Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-295-RC2, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "Improving the Mean and Uncertainty of Ultraviolet Multi-Filter Rotating Shadowband Radiometer In-Situ Calibration Factors: Utilizing Gaussian Process Regression with a New Method to Estimate Dynamic Input Uncertainty" *by* Maosi Chen et al.

Anonymous Referee #1

Received and published: 17 December 2018

This is a very interesting paper and also very helpful for UVMFR and MFRSR users in order to try to understand and improve a very important aspect that is the instrument calibration and the uncertainty of the calculated calibration constants. I think there is some room for improvement on basic aspects but there are no issues that would suggest the rejection of this work from AMT.

Concerning the introduction

I am missing previous results of (UV-) MFRSR comparisons with other standard AOD measuring instruments. For example in the 2015 the Filter Radiometer comparison in Davos, Switzerland various of this instrument types have participated and the results have been discussed. There are also earlier studies of such comparisons.

In Kazadzis et al., 2018: There were 4 MFRSR instruments in this campaign. The results were summarized in the following paragraph: "The four MFR instruments showed good agreement for the medians compared to the PFR triad, however, they exhibit larger scatter than the sun-pointing instruments resulting in a lower precision. McArthur et al. (2003) had previously reported that the MFR-derived AOD does not quite meet the accuracy of the sun-pointing instruments under clean atmospheric conditions. MFR_DE showed an AOD overestimation in various instances that gave results that are outside the WMO defined AOD limits (Fig. 2d). This small overestimation of the MFR_DE instrument compared to the PFR Triad could be due to uncertainties introduced while correcting for their angular response, the calibration procedure, or incomplete blocking of the diffuser by the shadow-band. The MFRSRs that are part of the SURFRAD network (MFR_US2 and MFR_US3) give a median AOD at 500-nm that is in very good agreement with the PFR triad and as good or better than some of the other sun-pointing instruments, e.g., CIMEL and POM; these two slightly underestimate the AOD at 865 nm, but are within the WMO defined limits. Again, these two MFRs' medians are comparable to the better sun-pointing instruments, but give larger scatter. These two MFRs are representative of the SURFRAD network that follow network protocols for calibration and alignment and frequent characterizations of the spectral and angular responses (Augustine et al., 2003, Michalsky et al., 2001)."

Would be helpful some of the above aspects to be included in the introduction section or in section 2.4

Authors are mentioning: "There are no other instruments measuring at 368nm" The World Meteorological Organization (WMO) instigated the Global Atmosphere Watch (GAW) program in 1989. Based on a recommendation by GAW experts, the World

Optical Depth Research Calibration Center (WORCC) was established in 1996 at the PMOD/WRC in Switzerland. WORCC has since been advised by the GAW Scientific Advisory Group for Aerosols. The standard instrument consist of a precision Filter radiometer (PFR measuring at 368, 412, 500 and 862 nm. So actually the WMO reference instruments (triad) is measuring at 368nm.

So the argument of the non existence of instruments measuring at 368nm (thus the choice of the AOD based comparison) is not correct. However, as it is not possible to repeat this study with one of the PFR instruments, probably the only solution could be the AOD comparison with the collocated cimels as the authors have initiated. Nevertheless, a short comment on the above text could be included in the paper.

Line 224 : probably you should comment also that ozone is also ignored .

Line 235: I guess that the cloud flagging method is not evaluated here, as comparison with CIMEL data includes only data that CIMEL algorithm considers as cloud free.

Line 250 : It would be informative to explain why S(lamda) appears in equation 9. Since F(lamda) is $\sim$4nm the integrated range is $\sim$366-370 nm. There you mention that AOD is the "interpolated ADO spectrum" which I guess you mean the linear (?) interpolated using 340 and 380 AERONET AODs ? Then S(lamda) is used for normalization in this small 4 nm range? Is this so different that the actual interpolated value of AOD at 368 nm? And if S(lamda) is used, why not S(lamda) – Rayleigh optical depth ? Have in mind that spectral function FWHM of the CIMEL is larger than 2nm.

The authors chose to evaluate their method by comparing the retrieved (from their Vos data) AODs. Here are my comments on this section:

- The comparison of UVMFR with AERONET would be essential to follow criteria that are defined by WMO –CIMO in order to assess the results in detail. https://library.wmo.int/pmb_ged/wmo-td_1287.pdf There (page 8) such conditions and formulas are defined. For example the U95 criterion where a number (here the lower

limit is 95%) of measurements have to be in the range of $\pm$0.005 + 0.010/m Where 0.005 accounts for instrument related uncertainties and 0.01/m for calibration related uncertainties (calibration uncertainty better than 1%).

Changing the analysis figures with the use of this criterion authors can:

a. better show the agreement and the improvements with their methods by showing the percentage of data within these limits for each case.

b. having in mind that calibration related uncertainties will be inherited in AOD retrievals as a function of air mass, the figures (a) including aod differences vs air mass can point out on Vo related issues. Still slopes and cor. Coefficients can be reported in the form of a table.

The AOD retrieval and the differences among two instruments are a consequence not only an uncertainty on the instrument calibrations but also other factors.

Here is a list:

- The calculation of Rayleigh optical depth from both instruments including the pressure measurement. Are the two instruments (UVMFR and CIMEL) use the same formulas ?

- The calculation of Rayleigh and aerosol air mass factors

- The potential differences in the field of view of the instrument

- CIMEL includes NO2 and Ozone optical depths

- The wavelength interpolation from 340 and 380 nm to 368 nm is not by definition linear but aerosol type related.

So in order to assess their results the authors at least have to mention the related uncertainties and the above issues raised by using retrieved AODs from two different instruments with different instrument characteristics and post processing AOD algo-

rithms and procedures, in order to validate the Vos.

In theory a direct comparison of direct sun signals for the UVMFR instrument and a reference instrument measuring at 368nm could be used in order to assess the differences in the Vo calculation, without having the AOD calculation related uncertainties.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-295/amt-2018-295-RC2-supplement.pdf

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