

Atmos. Chem. Phys. Discuss., referee comment RC2  
<https://doi.org/10.5194/acp-2020-1314-RC2>, 2021  
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## Reply on RC1

Anonymous Referee #2

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Referee comment on "A new conceptual model for adiabatic fog" by Felipe Toledo et al.,  
Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1314-RC2>, 2021

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## Review of ACP-2020-1314 : «A New Conceptual Model for Adiabatic Fog" from Felipe Toledo, Martial Haeffelin, Eivind Wærsted, and Jean-Charles Dupont

Recommendation : **Major Revision**

### Summary :

This work presents a conceptual model for adiabatic continental fog that relates fog liquid water path with its thickness, surface liquid water content and adiabaticity. This is an original powerful method to better understand fog life cycle and it could be the basis of a diagnostic tool for fog dissipation nowcasting.

Overall, I really like this work. It is the outgrowth of a good deal of soul-searching that began with Waersted's papers based on LWP budget. The manuscript is generally well written, and the figures in the manuscript are relevant. That being said, I would like the authors to be more upfront about the types of fog the model applies, the range of validity and the limits of the approach.

My concerns are presented below.

### General comments:

1. The conceptual model is applied to fog formation and fog life cycle statistics are produced: does it concern only fog by stratus lowering? In this case, the sample size should be given and it should be clearly said that it only applies to fog by stratus lowering to remove the ambiguity (to be corrected at different locations and in the conclusion). If other types than the fog formed by stratus lowering are included, the conceptual model cannot be applied as the adiabaticity criteria is not verified for thin fogs. This would call into question the validity of the conceptual model.

2. Concerning fog dissipation, it can be caused by three different factors: the increase of heat surface fluxes, the presence of higher clouds and the advection of dry or warm air. Most of the time, only the first factor has a slow effect on the LWP evolution, and can be detectable a few hours before, while the other factors have a drastic impact. I have understood that the cases with presence of higher clouds are excluded from the study. What's about the dissipation due to large scale conditions: are they also excluded and what is the criteria to exclude them? What are the statistics about the factors of dissipation at the SIRTAsite? In Waersted et al. (2019) it was written that more than half the fog events dissipate after sunrise transition to a stratus which lasts at least 2 h. It is important to remind these statistics for the SIRTAsite and to better define when the conceptual model can be applied to dissipation cases and to present the limits of the approach.

3. The approach does not take into account the droplet concentration ( $N_c$ ). But we know that for a same liquid water content (LWC), a fog will be optically thicker if  $N_c$  is high and vice-versa. It lasts also longer due to the droplet sedimentation which is reduced. In the same way, Dupont et al. (2012) have shown that evaporation of the droplets below the stratus is one of the main factors contributing to stratus lowering and fog formation, so a small concentration of droplets favors the growth of the droplets, their sedimentation and evaporation. How would you introduce these considerations in the approach? Do you consider that the impact of the microphysics is included in the LWP evolution, or that it is of 2<sup>nd</sup> order compared to the LWP and CTH evolutions? Again it is important to introduce this point of discussion.

4. The readability of the paper could be improved if all the formula/equations were grouped together in one initial part when the fog conceptual model is presented.

5. The different cases are presented as a catalog, with the first three illustrating a dissipation by stratus, except the last one which considers a fog by stratus lowering. Could you introduce the benefit to present the second and the third cases, as only the first and the fourth should be kept. Or you could present another type of fog, for instance an advective fog, to better discriminate the limits of the approach.

**Detailed comments:**

1. I 32 : "An adiabatic fog behaves similarly": *almost* must be added because eddies are smaller in fog than in a stratocumulus.

2. I 33: "stratocumulus clouds" must be replaced by "adiabatic fogs" as Nakanishi, 2000; Porson et al., 2011; Bergot, 2013, 2016; Wærsted et al., 2019 have not studied stratocumulus.

3. I 172: As you have applied the Tardif and Rasmussen (2007) identification algorithm, how are partitioned the fog types, between radiative fog, fog by stratus lowering and advective fogs? Do you keep all the types in the rest of the study?

4. I 206: It is not clear if cases with higher clouds detected by the radar are excluded.

5. Fig. 4: What are the heights of temperature and visibility measurements?

6. First case study: how do you use the fact that  $a$  is much more different than 0,66 after 7 UTC?

7. Fig.6,7,8,9: (a): this subfigure could be zoomed up to 500m height. As there is no cloud above, what is the subfigure (b) for? (c) : can you move the legend insert? (e) what is the height of temperature measurement? (f) the yellow does not go well. It would be nice to improve its readability by increasing its size as it is the most important subfigure.

8. I 349: "When there is strong cooling at the fog layer top, LWP increases and vertical circulation is intensified.": increased would be better than intensified as vertical velocity intensity is low. Where does this remark come from: is it a general consideration or the result of a figure which is not shown?

9. §5.2.1: Does it concern only stratus lowering? How many cases do you consider?

10. §5.2.2: How many cases do you consider in the statistics? Idem for §5.2.3

11. Fig.10b1: Is the ordinate axis the same for the cumulative and norm. distributions?

12. Fig.11: It would be interesting to plot the same kind of representation than Fig.10b2

13. l 412: What does "using the same data points involved the slope calculation" mean?

14. l 427-430 434-435: Are you not talking about the same thing?

15. l 470: The model is presented as "a diagnostic tool to predict how close fog is from dissipation at the local scale". What are you aiming for and for what kind of user: to predict the dissipation in the next hour for airports? This point could be slightly more developed.

16. What do you mean by "implement this framework on LES simulations"? A LES does not need a conceptual model as it resolves most of the processes. But you can use the results from LES to validate and improve your conceptual model.

17. l 485: "These proposals are presented in the following two chapters of the thesis." must be replaced by a reference to Toledo et al. (2020) in AMT.

**Minor corrections:**

- l 215 : consists

- l 369: an LWP

- l 387 and 399: **where**

- l 432: decrease**s**

- l 414 and 420 :  $h^{-1}$  instead of  $Hr^{-1}$