Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-506-AC2, 2020

Atmospheric Measurement Techniques Discussions

Interactive comment on "A new optical-based technique for real-time measurements of mineral dust concentration in PM10 using a virtual impactor" *by* Luka Drinovec et al.

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Received and published: 4 June 2020

amt-2019-506 - Answer to referee #3 (RC2)

Author's response: We thank the referee for her/his comments which have enabled us to improve the manuscript.

The paper presents a new technique relying on combining a virtual impactor with an eathalometer, and supports it with a substantial body of laboratory and field data, including both instrument characterization and intercomparisons. The technique under development has the potential to bring significant improvement to dust monitoring and

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characterization, especially in the context of mixed aerosol types. The text is well written and informative on the whole, but some stylistic detail should be improved, for example inconsistent use of different grammatical tenses (present, present perfect and past), making it difficult to differentiate between the authors' and previous work.

Some detail is not clear, potentially even leading to misunderstanding. For example, the introductory section is somewhat intidy, lacking a logical progression, and ought to be improved.

Author's response: We have taken all reviewer's comments in account and added to the Introduction to make it clearer.

The statement in lines 204-209 is unclear: is the nonlinearity due to filter saturation? And what are the "k values" - do they compensate for the nonlinearity? Are they constant over time, wavelength etc?

Author's response: The non-linearity caused by the filter loading effect is explained in Drinovec et al. (2015) article. The topic is quite extensive, for that reason it is kept out of this article.

Changes to the manuscript: Section 2.2.2, Line 213: "Given that the on-line filter loading compensation was not working efficiently for the AE33 coupled with the virtual impactor (see section 3.3, below), the obtained data was compensated using fixed filter loading compensation parameter k values as described in the Supplement S2. "

In the Supplement, tests of the virtual impactor (VI) are carried out with PSL, which has specific gravity close to that of water, less that half of that of typical mineral dust. Consequently, the geometric diameter of the latter is substantially smaller than the aerodynamic diameter (relevant in the context of the VI). This aspect is not highlighted and it is not always clear which diameter is discussed. Consequently, a reader using the reported (aerodynamic?) diameters could be misled into applying them to geometric dust sizes.

Author's response: Aerodynamic diameter is used throughout the article. For clarity the adjective "aerodynamic" was added in several places. The fact, that virtual impactor characteristic depend on aerodynamic particle size was emphasized at the beginning of the Chapter 3.2.

Changes to the manuscript: Section 3.2, Line 369: "The concentration efficiency of the virtual impactor depends on the aerodynamic particle diameter. For that reason, an Aerodynamic Particle Sizer (APS, model 3321) was used both for analysis of aerodynamic particle size distribution during the campaign and virtual impactor characterization (Supplement S1)."

A constant value of the enhancement factor (EF) seems to be used. Yet EF is variable, as the authors' own data shows, and it will depend on particle aerodynamic size, hence the composition of the sample at any given time. This may be a major shortcoming, affecting the accuracy of the technique. Is it feasible to improve accuracy by using this dependence, perhaps taking advantage of on-line data? While this may not be possible with the current setup alone, the authors should comment on it and suggest potential solutions.

Author's response: The uncertainty introduced by using a constant value of EF for calculation of mineral dust concentration is 18% as noted in Chapter 3.7, page 14, line 578. Using APS for real-time determination of EF would reduce that uncertainty.

Changes to the manuscript: Section 3.7, Line 578: "This uncertainty can be reduced by using time-resolved measurements of EF or modifying the virtual impactor design to sharpen its response."

My general concern is about an unspoken shortcoming of the technique: it would fail if the dust and black carbon was internally mixed. As a warning to potential users, this should be highlighted, and the "climatology" of internal as opposed to external mixing described from known historical data. Author's response: The proposed method is calibrated during the intensive campaign when MAC and EF are determined. Both

parameters depend on the source region: EF is affected by the changes in size distribution which with time moves toward the smaller particles. MAC can be affected by the mineral dust composition, for example iron content and ionic state and also by black carbon content. The coagulation of mineral dust and black carbon is most intense at the source location because the process depends a lot on the aerosol concentration (Rodriguez et al., 2011). During transport the mineral dust and black carbon are diluted slowing the coagulation process. In both cases MAC of the mineral dust depends on the source region. The uncertainty of the method can be greatly reduced if the source region is determined from back-trajectory analysis and a specific MAC value is applied. This subject is being studied and will be reported in a separate article.

Changes to the manuscript: Section 3.7, Line 589: "Desert dust may mix with BC emissions and this is relevant especially at source regions, where concentrations are large enough for efficient coagulation between dust and BC to occur (Clarke et al., 2004; Rodriguez et al., 2011), with up to a third of carbonaceous particles internally mixed with mineral dust (Hand et al., 2010). The presence of BC on large dust particles will increase the MAC of the coarse fraction. The presence of BC on dust means, that for these source regions, larger MAC values will be used to convert the optical measurements into dust concentrations. BC present on dust particles contributes negligibly to the mass and the resulting increase in PM10 concentrations is due to dust mass only. The increased MAC of these coagulated particles is also the relevant climate parameter, as dust and BC need to be taken into account together when estimating the direct radiative efficiency of such particles. To reduce the uncertainty resulting from different MAC values, a mineral dust source location can be determined using back-trajectory analysis and an appropriate MAC should be used for each source location."

Another absence is lack in the discussion (or introduction) of comparison of advantages and shortcomings with other methods, such as optical particle counting and aerodynamic sizing.

Author's response: Particle counting and sizing have not been included in discussion

because these methods do not discriminate between mineral dust and other aerosol. Other qualitative and quantitative methods have been discussed in the Introduction. This discussion has been extended in line with the reviewers' comments.

Typos and corrections: Line 76: "allow for hourly" is written but "allow hourly" is meant. Line 324: "Single" should be "single".

Author's response: The misspellings are corrected. Also the figure numbering was corrected.

References Rodríguez, S., Alastuey, A., Alonso-Pérez, S., Querol, X., Cuevas, E., Abreu-Afonso, J., Viana, M., Pérez, N., Pandolfi, M., and de la Rosa, J.: Transport of desert dust mixed with North African industrial pollutants in the subtropical Saharan Air Layer, Atmos. Chem. Phys., 11, 6663–6685, https://doi.org/10.5194/acp-11-6663-2011, 2011.

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