Brewer measurements in the visible range ES1207-17392

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Motivations

AOD measurements by Brewers

- open issues
  - standard algorithm? (EUBREWNET COST Action)
  - calibration?
  - radiometric stability?
  - temperature dependence?
  - internal polarisation?
  - straylight (spectral and FOV)?
  - pointing accuracy?
  - effect of filters?
  - ...
- $>$ 60 MKIV Brewers measuring in the visible range (425 – 453 nm)
  - easier case than UV
  - few works about AOD in the visible (Gröbner et al., 2004)

NO_2 measurements

- recent advances in NO_2 algorithm (Diémoz et al., AMT, 2014) and good average agreement with satellites ($\sim$-2.4%)
- **but** large sensitivity to wavelength misalignments and low correlations with satellites

Hosting institution

Academy of Athens

- MKIV Brewer #001 (2004 – now)
- Cimel photometer (2008 – now)
- large negative NO_2 trends observed by satellites over Athens due to economic recession

Algorithm

- standard data reduction
- spectral attenuation of ND filters taken into account
  - modified fi routine in the visible (standard lamp)
  - continuity between neighbouring measurements with different filters
- Earth-sun distance
- internal polarisation
  - Method 1: theoretical calculations (A. Cede, 2006)
- SZA and AMF calculations as in AERONET
  - Kasten and Young (1989) and Michalsky (1988)
  - refraction included
- same X-secs and trace gases concentrations as in AERONET

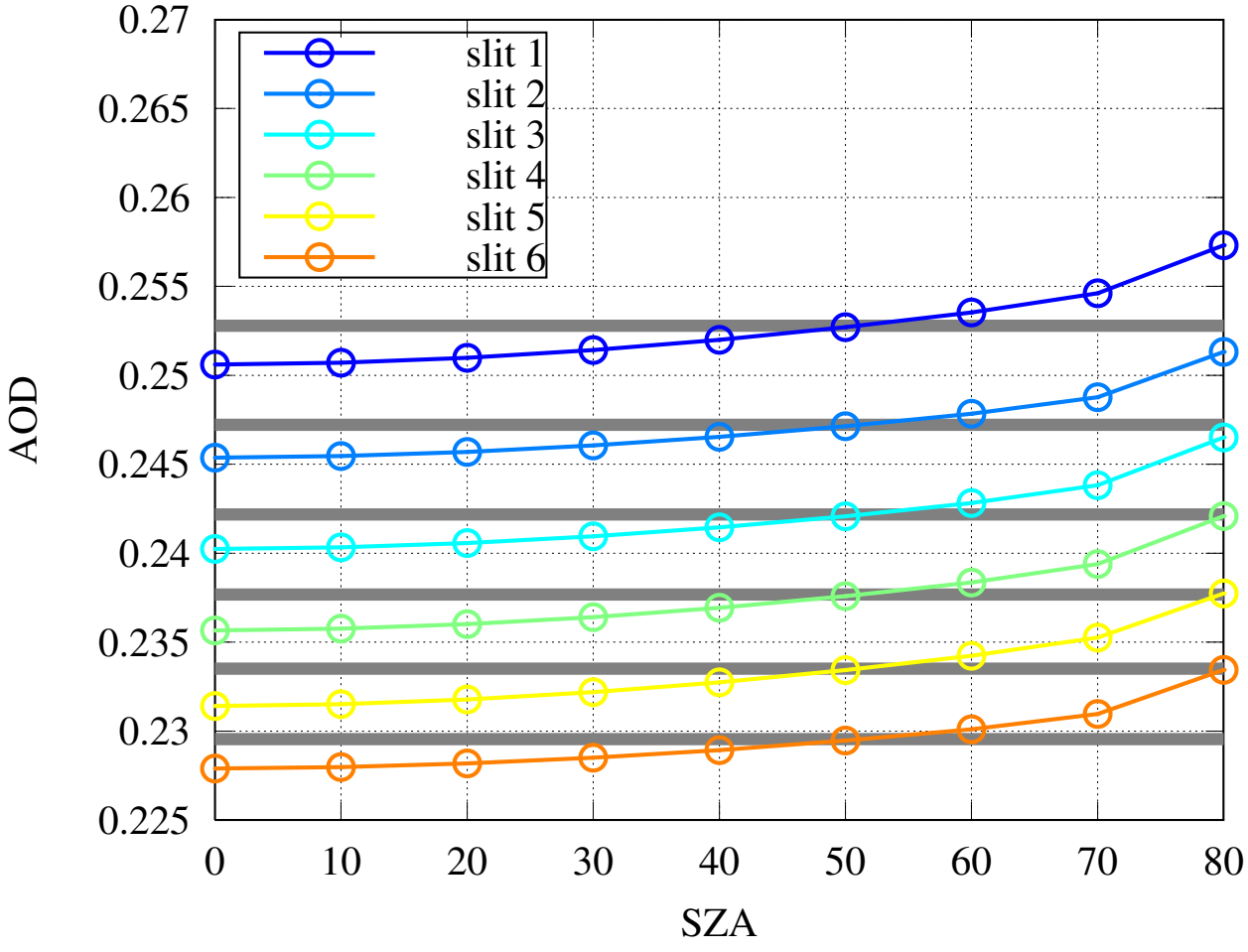
Method

- only simultaneous measurements ($\Delta t < 1$ min)
  - AERONET cloudscreening
- extrapolation of Cimel AODs to Brewer slits (Angstrom law)
  - 6 wavelengths
  - multispectral analysis
- Brewer ETC transferred from Cimel
- 2 parts: historical series (Level 2.0) and STSM (Level 1.5)

Implementation

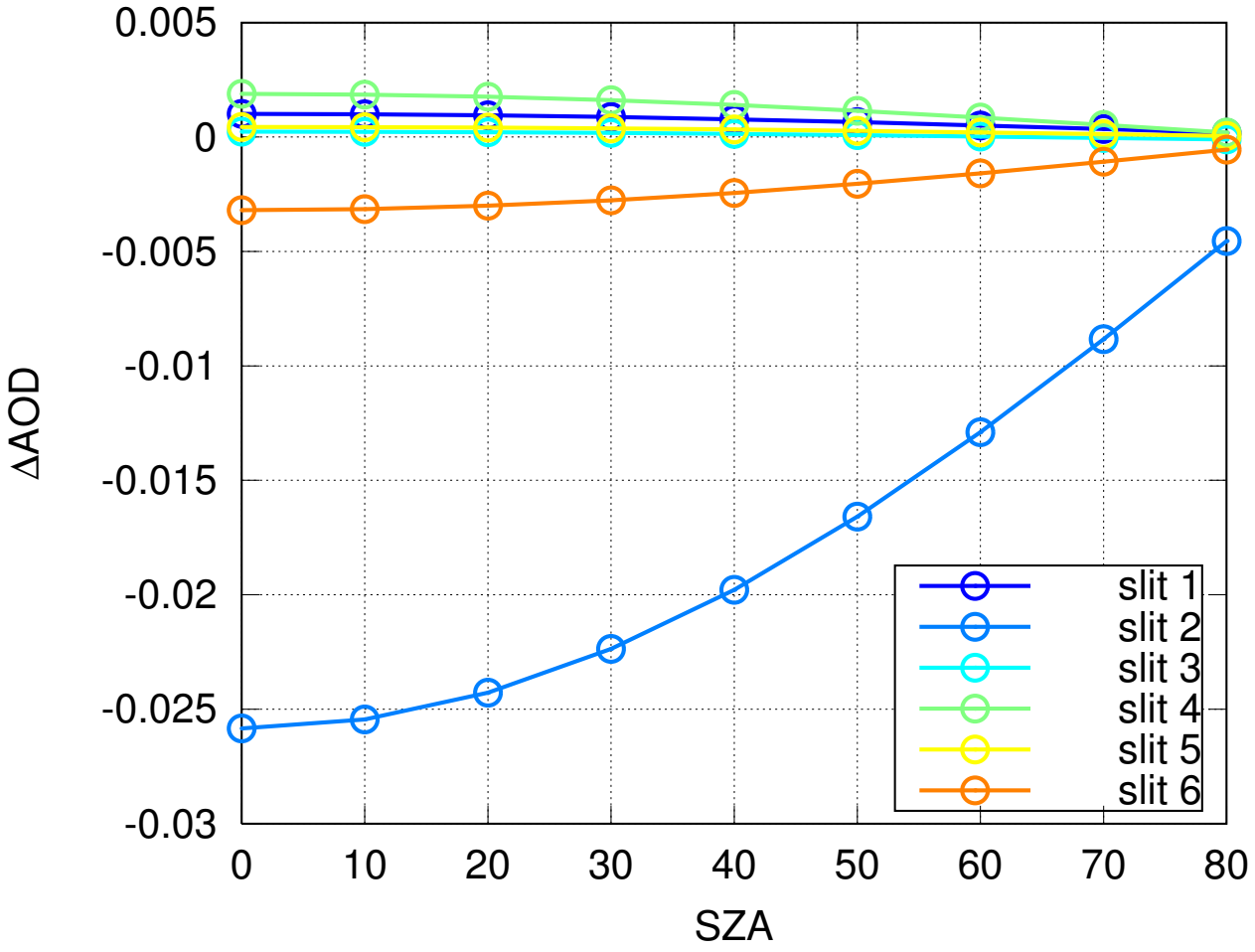
- special schedule
  - `n2ds` and `n2sl` measurements
- `bform.pl`
  - reads B files and output a matrix of data
- Octave/Matlab `aod440.m`
  - process data in vectorised form

Validation



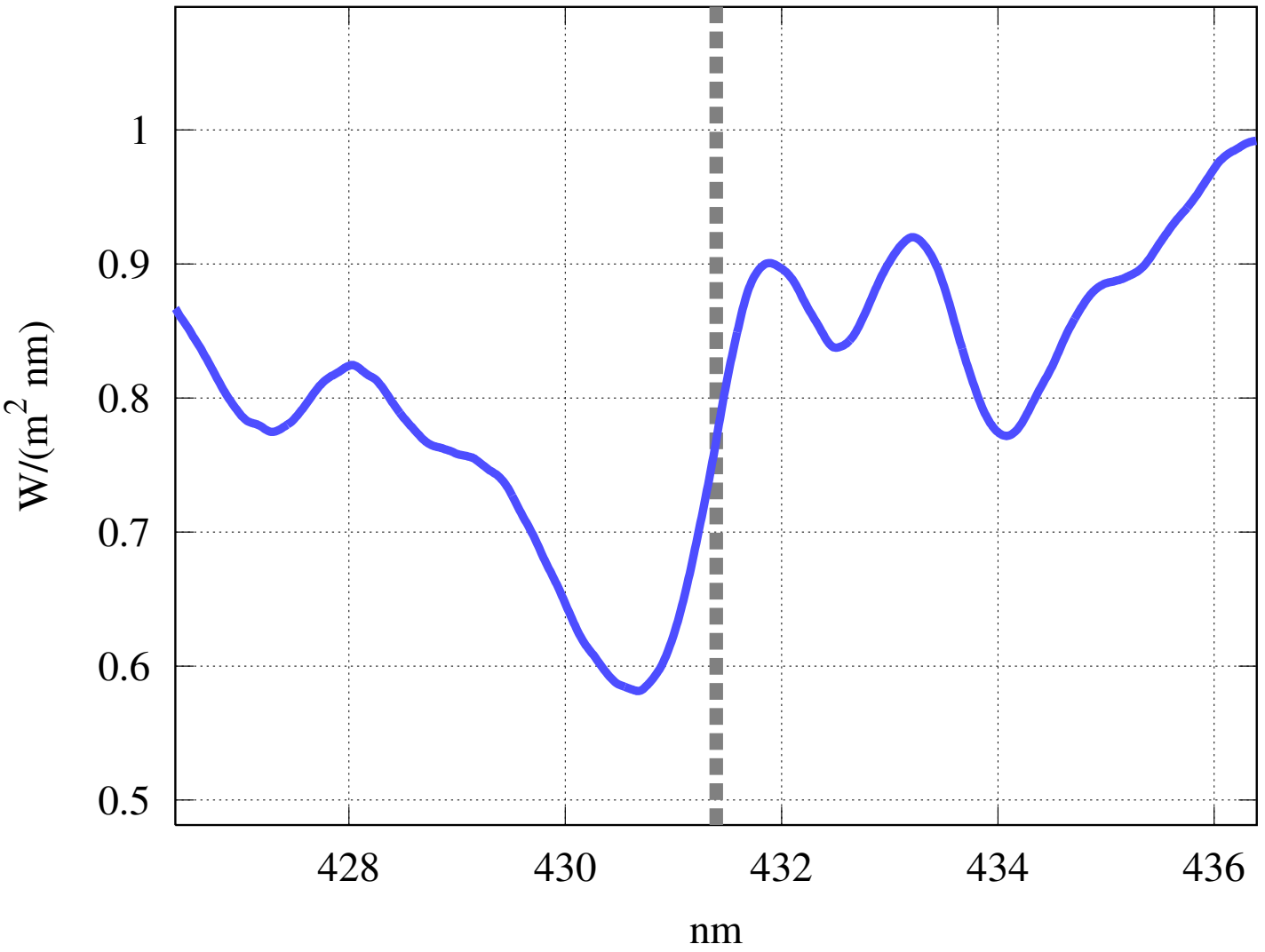
FOV effect calculated to be negligible in visible
(as expected from Russel et al., 2004)

Simulation of wavelength shifts

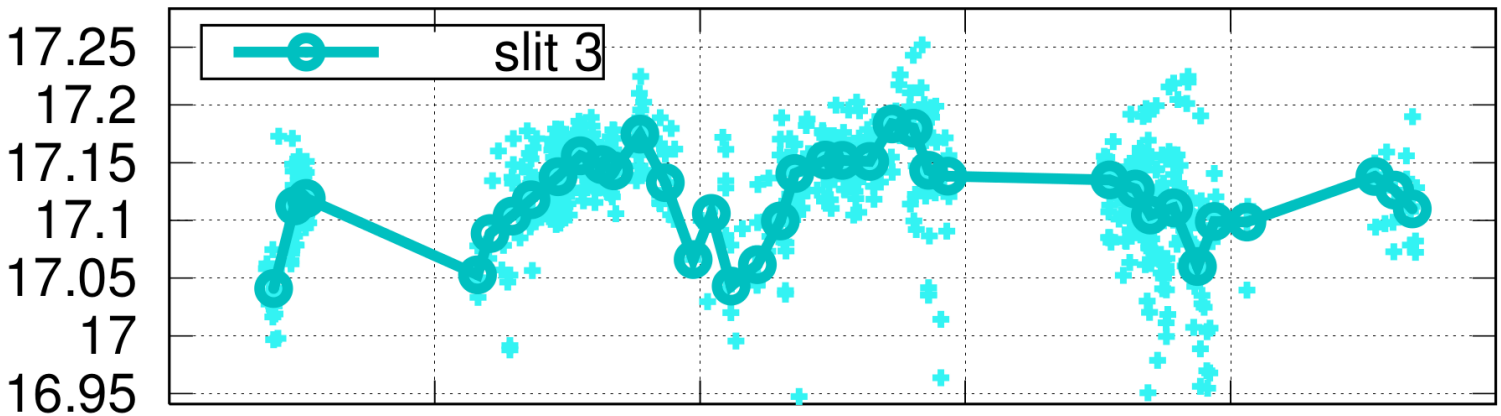


Shift of +4 micrometer steps (about 0.04 nm)

Simulation of wavelength shifts

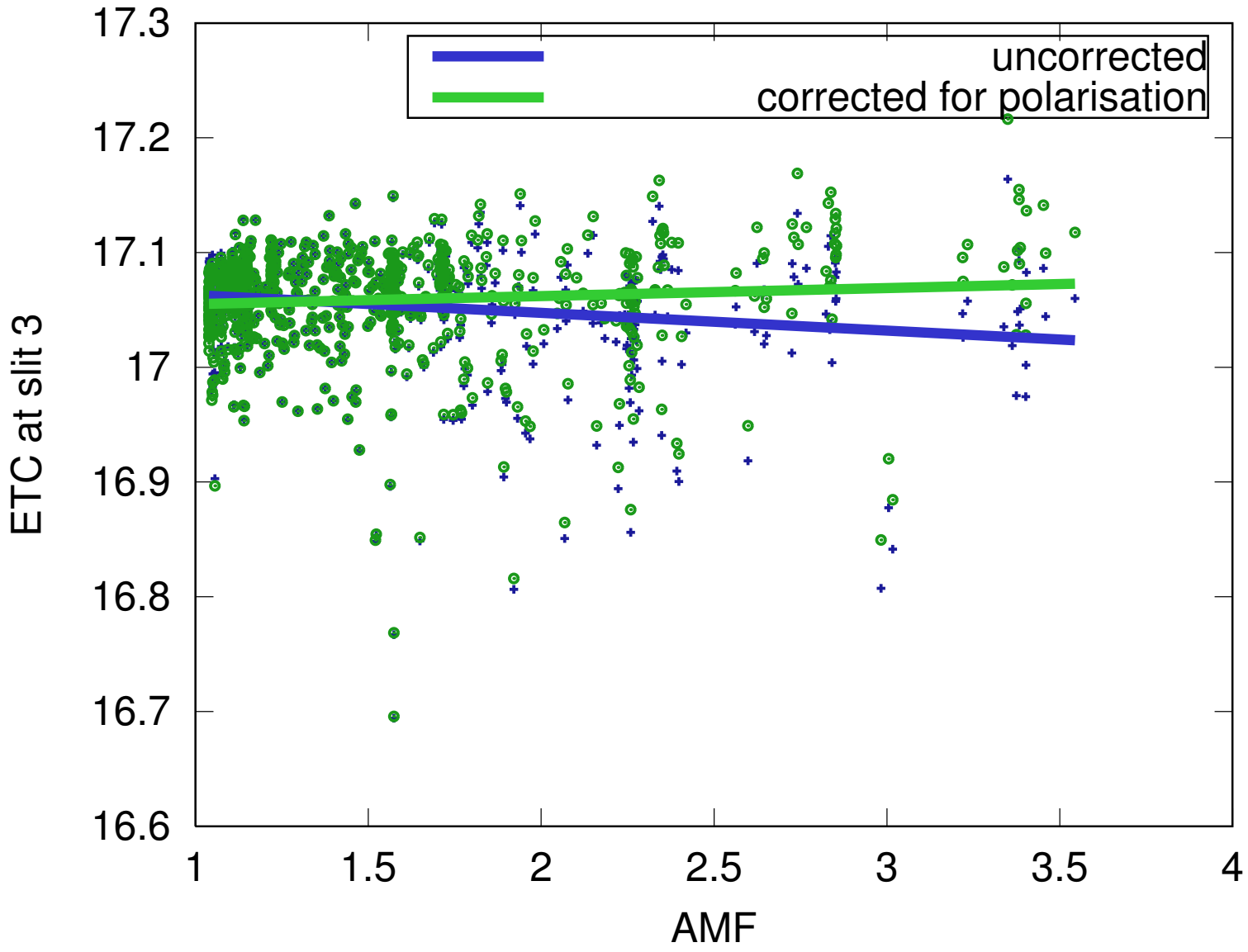


ETC transfer from Cimel

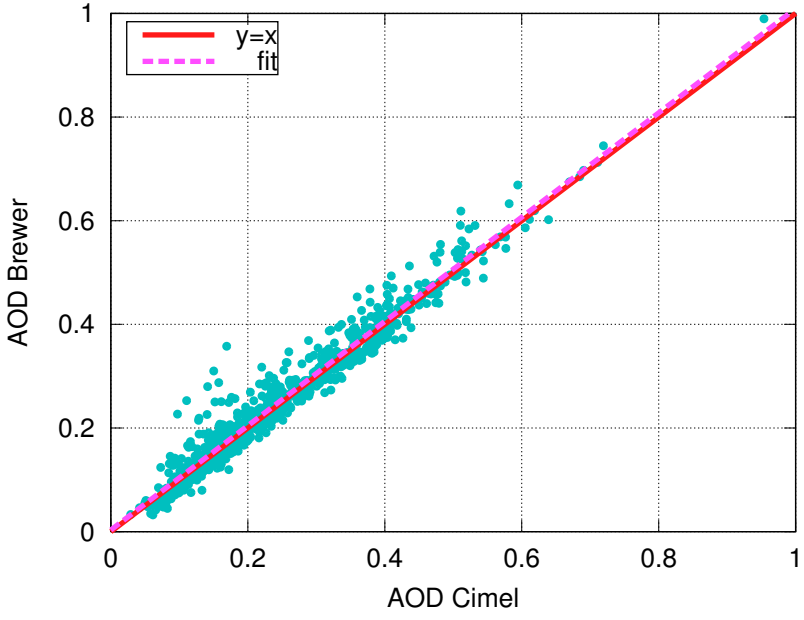


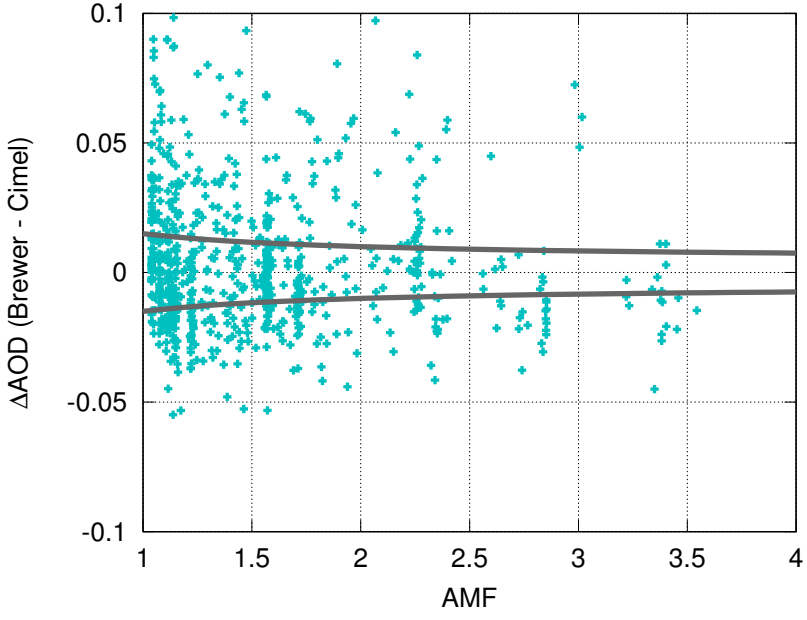
AERONET level 2.0
standard deviation 0.03 (logarithmic ETC)

Effect of internal polarisation



Comparison between long datasets



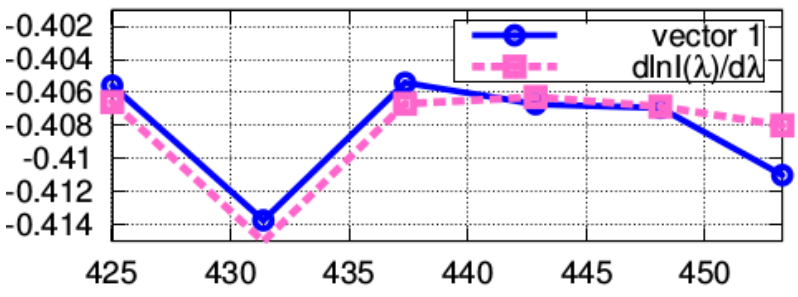


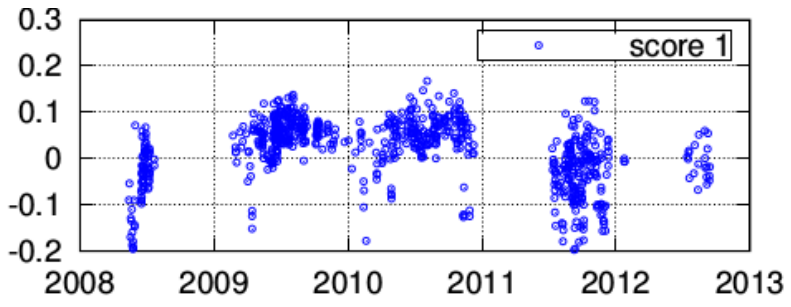
Slope: 1.006; offset: 0.003; Pearson's correlation coefficient ρ: 0.98

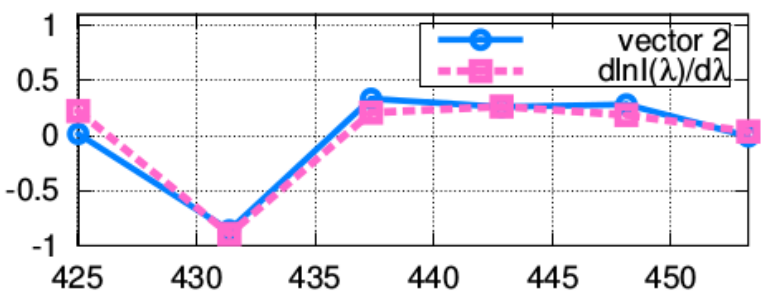
Only 40% within WMO limits (95% needed for traceability)

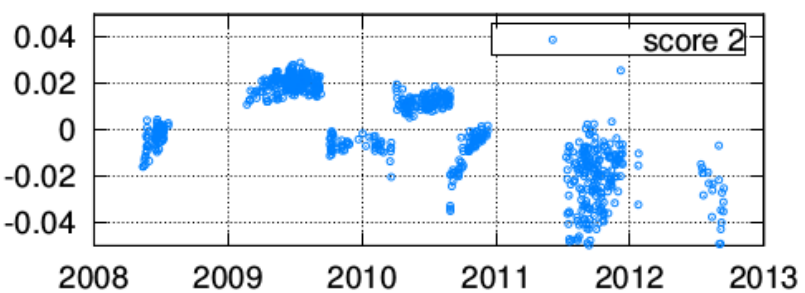
PCA

Principal Component Analysis (PCA) of
$\Delta AOD(\lambda) = AOD_{Brewer}(\lambda)$ - $AOD_{CIMEL}(\lambda)$

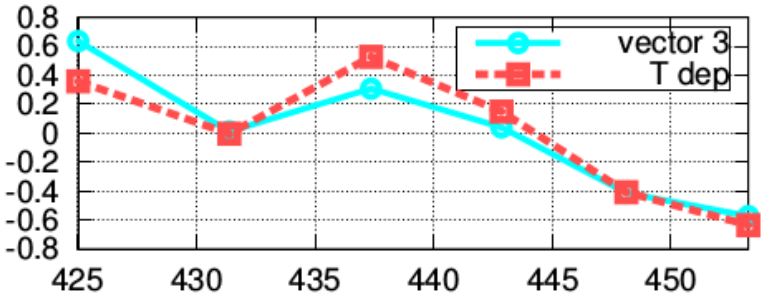








PCA


0.8
0.6
0.4
0.2
0
-0.2
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425
430
435
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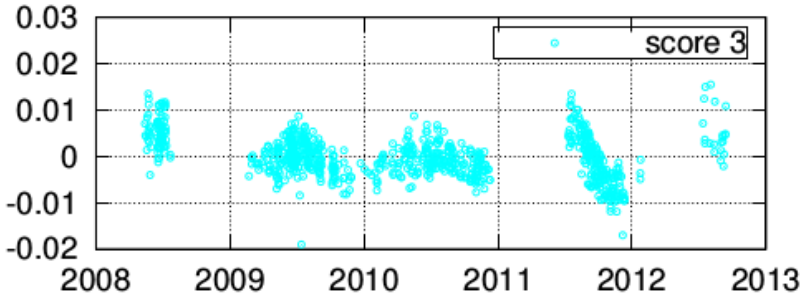
0.03
0.02
0.01
0
-0.01
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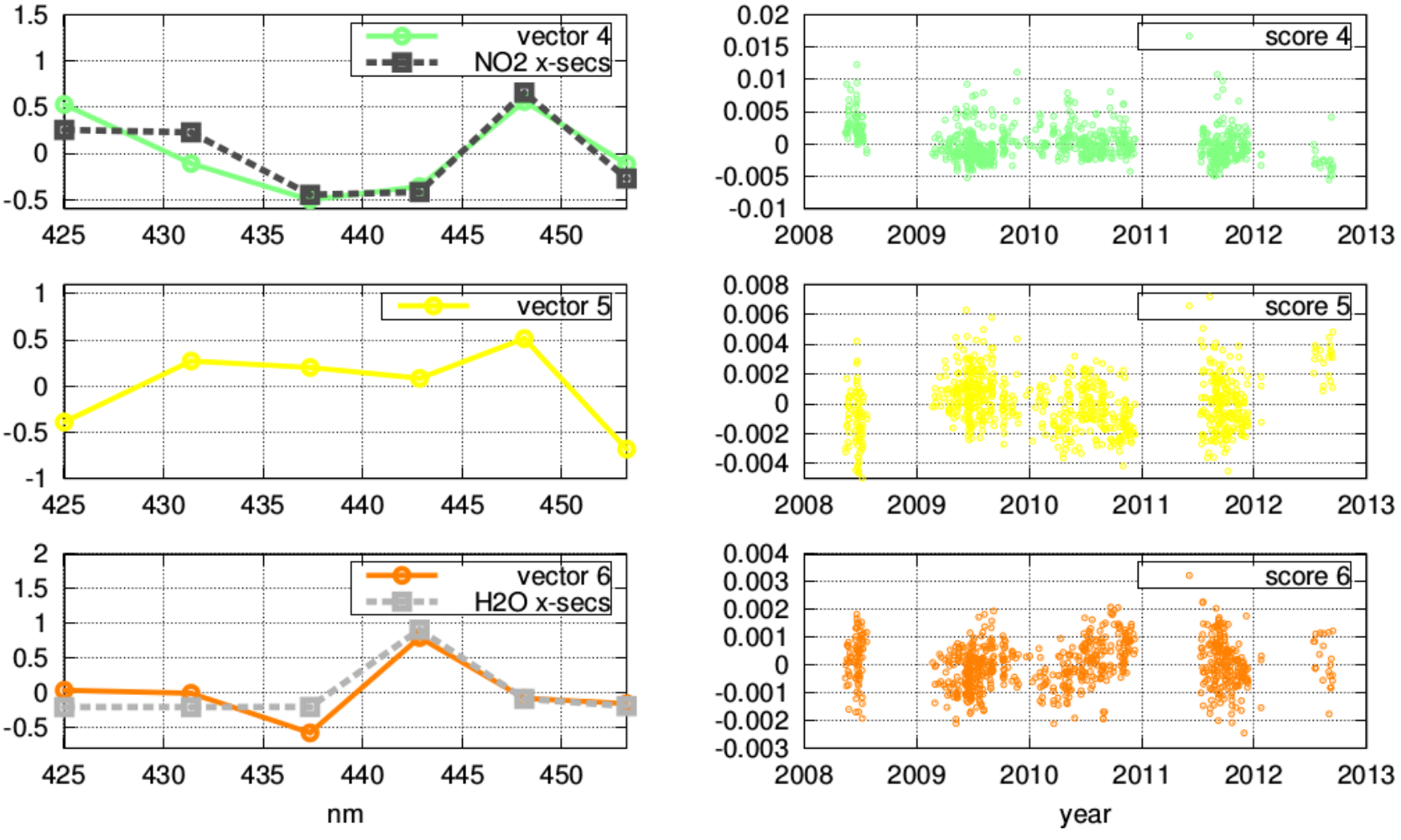
2008
2009
2010
2011
2012
2013
score 3

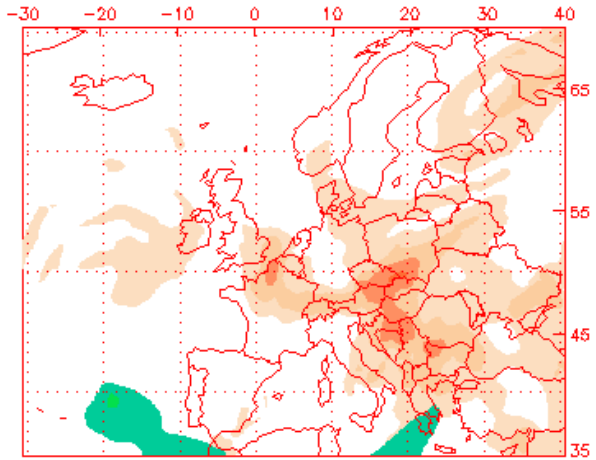
Brewers and aerosols

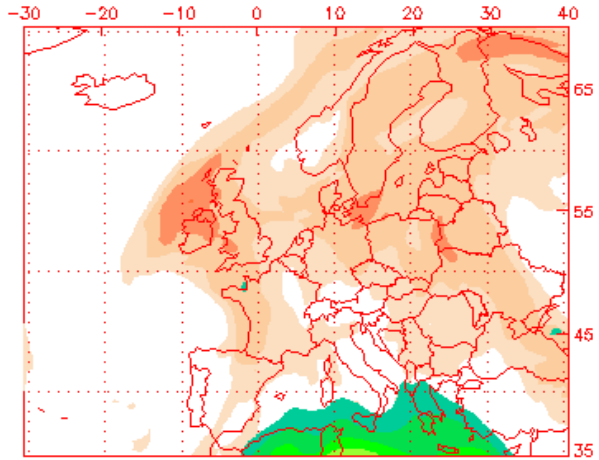
Historical series

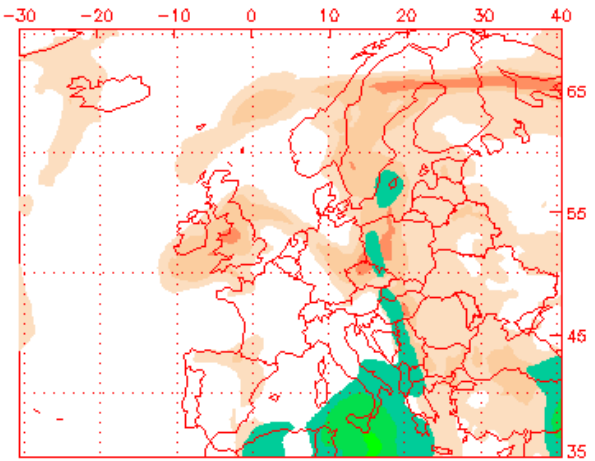


Campaign

- May 5 – 16, 2014
- AOD ranging from 0.05 to 0.4
  - 3 Saharan dust events

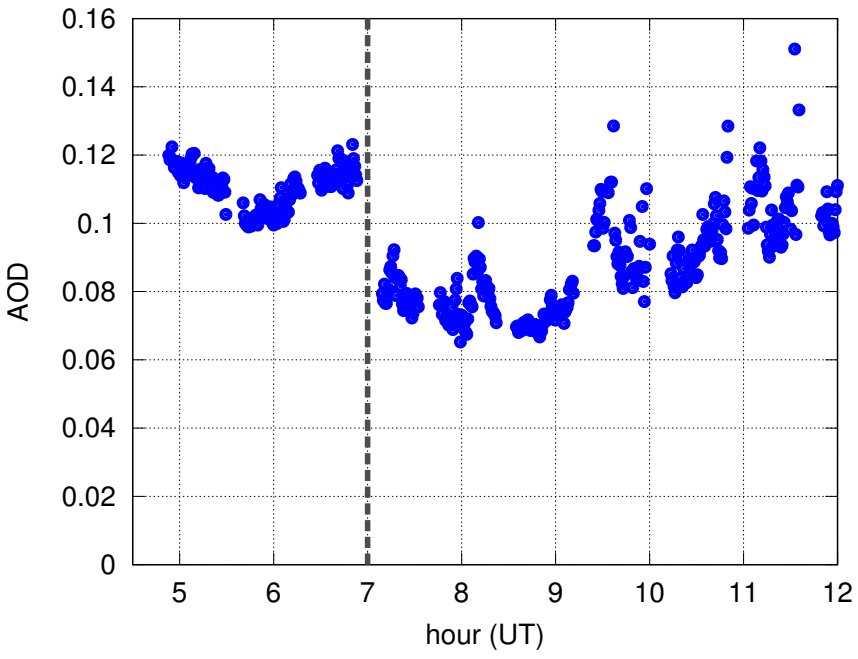




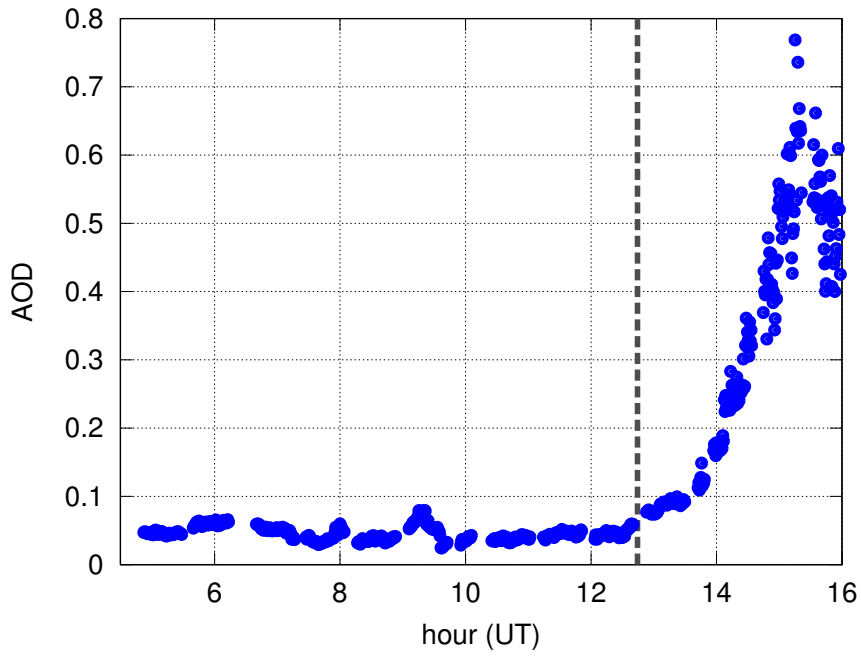


Effect of cleaning and sighting

a) effect of cleaning

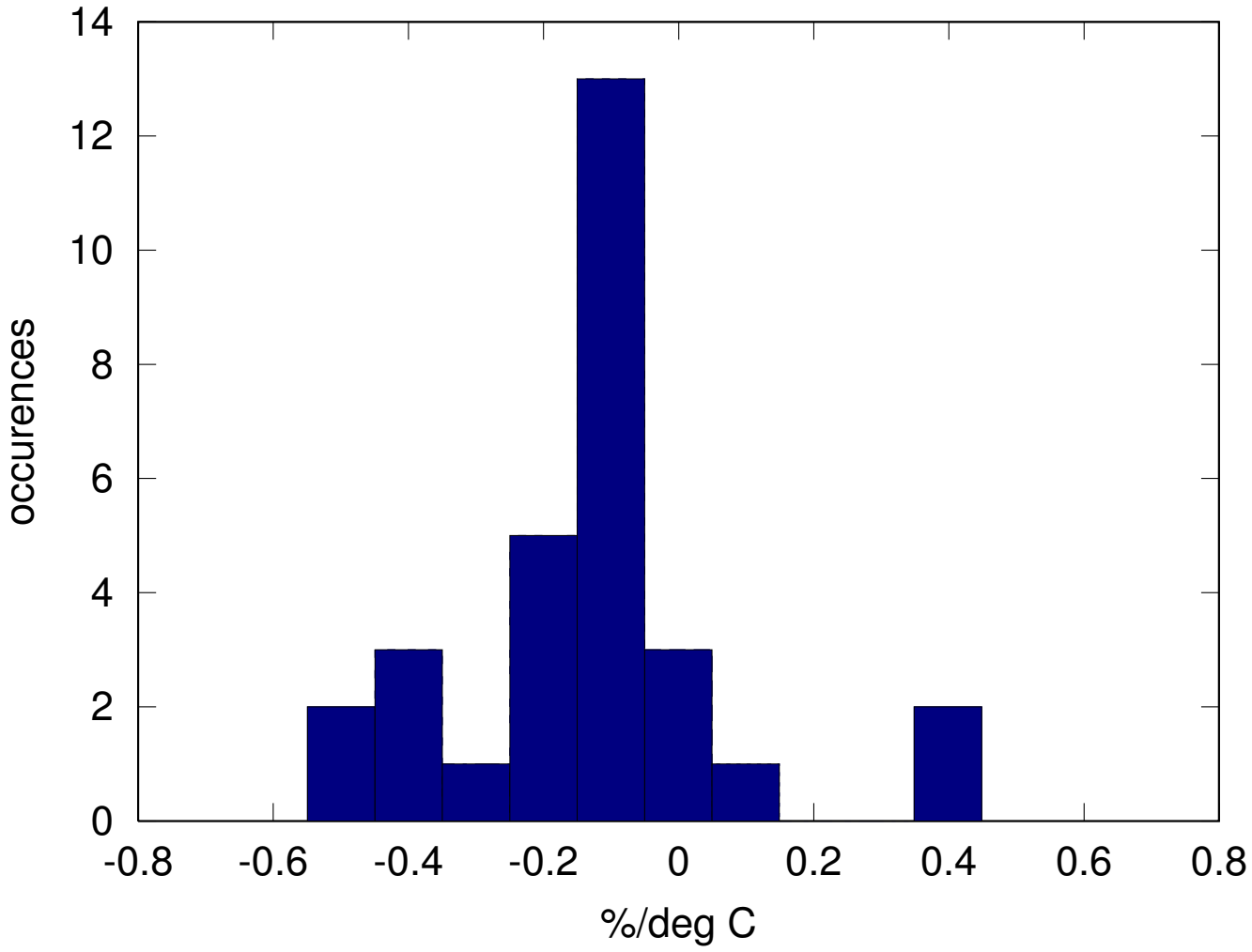


b) pointing error



Temperature dependence

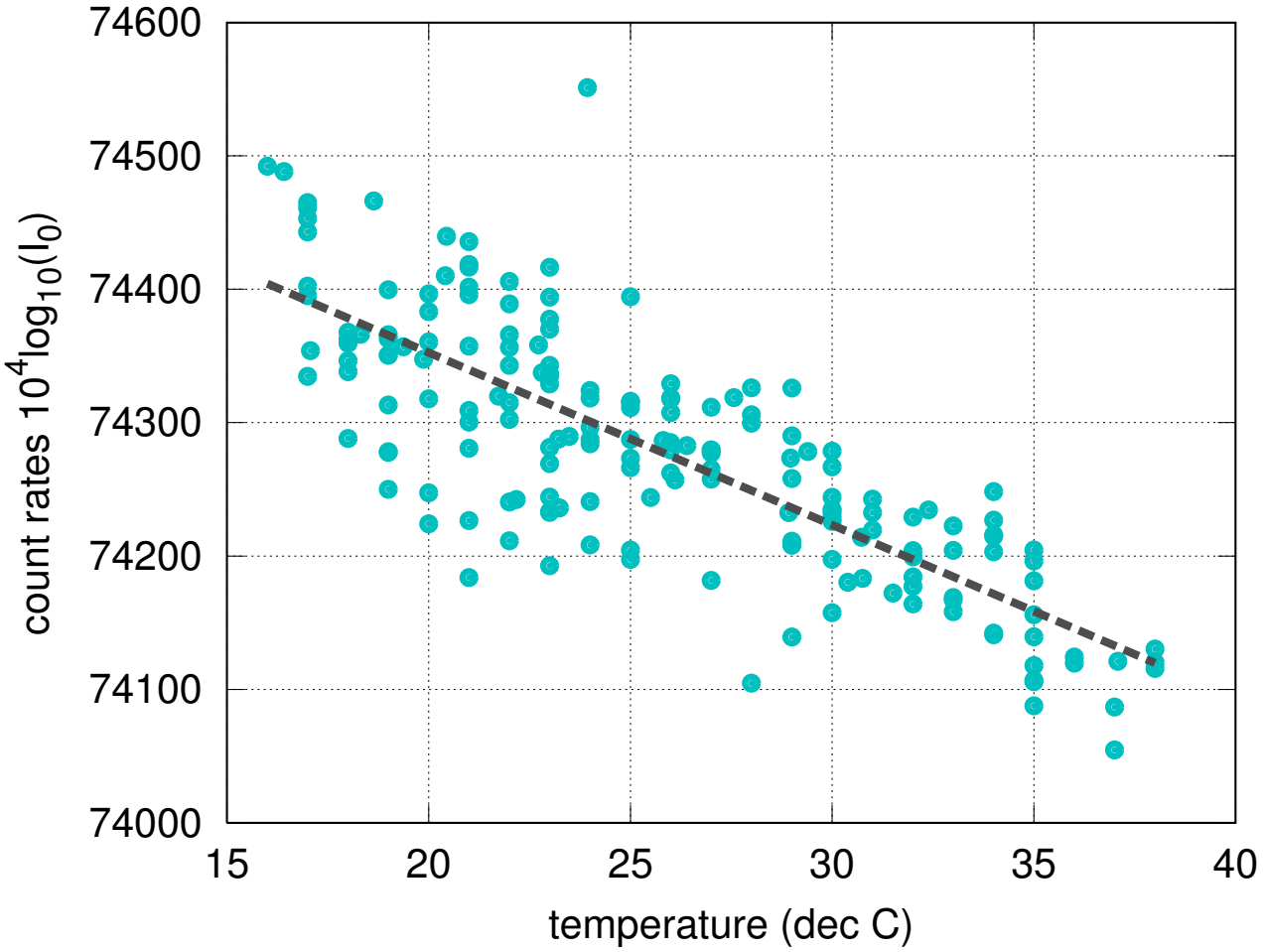
SL results



Negative dependence, not very clear

Temperature dependence

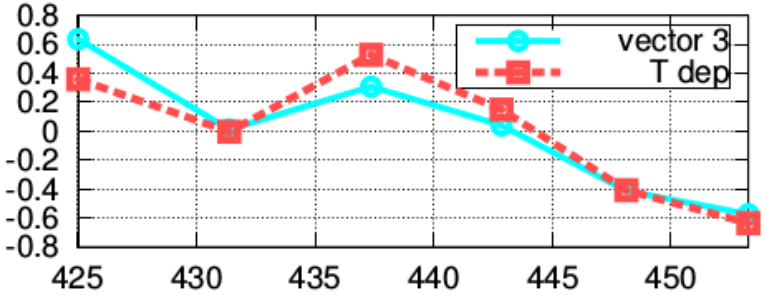
Comparison to Cimel

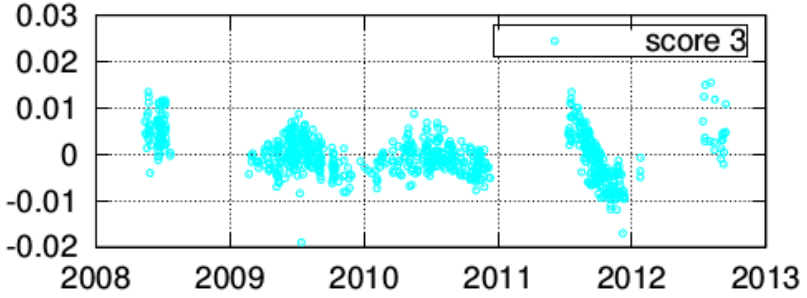


$\sim$ -0.3%/°C, slightly dependent on wavelength

Temperature dependence

Comparison to Cimel



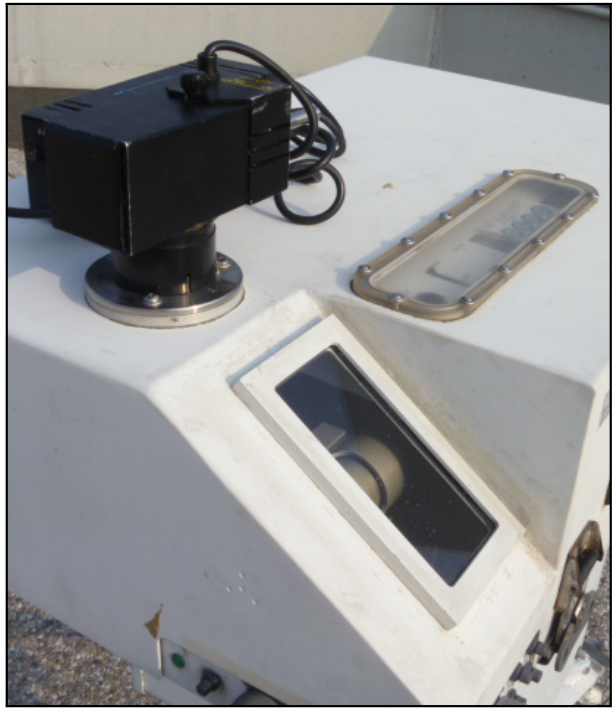


$\sim$ -0.3%/°C, slightly dependent on wavelength

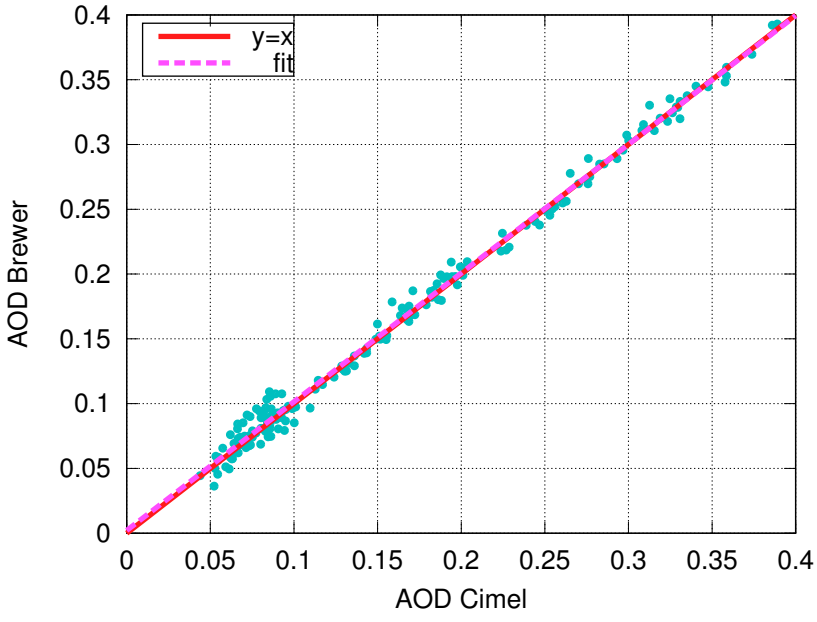
Temperature dependence

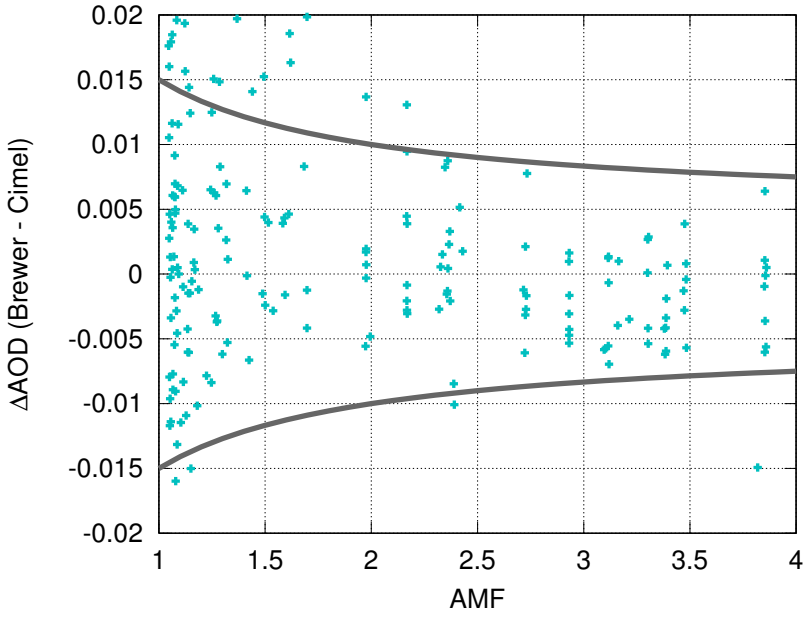
Differences between temperature dependences determined by SL and Cimel

- expected dependence is very low
- misalignments of FWs at $\sim 77^\circ$ SZA?
- where is internal temperature measured?
- warm-up time
  - would be useful to record warm-up times in Brewer files
- visible light entering from the transparent cover
- is T dependence completely removed from Cimel?



Results of the comparison during the STSM





Slope: 0.993; offset: 0.002; Pearson's correlation coefficient ρ: 0.997

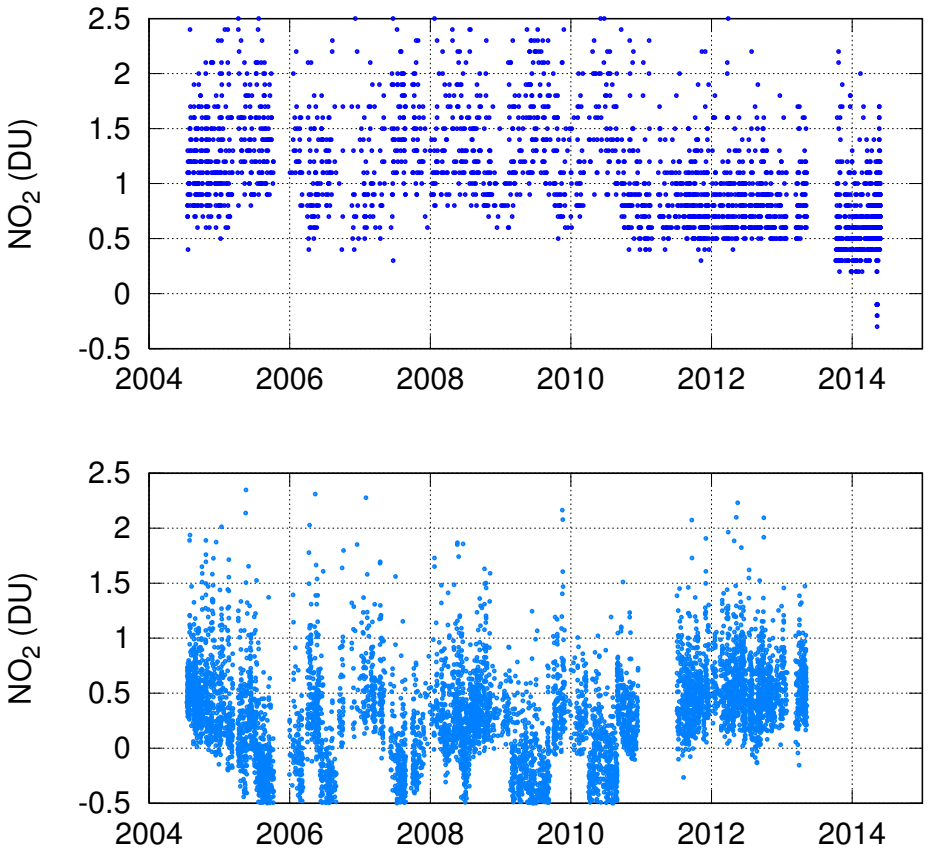
$\sim$ 90% within WMO limits

New retrieval

vector $(\frac{\partial \log I}{\partial \lambda}|_{\lambda_1}, ..., \frac{\partial \log I}{\partial \lambda}|_{\lambda_6})$ included in the fit
(Kerr et al., 2002; Cede et al., 2006)

- low 2^{nd} weighting (0.04) "tells" the algorithm to mostly ignore slit 2
- absorbs wavelength misalignments
- quality control parameter

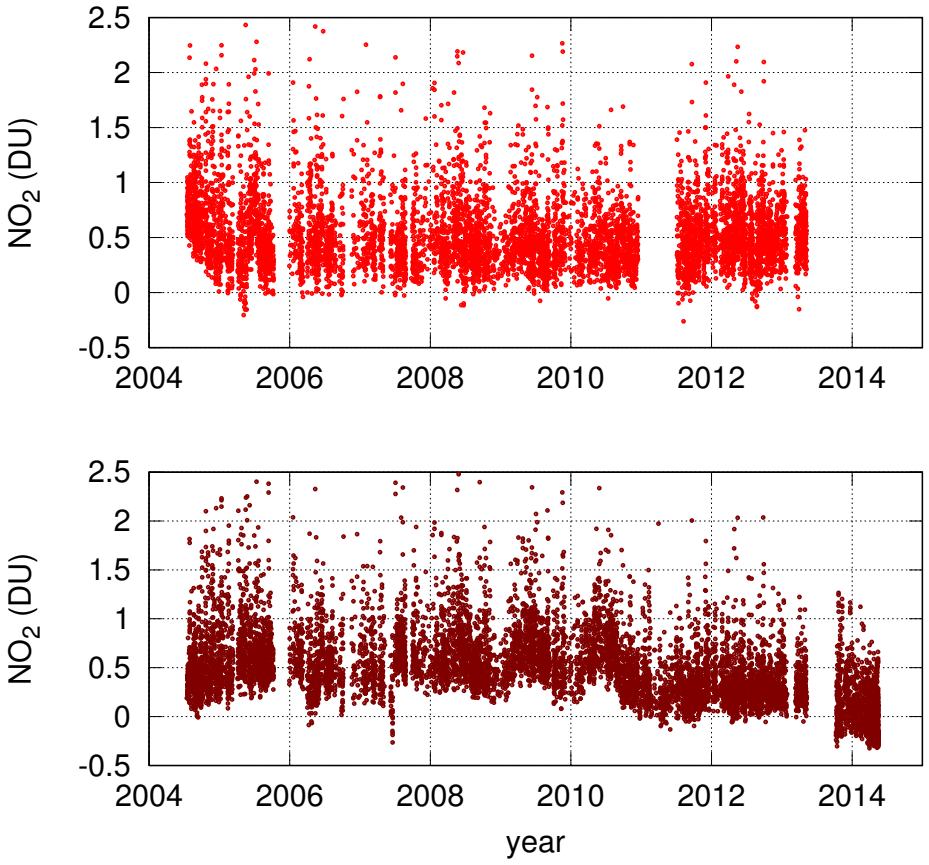
Comparison of algorithms



a) Brewer operating software (standard algorithm, no ETC calibration)

b) Diémoz et al., 2014 (constant ETC with bootstrap method)

Comparison of algorithms



c) Diémoz et al., 2014 (piecewise calibration)

d) STSM algorithm (constant ETC with bootstrap method)

Results

- seasonality is opposite than expected
- some instabilities
- better correlation with in-situ concentration measurements with the new algorithm
  - $\rho \sim 0.6$
- daily OVP data from TEMIS (screened for max foot distance and cloudiness)
  - good point-to-point correlation ($\rho \sim 0.6$)
  - total VCD from TEMIS much lower ($\sim$4 times) than IUP data
  - TEMIS cycle opposite than IUP

AOD

- cleaning of optics and pointing accuracy
- large wavelength dependence on 2^{nd} slit
- temperature dependence of $\sim -0.3\%/^{\circ}C$
- sl tests inherently limited to measure temperature dependence
- interferences by other absorbers are likely

NO_2

- including derivative of solar spectrum reduces dependence on wavelength
- satellite data from different groups are highly conflicting

Outcomes

- new acquaintances and scientific collaborations
  - Christos Zerefos
  - Stelios Kazadzis
  - Panos Raptis
- poster at Mediterranean City Conference 2014
- foreseen publications about aerosols and NO_2 by MKIV Brewers
- ... and the Souvlaki, of course!

Thank you