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Comment on acp-2021-1027

Anonymous Referee #2

Referee comment on "Experimental study on the evolution of droplet size distribution during the fog life cycle" by Marie Mazoyer et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-1027-RC2, 2022

The study presents a set of observations on fog microphysics, and analyses how droplet microphysics depends on the fog formation method and also the fog lifecycle. This is one the largest datasets presented for the fog properties, and thus provides a nice addition into previous data presented in literature. The study also fits well in the scope of ACP. I agree with the Referee #1 related to analysis between local and non-local effects, and more detailed analysis would make the study stronger. Below are some additional comments and suggestions to help clarify some points. After those have been considered, the manuscript can be accepted for publication in ACP.

- I would like to see more detailed analysis especially related to presence of cloud droplets with two modes. Can it be related to stability within fog or aerosol concentration? For example, do you trust enough to the temperature observations and could the temperature difference between 1m and 30m be used to estimate stability?
- Abstract, line 10: This statement should be studied in more detail, please see the comments below.
- Abstract, line 14: I'm not sure if I understand this correctly but isn't surface also warmed because of decreased radiative cooling from the surface as fog grows optically thick, and then the heat from the ground is starting to produce sensible heat flux.
- Abstract, lines 17-18: "Although a positive relationship is found in most of the events due to continuous activation of aerosol into fog droplets" Please see later comments related to this statement.
- Abstract, lines 19-21: I agree with this!
- Page 2, line 2: REferecne to Boutle et al (2021) can be now updated to final published version.
- Pager 4, lines 24-27: The definition of optically thin and thick fog seems to be related to fog actual height here and thus local property, and not to the fog actual optical depth or change in atmospheric stability and turbulent mixing within the fog. Please formulate this more clearly.

- Page 5, line 21: "*These results confirm that the predictability of droplet activation in fog can not be described by LWC only."* I don't understand this statement as droplet number concentration is more likely to drive LWC in fogs than opposite.
- Page 5, line 27: 46 g/m3 is probably wrong for liquid water content.
- Page 6, line 5: Radiation fog can develop in height also under low wind speed, but wind and turbulence caused by surface can certainly fasten the growth. But, if the wind speed is too strong, radiation fog can't form at all.
- Page 7, line 17: At what time did the fog form at 150m and how quickly did it lower to be a fog?
- Page 8, line 24: New droplets are formed through most of the fog lifecycle, but maybe you should state that the droplet number concentration is just increasing as more is formed than lost in fog processing and sedimentation.
- Page 9, lines 19-21: This is true, but behind the process should be a very stable fog without turbulence. In such conditions the new droplet formation is taking place at the top of fog in the layer radiatively cooling, and thus the fog droplet size distribution is developing as described and observed in the lower parts of the fog.
- Page 10, lines 16-21: "*The increase of LWC with increasing Nd in most of the fog events is mainly due to the continuous activation of aerosol into droplets (i.e. section 3.4)".* I would state this in other way. The droplet size in stable fog is limited by sedimentation of larger droplets. Thus, after growing to large enough sizes droplets are simply removed from the system and thus the liquid water content is quite strongly correlated with droplet number concentration especially close to the surface. Situation could be different if liquid water content and number concentration are compared at the altitude where droplets are forming inside the fog.
- Page 10, lines 16-21: "*It is plausible that the low supersaturation limits the growth of droplets by condensation and the consumption of the water content. The excess water vapor could therefore become available for additional activation of aerosols into cloud droplets."* If the supersaturation is low enough to prevent growth of droplets, it is certainly also low enough to prevent the activation of new droplets unless there is some source of efficient CCN. It is plausible that droplet number is so low, that if there is turbulence within the fog, some aerosols can be activated. But turbulence can form only after fog has grown into unstable phase as described in Boutle et al (2018), or due to some local topography effect.
- Page 10, Discussion: The selection of wet critical diameter is difficult, and it is also complicated by the fact that hydrated aerosol particles can also reduce the visibility within the fog. So in some conditions the knowledge of aerosol is also needed to be able to forecast visibility, as using the actual fog droplet number concentration can lead to too high visibility forecast.
- Figure2: Related to connection of wind speed and droplet growth, it would be interesting to see wind speed and direction also at the higher observation altitude. It could give hint if it is turbulence that is enhancing fog growth, or opposite and growth will increase turbulence. Also, as you have data up to 30m, please show it also here. In case it is local radiation fog it should grow steadily in height, but in case the transition at different altitudes is taking place simultaneously, there is mor likely some advection affecting the observations.