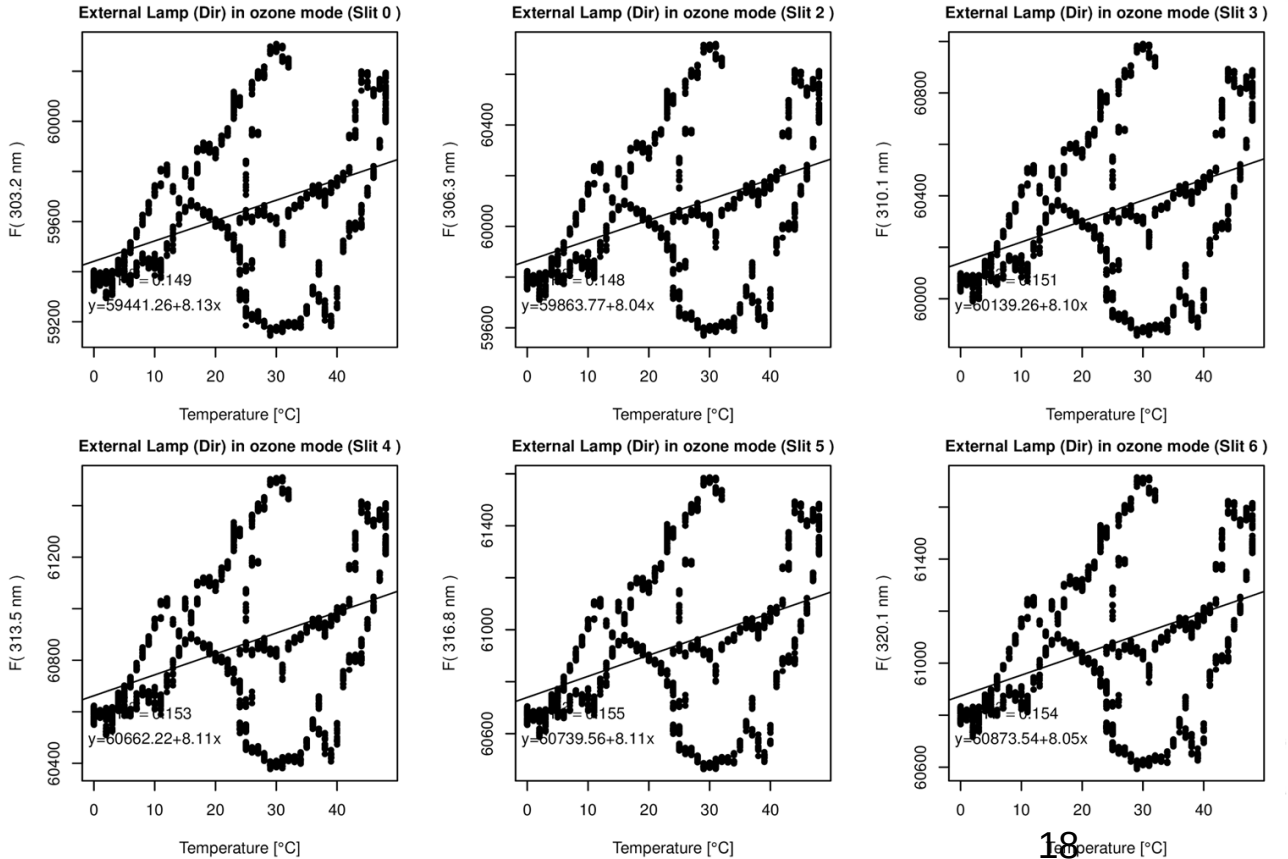
PTB Jan2016 #185



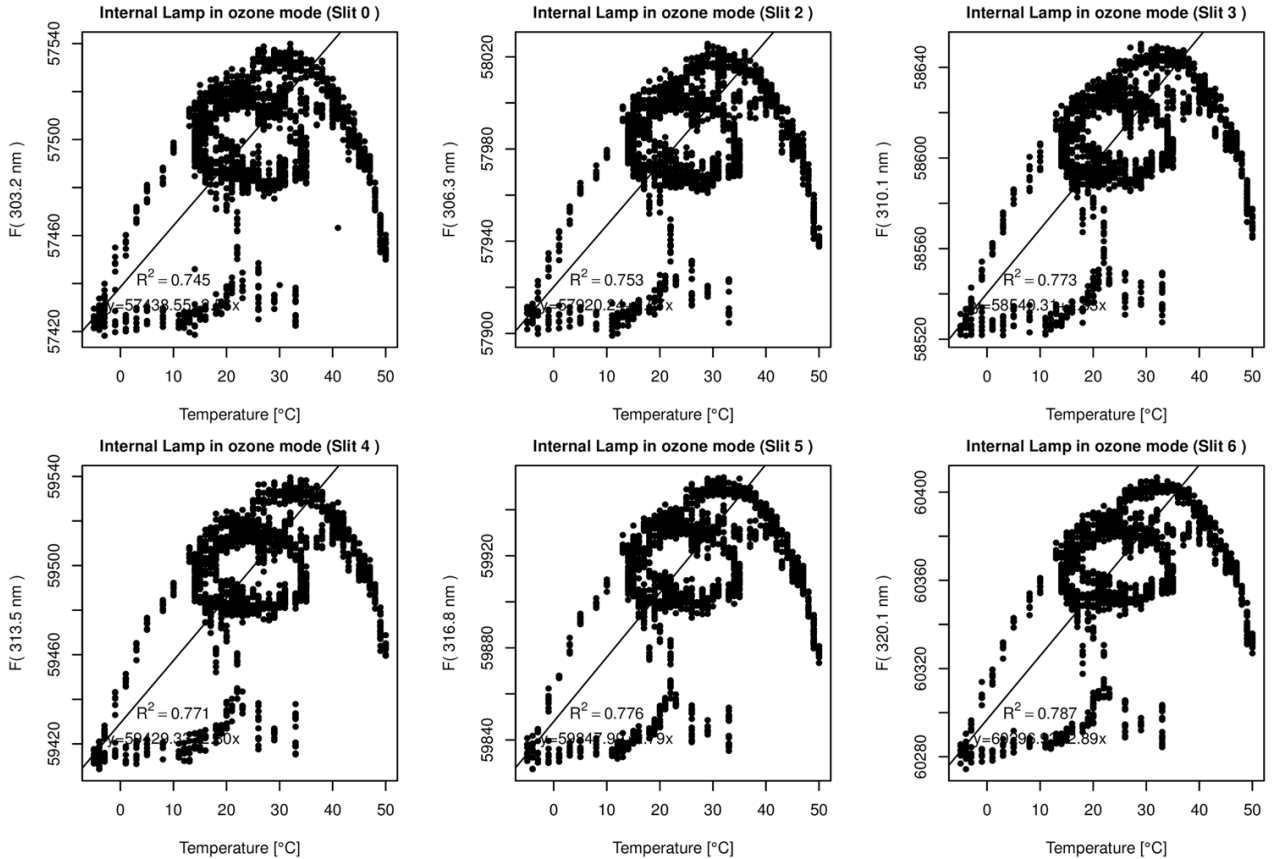
Kipp&Zonen #233



Kipp&Zonen #233



PTB Mar2017 #185



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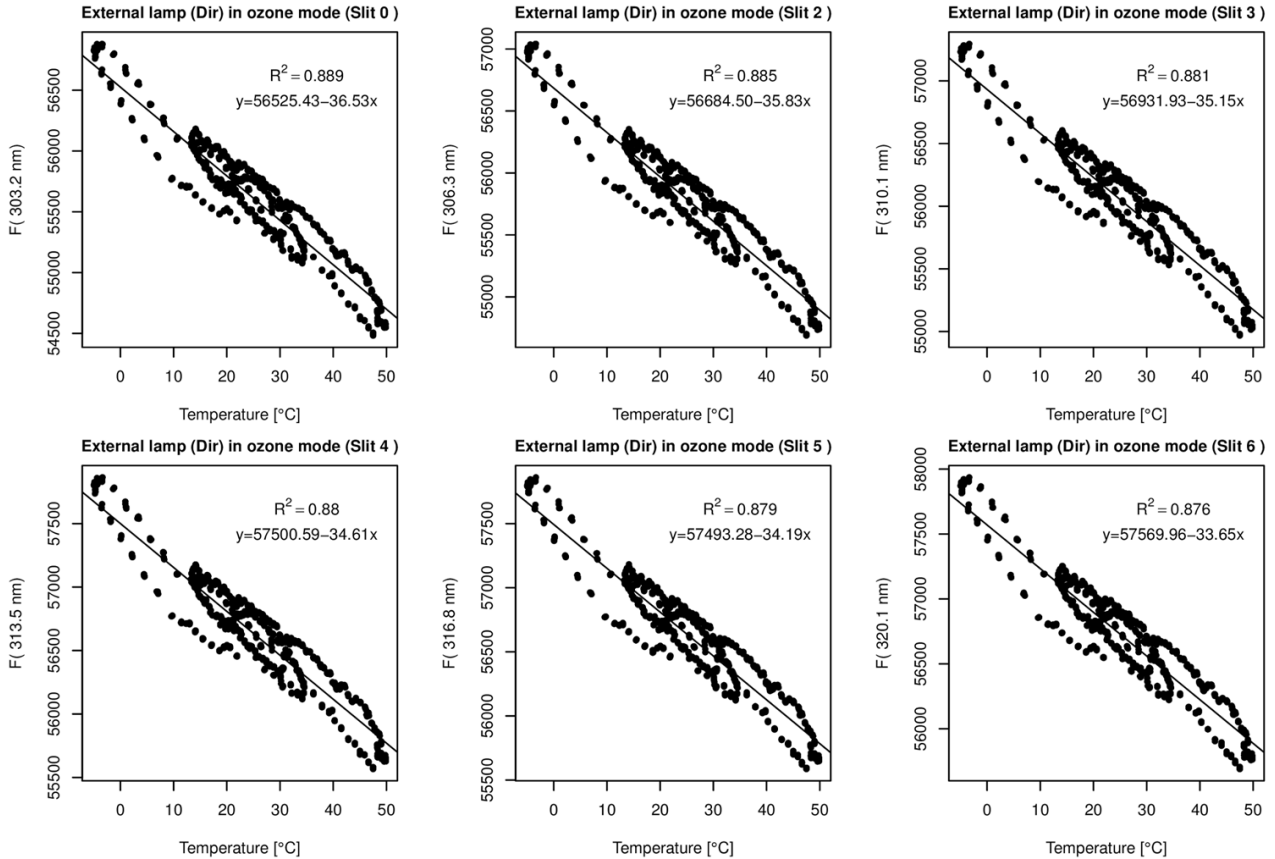
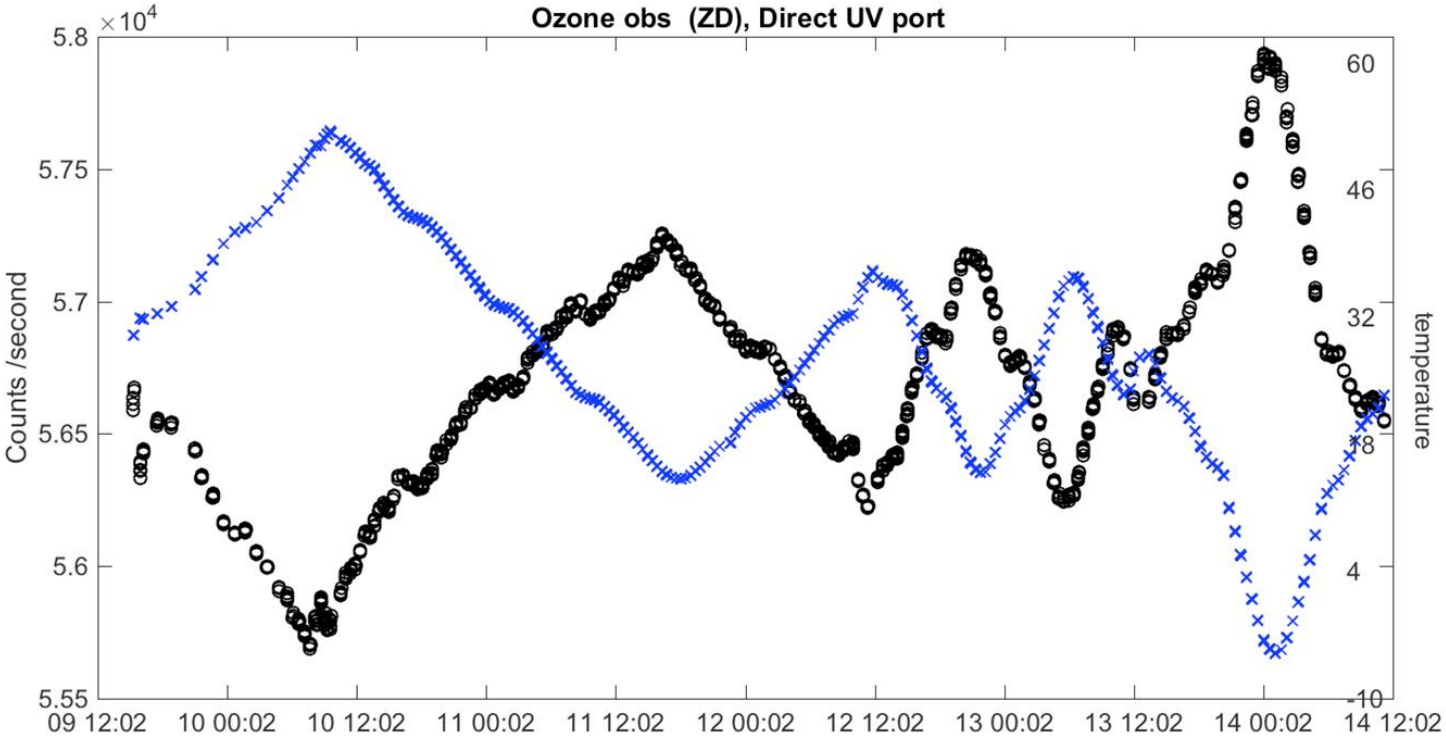
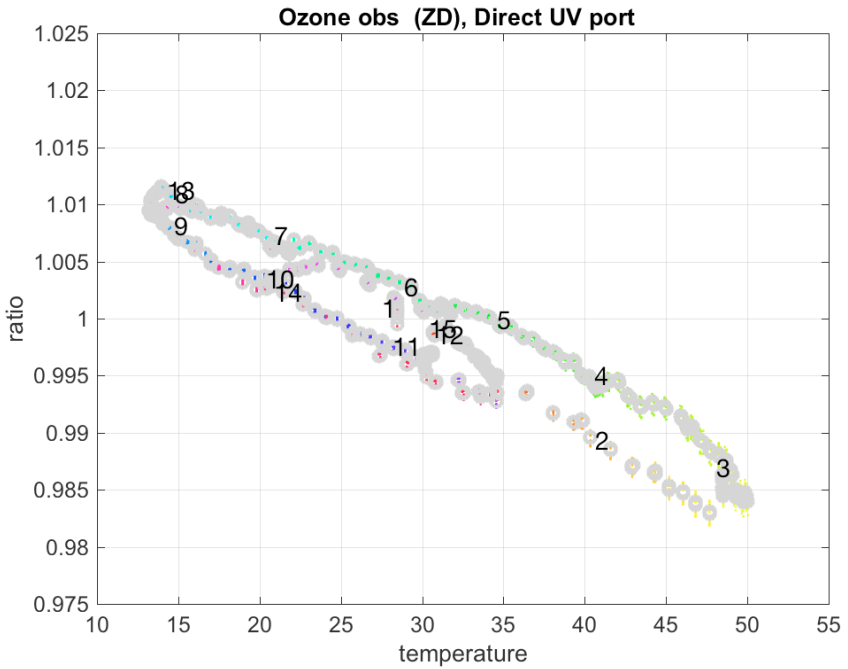
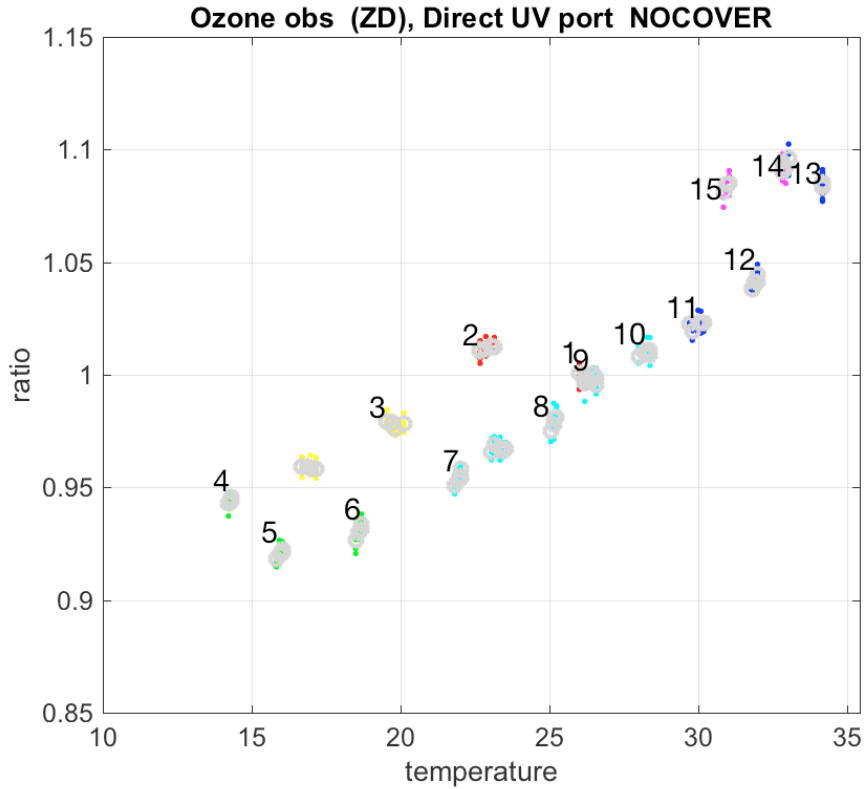


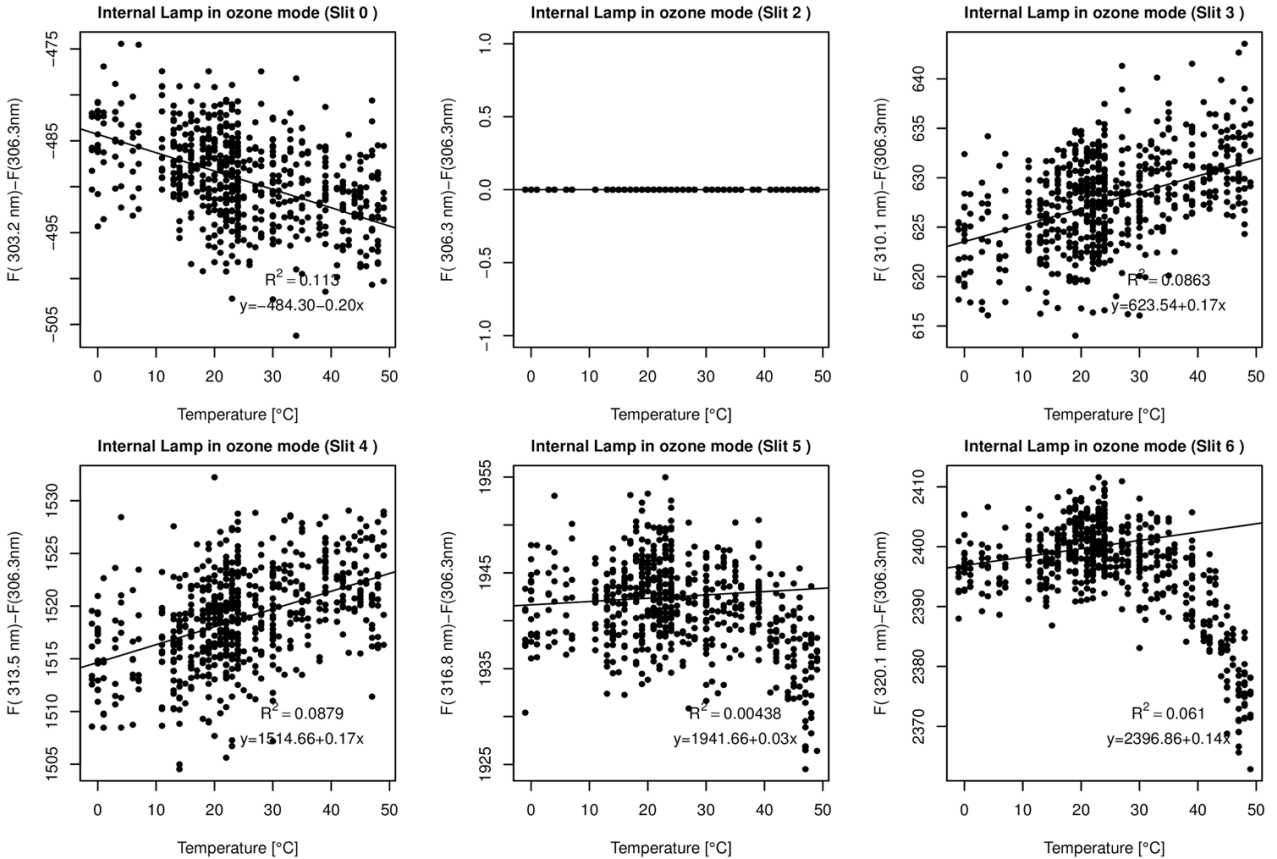

Ozone obs (ZD), Direct UV port
×10^4
5.8
5.75
5.7
5.65
5.6
5.55
Counts /second
60
46
32
18
4
-10
temperature
09 12:02
10 00:02
10 12:02
11 00:02
11 12:02
12 00:02
12 12:02
13 00:02
13 12:02
14 00:02
14 12:02


Ozone obs (ZD), Direct UV port
ratio
temperature
1.025
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
0.98
0.975
10
15
20
25
30
35
40
45
50
55


Ozone obs (ZD), Direct UV port NOCOVER
ratio
temperature
1.15
1.1
1.05
1
0.95
0.9
0.85
10
15
20
25
30
35

Single Ratios vs. Temperature

PTB Jan2016 #185



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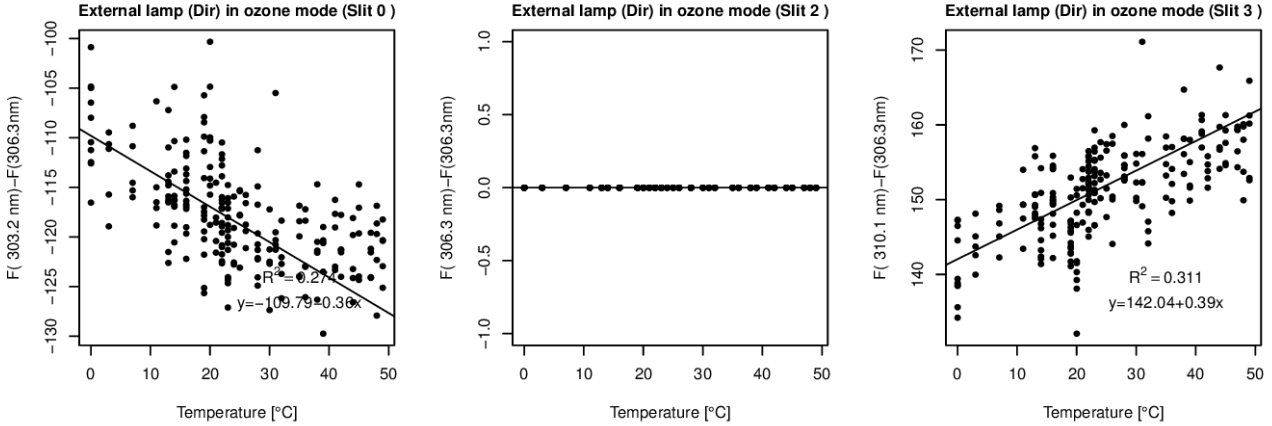
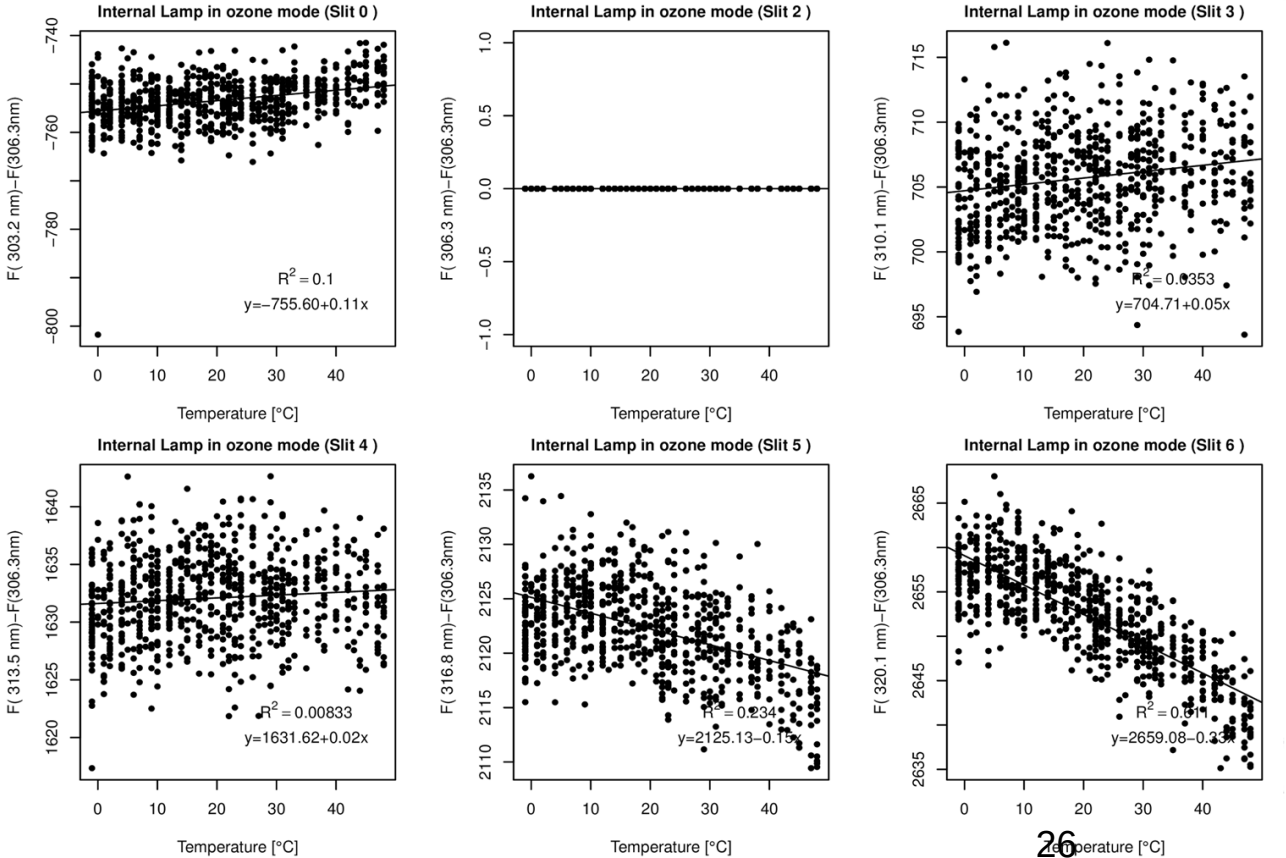
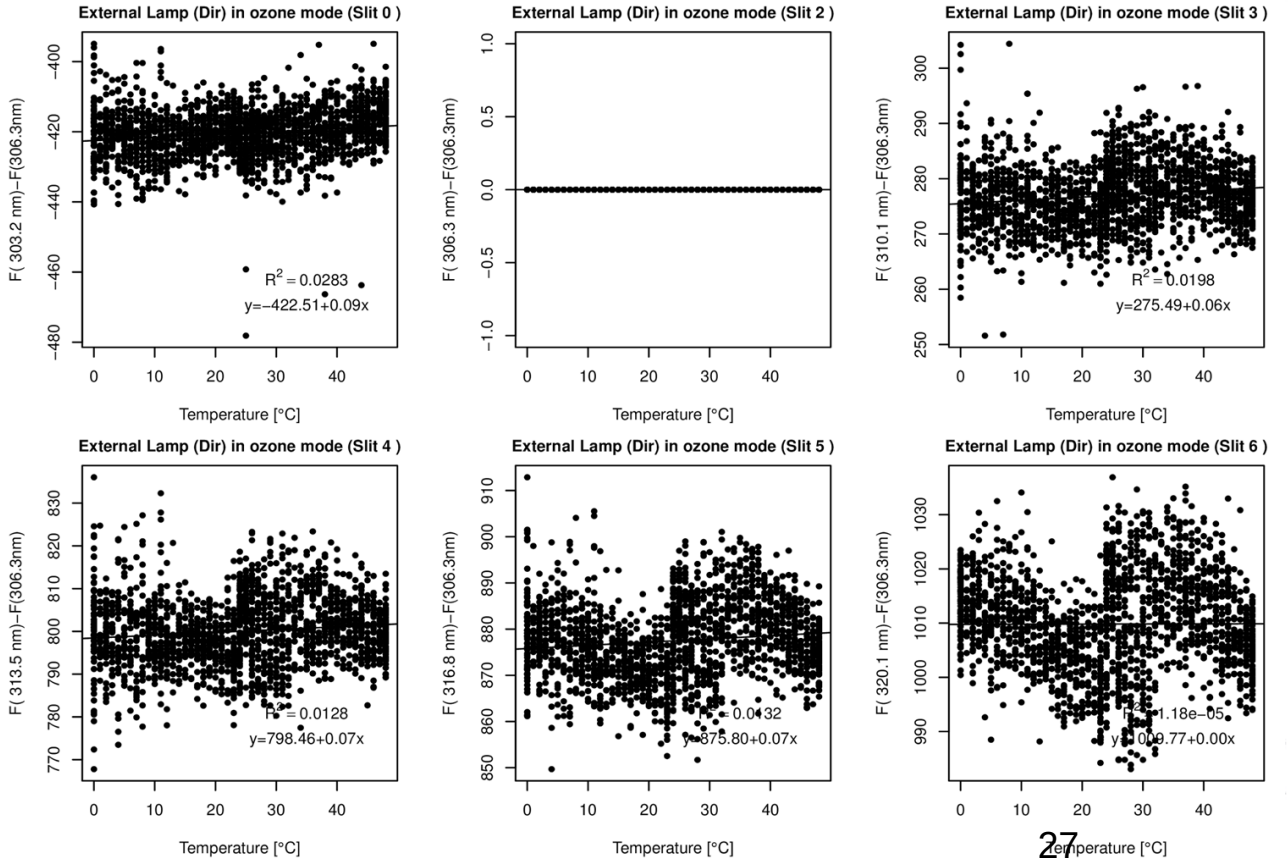


Kipp&Zonen #233



Kipp&Zonen #233



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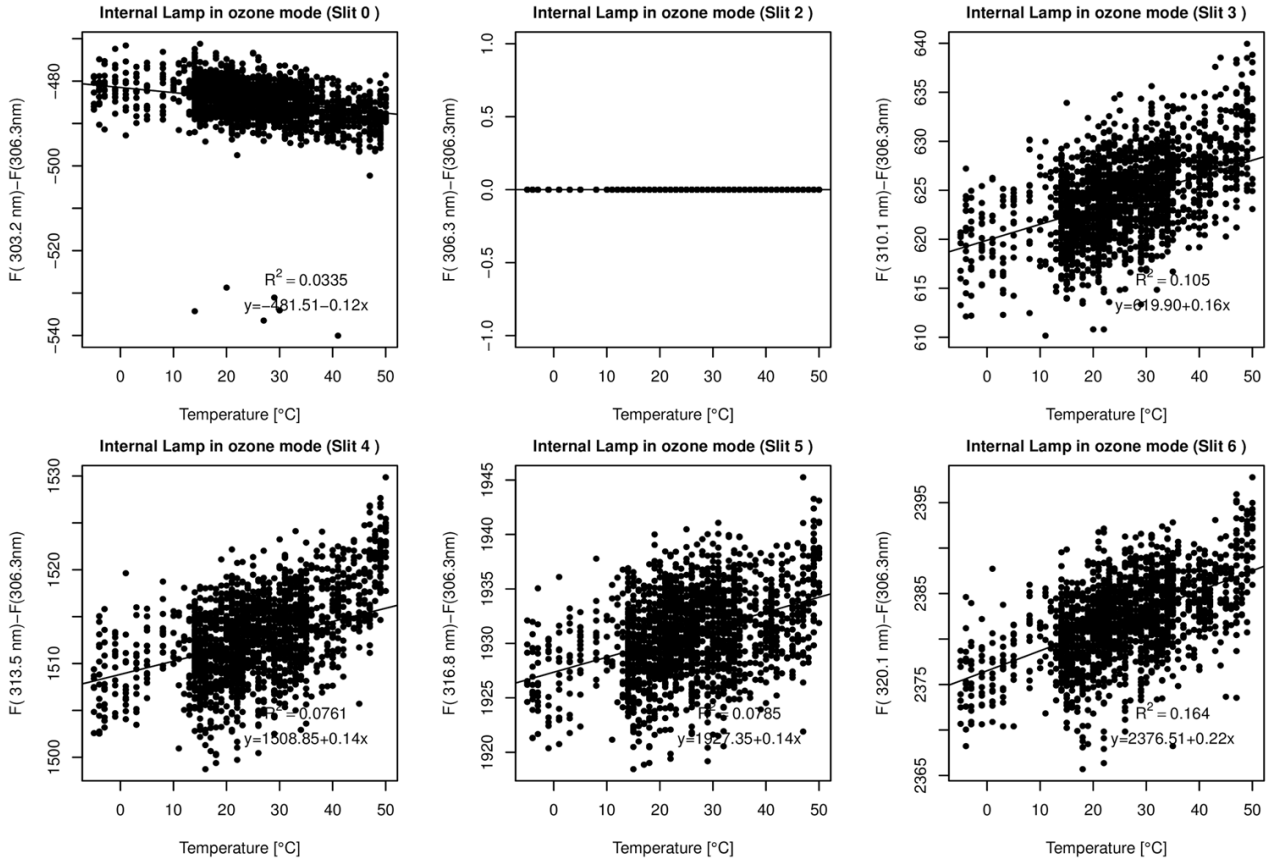

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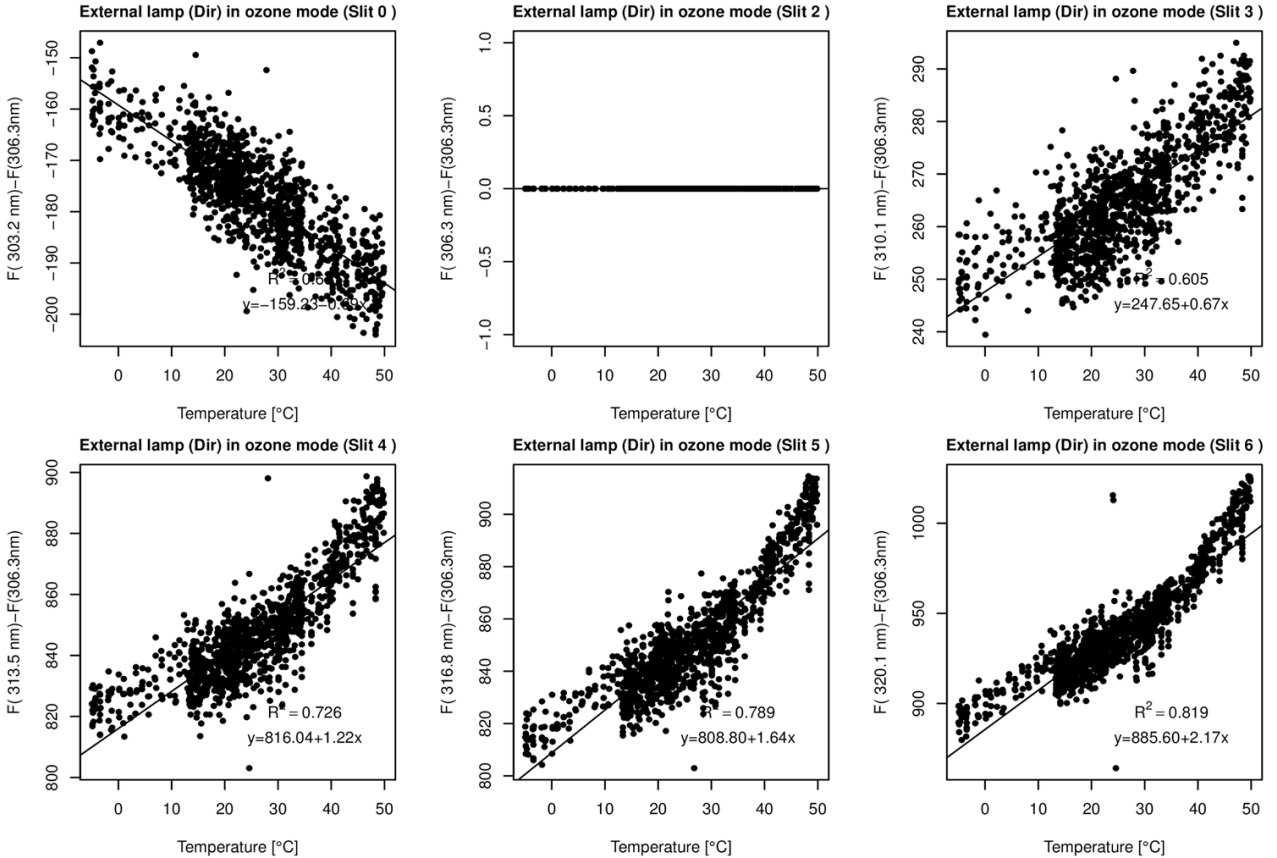
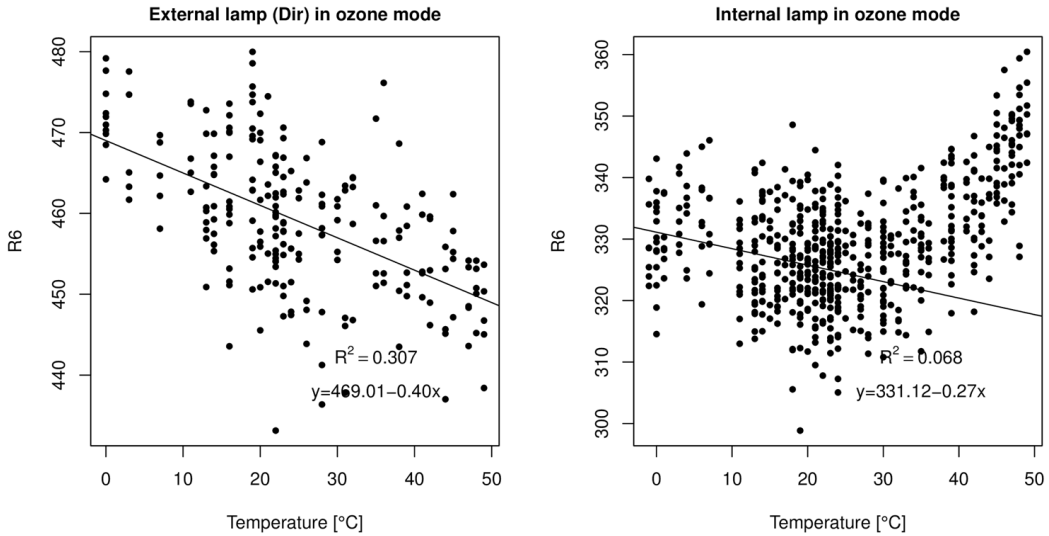
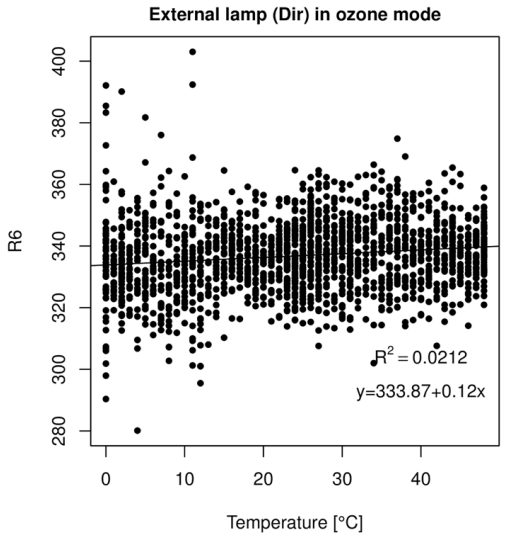


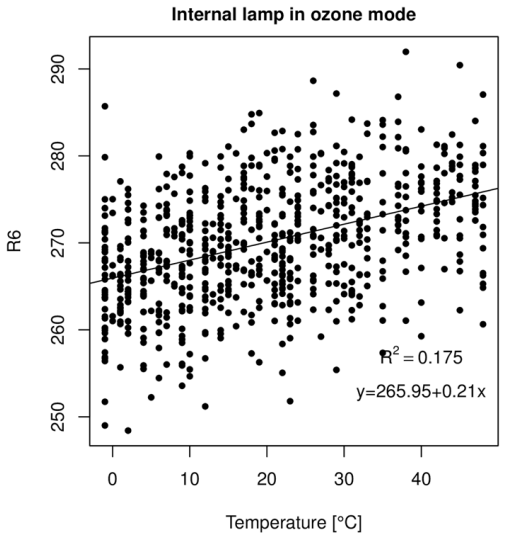
Double Ratios vs. Temperature

PTB Jan2016 #185

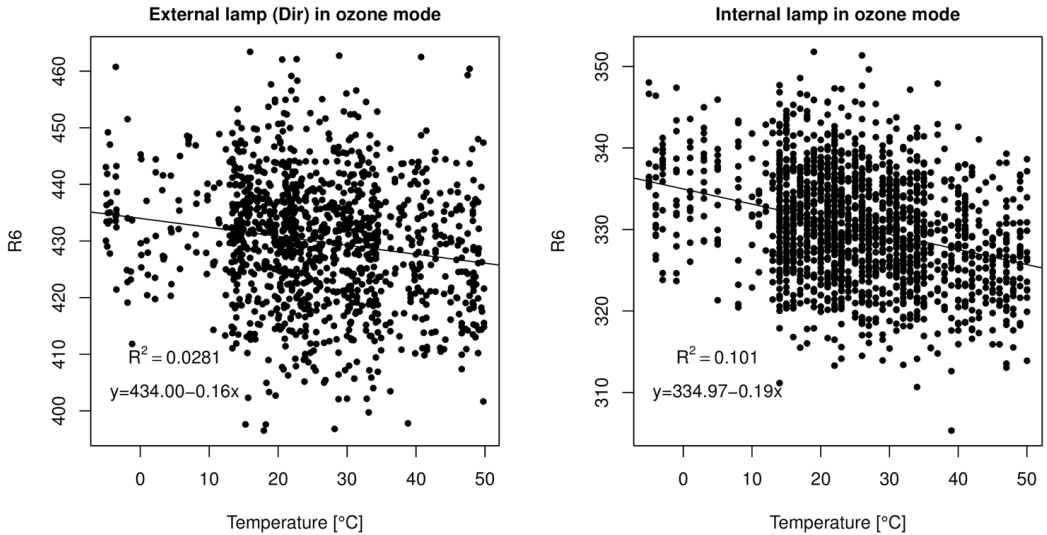


Kipp&Zonene #233

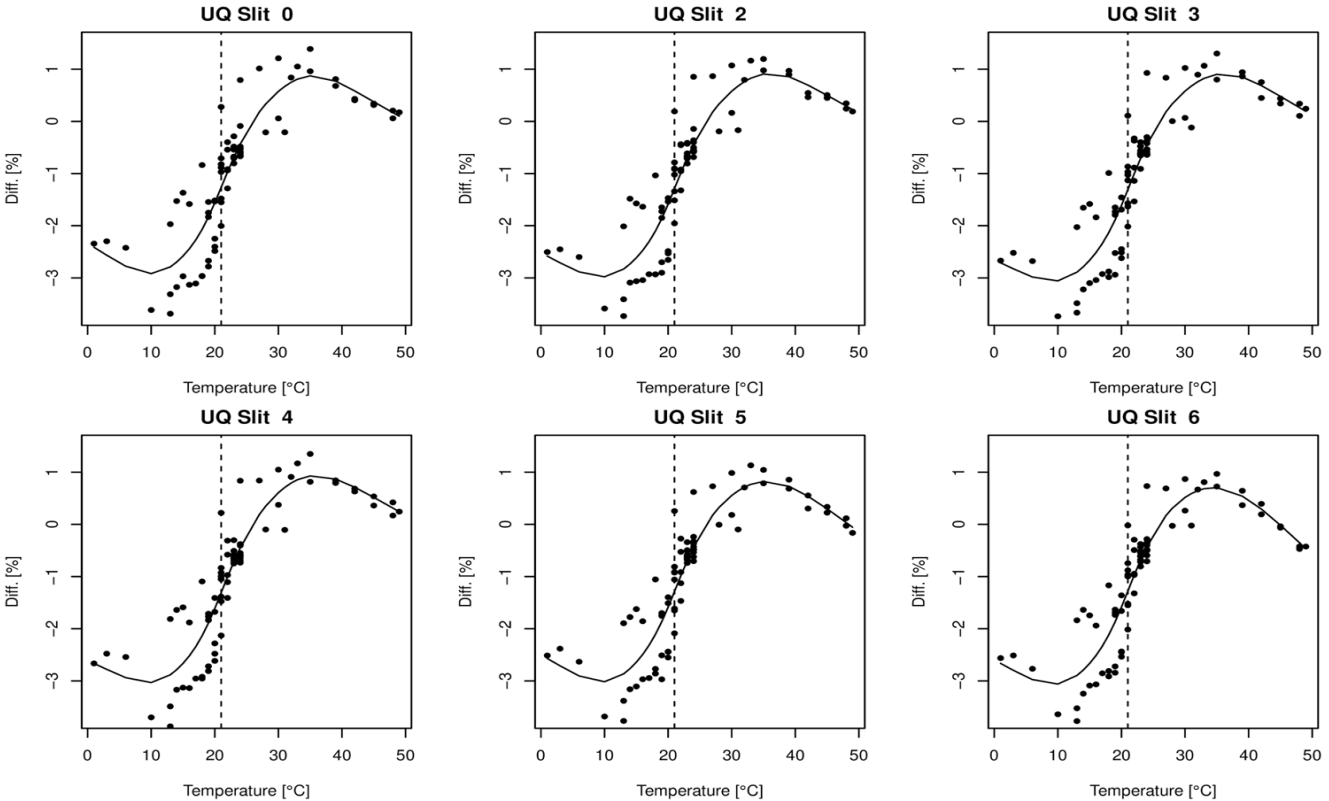


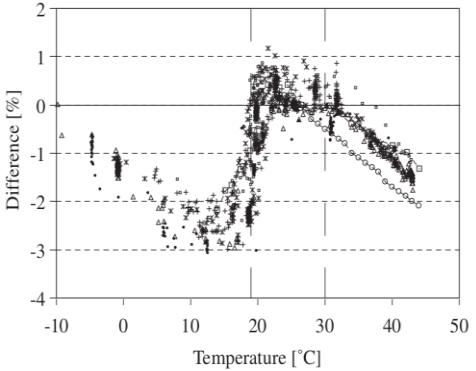


PTB Jan2016 #185



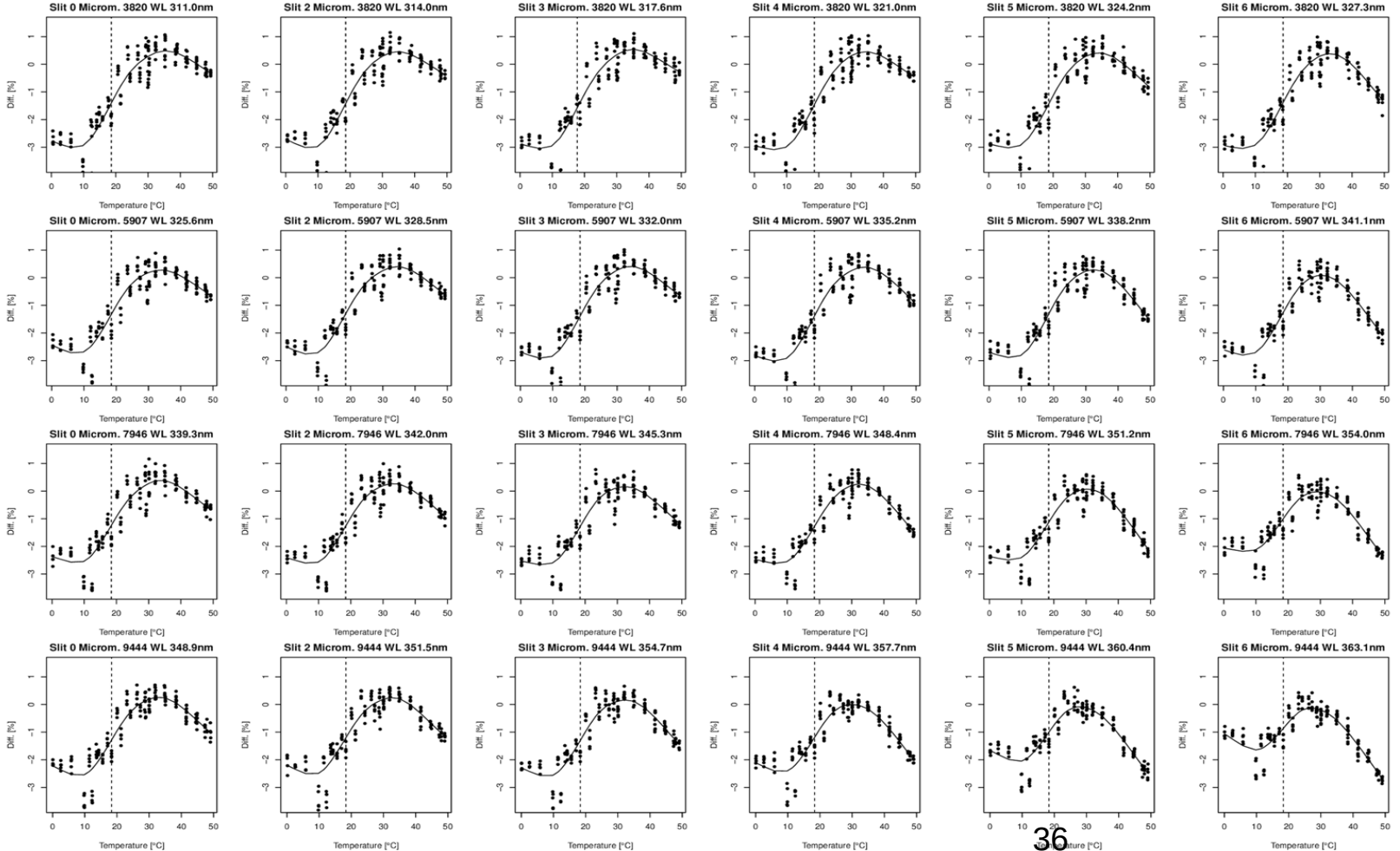
Measurements through the Global Port to the external Xe lamp

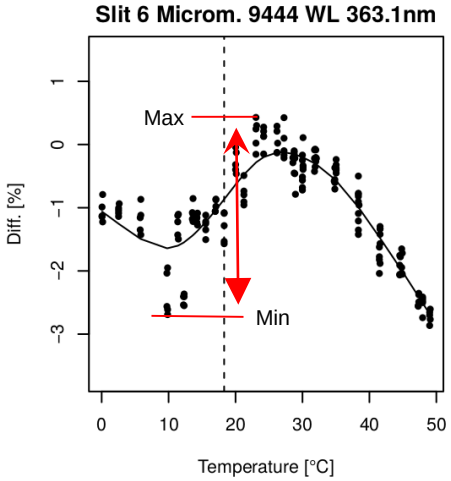


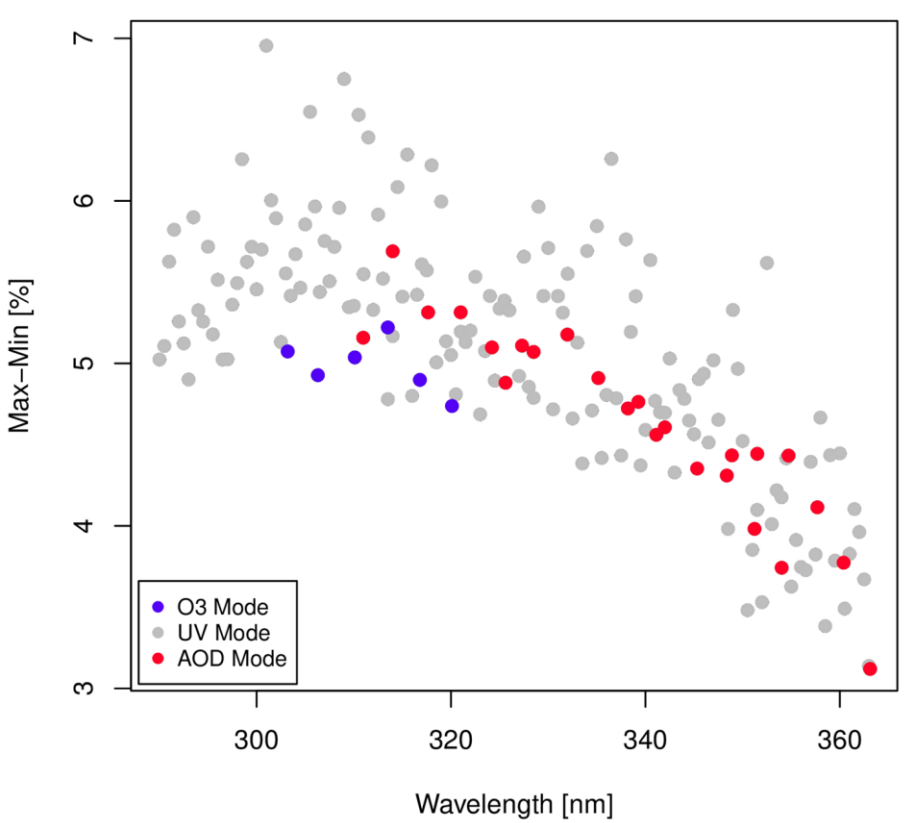


Ylianttila and Schreder [2005] “Temperature effects of PTFE diffusers”

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

- Stability of the lamps/Instrument seems not to be enough in most of the cases to determine absolute temperature coefficients.

- Brewer measurements made inside thermal chamber present a hysteresis with respect to temperature variation. This may be due to a non homogeneous temperature distribution inside the instrument or to differences between instrument temperature and photomultiplier temperature.

- Relatives coefficients obtained from single ratios of internal and external measurements very much stables but they have certain discrepancies. In this case all temporal variation affecting all wavelengths are removed.

- These discrepancies are significantly reduced when we calculate the temperature sensibility of double ratio (R6). In this case all linear effects are removed. Discrepancies between the internal and the external lamp methods are very small, about 1 ETC with a change of 10°C.

- Brewer global measurements made inside thermal chamber shows a increment similar to the observed by different authors and due to the phase change of PTFE diffuser at around 20°C. This can affect a high percentage of field measurements in those Brewers equipped with an internal heating that keeps the system at a minimum temperature of 20 °C. As an example, during The field observations of Brewer #185 in 2015, the temperature ranges from 17 to 38 degrees with the 60% of observations made at 19°C. The correction of this effect is compounded in the absence of a direct measurement of the temperature of the diffuser.

- The measurements made in ozone mode show a transmittance change of around 5% due to the PTFE diffuser. But this effect present a wavelength dependence for measurements in UV and AOD mode, and it is reduced to 3% at 360 nm.