Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-506-AC3, 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.

Luka Drinovec et al.

luka.drinovec@ijs.si

Received and published: 4 June 2020

amt-2019-506 - Answer to referee #2 (RC3)

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

This work presents a novel on-line detection technique of dust absorption (named VI-PM1) by comparing a coupled high flow virtual impactor sampler with an Aethalometer (model AE33) with the absorption of the submicron aerosol fraction measured with the same absorption photometer. This method was applied for detecting desert dust

Printer-friendly version

Discussion paper

and was tested in the field for a period of two months at a regional background site in the Eastern Mediterranean. Such new techniques are most valuable to the field and VI-PM1 is expected to provide valuable information about dust particles and their properties. The authors however need to emphasize more the limitations of the method especially under conditions that the mineral dust is contaminated with black carbon.

Author's response: The method uses a single MAC value to calculate mineral dust concentration from the absorption data. MAC for different source locations is affected both by the variation of mineral composition (see chapter 3.7) and also by the possible contamination by black carbon. We treat the mineral dust contaminated by BC as the mineral dust that is measured at the receptor site, including the possible contamination. The uncertainty due to variation of the MAC can be lowered by using source location specific MAC value.

Changes to the manuscript: Section 3.7, Line 594589: "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. "

Specific Comments

L 195: The effect of water uptake in the sampling line, as could occur in Cyprus in spring time due to high ambient temperatures and RH, would require a drying step prior to the aethalometers which is however not described here. On the other hand, the APS and the nephelometer were connected to a nafion providing measurements in dry conditions. How were data handled since different conditions were applied? What limitations may be introduced due to water uptake by the particles?

Author's response: Certain aerosol species are hygroscopic which cause the increase in particle size in increased RH. The most hygroscopic are salts (sea salt, nitrates and sulphates) and oxygenated organic compounds. Mineral dust and black carbon alone are not hygroscopic and thus (if not coated) not susceptible to changes of optical properties due to humidity changes. Aethalometer samples have not been dried, as stated in the manuscript. The station temperature was kept at 25+/-2 deg. C. Due to the high sample flow the virtual impactor operated at ambient temperature. During the campaign, the average ambient temperature was 20 deg. C with 35% relative humidity. Due to small differences between ambient and station temperatures, we did not apply any correction to the data.

L 341: In Fig. 3 there are some periods when PM1 measurements seem to be higher than TSP (e.g. 19 April). Can this be attributed to the unit to unit variability?

Author's response: Yes, the difference is attributed to the unit-to unit variability, which was quantified in the Supplement S3. It shows that measurement uncertainty at 370 nm is about 18%.

Changes to the manuscript: Section 3.1, Line 360356: ÂżThe differences are inside the measurement uncertainty of the Aethalometers (Supplement S3). Âż

L. 350: Since the laboratory tests for the enhancement factor were originally performed with flows 75 and 1.5 lpm and 95 and 5 lpm, why did the flows were finally chosen to be 100 and 2 lpm?

Author's response: We wanted to obtain higher concentration efficiencies which depend on the ratio of the flows Fin/Fout. With the minimum sample flow through the AE33 of 2 lpm we chose Fin of 100 lpm. We used the calibration curve obtained at 75 lpm to 1.5 lpm which has the same theoretical concentration efficiency of 50.

Changes to the manuscript: Section 3.2, Line 376372: "Using the minimum sample flow of AE33 of 2 lpm and maximum flow of the virtual impactor pump we obtained we obtained the maximum Fin/Fout ratio of 50.Âń

L. 357: It would be better the axis to be in μm rather than nm.

Author's response: The axis units on Figure 4 was changed to μm.

L 410: To my opinion babs, mineral dust is not appropriate to describe the right term of this equation. This would require that there is no BC in the coarse mode, it would fail to describe the possibility of internally mixed BC and dust particles. Once internally mixed, the particles would have different optical properties than those of pure dust (e.g. Scarnato et al., 2015). In the Eastern Mediterranean such a mixture is possible. I recommend to change the left term to bcoarse or similar. This applies to Equation 7 and the subscript of MAC as well. Overall, a short discussion should be dedicated to this issue, expanding the sentence in Line 510 and on.

Author's response: The absorption coefficient in Equation 6 represents all absorbing species in the coarse aerosol fraction, thus the caption can be changed from babs, mineral dust to babs, PM10-1. The situation is different for MACmineral dust, 370 nm, which is calculated using reference mineral dust concentration and not coarse mass concentration. In the same way Equation 7 represents calculated mineral dust concentration and not coarse fraction mass concentration.

Changes to the manuscript: Equation 6 is changed to b_(abs,PM10-1)=(b_(abs,VI)-b_(abs,PM1))/EF .

Author's response: As explained above, MAC is a property of the mineral dust sampled

during the calibration campaign. The value is representative for the source region during the campaign. As observed during our measurement campaign, the dust was probably contaminated by black carbon. The uncertainty of the method can be further reduced by applying MAC values specific for each source region. The subject is being studied and will be reported in a separate article.

Changes to the manuscript: Section 3.24, Line 541537:"Simulations show that black carbon stuck to the mineral dust particles can severely change its optical properties, but the effect depends on the particle size (Scarnato et al., 2015). Because of the differences in dust mineral composition and contamination with BC, we expect MAC to be source region specific."

Changes to the manuscript: Section 3.7, Line 594589: "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."

Changes to the manuscript: References, Line 830832: "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. Changes to the manuscript: References, Line 834836: “Scarnato, B. V., China, S., Nielsen, K., and Mazzoleni, C.: Perturbations of the optical properties of mineral dust particles by mixing with black carbon: a numerical simulation study, Atmos. Chem. Phys., 15, 6913–6928, https://doi.org/10.5194/acp-15-6913- 2015, 2015.”

References

Scarnato, B. V., China, S., Nielsen, K., and Mazzoleni, C.: Perturbations of the optical properties of mineral dust particles by mixing with black carbon: a numerical simulation study, Atmos. Chem. Phys., 15, 6913–6928, https://doi.org/10.5194/acp-15-6913-2015, 2015.

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.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-506, 2020.

Printer-friendly version

Discussion paper