Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
https://doi.org/10.5194/amt-2022-132-RC1, 2022

Comment on amt-2022-132

Anonymous Referee #2

Referee comment on "Atmospheric visibility inferred from continuous-wave Doppler wind lidar" by Manuel Queißer et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-132-RC1, 2022

Here, visibility is estimated from a continuous-wave (CW) Doppler lidar and compared with visibility sensors at two locations: Cabauw, Netherlands and Pershore, United Kingdom. Retrieving visibility or aerosol backscatter from CW Doppler lidars would enable further studies with a widely-spread instrument type, which is currently not utilised to retrieve aerosol-related parameters. Therefore, I consider this manuscript within the scope of AMT.

Unfortunately, agreement between the CW Doppler lidar and visibility sensor is not very good, and it is questionable how useful this method would be. What is missing, is a more detailed analysis into the reasons for the observed discrepancy.

Major comments

I am not convinced that the observed differences are due to aerosol properties for the most part. Especially, since the backscatter coefficient retrieved from the CW Doppler lidar is not corrected for range, focus or attenuation. For instance, attenuated backscatter from ceilometers is considered to require calibration before use (e.g. Kotthaus et al., 2016; Hopkin et al., 2019). Also pulsed Doppler lidars require substantial post-processing for aerosol parameter retrievals (e.g. Vakkari et al., 2019; Pentikäinen et al., 2020). Please compare attenuated backscatter from CW Doppler lidar with attenuated backscatter from a reference instrument (e.g. ceilometer with proper post-processing).

Lines 218-220 "Towards lower visibilities, the dependence becomes increasingly nonlinear. Only visibilities of at least 4 km are considered, which helps to select a data range with reasonably linear correlation between backscatter and inverse visibility and excludes the impact of fog or cloud on the visiometer readings." In my opinion, the low visibility end of the spectrum is even more interesting than > 4km range (e.g. fog detection). Please include <4km visibility in the analysis.

Specific comments

83-85 "The backscatter coefficient has a higher sensitivity to the size of the aerosols along the beam path and hence to the aerosol size distribution (SD) than the extinction coefficient." Please provide reference.

103-105 "Due to the longer wavelength (~1550 nm) of most CW wind lidars compared with visible backscatter lidars described above, at normal working ranges (up to 300 m), the return signal is not sensitive to atmospheric extinction, but is practically governed by the backscatter coefficient only." If visibility is low, I'd expect extinction to substantial. And for many applications low visibility is the interesting part. Can you indicate a visibility range when extinction can be ignored?

134-135 How good is the cloud removal algorithm? Has it been compared with a ceilometer for instance?

137 Please define “pi”.

180-181 “As stated above, the backscatter coefficients from the wind lidars are time series in units of 1.3×10-6 m-1 sr-1.” Please give backscatter in units of [m-1 sr-1] throughout the paper. Scaling by 1.3 x 10^6 makes it hard to follow the results.

Figure 2c seems identical to a photo in Knoop et al. (2021). Please indicate source and license to reproduce it.

204-205 “A typical value for ð□□¼ has been empirically determined as 1.4 for visibilities between 6 and 20 km (Nebuloni et al., 2005), which is adopted here.” Yet, on line 252-253 Angstrom exponent is changed to 2.0. Please give some more references to justify the selected Angstrom exponent and lidar ratio. At least Baars et al. (2016) and Illingworth et al. (2015) give some values for a few aerosol types, but there are probably better (and more recent) references.

209 Please check “Figure 3 3 shows”

225-226 “The nonlinearity of the visibility with backscatter could be attributed to different contributions to the average aerosol size distribution (Curcio et al., 1958).” I don’t quite understand what are the “different contributions” here, please clarify.

Figure 3: Please plot backscatter on logarithmic scale without the scaling factor.

265-269 Please provide a literature overview of lidar-retrieved Angstrom exponent and lidar ratio at Cabauw and Pershore, or similar environments, if measurements are not available for these sites.

279 “The lidar backscatter coefficient can be quite dynamic, changing by several factors within minutes.” Please specify which factors.

Figure 5 and 6 captions: please define “BS”.

309-310 “general observations of a vertically weakly exponential decrease in lidar signal strength (hence backscatter) that becomes significant above ~100 m agl.” Is this due to lack of range correction in the backscatter retrieval?

345-346 “A backscatter minimum around July has been measured with different CW wind lidars in other locations in the Northern Hemisphere.” Please add reference.

433-438 Are there any other studies that report similar seasonality for backscatter?

455-457 and 462-464 See e.g. Illingworth et al. (2015) and Baars et al. (2016) for range of values associated with different aerosol types. Please also check if you can find better references on the topic.

525-527 “For Cabauw, lidar backscatter derived visibility was found to be height dependent (Fig. 8), in line with the observation that under cloud free conditions backscatter from CW-wind lidar usually tends to slightly decrease with height in the lower part of the planetary boundary layer.” Is this due to lack of range correction in the backscatter retrieval?

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