COST-STSM-ES1207 Proposal
Brewer AOD calibration and retrieval in the UV-B

Izaña Atmopheric Research Centre – PMOD / WRC

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Brewer AOD calibration and retrieval in the UV-B

Main goals:

- Continuing and completing the development of a standard methodology to transfer aerosol optical depth (AOD) calibration factors between Brewer spectrophotometers, using as a reference a standard instrument
- Define a proposal for a uniform Brewer AOD algorithm

This will contribute to standardize the Brewer aerosols measurements within the scope of the Eubrewnet network.

Involved Steps I

1. Development of a series of algorithms to process AOD absolute calibration (Langley method) for the RBCC-E triad members, including analysis and calculation of correction factors for non-linearity effect on Brewer neutral density filters.
2. Establishment of a common algorithm applicable to the Eubrewnet network to compute AOD using a data set of total ozone measurements (DS measurements).
3. A comparison of the calculated AOD by Brewer with co-located Cimel data and a UV-PFR.

Involved Steps II

4. Analysis of the Brewer results and assessment of the long-term stability of the Brewer. Seven years of spectral solar measurements will be analyzed (2008-2014).
5. Development of a standard methodology to transfer the absolute calibration of direct spectral irradiance measurements from the RBCC-E travelling standard to instruments within the European Brewer network.
6. Application / validation of the developed methodology by use of Brewer dataset corresponding to the last RBCC-E Brewer intercomparison (El Arenosillo 2013).

Aerosol Optical Depth Retrieval I

The optical depth of the atmosphere can be divided into several components, ascribed to Rayleigh scattering, aerosols and gaseous absorption:

Aerosol Optical Depth Equation

$$\begin{aligned}\tau_{\alpha,i} \quad = \quad & -\frac{1}{\mu_\alpha}\Bigg\{ \ln\left[\frac{I_i(\lambda)}{I_o(\lambda)}\right] \\ & -2.6858 \times 10^{16} D_{O_3}\sigma_i(T,\lambda)\mu_{O_3} \\ & -\frac{p}{p_o}\beta_i(\lambda)\mu_R \Bigg\}\end{aligned}$$

Note that we multiply the ozone optical depth by the factor

$$1DU = 2.6858 \times 10^{16} molecules\ cm^{-1}$$

Aerosol Optical Depth Retrieval II

$I(\lambda)$	$\equiv$	measured spectral irradiance
$I_o(\lambda)$	$\equiv$	extraterrestrial spectral irradiance
$\sigma_i(T,\lambda)$	$\equiv$	differential ozone absorption cross section per molecule at temperature T
D_{O_3}	$\equiv$	total ozone content [DU]
$^{*}\boldsymbol{\mu_{O_3}}$	$\equiv$	ozone airmass factor
p_o	$\equiv$	mean sea level pressure
p	$\equiv$	station pressure
$^{*}\boldsymbol{\beta_i(\lambda)}$	$\equiv$	Rayleigh scattering coefficient
$^{*}\boldsymbol{\mu_R}$	$\equiv$	Rayleigh airmass factor
$\tau_{\alpha,i}$	$\equiv$	aerosol optical depth
$^{*}\boldsymbol{\mu_\alpha}$	$\equiv$	aerosol airmass factor

Aerosol Optical Depth Retrieval III

Open Issues:

- We can neglect gaseous extinction due to NO_2, but ... what about SO_2? Can RBCC-E provide any SO_2 calibration?
- Beer's equation assumes monochromatic irradiance $\Longrightarrow$ stray light
- Normal optical depth for Rayleigh as defined in ... Brewer algorithm [Nicolet. M., 1984; Groebner and Meleti, 2004]?, AERONET algorithm [Bodhaine et. al., 1999]?
- Both Brewer and AERONET use the same approximation for air mass factor calculation [Kasten and Young, 1989]
- Should we normalize our calibration factors to 1 U.A.?
- Correcting for internal polarization
- We have to deal with non-neutrality effects on Brewer *Neutral Density* filters

Aerosol Optical Depth Calibration Transfer I

Aerosol calibration is done similar to the ozone one; only it is done for each slit separately rather than the ratios. The basic idea would be, from

$$\ln I_i(\lambda) = \ln I_{i,o}(\lambda) - [\tau_{O_3,i}\mu_{O_3} + \tau_{R,i}\mu_R + \tau_{\alpha,i}\mu_\alpha]$$

to derive the instrument's individual $I_{i,o}(\lambda)$ by imposing $\tau_{\alpha,i}^{instrument} = \tau_{\alpha,i}^{reference}$ for near-simultaneous measurements.

It is important to have the instrument properly characterized (both instrumental and wavelength) as well as ozone-calibrated. Transfer and checking of AOD calibration constants would be desirable as part of ozone calibration

Aerosol Optical Depth Calibration Transfer II

Langley Extrapolation method. We need:

1. Direct monochromatic irradiance
2. Extraterrestrial irradiance needs to be stable during the measurements included in the Langley plot
3. Same as above, for atmospheric conditions
4. A wide range of air masses is needed for the Langley plot method $\Longrightarrow$ low-latitude stations

The Izaña Observatory, being a subtropical high-altitude station, allows reliable AOD calibration factors calculation which will be later transferred to the European Brewer network