

amt-2016-182

Title : Radiation fog formation alerts using attenuated backscatter power from automatic Lidars and ceilometers

Response to Reviewer 1 comments

The authors would like to thank the Anonymous reviewer #1 for helpful comments and suggestions. Reviewer comments are shown in black colour. A response is provided for each comment and shown in blue colour.

Reviewer 1 introductory comment:

This paper presents a very interesting method for the nowcasting of radiation fog using measurements from Lidars and ceilometers, as well as some additional instrumentation. The findings are of great interest for the forecasting of radiation fog, especially in areas with availability of these instruments (e.g. airports, where the problems associated with fog are especially important). The paper is well structured, although other options for the structure of the paper are possible. A good introduction to the algorithm is presented, where the authors show clearly all the problems/solutions for the applicability of the method. Then, the authors present more specific analyses for four case studies, as well as several results for 45 cases of radiation fog at two locations. I strongly recommend the publication of this paper in Atmospheric Measurements Techniques journal, since it provides a clear, good, interesting and potentially applicable method for the nowcasting of radiation fog. However, I have also some minor comments that could be addressed before the final publication.

GENERAL COMMENTS

REV1GC1: The Introduction section provides a good overview of the current problems in fog forecasting and the process of hygroscopic growth of fog condensation nuclei. There is a lack of references from lines 4 to 12 of page 4. I recommend to include more references here.

[Response to REV1GC1: four references have been added to this paragraph.](#)

REV1GC2: Section 2 introduces the sites, the differences between the instrumentation used at SIRTA and UCCLE. In this section, I think that section 2.3 (fog dataset description) is more a description of types of radiation fogs than a description of the cases used in the work, which is given in Table 3. Maybe the authors could re-consider the inclusion of this subsection in the final paper.

[Response to REV1GC2: we agree with the reviewer that the section was ill named. We rename Section 2.3 as "Radiation fog types used in this study". The last sentence of Section 2.3 is changed to "Our study relies on 45 cases of developed radiation fog, as defined above, observed at SIRTA and UCCLE."](#)

REV1GC3: Section 3 is the most theoretical part of the paper, where relationships of relative humidity, aerosol properties and measurements from ALCs are given. In this section, it is also explained technically how the hygroscopic growth of aerosols can be derived from

attenuated backscatter profiles of ALCs and RH measurements from a hygrometer. Since I am not an expert on this, I cannot correct or make suggestions on the development of these relationships and on the experiments performed. However, I have found this section very interesting and clear for readers not familiar with these relationships.

[Response to REV1GC3: We thank the reviewer for the positive feedback on Section 3.](#)

REV1GC4: In Section 4, an algorithm to detect rapid changes in aerosol backscatter is presented, which is used to detect pre-fog periods.

In step 1 of the algorithm (start), the authors could also suggest the use of previous works on detection of pre-fog periods to complement or improve this step, such those works presented by Menut et al. (2014) (DOI 10.1007/s10546-013-9875-1) or in Román-Cascón et al. (2016) (DOI: 10.1002/qj.2708). The results used in these works could be a good complement to improve this step, although more instrumentation would be required. I think the authors could suggest this in this part.

Briefly, all the steps and thresholds described and determined in the work seem to be quite studied and analysed by the authors, which demonstrate that the preparation of the work have been done in a proper way.

[Response to REV1GC4: We agree with the reviewer that other meteorological parameters could be used to determine if PARAFOG should be turned ON or OFF. For example the authors cited above use also air temperature temporal gradient, wind speed and Net infrared flux. The temperature temporal gradient distribution in pre-fog condition reveals predominantly negative values. It could be added as criteria to turn PARAFOG ON. High wind speed could be added as criteria to turn PARAFOG OFF. We do not use net infrared fluxes directly, instead we use cloud fraction as a proxy to determine if radiative cooling conditions are present or not.](#)

[The following sentence is added at the bottom of page 13: "Other parameters could also be used to identify conditions that are potentially favorable for fog formation, such a air temperature temporal gradient and horizontal wind speed, as suggested by Menut et al. \(2014\), although more instrumentation would be required. "](#)

REV1GC5: In subsection 4.1, the authors test the algorithm over 3 situations at SIRTA and 1 at UCCLE.

Figures 6, 7, 8, 9: I would recommend to include more details about the figures in the figure captions. For example: "Figure 6: Time series presenting measurements and alert levels in pre-fog conditions on 15-16 November 2011 at SIRTA. (a) ALC attenuated backscatter (colour contours) and horizontal visibility (grey line). (b) Alert levels (colours) and altitude of Hmax (purple points)."

- Figures 6, 7, 8, 9: Please, add height of measurement of horizontal visibility. Add also the meaning of horizontal green and orange lines in figure captions.

- Figure 7: Where is the line of visibility?

- Figure 8: “Low-level alert 90 min before fog formation. Severe alert 30 min before fog formation” (is this correct?)

Response to REV1GC5: Figure caption text has been modified following the suggestion. A sentence has been added to explain the meaning of the green/orange line. Visibility measurements are not available in UCCLE, hence they don't appear on Figure 7. Figure 8 caption has been changed.

REV1GC6: In the whole text, I think the term “low-level” (referring to alert level) can lead to confusion (alert in the low-level atmosphere). I recommend to use the term “minor” or another one to avoid this.

Response to REV1GC6: The word “minor” is a good suggestion instead of “low-level”. Text and figures have been changed to reflect that suggestion.

REV1GC7: Case studies of section 4.2 and section 5.4 (alert altitudes): It is shown how in many cases of radiation fogs studied, the activation of the droplets occurs at certain height at both sites (around 100 m (mean) and even higher at the urban site) and then it is observed the subsidence of Hmax. For me, it is not clear if this also means the subsidence of the “fog layer”, as written in page 19 (lines 24 to 26) or only the activation. If the results refer to the subsidence of the fog layer, I wonder if this could be checked with different visibilimeters at different heights (maybe not available) or if this result could be an artefact from the algorithm or from the ALC measurements (maybe with more problems with layers below 70-100 m (not only at UCCLE)). These results are quite interesting, since normally (and based on other studies), radiation fog normally starts to be formed quite close to the ground and then it evolves into higher heights, except for “cloud-base-lowering (CBL) fog types”, when a fog occurring certain day is the result of the lowering of “elevated” clouds from previous fog of the precedent day or even the result of the dissipation of previous fog (but with more availability of humidity at some elevated layer). Maybe most of the cases studied here are CBL fog more than pure radiation fog (see Tardif and Rasmussen (2007) classification (<http://journals.ametsoc.org/doi/pdf/10.1175/JAM2516.1>)). Could the authors discuss or demonstrate a little bit more about this? Maybe the authors could check somehow if the studied fogs are preceded by other foggy periods or if this fact (previous foggy days) can influence the height of Hmax, since it seems logical that Hmax could be higher if fog were observed the previous days.

Response to REV1GC7: We agree with the reviewer that typically a radiation fog occurs due to cooling of the air just above the surface. This occurs predominantly in the absence of a cloud ceiling. However, as noted by Tardif and Rasmussen (2007) in their fog definition, a radiation fog can also start with an elevated fog formation, with a cloud ceiling near or below 100 m followed shortly by fog at the surface. Here, prior to the elevated fog formation, the sky is predominantly cloud-free enabling surface radiative cooling. We find that those are quite frequent at both sites studied here.

In contrast a “cloud-base-lowering (CBL) fog type” corresponds to a gradual lowering of a cloud ceiling during several hours prior to fog occurrence at the surface. Hence during several hours, the sky is mostly overcast, preventing any significant surface radiative cooling.

SOME SPECIFIC COMMENTS

Page 3, line 4: airports, air traffic. . .

Page 3, line 6: reduced, possibly affecting. . .

Page 3, line 6: Hence, accurate. . . (please, revise the use of commas in the whole text).

Page 3, line 10: References in chronological order (please, revise in the whole text).

Page 5, line 13: 100 m (please, revise the space before “m” in the whole text).

Page 6, line 1: whose size ranges.

Page 7, line 7: “under cloud-free atmosphere”.

Page 7, line 12: “. . . and 3 km (Dupont et al. (2015), where the low visibility. . .”)

Page 7, line 11: QFOG can also be similar to the definition of mist by AMS?

Page 17, line 15: I would recommend to add: “This suggests that once fog droplets. . .” (since visibility measurements are not available at several heights to be absolutely sure).

[Response to specific comments: all 10 suggested changes have been made.](#)