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UV Aerosol Optical Depth in the European Brewer Network

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Introduction

Networks operating in near-real time over large areas are key to characterize aerosols, because this atmospheric component features high temporal and spatial variabilities (IPCC, 2014). Furthermore, the optical properties of aerosols in the UV are quite different from those in the visible – producing, for example, higher aerosol optical depths (AOD) – and not yet well known (Bais *et al*., 2015). This makes measurements in the UV wavelength range of high scientific interest, in particular in the case of mineral dust, which is responsible of a large contribution to the AOD at worldwide level.

Here we present results of a near-real time UV AOD product developed for the Brewer spectrophotometers of the European Brewer Network (EUBREWNET). Building upon previous works, this AOD product has been designed to use data from standard ozone measurements and calibrations which are already available at EUBREWNET's data server (http://rbcce.aemet.es/eubrewnet), operated and mantained by the Regional Brewer Calibration Center for Europe (RBCC-E). Once publicly available, this AOD product will provide data in a wavelength range where few instruments operate.

The Brewer spectrophotometer

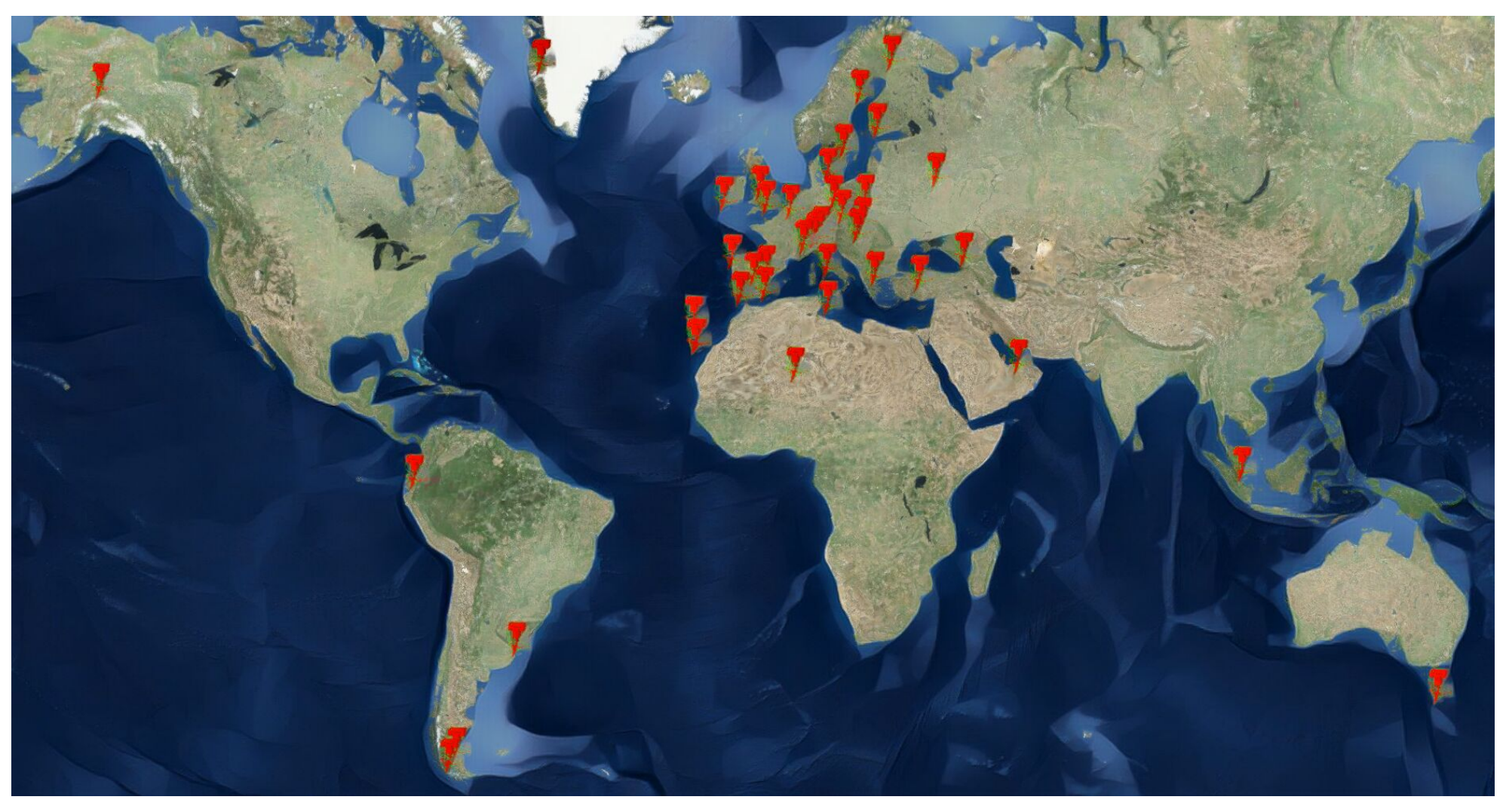
Together with the Dobson, the Brewer spectrophotometer has been the backbone of the WMO ozone observation network for the last 30 years. Besides the total ozone column, Brewers are routinely used to provide UV radiation data.

Three different Brewer models are in operation in EUBREWNET, all of which perform measurements at five wavelengths between 306 and 320 nm as part of their standard ozone measurement programs. Brewer instruments are reliable and stable, and are often calibrated just once every 2 years at international intercomparison campaigns. These intercomparison campaigns now also provide the opportunity to transfer the AOD calibration from a reference instrument. In the case of the RBCC-E, a reference Brewer is calibrated by the Langley method at the Izaña GAW Observatory (AEMET, Spain), see López-Solano *et al*. (2018) for this and other details on EUBREWNET's AOD product.

EUBREWNET

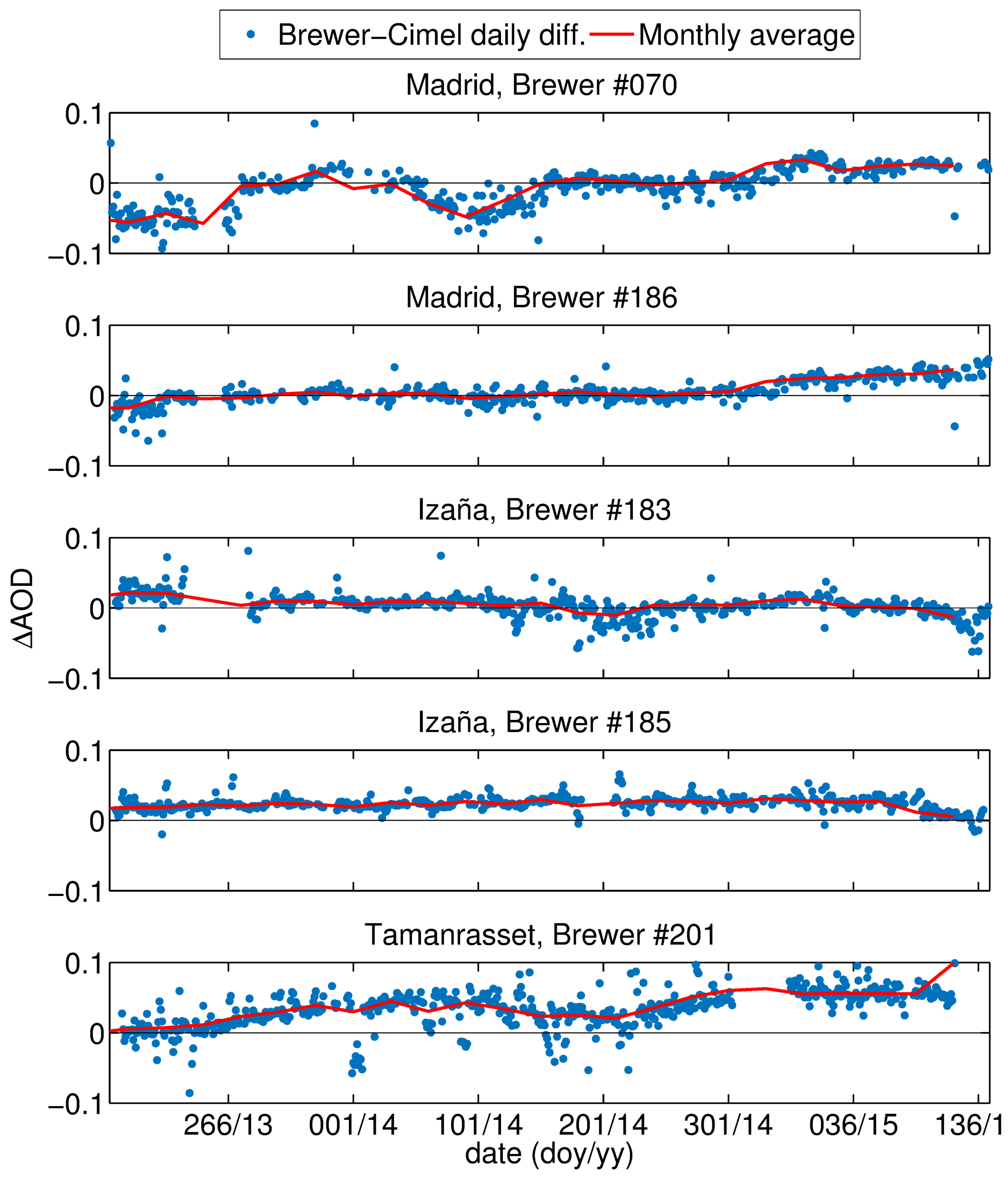
The European Brewer Network (COST Action 1207; Rimmer *et al*., 2018; http://www.eubrewnet.org/cost1207/) was stablished in 2013 to harmonize Brewer operational procedures. The network also aims to develop approaches, practices, and protocols to achieve consistency in quality control and quality assurance of all the data retrieved by Brewer spectrophotometers.

EUBREWNET is currently comprised by close to 50 Brewer instruments operating at 43 sites, most of them in Europe, as shown in the map.



Brewer-Cimel comparisons

We have compared Brewer and Cimel data at selected stations over a period of 2 years. For the Brewer, we used data for highest wavelength measured in normal ozone operation, 320 nm. For the Cimel, we used the level 2.0 product provided by AERONET (http://aeronet.gsfc.nasa.gov), extrapolating the data for the 340 nm wavelength to 320 nm using the 340-440 Ångström exponent.

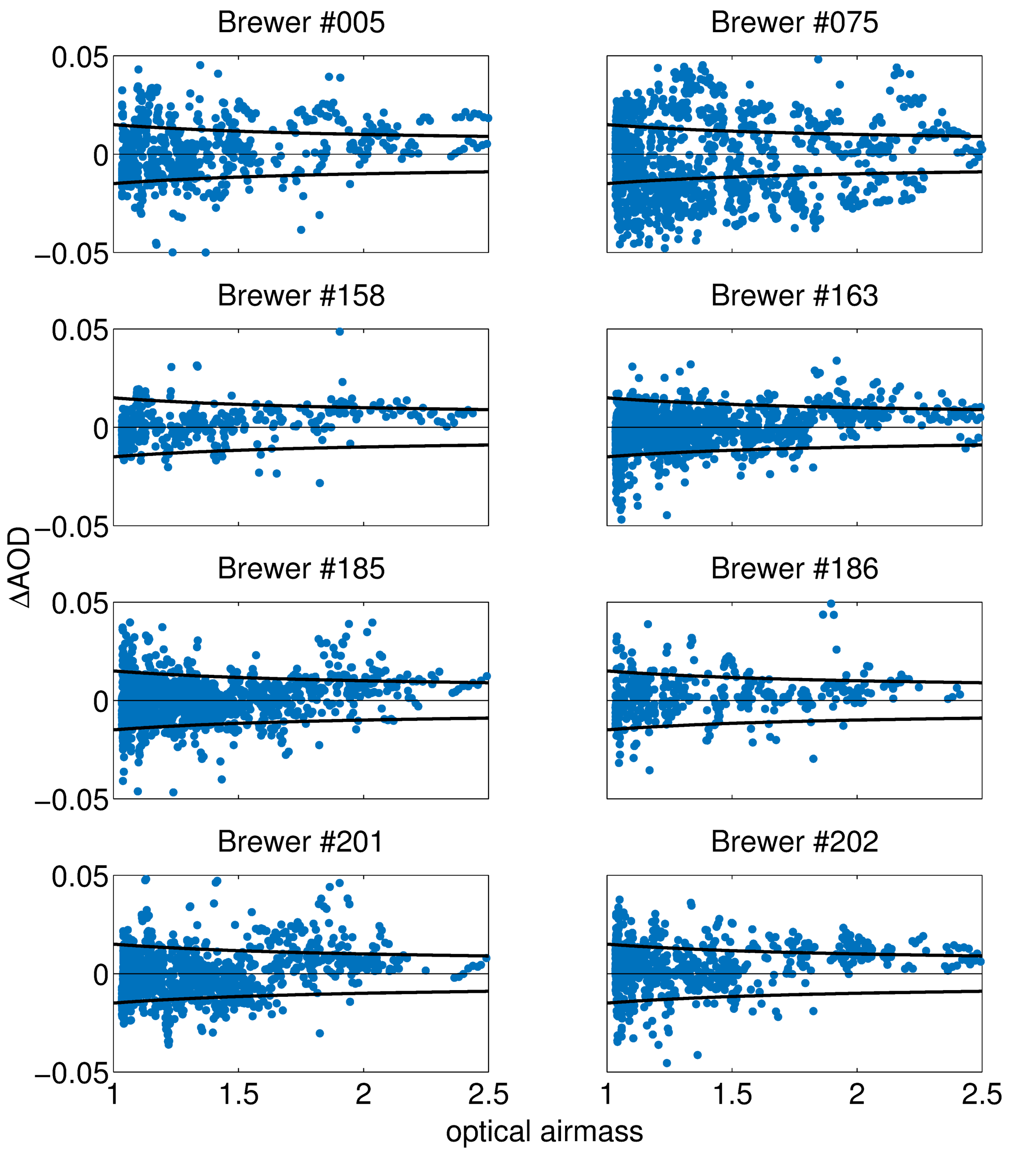


As shown in the figure, the difference in AOD is in most cases quite stable over a period of 1.5-2 years. The largest deviation of the AOD difference corresponds to the data from the Tamanrasset station. This may be explained by the severe weather conditions at this station, which makes extra instrumental maintenance a must.

From this comparison with the Cimel we can conclude that the Brewer AOD product is roughly as stable as the ozone one. The intercomparison campaigns held every 2 years could thus be used to check both the ozone and AOD calibrations.

Brewer-UVPFR comparisons

A UVPFR instrument (Carlund *et al*., 2017) was operated by the PMOD/WRC at the X RBCC-E Brewer Intercomparison Campaign, held at El Arenosillo Observatory (INTA, Spain) in summer 2015. This provided an opportunity to compare the Brewer AOD with the data from a high precision and low uncertainty instrument which also operates in the UV range. Below we show the Brewer-UVPFR AOD differences at 313.5 nm for ~1/3 of the participating instruments. The thick black lines correspond to ±(0.005+0.010/*m*), which are the limits of the WMO traceability criteria (WMO/GAW, 2005).



Brewers #158 to #202, all of them Mk III models, have 81-91% of the data points within the WMO limits. Brewers #005 and #075 – a Mk II and a Mk IV, respectively – show larger differences with the UVPFR. This seems to indicate that some specific characteristic of these Brewer models plays a role in the AOD determination and has not been completely taken into account in our algorithm. Despite this, the agreement between the Brewer and UVPFR AOD is quite reasonable.

Uncertainty and precision

The comparison with the UVPFR also allowed us to determine the uncertainty of the Brewer AOD, obtaining values from from 0.05 at 306 nm to 0.01 at 320 nm. This result is very close to the one obtained in a simplified analytic derivation, considering only some contributions to the total uncertainty, see López-Solano *et al*. (2018) for full details. Previous works have found an uncertainty of 0.02 for the Cimel in the UV (Holben *et al*., 1998), and between 0.04 and 0.02 for the UVPFR (Carlund *et al*., 2017).

From Brewer-Brewer comparisons we have determined the precision (or repeatibility) of the AOD measurements, obtaining between 0.010 and 0.005, depending on the wavelength. The precision of the Cimel is quoted as better than 0.002 in the visible (Mitchel and Forgan, 2003), but the value is likely higher in the UV range. For the UVPFR, Carlund *et al*. (2017) calculated a precision of 0.01.

Looking at these data, we can thus conclude that the uncertainty and precision of the Brewer UV AOD product are comparable to those of other instruments.

Concluding remarks

►Once publicly available, EUBREWNET's UV AOD product will provide near-real time data in the 306-320 nm wavelength range for almost 50 instruments operating at 43 sites. All the data required for the AOD calibration and determination is available from intercomparison campaigns and the standard ozone measurements. Specific AOD measurement programs will allow to obtain data up to 360 nm, or even higher for some Brewer models.

►According to our Brewer-Cimel, Brewer-UVPFR, and Brewer-Brewer comparisons, the stability of the Brewer AOD is similar to that of the ozone measurements, the uncertainty is less than 0.05, and the precision is at least 0.01. These parameters are similar to those of the Cimel and UVPFR.

►Despite the overall good results obtained, there is still room for improvement. Further study is needed, for example, to determine if there are parameters specific to each Brewer model which have not been taken into consideration in our algorithm. We also plan to study in more detail the AOD stability, with a view to determine if there are maintenance issues which affect only the AOD and not the ozone retrieval.

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