We have addressed all of the points raised by the reviewer (copied here and shown in black text), and include our responses to each point below (in blue text). Where there has been a major change in the manuscript we provide the original text (in black italics) and the new text (in blue italics).

1 Anonymous Referee 1

The manuscript deals with a methodology that can be used to derive the telescopic functions of a pulsed Doppler lidar. The idea is to use the information on the lidars telescopic functions to derive the attenuated backscatter profile from the SNR signal from the wind- lidar. The telescopic functions are estimated by comparing (by iteration) with the attenuated backscatter profile measured by a ceilometer.

After having read the paper several times I am still in doubt whether the methodology is intended for applied use or if is a purely academic exercise. I would like the authors to put more emphasis on the use of wind-lidars in practical applications for the measurements of attenuated backscatter profiles and what can achieved by such measurements from wind-lidars.

We have also included a statement outlining the advantage of obtaining attenuated backscatter and Doppler velocity measurements in the same measurement volume, with reference to the potential of deriving mass-fluxes, e.g. aerosol or cloud.

There is also an advantage to obtaining attenuated backscatter and Doppler velocity measurements in the same measurement volume, since this will simplify the calculation of cloud or aerosol mass-fluxes (Engelmann et al.*, 2008).*

1) It needs to be clarified why the data filtering is so strong, why are there so few good profiles out of so many available profiles in table 3. Are some of these data simply considered outliers - it is always dangerous to neglect outliers.

The majority of the filtering is to remove profiles that are not suitable for this method - profiles that contain clouds, precipitation or multiple aerosol layers (some sites are more cloudy than others). This explains the reduction of 'available profiles' to 'total estimates'. Then, the outlier filtering using MAD is the difference between 'total' and 'good estimates' and is usually $< 10\%$, except for the NSA site. The SNR for both instruments is quite low at NSA due to the low aerosol loading; hence the outlier filtering is stronger. The outliers are still plotted in Fig. 3 but not used in calculating the uncertainties.

2) How much does the improved telescopic functions improve the attenuated backscatter profile as compared to the information from the factory setting of the telescopic functions?

This will vary from instrument to instrument. D is often quite close to the nominal value provided by the manufacturer, but f may not be or may be unknown, and for some models, f can also be adjusted by some known or unknown amount by the operator.

3) How well does the attenuated backscatter profiles determined from the wind lidar SNR profile compare to the profiles observed by ceilometer. Only a few examples are shown in the paper, and a real quantification based on many (all) profiles from these rich data sets would be an considerable improvement to the paper. The main question is if the wind lidar is able on a routine basis to produce reliable profiles of attenuated backscatter profiles. A ceilometer is a very cheap instrument compared to a wind lidar, is it still recommendable to have a ceilometer next to a wind lidar or can the ceilometer be omitted and the backscatter profile determined with sufficient accuracy from the SNR?

The absolute values of the attenuated backscatter from the Doppler lidar and the ceilometer are not expected to be the same due to the difference in the wavelength, but for a homogeneous aerosol layer, the profile shape will match. The Doppler lidar is expected to then provide reliable profiles on a routine basis after applying the telescope focus function calculated using this method together with a calibration factor calculated using e.g. (Westbrook et al., 2010a).

Calculation of the telescope focus function can be made from a short time-series next to a ceilometer; the instrument can then be moved to another location, for campaigns for example. In practice this method can be performed during commissioning, and in principle, the manufacturer could also provide this service.

1.1 Minor remarks

1. Line 28 – page 5. Why is the threshold chosen to be 22.2 dB, the number sounds arbitrary. Why not simply set a very high threshold value for this exercise – e. g. -15 dB, to secure high quality data?

   The threshold is based on the SNR limit in Manninen et al.(2016) as the data we used has been processed with the same method. This threshold is based on the expected noise floor for the instruments considered here (Halo Streamline and Streamline XR) and should probably be modified for different instruments. A citation for the threshold has been added. We agree that a higher threshold could be used to secure high quality data, but we also wanted to test the applicability of the method in situations where mostly low SNR is expected, e.g. at the NSA site in Alaska where the aerosol loading is very low.

2. Line 28 page 5, If observations below -22.2 dB are discarded, the averaged SNR will be biased – is this accounted for?

   The order of these two steps was written incorrectly in the manuscript. The averaging was done prior to discarding the low SNR data, and the threshold then applied to the averaged data. The manuscript has now been corrected.

Before input, the Doppler lidar SNR data had a background correction applied to reduce bias (Manninen et al., 2016), and data below a minimum SNR threshold of -22.2 dB was discarded. Then, both ceilometer and Doppler lidar data were averaged to a common 30-minute, 30 m vertical resolution grid, using interpolation where necessary (only for one period from Darwin).

Before input, the Doppler lidar SNR data had a background correction applied to reduce bias (Manninen et al., 2016). Both ceilometer and Doppler lidar data were averaged to a common 30-minute, 30 m vertical resolution grid, using linear interpolation where necessary (only for one period from Darwin). After averaging, data below a minimum threshold of -22.2 dB (Manninen et al., 2016) was discarded.

3. Line 29 page 5. Explain what is meant by "using interpolation where necessary".

   Interpolation may necessary to get the ceilometer and Doppler lidar data on the same vertical grid. Usually, the vertical resolution of the ceilometer data is high enough (10 m) so that 2 or 3 range gates in the vertical can be summed to match the Doppler lidar vertical resolution, however at one site the difference between the vertical resolutions of the two instruments required linear interpolation between ceilometer range gates to match the Doppler lidar resolution.

4. Line 9 page 6. How is the cloud base detected? Do you use a threshold method (if yes what is the threshold) or a more sophisticated method?

   Here we use the Vaisala cloud base detection, which uses a gradient method on the ceilometer attenuated backscatter profile. A more sophisticated shape method (e.g. Tuononen et al., 2019) could also be used but we are not so interested in the precise cloud base value, more whether a cloud layer exists in the profile - this is also why we only use data more than 150 m below cloud base.

5. Line 17, Page 8: Explain why you expect f-2 to be superior.

   When examining Equation (2), we expect f-2 to be superior to f, and f-2 is closer to the distribution observed for the telescope focus in figure 3. Additionally, figure 1a, which is plotted with range in logarithmic units also suggests this relationship.

6. Why do you mix two parameters for the flagging in Eq. (8), It seems more natural to flag the individual parameter.

   Our best estimate for the Telescope Focus Function parameters is the peak of the bi-variate (f,D) distribution, and thus for the flagging we use distance from the peak of the bi-variate distribution.

References

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