

Comments on “Synoptic and microphysical lifetime constraints for contrails” by Sina Maria Hofer and Klaus Martin Gierens
<https://doi.org/10.5194/egusphere-2025-326>

The objective of this study is to identify the typical synoptic and microphysical time-scales that constrain contrail lifetime and inform the targeted use of alternative fuels.

The manuscript uses hourly aviation weather forecast data based on ICON simulations from the German Weather Service. The model output of temperature and relative humidity is used in combination with the Schmidt-Appleman-criterion to estimate the potential for contrail formation, the persistence of contrails, and their tempo-spatial evolution over a 24 hour period. Information about the wind speed and wind direction is used to infer the advection of the detected ice supersaturated regions (ISSRs) and to calculate parcel trajectories.

The analysis is based on a total of three days in April and Mai 2024.

Based on this analysis, the authors find that in most of the analyzed cases, the synoptic and microphysical time-scale are of similar length and argue that they are likely to be equally important. The authors further state that an efficient application of alternative fuels requires the microphysical time-scale to be smaller than the synoptic times-scale.

I do have some major comments, which mostly address the structure of Section 4.1, which could be clearer and in a better order. In general, a more concise writing, for example by avoiding jargon, can aid the understanding of the entire paper.

Besides the major comments there are a number of minor comments, mostly related to style, which does not follow the ACP submission guidelines. These could easily be avoided. Some of the comments are of a suggestive nature and could be considered by the authors. Other comments ask for more precise wording.

After the authors have adequately addressed the major and minor comments below, the manuscript may be considered for publication in ACP.

Major comments:

Section 4.1 is, in my opinion, unnecessary long. The authors discuss about potential definitions. This section could be much shorter and to the point by defining their time-scales. But this is already done in Section 3.1. Why not include Section 4.1 in Section 3 and define your time-scales and lifetimes there?

L216: Regarding the comparison between observations and models. Isn't this a more fundamental question of several components? In both, the measurements and in the simulations, you have to define a cloud by some kind of threshold (see also minor comments L178ff). What is detected as a cloud depends strongly on the definition of a cloud, the threshold, and how and by what means the cloud is detected.

Second, the authors identify ISSRs, i.e., regions that **allow** the formation of persistent contrails. Contrarily, observing contrails from satellite, identifies and tracks contrails that **actually formed**. It would be good if the authors could comment on this.

Third, what is the effect of your threshold of $RH_i > 93\%$ for ice-supersaturation and the size of the ISSRs? To answer this question, the authors could vary the threshold for ice-supersaturation and check the robustness of the results.

In the second last section of the summary, the authors state that for targeted use of alternative fuels, trajectory calculations are required. If I am not mistaken, this would be required for several flight levels and over larger areas, where aircraft are flying and potentially interact with ISSRs. This can be computationally challenging. Perhaps the authors could provide a few comments on the following points:

- My interpretation of this approach is that it is a near real-time avoidance strategy that may be limited by airspace restrictions and air traffic control, as flight plans and routes are well defined days to months in advance. This may change in the future, but is difficult to apply today.
- Trajectory calculations are time consuming, requiring the calculation to be started well in advance of the flight day in order to adjust the flight path (if at all possible on short notice).
- The approach relies on the accuracy of the underlying weather model to predict the exact location of the ISSRs several days in advance, since it must include the time for the trajectory calculation plus the time to adjust the flight.

The authors could partially answer this by providing the times they needed to perform the calculations.

Minor comments:

L20: “ in air with sub-saturated water vapor” Please reconsider this phrase. Water vapor cannot be subsaturated by itself. You are probably referring to the air, which can be subsaturated.

L27: Please clarify what you mean by “All of these effects should become stronger with increasing contrail lifetime”. If one considers constant illumination conditions but a thinning of the contrail with time, as you show in the manuscript, then the radiative effect would decrease even though the contrail can be considered persistent. By rephrasing this sentence, you might better explain your actual intent.

L36: "dominate" instead of "dominates"?

L38. "Fewer" instead of "less"?

L56: "data inform". Data is singular, so I think it should be "data informs". You might consider rephrasing it, since data itself cannot inform. You could write something like: "based on the data,"

Fig1 and subsection: Please specify the unit of r_0 on the y-axis. Furthermore, if the isolines represent the time-scale, why did the authors choose an example that is “not included” in the figure. It would be more intuitive and easier for the reader to choose an example with a time-scale of 4.5h

or 6h, since these lines are included. Conversely, you could add the 5h isoline. Does the word “deep” refer to the geometric thickness of the cloud?

Eq.6 Please check that the double “ln” is correct.

L135-136: Instead of “transported downwards to the ground” the term "subsidence" could be used, which is shorter and more common in this context and refers to large-scale sinking air masses.

Fig4. You might consider adding (a) and (b) to the panels to make them more easily referenced in the caption and text.

L146: Instead of qualitative measures, it would be better to quantify and provide absolute numbers and/or percentages of how many air parcels remained ice-supersaturated.

Fig5.: Equation 5 uses “ln”, which has a base of e. However, the y-axis in Fig.5 uses “log”, which usually has a base of 10. Please check for consistency.

L154: Here and elsewhere in the text, e.g., L67: Please check the date format here, in the caption of Figure6, and compare with the ACP submission guidelines.

Copied from the ACP submission guidelines:

“Date and time: 25 July 2007 (dd month yyyy), 15:17:02 (hh:mm:ss). Often it is necessary to specify the time if referring to local time or universal time coordinated. This can be done by adding "LT" or "UTC", respectively. If needed when referring to years, CE (common era) and BCE (before the common era) should be used instead of AD and BC since CE and BCE are more appropriate in interfaith dialogue and science.”

L159-161: You might consider quantifying “many” and “almost all”.

L161: Please quantify “excellently”. For example, by providing an r-squared for the fit.

L178-179: The phrase “...can no longer be seen...” is imprecise. “Visibility” of contrails and water vapor is strongly dependent on wavelength. Thus, the authors would need to provide a wavelength range in which the observation takes place. Please see Driver et al. 2025, where they state that there is no clear threshold (<https://amt.copernicus.org/articles/18/1115/2025/>). It might be better to provide a threshold to describe the presence of contrails, such as, ice mass.

L179: “In principle, such a period can precisely be determined,...” I doubt that this is an easy task. As mentioned before, it is almost a philosophical question what counts as a cloud or water vapor. Clouds that are optically thin at solar wavelengths can still be very effective at absorbing radiation in the thermal infrared. To make such a judgment, a threshold must be used. Since, to my knowledge, there is no consensus on such a threshold, the authors may define their own threshold based on reasonable judgment.

L181: “... (another vague word) ...” What is the authors intention of this insert? The first paragraph of this section could be omitted, or at least shortened, by providing a clear definition of the time-scale as understood and defined by the authors.

L198: “One might believe...” and “.. but we do not think so” are expressions that should be avoided in scientific publications. Hypotheses and conclusions are based on reasoning and facts. Please consider rephrasing this sentence.

L216-219: Please check the grammar in this sentence

L219-222: Please consider rephrasing this sentence. What you probably mean: There are two types of trajectory calculations: 1) following the air parcel in normal mode, and, as I understand it, 2) following the air parcel but with precipitation / sedimentation and condensation switched off. This is mentioned later in L231, but would fit here.

L219-222: The term of “virtual” humidity may be an unfortunate choice, as it may be confused or associated with other metrics such as virtual temperature. You might consider calling it along the lines of “idealized simulations”. However, this is just a personal impression and I would not insist on a change.

L225 and 226, RH_i should be “ RH_i ” for consistency

L249ff: the word “height” is used, which is misleading. I assume you mean cirrus / cloud geometric thickness, right?

L312: The authors please better explain what they mean by "real world". A better term might be "in nature"?

L315: “soor-poor-regime” is mentioned here for the first time. The authors could mention this earlier when introducing the targeted use of alternative fuels.

For the entire text:

- If I am not mistaken, the first appearance of the figures in the text follows: 3, 4, 5, 2, 6, 10, 8, 11, 1, and 12. Consequently, the inclusion of the figures should be reordered. Figures 9 and 11 are not referenced anywhere in the text. Either refer to them in the text or, if they are not needed, remove Figures 9 and 11.
- The authors are inconsistent in their use of "Section", "section", and "Sec."
Copied from the ACP submission guidelines: "The abbreviation "Sect." should be used when it appears in the running text and should be followed by a number unless it is at the beginning of a sentence."
- "Figure" is written at the beginning of a sentence and abbreviated within a running sentence.
Copied from ACP submission guidelines: "The abbreviation "Fig." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence, e.g.: "The results are depicted in Fig. 5. Figure 9 reveals that..."
- Please be consistent in your use of the serial comma if you choose to use it.
- Please be consistent in your use of units. Sometimes "hours" is used and sometimes "hrs".
Check the ACP guidelines.
- Variables are usually in italics, while subscripts are in normal font. For example: instead of RH_i write RH_i