Review of egusphere-2023-1224 : Role of thermodynamic and turbulence processes on the fog life cycle during SOFOF3D

This manuscript presents case studies of four of the heaviest fog events from the SOFOG3D field experiment in Southern France during autumn / winter 2019/20. The field experiment deployed a wide range of in-situ and remote sensing instruments and so the fog events are well documented. A conceptual model for fog previously developed for another site (Toledo et al, 2021) is used to interpret the observations and help to understand the physical processes leading to the onset, development and dissipation of fog in each case. The observational data clearly represents a novel and valuable resource for studying fog, however I have some questions / suggestions regarding the interpretation of the results and the presentation of the work which I feel need addressing before the manuscript can be published.

Major comments

1) Case study papers such as this can often be very descriptive – simply documenting what is seen. While there is value in this, more impact usually comes from the interpretation of the results to learn something new about the underlying physical processes or to identify biases in models. The authors have attempted to do this through the use of the conceptual model, but I still felt that this was only partly successful. The description of the four cases takes up much of the paper and includes the quoting of lots of figures in the text. This is quite hard to read, and by describing each case separately it is hard to compare the figures. A lot of the figures are summarised in table 2. I wonder if they need to all be given in the text as well? Shortening the descriptions in the text would help focus on what was different / interesting about each case.

2) The paper talks about the "conceptual model" and how it can be used for nowcasting, but I struggled to make this link. So far as I can see, what is being presented is a series of diagnostics based on some assumptions about the structure of the fog. These can be used to understand what is happening in the fog, but not necessarily to make predictions about when and how the fog will change. I would suggest that i) you make clear this is a diagnostic model and ii) you either explain how this can be used for nowcasting or remove the references to this. The results seem to suggest that the model diagnoses dissipation an hour or so before the observations show it, but it is not clear to me whether this is due to any real predictive power (i.e. detecting precursors of dissipation) or just because of the different definitions of dissipation used. Either way it gives at most an hour's advanced warning of dissipation, which is of some use, but is a rather limited nowcasting tool.

3) What is the new understanding this paper gives us? We know that radiation fog occurs on its own or sometimes as radiation-advection fog. These are nice case studies of these processes, but it's not clear to me what new understanding we get from them. Can you articulate that clearly both in the introduction (i.e. what the aim of the paper is) and in the conclusions?

4) The use of remote sensing does give valuable information on the vertical structure of the atmosphere, but these instruments do have some limitations in terms of vertical resolution and lowest range gate. In particular the lowest range gate for the radar is 37.5m and for the wind profiler it is 40m. Often fog can be shallow than this and so you are likely missing the early stages of the fog and also cases of shallow fog which does not deepen.

5) The lowest range gate and resolution for the microwave radiometer (MWR) are not given. You mention that lower angle scans were done as well as vertical stares in order to improve vertical resolution. It's not clear what has been presented here in the results though. Do they use a combination? The low angle scans improve vertical resolution, but at the expense of spreading the profile out in the horizontal. Is this important given the heterogeneity at the site? The MWR is also

doing an inversion calculation using neural networks to retrieve the temperature and humidity profiles. In my experience this can often smear / smooth out the profiles compared to radiosondes. You can see your profiles are very smooth curves (unrealistically so). This can be particularly important when looking at features like inversions. Can you comment on this in the context of your results? It might be worth mentioning this as a caveat to the reader.

6) Paragraph at lines 140-147. I was a bit confused what was installed where here. Are the Licor IRGAs at 3m and the sonic anemometers at 10m? Why not mounted at the same height so you can get latent as well as sensible heat fluxes and also use the water vapour to correct the sonic temperature to the true temperature? If at different heights, how do you get the temperature from the Licor? The Licor's are good for measuring rapid fluctuations in water vapour, but have a tendency to drift over time so are not necessarily good for measuring absolute values of humidity without regular calibration. Was this done? They also suffer from issues with water on the lens in rain / fog which can impact on the data quality. Was this an issue? So far as I can see you don't actually use the high frequency water vapour measurements anyway? Later on you plot TKE at 3m (figs 4f, 6f, 8f, 10f) which seems inconsistent with having the sonic anemometer at 10m?

7) In figs 4f, 6f, 8f and 10f you plot TKE from both the sonic anemometer at a point and averaged over layers (from the lidar). How comparable are these values given the different sampling intervals and sampling volumes of the two instruments? It might be worth mentioning that these lines are from very different instruments and so might not be directly comparable.

8) Section 2.1.4. I found this section a bit unclear. I appreciate the authors do not want to reproduce the whole conceptual model here, but there needs to be sufficient detail for the reader to understand the results. The split between the paper and the appendix also seemed slightly arbitrary at times. For example, the critical LWP is a key parameter in determining the RLWP, but this is only defined in the appendix.

Minor comments

1) Title "SOFOF3D" → "SOFOG3D"

2) Line 189. "becomes" → "has become"

3) Lines 243-244. "The RLWP gives information about the predictability of fog dissipation time at nowcasting range." - I don't agree with this as written. It does not give information about the predictability at all. What it tells you is whether the fog is likely to begin dissipating due to insufficient water vapour to maintain the surface visibility below 1000m.

4) Line 249. "expectation" → "inspection"?

5) Line 255-256. "At the supersite, the LWP observed during that transition is lower than the threshold at SIRTA (LWP > 30 g m-2)". Why might this be the case? Is it differences in the topography affecting the depth of the fog layer or is it differences in the processes causing fog in this region?

6) Line 263 "triggered" → "were triggered"

7) Line 314. How do you calculate a deep and strong inversion of 14°C km^{-1}? I cannot see that big a temperature difference in the figures. This figure is quoted elsewhere in the paper too.

8) Line 316. How do you know this is a low-level jet? The wind field plotted show wind increasing with height. There is no evidence I can see that this is a jet. It might be, but I don't think the observations show it.

9) Line 323. "very low radiative cooling rate". You don't actually measure or plot the radiative cooling rate. I assume you just mean the rate at which the temperature decreases and you are assuming this is all due to radiative cooling? Since you only have the SHF at one height you can't rule out there being some flux divergence leading to warming. Just be careful about how you describe this.

10) Line 356-357. This sentence is confusingly worded. What you mean is "At the supersite, in the absence of any cloud above the fog layer, the fog dissipates after sunrise".

11) Line 362. You talk about "thermal turbulence" in several places, but this can actually be referring to two different processes – either turbulence generated at the top of the dense fog layer due to radiative cooling overnight or turbulence generated at the surface due to solar heating after sunrise. I would be a bit more specific when you talk about thermal turbulence which process you mean.

12) Line 390. "Thin fog (71m)". This is a very precise value given the vertical resolution of the remote sensing instrumentation. This comment applies in general through the paper when giving heights of the fog top / cloud top.

13) Line 392. "associated with decrease" → "are associated with a decrease"

14) Line 421. "fog layer with fall" → "fog layer that then fall"

15) Line 422. "gravity" → "size"? It's not the gravity of the snowflakes which is important it is their weight / size leading to a higher fall speed under the action of the Earth's gravity.

16) Line 460. "low intensity of about 3°C". What does this mean? Do you mean the inversion strength?

17) Line 460-461. "from 20:40 UTC and 23:00 UTC" → "from 20:40 UTC to 23:00 UTC" or "between 20:40 UTC and 23:00 UTC".

18) Line 485. "sustainable dissipation". What does this mean? Do you mean a sustained dissipation rather than a temporary increase in visibility?

19) Line 489. "Advected air mass" → "The advected air mass"

20) Line 494. "resulting to the evolution as a stratus" → "resulting in the evolution of the fog into a stratus cloud".

21) Line 507. "ftime" → "time"

22) Line 507. "such as in" → "as in"

23) Line 518-520. How do the the occurrence of middle and high clouds allow the identification of this as a radiative-advective fog case? I don't follow the logic in this sentence.

24) Line 532-533. “Therefore, …” How does this sentence follow on from the previous sentence? I don’t follow the logic.

25) Line 617. “04:00 and 06:40” → “04:00 and 06:40 hours”. Same on line 619.

26) Line 623. “fog adiabatic by closure parameter” → “fog adiabatic closure parameter”

27) Line 672-676. Not sure I agree. You have shown these instruments are useful to understand the processes. You’ve not demonstrated how they help with nowcasting, or indeed that you would need all of them for that. It’s a lot to install at a site for nowcasting.

28) Table 2. “Fog top height (FTH)”. You only use this phrase / abbreviation in the table. In the text you talk about CTH. Be consistent.