

Responses to Community Comments (from Sina Hofer and Klaus Gierens)

“In putting their results and model assumptions into perspective, the authors feel the need to argue that ISSRs can last many hours. In order to support this, the authors write:

"This is further supported by a recent preprint (Hofer and Gierens, 2024) which analyzed a larger ECMWF dataset and found that contrail lifetime is most commonly limited by sedimentation, as opposed to advection of the contrail out of the ISSRs."

Here, we find an error and a misinterpretation. The error is: we have used data from the ICON model of the German Weather Service, not ECMWF data.

The misinterpretation is: Although the movement of ISSRs is often aligned to the wind, this does not imply that contrail lifetimes are most commonly limited by sedimentation. To the contrary, in another recent preprint (Hofer and Gierens 2025) we show that contrail termination by sedimentation and contrail termination by synoptic processes (contrails leaving the ISSR with the wind and large-scale subsidence turning super- into subsaturation) have similar time-scales of a few hours. It is difficult to say in advance which time-scale is shorter."

Author's response: This comment raises a misunderstanding and an error in Section 3.2.1. We have corrected the error and the misconception in the revised manuscript.

Author's changes in manuscript: Replaced “which analyzed a larger ECMWF dataset” with “which analyzed the ICON dataset” in Section 3.2.1.

Replaced “found that contrail lifetime is most commonly limited by sedimentation, as opposed to advection of the contrail out of the ISSRs” with “found that contrail lifetime is most commonly limited by sedimentation and synoptic processes such as advection of contrails out of the ISSRs”.

Added the statement “Further, a second preprint by Hofer and Gierens (2025) found that the sedimentation and synoptic timescales are both in the order of a few hours.”

We also added a comment on the new preprint to Section 4.1.3: “To understand the sensitivity of our findings to the contrail lifetime, we define the global model difference (δ) as the sum across all simulations of the APCEMM integrated total extinction minus the CoCiP integrated total extinction (at each timestep):

$$\delta(t) = \sum_{\text{all cases}} (\hat{E}_{\text{APCEMM}}(t) - \hat{E}_{\text{CoCiP}}(t)), \quad (6)$$

$$\hat{\delta}(t) = \frac{\delta(t)}{\delta(t = 24 \text{ h})}, \quad (7)$$

where $\hat{\delta}(t)$ is the normalized global model difference. The variable t in Eqs. 5 and 6, is the upper limit of integration in Eq. 2.

Figure 10 shows how $\hat{\delta}(t)$ varies as a function of time. We hence find that 90 % of the global model difference is produced within 12 hours from formation. For more evidence-based contrail lifetime estimates, we take 4 h and 8 h from a recent preprint by Hofer and Gierens (2025). The

proportion of the total model difference reached by 4 h and 8 h are 27 % and 72 % respectively. These results indicate a large sensitivity in our findings to the lifetime of typical contrails. However, they also indicate that our findings are particularly relevant to those 6–7 % of contrails that persist beyond 8 h (Gierens and Vazquez-Navarro, 2018). Such contrails are also likely to be the greatest contributors to aviation warming on an individual basis and are hence important for contrail avoidance.”

A similar statement is found in the conclusion: "the predominant mechanism for contrail evaporation is through sedimentation, as opposed to advection (Hofer and Gierens, 2024; Irvine et al., 2024)." We do not know Irvine et al. wrote (by the way, this was 2014, not 2024), but it is not our statement.

Author’s response: This comment raises an oversight and a misunderstanding in Section 6. Other than the typo in the citation to Irvine et al (2014), upon further review, we believe that the way the citation is used is incorrect since Irvine et al (2014) talked about ice supersaturated regions, and not contrails. We have also addressed the misinterpretation from the comment CC-01 in the conclusion.

Author’s changes in manuscript: We removed the citation to Irvine et al (2014) in line 375 of the original manuscript, and modified the erroneous statement to reflect the findings from the most recent preprint by Hofer and Gierens in the paragraph starting at line 448 of the revised manuscript: “However, tropospheric ice supersaturated regions are generally sufficiently large that contrail demise occurs through sedimentation, synoptic processes, or both at similar timescales (Hofer and Gierens, 2024; Hofer and Gierens, 2025). Furthermore, 72 % of the model disagreement on the time-integrated total extinction can be attributed to the first 8 hours of the simulations (see Sect. 4.1.3). This makes the conceptual findings from this study applicable to those real contrails which persist for long.”

More arguments for long-lasting ISSRs can be found in case studies by Bakan et al. and Spichtinger et al., if needed.

Author’s response: We are grateful for having received specific pointers to references that support our work. However, with the new preprint by Hofer and Gierens and our sensitivity analysis to lifetime, there is no need to further substantiate the point we were trying to make.

Author’s changes in manuscript: No changes to the manuscript.

Statistical arguments about the unobservable fraction of contrail lifetime can be found in a paper by Gierens and Vazquez-Navarro (2018). You might want to check whether your results agree with those from the statistical arguments.

Author's response: We greatly appreciate this suggestion, and agree. We now cite Gierens and Vazquez-Navarro (2018) in Section 3.2.1 of the revised manuscript, citing the proportion of contrails with lifetimes over 8 hours.

Author's changes in manuscript: Added the following sentences to 3.2.1 (line 270 of the revised manuscript): "This is corroborated by a study estimating the full-lifetime of contrails with statistical methods applied to satellite observations (Gierens and Vazquez-Navarro, 2018). Interpolating Fig. 8 from Gierens and Vazquez-Navarro (2018), it can be estimated that the proportion of contrails with lifetimes exceeding 8 h is ~6–7 %."