

Aerosol Optical Depth

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Introduction

Within the ESA IDEAS+ project, at the RBCCE we have been working on the development of an AOD product

Although we are still on the early stages, we expect to integrate this product in EUBREWNET's server soon

In this talk, we provide a brief description of our calculation method and compare our first results with the UVPFR operated by the PMOD/WDC at the XRBBCE “El Arenosillo 2015” campaign, and with selected CIMEL instruments from AERONET

The Beer-Lambert-Bouguer equation

Attenuation of solar radiation by the Earth's atmosphere:

$$f = f_0 e^{-\tau m}$$

In the UV range, and ignoring the SO_2 contribution,

$$\tau m = \tau_o m_o + \tau_R m_R + \tau_a m_a$$

ozone Rayleigh aerosols



AOD equation for Brewer spectrophotometers

For each wavelength:

$$\tau_a = \frac{1}{m_R} \left\{ \log f_0 - \log f - D_o \frac{k_o \log 10}{1000} m_o - \frac{p}{1013} \frac{k_R \log 10}{10000} m_R \right\}$$

Annotations below the equation:

- $m_a \approx m_R$ (red arrow from m_R)
- Brewer counts (red arrow from $\log f$)
- Calibration constant (red arrow from D_o)
- ozone (red bracket under $k_o \log 10 / 1000 m_o$)
- Rayleigh (red bracket under $p / 1013 k_R \log 10 / 10000 m_R$)

See my talk on the AOD configuration for more details

Calibration by Langley plots

Beer-Lambert-Bouguer equation:

$$\log f = -\tau m + \log f_0$$

Stable atmospheric conditions:

$$\tau = \text{constant}$$

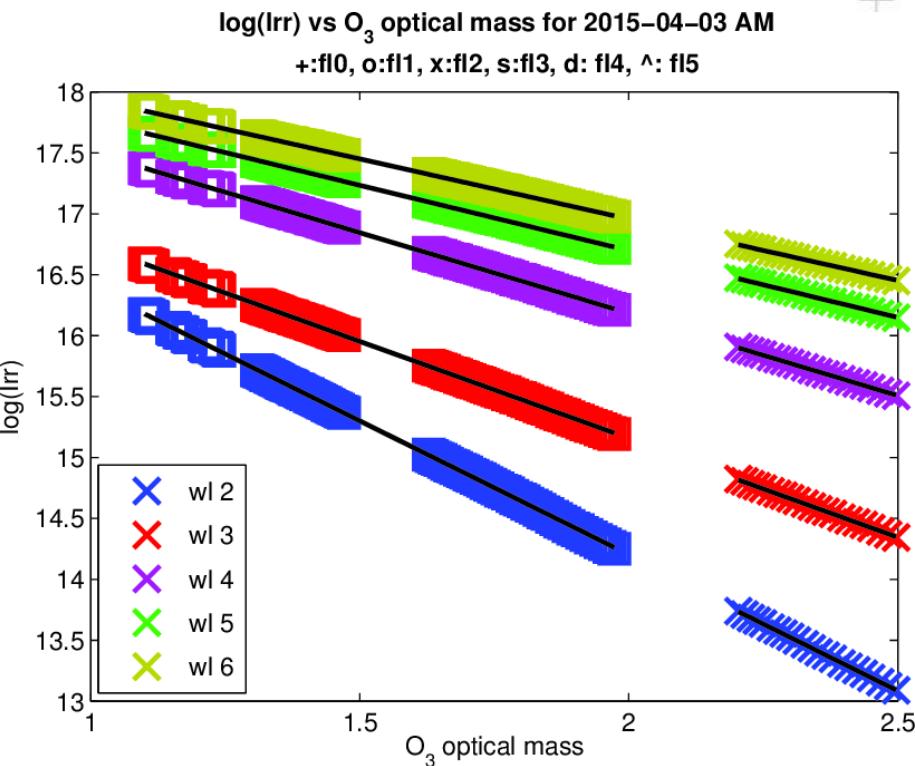
Plot $\log f$ vs $m \approx m_o$

Linear regression:

$$\text{intercept} = \log f_0$$

After T. Carlund's STSM:

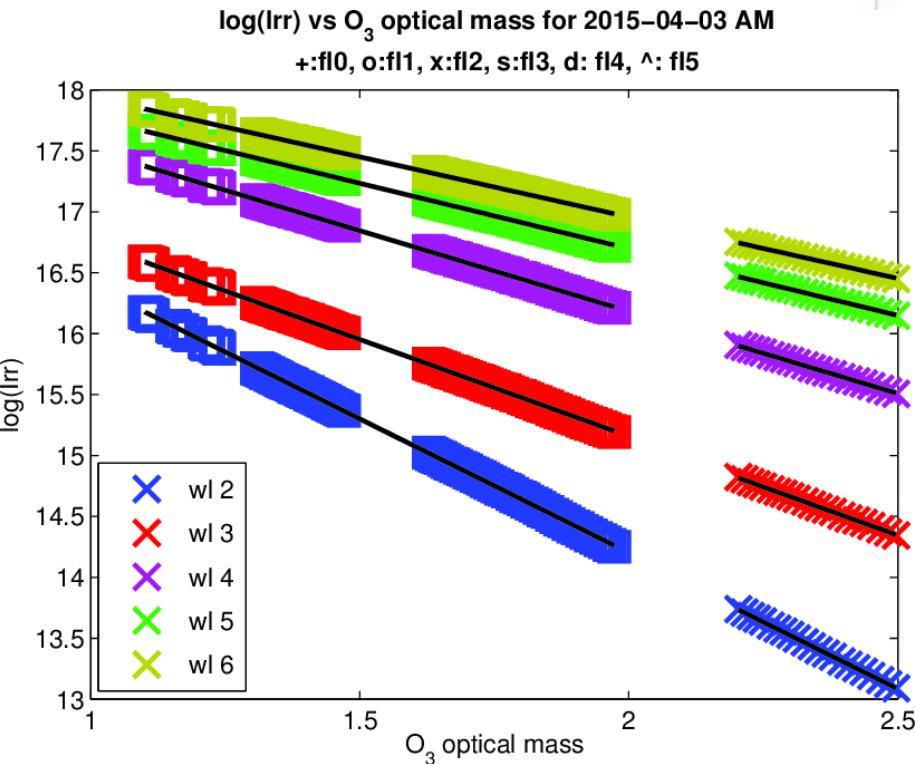
$$\log f + \tau_R m_R = -\tilde{\tau} m_o + \log f_0$$



Calibration by Langley plots (2)

One regression for each wavelength (colors in the plot) and filter (symbols, just two in the plot)

One calibration constant f_0 for each wavelength and each filter





Calibration by Langley plots (3)

Langley calibration of Brewer #185:

~2 months of data, with two Langley plots per day (morning and afternoon)

Only include data with ozone optical mass between 1.1 and 3.5

Discard Langley plots with a low-quality linear regression: $r^2 < 0.9985$

Calculate the median of the f_0 of each Langley

Discard f_0 values above/below 2% from the median

Final $f_0 = \text{mean of the } f_0 \text{ of each Langley}$



Calibration by transfer

Don't have stable atmospheric conditions, but
do have simultaneous observations with a reference instrument:

$$\log f_0 = \tau_a^{\text{ref}} m_R + \log f + D_o \frac{k_o \log 10}{1000} m_o + \frac{p}{1013} \frac{k_R \log 10}{10000} m_R$$

Reference
instrument

Brewer being calibrated



Calibration by transfer (2)

Calibration of Brewer #163 by transfer from Brewer #185:

“Good” days of the X RBCCE campaign at El Arenosillo, May-June 2015

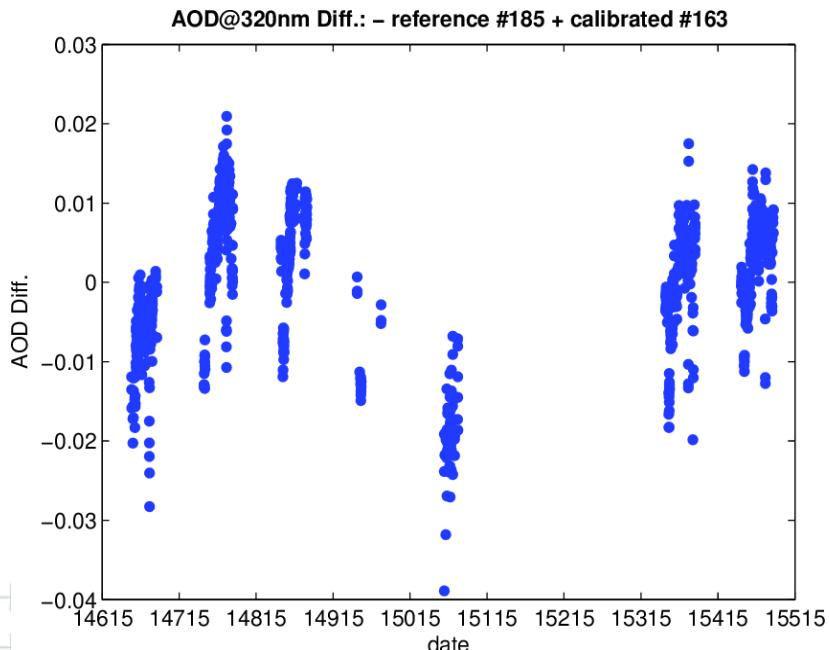
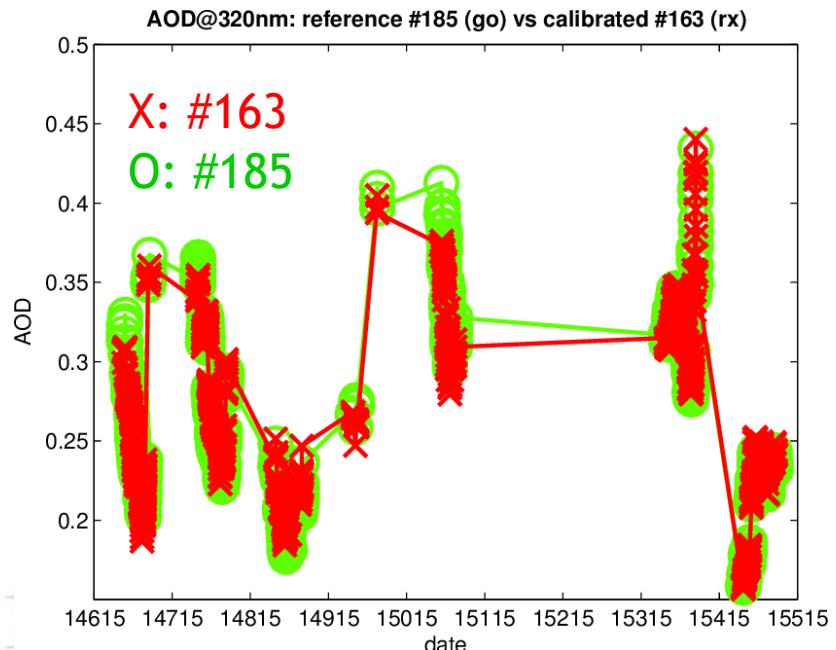
Simultaneous observations = within 1 min

One f_0 for each simultaneous observation

Final f_0 = mean of the f_0 of each observation

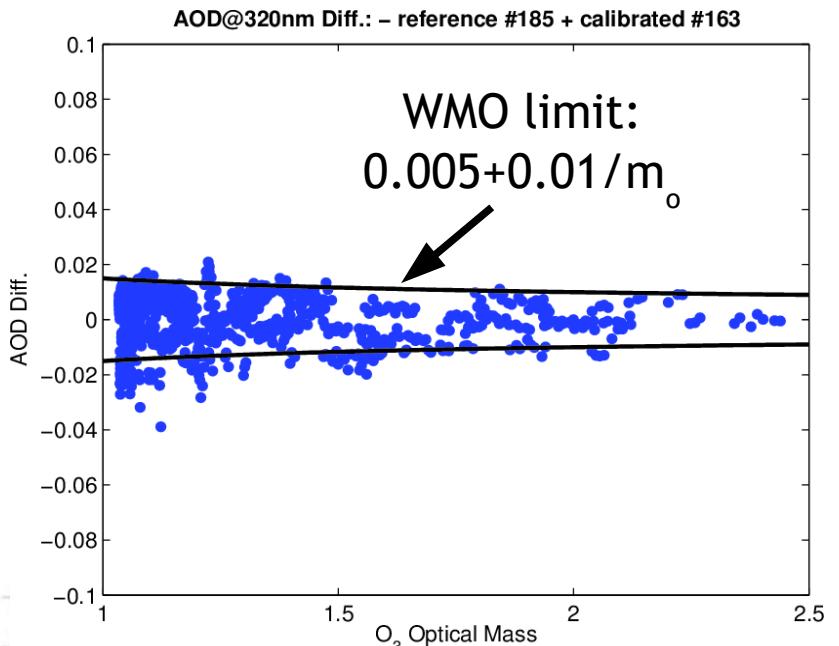
Calibration by transfer (3)

Calibration of Brewer #163 by transfer from Brewer #185:



Calibration by transfer (4)

Calibration of Brewer #163 by transfer from Brewer #185:

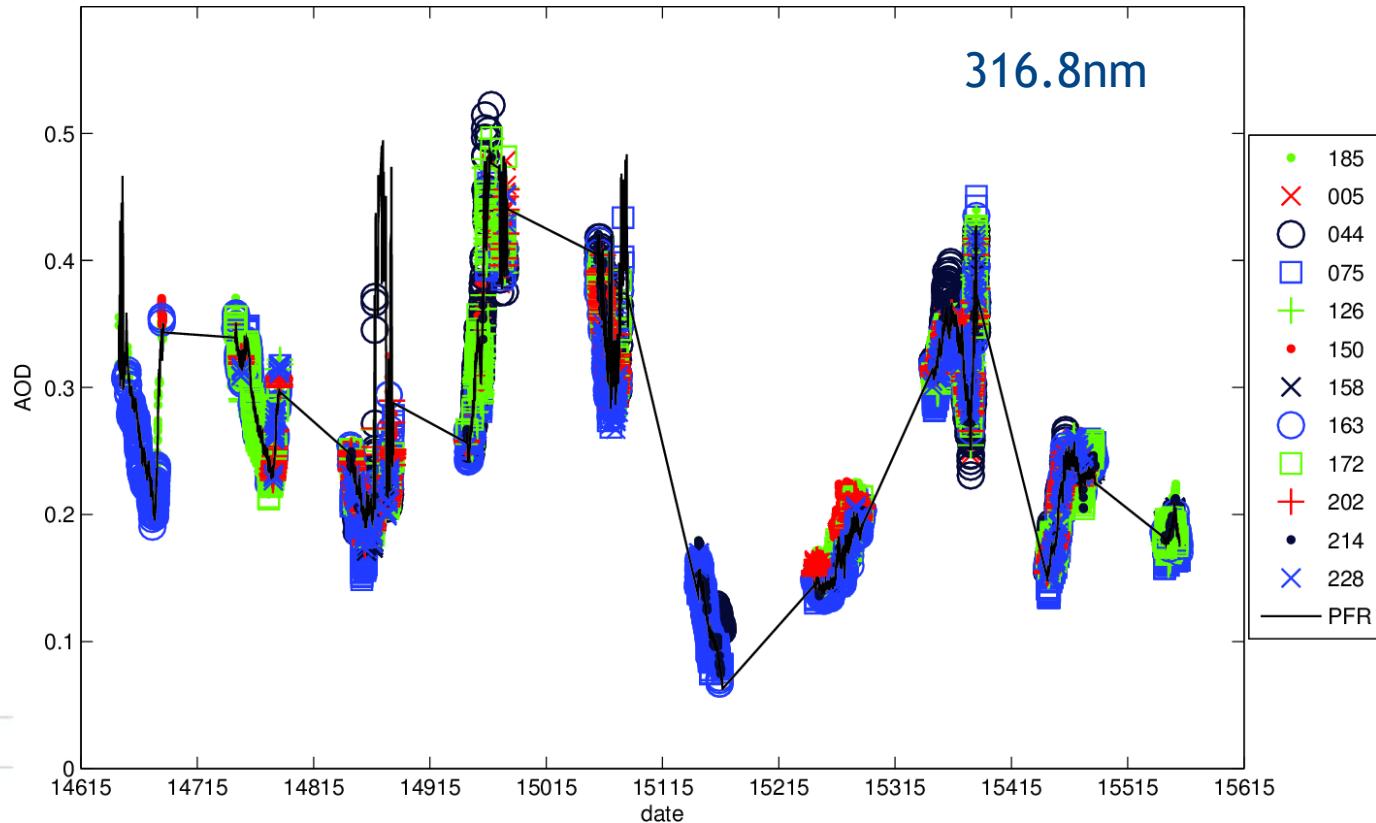


% of observations within the
WMO limit at each wavelength

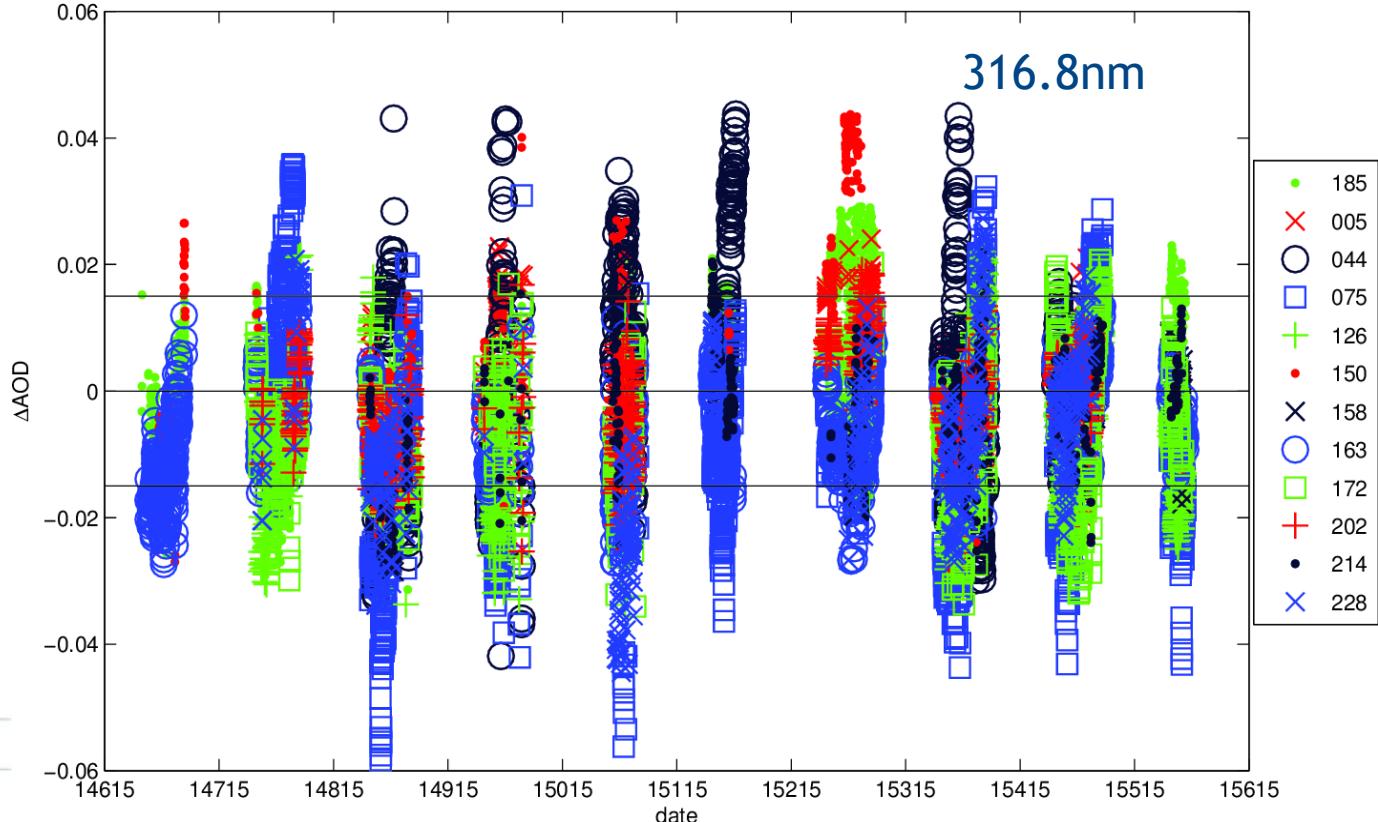
-
- 306.3 nm : 66.2%
 - 310.1 nm : 80.3%
 - 313.5 nm : 83.5%
 - 316.8 nm : 86.3%
 - 320.1 nm : 87.3%
-

WMO traceability limit : 95%

XRBCCE “El Arenosillo 2015”: Brewer vs. PFR



XRBCCE “El Arenosillo 2015”: Brewer vs. PFR (2)





XRBCCE “El Arenosillo 2015”: Brewer vs. PFR (3)

Brewer ID	No. obs.	Lin. Reg. slope	Lin. Reg. intercept	Lin. Reg. r2	Pearson's corr.	% within WMO
005	700	0.975	0.005	0.980	0.990	74.0
044	773	0.982	0.006	0.969	0.984	52.3
075	1402	0.999	-0.008	0.946	0.973	34.8
126	1544	0.964	0.003	0.977	0.988	69.4
150	695	0.933	0.018	0.946	0.973	60.6
158	610	1.017	-0.009	0.980	0.990	80.0
163	1642	0.982	-0.002	0.989	0.994	83.4
172	965	0.972	0.001	0.977	0.989	71.4
185	2073	0.920	0.019	0.972	0.986	66.4
202	946	0.969	0.005	0.986	0.993	85.9
214	670	0.977	0.003	0.987	0.994	79.0
228	631	0.976	0.002	0.972	0.986	67.6



XRBCCE “El Arenosillo 2015”: Brewer vs. PFR (4)

Brewer ID	No. obs.	Lin. Reg. slope	Lin. Reg. intercept	Lin. Reg. r2	Pearson's corr.	% within WMO
005	700	0.975	0.005	0.980	0.990	74.0
044	773	0.982	0.006	0.969	0.984	52.3
075	1402	0.999	-0.008	0.946	0.973	34.8
126	1544	0.964	0.003	0.977	0.988	69.4

Mean	1054	0.972	0.003	0.972	0.986	67.5
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172	965	0.972	0.001	0.977	0.989	71.4
185	2073	0.920	0.019	0.972	0.986	66.4
202	946	0.969	0.005	0.986	0.993	85.9
214	670	0.977	0.003	0.987	0.994	79.0
228	631	0.976	0.002	0.972	0.986	67.6

April-May 2015: Brewer #185 vs. CIMEL

CIMEL from 340nm to 320nm using the 340-440nm Ångström exponent

Simultaneous obs. (30 min) : 1256

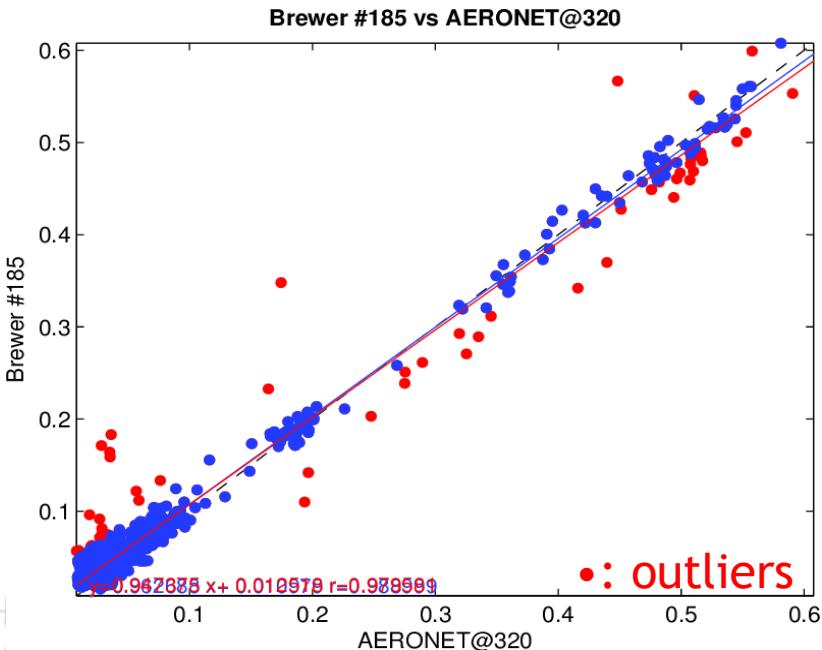
Linear regress. slope : 0.963

Linear regress. intercept : 0.011

Linear regress. r^2 : 0.989

Pearson's correlation : 0.994

Obs. within WMO limit : 61.0%



June-December 2015: Brewer #163 vs. CIMEL

CIMEL from 340nm to 320nm using the 340-440nm Ångström exponent

Simultaneous obs. (30 min) : 1203

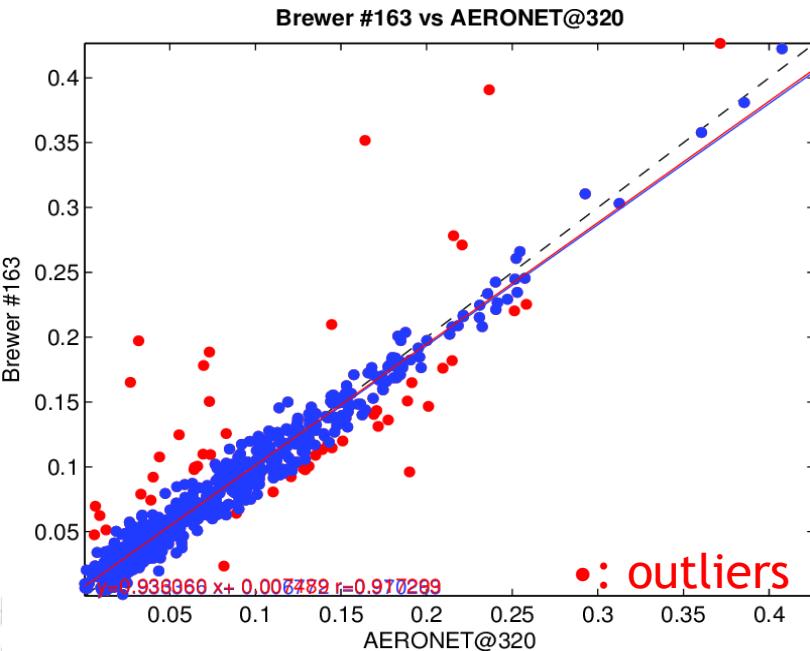
Linear regress. slope : 0.993

Linear regress. intercept : 0.007

Linear regress. r^2 : 0.970

Pearson's correlation : 0.985

Obs. within WMO limit : 68.7%



June-December 2015: Brewer #214 vs. CIMEL

CIMEL from 340nm to 320nm using the 340-440nm Ångström exponent

Simultaneous obs. (30 min) : 366

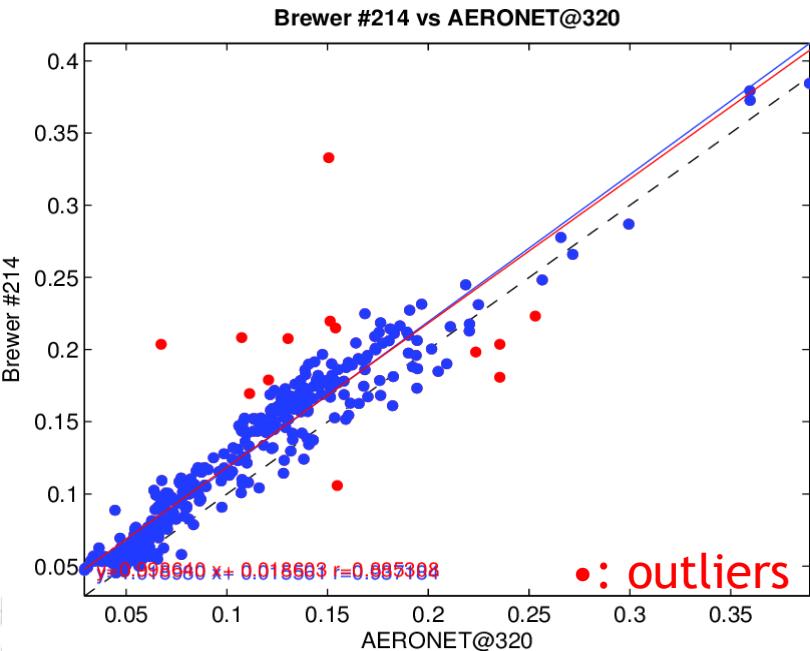
Linear regress. slope : 1.019

Linear regress. intercept : 0.016

Linear regress. r^2 : 0.937

Pearson's correlation : 0.968

Obs. within WMO limit : 29.5%





Closing remarks

Our preliminary AOD results are in reasonable agreement with the UVPFR and CIMEL data

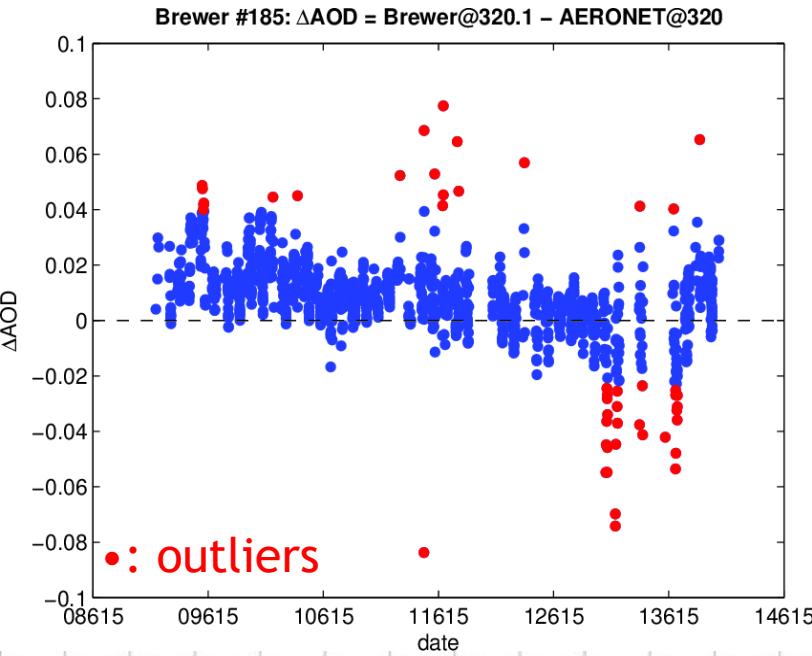
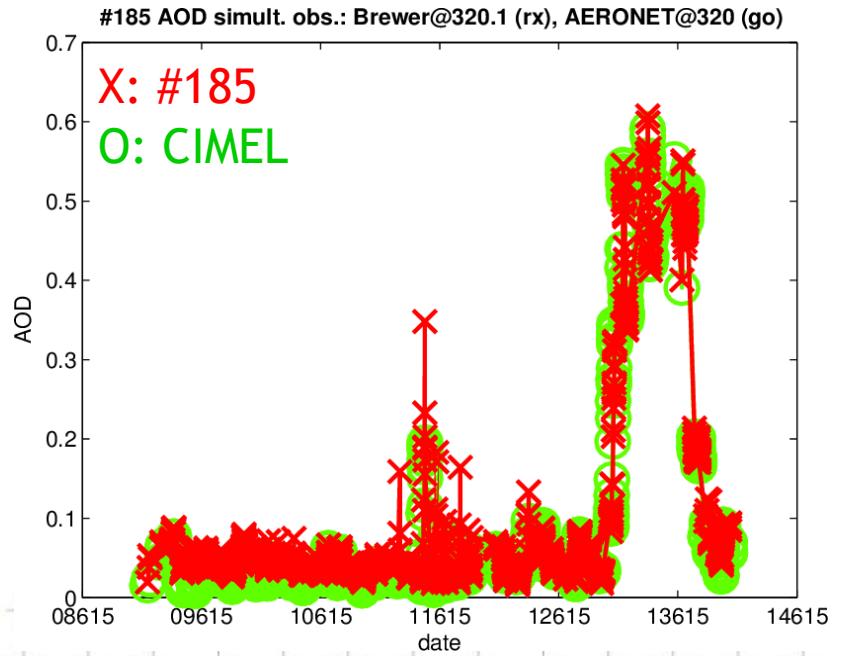
See my next talk on the AOD configuration for further details on the corrections and parameters used

Still in development, all suggestions are welcome!

Brewer operators should check the configurations at EUBREWNET's server

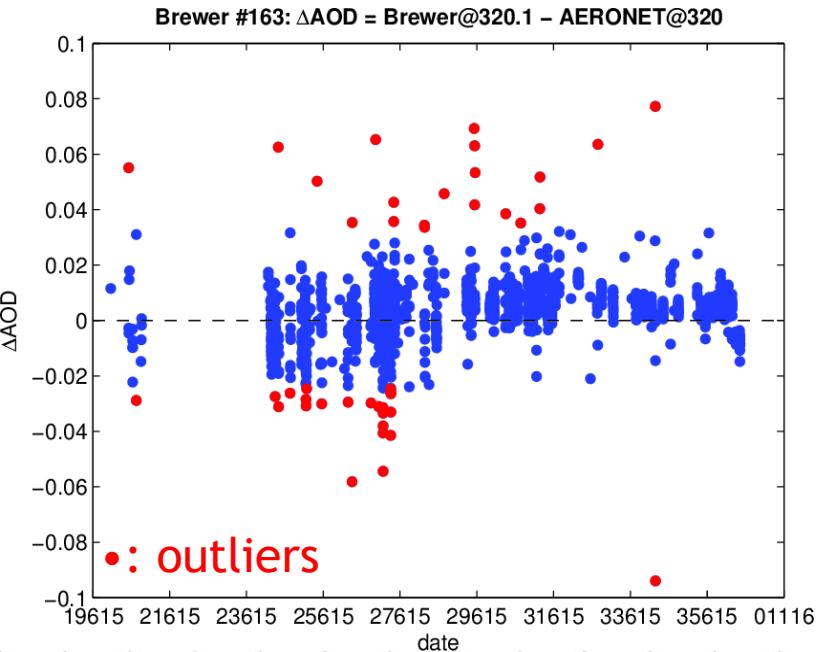
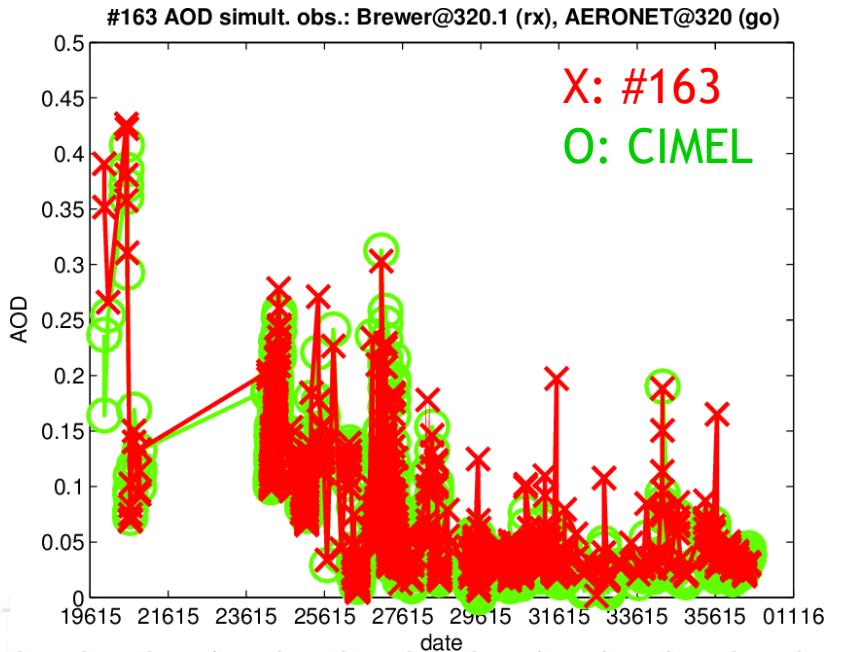
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CIMEL from 340nm to 320nm using the 340-440nm Ångström exponent



June-December 2015: Brewer #163 vs. CIMEL

CIMEL from 340nm to 320nm using the 340-440nm Ångström exponent



Calibration by transfer (4)

Calibration of Brewer #163 by transfer from Brewer #185:

