AMT-2022-12: Response to review of revised submission

03 August 2022

We would like to thank the editor and two reviewers for carefully considering our revised manuscript and provide a response to the addition recommendations from reviewer #3 below.

Original reviewer comments are included in *italics*. Co-author responses are in simple text, and quotations from the revised manuscript are enclosed in square brackets [“..”]. All line numbers refer to the final revised version of the manuscript.

Response to anonymous referee report #2:

Line 90 : Can you mention that the relative LWP uncertainties from MWR for low LWP alone can be reduced by a combination from a 1 channel infrared spectrometer (Marke et al, 2016).

I have added the following sentence:

Lines 88-90: [“These errors can be reduced by combining the MWR data with measurements from infrared spectrometers (either with single or multiple channels) that are more sensitive to small amounts of liquid water (Marke et al., 2016.)”]

Table 3 is cut on the right.

This is only the case for the tracked-changes document, the table is correct for the final submission.

Line 287 : initial increase in LWP associated with fog formation and visibility reduction. As you cannot be 100 % sure that this is associated with fog I would change into :
« initial increase in LWP defined as an indicator of fog formation in this study that might lead to visibility reduction by defining ‘fog onset’ as where the retrieved ….. »

I have made this change (line in revised manuscript: 283-284)

Line 409 : as the new fog definition used in the manuscript has been defined quite far from this section, I would remind the reader of this definition here :
the development of radiation fog under clear skies is detected earlier in the AERIoe retrievals compared to the MWRoe (following our fog definition as the presence of near surface liquid water that has a detectable radiative impact).

I have added this sentence (line in revised manuscript: 401)

Line 418 (figure 10) : Could the authors clarify if they are sure that the new « fog » definition from the ceilometer backscatter coefficient (increase in the ceilometer mean backscatter by more than three standard-deviations) represent well the fog formation and not the aerosol hygroscopic growth. In fact, Haeffelin et al 2016 demonstrated that an increase in the ceilometer backscatter coefficients can be associated with the aerosol hygroscopic growth and not the fog formation. This is used in pre-fog alerts to identify the aerosol hygroscopic

growth occuring in fact before fog formation. I have some doubts because, in figure 10, the ceilometer output is « obscurred signal » and not « vertical visibility » up to ~1h30 UTC. This would make a difference with the MWR detection of ~ 40 minutes instead of ~ the announced 2 hours by using the fog onset definition based on the LWP increase or the ceilometer backscatter coefficient increase.
Could you please explicit why you think that the ceilometer backscatter coefficient increase can be considered as fog formation between 0 and 1h30 and not due to aerosol hygroscopic growth ?
If you think that obscured signal means that droplets are present, in that sense it would be in line with your new fog definition but I think it would be valuable for the paper to just add a few lines of discussion on this subject (aerosol growth versus presence of fog droplets and remind again that if this is for sure liquid droplets this is in line with the fog definition used in the paper).

Thank you for highlighting this point. We do not distinguish between the detection of droplet formation or aerosol hygroscopic growth using the simple ceilometer backscatter threshold and I have added the following sentences to make this clear:

Lines 412 to 418: ["Ceilometer attenuated backscatter is sensitive the scattering cross section or molecules and particles in the atmosphere and can be sensitive the presence of atmospheric aerosols (e.g. Markowicz et al., 2008), and to the hygroscopic growth of aerosols prior to their activation into fog droplets (Haeffelin et al., 2016), the latter of which can be a precursor to radiation fog formation (Haeffelin et al., 2016). At Summit, the aerosol scattering cross section is usually extremely small (< 2x10−6 m−1 at 550 nm, Schmeisser et al., 2018), and any signal due to the presence of aerosols is incorporated into the calculation into the mean 'clear-sky' backscatter. We do not distinguish between the detection of aerosol hygroscopic growth and droplet formation in the ceilometer backscatter"]

For the case study described in the text and shown in figure 10, we can say for certain that that there was fog present reducing visibility to just 400 m at 00 UTC since it was recorded by the onsite observer performing weather observations at the time (described in lines 420 to 421). At this time the ceilometer did only report an 'obscured' signal (rather than vertical visibility, fig. 10) demonstrating that this can indeed be the case when fog is present (even using the more traditional definition of fog).

I also added in line 424 the ceilometer signal could be either due to droplet formation or aerosol hygroscopic growth.

<u>Line 536</u> : « This means that the AERIoe is consistently able to detect small changes in LWP that
signify the onset of radiation fog and reduction in horizontal visibility ». According to your fog definition, I would change into :
This means that the AERIoe is consistently able to detect small changes in LWP that might initiate radiation fog and reduction in horizontal visibility

I have made this change (line in revised manuscript: 517)