amt-2016-182
Title : Radiation fog formation alerts using attenuated backscatter power from automatic Lidars and ceilometers

Response to Reviewer 2 comments.

The authors would like to thank the Anonymous reviewer #2 for helpful comments and suggestions. Reviewer comments are shown in black colour. A response is provided for each comment and shown in blue colour.

Anonymous Referee #2

GENERAL COMMENTS (GC)
This manuscript presents a practical method for providing fog alerts from routine measurements that will be of major benefit to society. The study takes a pragmatic approach suitable for routine measurements, together with excellent analysis, and demonstrates applicability to real cases. The manuscript provides a clear methodology that can potentially be objectively applied to numerous sites across the globe. I believe this paper is ready for publication after a few very minor modifications.

REV2GC1: The method understandably uses threshold values for some of the alerts. A quick discussion on how sensitive the method is to the choice of threshold values would be very useful; the authors already note that the method will probably require some tuning at different locations. The method also assumes homogeneous aerosol properties; there may be locations where this assumption may not be so reliable, could the authors elaborate a little on the likely impact in terms of fog alerts?
Fog is a rare event, so I assume it is better to have some 'false alarms' rather than any 'misses'.

Response to GC1: Changing alert threshold values, and changing reference relative humidity both have an impact on the time at which the alert occurs. Changing the reference relative humidity from 40% to 80% delays a minor-level alert occurrence by 30-60 min. Changing the minor-level alert value by one order of magnitude also delays the alert occurrence by 60 min. This last sentence has been added to the text page 16, lines 13-14. Depending on the nature of the aerosols, hygroscopic growth may require different relative humidity conditions. A more in depth study involving more data is required to study alert occurrences depending the aerosol chemical nature or size distributions.

REV2GC2: It should also be noted that this method requires ALCs that have full overlap already at quite low altitudes so that reliable attenuated backscatter values are available from 50 m or so in height. This is a major implication in terms of instrument selection.

Response to GC2: Alerts at minor, moderate and severe levels are computed based on Eq. 18, that depend on the ratio of an ALC backscatter at a given time to that of an ALC backscatter in a drier condition that occurred earlier. Reaching full overlap is not required to derive this ratio, as the overlap value cancels out in the ratio. However, the overlap function could be temperature dependent and hence could change with time. Hence calculating the

backscatter ratio at heights where the overlap function is less than 0.1 could introduce significant uncertainties in the ratio calculation. For example, Vaisala does not recommend to use the CL51 data below 50 m agl. For the CL31, the lower limit is about 10 min.

SPECIFIC COMMENTS

Page 1, line 26: I suggest that you start this sentence with 'We find that an alert for pre-fog conditions predominantly occurs ..'

Response: changed.

Page 2, line 1: Replace 'sensitive to relative humidity' with 'sensitive to the relative humidity'.

Response: changed.

Page 3, line 3: I suggest that you replace 'formation of a liquid layer near the ground' with 'formation of a layer containing liquid water droplets near the ground'.

Response: changed.

Page 3, lines 7-8: Replace 'air traffic in the' with 'air traffic over the'. Page 3, line 21: Replace 'scores' with 'skill scores'.

Response: changed.

Page 4, line 10: Here and elsewhere, replace 'could' with 'can'. Page 5, line 3: Replace 'are' with 'have been'.

Response: changed.

Page 5, line 10: Table 1 states 910 nm, as do the manuals. Also page 16, line 17. Page 6, line 1: Replace 'size' with 'sizes'.

Response: changed.

Page 6, lines 2,3: Suggest that you state 'relatively low SNR' as the latest CL51 instrument usually exhibits high SNR in the boundary layer at night.

Response: changed.

Page 6, line 24: Suggest replacing 'for bi-axial ALCs full overlap can be reached' with 'for bi-axial A LCs full overlap can only be reached'.

Response: changed.

Page 7, lines 9, 10, 11, 13 (and elsewhere): Remove the indefinite article 'a' when referring to fog. Also, do not use the plural 'fogs' on line 11.

Response: changed.

Page 7, lines 7-9,11: Use 'vertically-developed' and 'quasi-radiation'.

Response: changed.

Page 7, lines 11-12: I suggest that you combine these two sentences otherwise it could be read as saying that all fog is due to inactivated haze particles.

Response: changed.

Page 8, lines 14, 15: The real part of the refractive index may be lower for pure water than aerosol; here you are dealing with a mixture of water and aerosol and it is the relative change in the amount of water in the droplet that changes the refractive index. Note that the imaginary part of the refractive index is small but not zero for pure water, and that this also varies with wavelength.

Response: changed to "The imaginary part of water is near zero…".

Page 9, line 12: Replace 'properties as' with 'properties such as'. Page 9, line 14: Replace 'describe that' with 'assume that'.

Response: changed.

Page 10, line 16: Replace 'follow' with 'follows'.

Response: changed.

Page 10, line 18: Replace 'dividing' with 'by dividing'.

Response: changed.

Page 10, line 20: Replace 'in periods' with 'over periods'. Is there a suitable reference showing the instrument calibration stability (i.e. that the calibration factor and the overlap function are stable)?

Response: there is no reference showing Vaisala ceilometer calibration stability. Studies performed in the framework of the TOPROF COST action show that calibration coefficient change over time on seasonal scales (not diurnal scales). Day-night differences of about 10-20% in the overlap function of Lufft CHM15k ceilometers have been found by Hervo et al. (2016). According to Kotthaus et al. (2016), overlap function uncertainties in CL31 ceilometers are expected to be less than 10% due to low internal temperature variations.

Hervo, M., Poltera, Y., and Haefele, A.: An empirical method to correct for temperature dependent variations in the overlap function of CHM15k ceilometers, Atmos. Meas. Tech., doi:10.5194/amt-2016-30, in press, 2016.

Kotthaus, S., O'Connor, E., Münkel, C., Charlton-Perez, C., Gabey, A. M., Grimmond, C. S. B., and Haeffelin M.: Recommendations for processing atmospheric attenuated backscatter profiles from Vaisala CL31 Ceilometers, Atmos. Meas. Tech., doi:10.5194/amt-2016-87, 2016.

Page 13, line 10: Replace 'had' with 'has'.

Response: changed.

Page 16, line 9: Should this be attenuated backscatter?

Response: changed to attenuated backscatter.

Page 17, lines 16, 21 and elsewhere (page 21): Suggest using 'm hr-1' rather than 'm/h'.

Response: changed to 'm h^{-1} ' page 17 and 21

Page 18, line 4: Replace 'alert' with 'alerts'.

Response: changed.

Page 19, line 2; Replace 'moistest' with 'most moist'. Page 22, line 11: Replace 'pre fog' with 'pre-fog'.

Response: changed Page 19. Page 22 'pre radiation fog' replaced by 'pre-radiation-fog'

Table 1: Full optical overlap for CL51 much lower than the 500 m stated here. You could include temporal resolution in this table.

Response: Wiegner et al. 2014 suggest that the CL51 signal is generally overestimated below 500 m due to an internal overlap correction function applied by the VAISALA software. Unfortunately this function is unknown to the user. During the Ceilinex campaign http://ceilinex2015.de/special-topics/overlap, a comparison between two CL51 on the same site showed significant differences in the CL51 signal below 500 m probably due to this internal overlap correction function. The figure caption now refers to this publication for further details about the CL51 optical overlap function.

Wiegner, M., Madonna, F., Binietoglou, I., Forkel, R., Gasteiger, J., Geiß, A., Pappalardo, G., Schäfer, K., and Thomas, W.: What is the benefit of ceilometers for aerosol remote sensing? An answer from EARLINET, Atmos. Meas. Tech., 7, 1979-1997, doi:10.5194/amt-7-1979-2014, 2014.

Temporal resolution added to Table 1.

Figure 3: There is a slight departure from the fit between 75% and 85% which looks like hysteresis in the aerosol response to RH - is this during the increase in RH or decrease?

Response: Figure 3 shows data for a monotonous increase of RH (no decrease, except a plateau near 65% RH), so the departure from the fit cannot be explained by a hysteresis in the aerosol response to RH.

Figure 5: Replace ’time series’ with ’Time series’.

Response: changed.

Figures 6, 7: Note somewhere in the caption that white is at either end of the colour scale (noise and cloud), or fill cloud (> 1e-4 m-1 sr-1) with some colour.

Response: RCS values below 1e-7 m-1 sr-1 are now shown in black instead of white.

Figures 6-9: In panel b, the colour for the line at the top of the panel (PARAFOG status?) is not described in the caption. What do you mean by ’Pre-fog conditions are clear’? Clear skies?

Response: PARAFOG status explained in the caption now. ’Pre-fog conditions are clear’ changed to ’Pre-fog conditions are cloud-free’.

Figure 11: It would be easier to read this figure if the colour scale was separate from the plot panels.

Response: changed.