Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-79-RC2, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "A multi-wavelength numerical model in support to quantitative retrievals of aerosol properties from automated-lidar-ceilometers and test applications for AOT and PM10 estimation" *by* Davide Dionisi et al.

Anonymous Referee #2

Received and published: 22 May 2018

General comment: The approach described in this manuscript can provide a helpful expansion of the data analysis of lidar-ceilometers. How much information can be added to the data however depends on the input to the model. Here, the model is trained with observations representing a continental European aerosol. Thus the results are representative for this type of aerosol and regions/times where/when it occurs. The approach in general is able to add significant benefit to climatologies derived from lidar-ceilometer networks and should therefore be published. The presentation of methods

and results is sound. Limitation of the applicability to specific situations have mostly clearly been addressed by the authors. The manuscript deals with as-far-as-possible exploitation of ceilometer data – that is good. But at the point of estimating mass concentrations (see below) I have concerns, because the results you show suggest that PM10 can be estimated within 10-20% accuracy by ceilometers, which I don't think is generally true. Given the uncertainties and assumptions involved, the presented time series comparison may not even be representative for your sites at all times. Though inversion of optical data is often remarkably good-natured and your 'calibration' works for the related conditions and regional climate, this does not take into account the complexity of PM10 measurements which reflects in the +/- 25% measurement accuracy in the EC 2008/50 directive.

The manuscript presents a model-based approach to infer extinction coefficients, particle surface- and volume/mass-concentrations from backscatter coefficients measured by lidar-ceilometers, based on statistical relations. Mie-calculations are performed for empirical ranges of particle sizes and refractive indices, yielding conversion factors which are stored into a look-up table. As the influence of unsperical particles is shortly discussed, the Mie approach seems sufficient. The aerosol modal representation and refractive indices for model input are based on a comprehensive literature survey. Owing to the size distributions and the range of refractive indices used for the ensemble calculations, it is valid for 'continental aerosol'. The inversion of ALC profiles uses state-of-the-art absolute calibration and the Rayleigh method according to Wiegner et al. 2012.

Evaluations are the most important part of the manuscript: The simulations (not including measurements) are evaluated against measurements: First the backscatter coefficient (BSC) vs Lidar ratio (LR) relation is compared against climatologies from EARLINET, CALIPSO and other networks. It is shown that average climatological LR are reproduced and that the frequency distribution of simulated BSC-LR pairs is roughly consistent with the corresponding distribution of EARLINET observations. There are, however, deviations, which are attributed to particle sizes and compositions which are, by design, not captured by the model.

Then, AOD inferred from CHM15k lidar-ceilometers are compared against each 1-2 years of data from 3 Italian stations with radiometers. Frequency distributions of the bias between inferred and measured AOD are shown and one example for illustration. The usual extrapolations of radiometers to 1064 nm and of the profile below 400m towards the ground (overlap) are done.

Thirdly, volume and mass concentrations are estimated from lidar-ceilometers, based on the proposed model and compared to in-situ measurements with optical particle spectrometers. Given your limitation to 'continental type aerosol', the large variability in essential conversion factors showing up in the statistical evaluations, uncertainties due to the overlap extrapolation, I wonder how representative these results are. As OPS measure dry aerosol while lidar/ALC measure optical parameters under ambient conditions: I can hardly believe that the parametrisation in your model and the information about atmospheric humidity as such is accurate enough to allow proper humidity correction in the range of the uncertainties given here. I think that these results can only be achieved under very specific conditions - aerosol type, stratification, homogeneity etc. This should be discussed in more detail.

Specific comments: Line 80: . . .and affordable for aerosol applications, . . .

Line 108: this is at best true in a climatological sense, but not on shorter time scales. But even on the long-term, Putaud et al. 2010 report large differences in the aerosol distribution over Europe

Line 181: In this formula mRH converges to 2m0 for rmi_RH » rmi_0, i.e. for a large aequous droplet. Replace by mRh = mW + . . .

Line 187: In eq. 4 and 5, rim_RH and miRH are the. . . should be . . .rmi_RH. . .

Line 225: It is unclear to me what that means – what is 1%?

L 235: weighted-LR' $\pm$ 1 s. d. -> write: standard deviation

Line 305 and Fig 4: but only as a statistical ensemble average over all data without evaluating the temporal correlation

Line 319ff: Hamburg (and the others as well) is not really a continental site but considerable sea-salt contribution can be expected in the coarse mode, (at least for Hamburg) likely not less on average than from dust. So does the statistical agreement with your model results confirm the significance of your model? Are you sure, you'd get a worse agreement e.g. for Mace Head and would you expect to be able to draw significant conclusions about the aerosol type?

Line 420: why do you exclude desert dust days?

Line 434: you should note that these conclusions are valid only in a statistical sense

Line 452: the data from 0-75m are those from 300 m a.g. (where overlap correction is feasible) extrapolated to the ground?

Line 444ff: You should specifiy that these OPC channel data are given as diameters, while above you mostly discuss sizes in terms of radii

Line 480: what is the meaning of a particle density of 2 μg/m^3? Typical densities are of the order 1000 kg/m^3. There seems to be a conversion factor included.

Line 486ff: Isn't the nocturnal boundary layer depth often in the range of few tens to hundreds of meters, even in summer? Strong vertical gradients in the lowest 200-300 m seem quite likely to me.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-79, 2018.