Temperature characterisation of Brewer determined in the laboratory

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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: \[ \text{TOC} = \frac{R_6 - ETC - B}{A\mu} \]

Intensity corrections:
- Dark counts
- Deadtime
- Temperature
- Filter transmittance

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

\[ F(\lambda_i) = 10^4 \log(I(\lambda_i)) \]

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

\[ B = v \frac{p}{p_0} \sum_{i=1}^{n} w_i \beta(\lambda_i) \]

\[ A = \sum_{i=1}^{n} w_i \alpha(\lambda_i) \]
Temperature correction

\[ I = I_c - \tau_0 (T - T_0) \]
\[ I_c = \frac{I}{1 - \tau (T - T_0)} \]
\[ \tau = \frac{\tau_0}{I_c} \]

\[ \ln(I_c) = \ln(I) + \tau (T - T_0) \]
Temperature correction

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

\[ 10^4 \log(I_c) = 10^4 \log(I) + \tau_b T \quad F_c = F + \tau_b T \]

\[ \tau_b = 10^4 \log(e) \tau \]
Temperature correction

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

\[ \sum_{i=1}^{n} w_i = 0 \]

\[ \tau'_b(\lambda_i) = \tau_b(\lambda_i) - \tau_b(\lambda_0) \]
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Statistics from The EUBREWWNET DB
Temperature characterisation of Brewer determined in the laboratory
Description of the experiment
Measurements at the PTB

TH – Temperature and humidity sensor
SIC – Silicon carbide photodiode
CVC – Current-to-voltage converter
CC – Climate chamber
DVM – digital voltmeter

LCB Xe light source
Climate chamber

TH (CC)
Global port
Direct port
SIC (internal)
Fibre bundle
Diffuser heads
BREWER
SIC (external)
PT-100
CVC
CVC
MUX inputs

Spectrometer
DVM+MUX
PC
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Measurements at the PTB
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<tr>
<th>Mode</th>
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<th>Cycles</th>
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- Direct port in ozone mode
  - $R^2 = 0.72$

- Direct port in uv mode
  - $R^2 = 0.669$

- Direct port in aod mode
  - $R^2 = 0.719$

- Global port in ozone mode
  - $R^2 = 0.591$

- Global port in uv mode
  - $R^2 = 0.479$

- Global port in aod mode
  - $R^2 = 0.597$

- Int. Lamp in ozone mode
  - $R^2 = 0.584$

- Int. Lamp in uv mode
  - $R^2 = 0.599$

- Int. Lamp in aod mode
  - $R^2 = 0.534$
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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- **External lamp (Dir) in ozone mode (Slit 0)**
  - $R^2 = 0.329$
  - $y = 111.89 - 0.24x$

- **External lamp (Dir) in ozone mode (Slit 2)**
  - $R^2 = 0.443$
  - $y = 143.15 + 0.33x$

- **External lamp (Dir) in ozone mode (Slit 3)**
  - $R^2 = 0.445$
  - $y = 604.16 + 0.40x$

- **External lamp (Dir) in ozone mode (Slit 4)**
  - $R^2 = 0.445$
  - $y = 533.70 + 0.08x$

- **External lamp (Dir) in ozone mode (Slit 5)**
  - $R^2 = 0.0326$
  - $y = 509.75 + 0.23x$

- **External lamp (Dir) in ozone mode (Slit 6)**
  - $R^2 = 0.223$
Temperature characterisation of Brewer determined in the laboratory
Comparison of Temperature coefficients obtained from laboratory measurements and field measurements
Temperature characterisation of Brewer determined in the laboratory

RBCC-E

<table>
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<th>Dates</th>
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Jun-Nov

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Temperature characterisation of Brewer determined in the laboratory
Effect of PTFE diffuser on the instrument temperature dependence.
Temperature characterisation of Brewer determined in the laboratory

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