Response to Reviewer Comments

We thank the referees for reviewing the revised manuscript. Their detailed comments further improved the quality, clarity, and narrative of this manuscript.

The reviewer's remarks are *italicized*, while our responses are presented in normal text. Blue text is used to cite passages from the manuscript and to track the changes made from the original to the revised manuscript. References cited in the blue text can be found in the revised manuscript. Line numbers refer to the clean version of the revised manuscript.

REFEREE 1 (RC1)

General comments

I acknowledge the efforts to substantially revise selected parts of the manuscript. Moreover, I appreciate the detailed point-to-point replies. However, I believe that a few aspects still require improvement. Several plots are quite fuzzy and some are not adequately described in the legend/caption or text body. Furthermore, the analysis does not fully exploit the observational data set. I believe that more conclusive results could be achieved with little additional effort.

Major specific comments

1. *Contrail persistence: A more conclusive analysis and comparison between observation and simulation could be achieved. In lines 190–195, three lifetime categories for contrail observations are mentioned. However, the analysis does not make significant use of the 2-10 min and >10 min categories.*
    - Thank you for this feedback. We have now utilised these lifetime categories in two additional analyses as suggested by the reviewer (see Comments 2 and 5).

2. *Table 1: In Table 1, CoCiP persistence is compared to "Camera observes contrail," but a more accurate comparison would be to "Camera observes contrail with lifetime > 2 min". It is recommended that a third block be added to the table using "YCamera>2min", which hopefully improves the agreement with CoCiP.*
    - Thank you for this suggestion. After further consideration, we believe this additional analysis is more suitable for inclusion in the text of Section 3.1 rather than in Table 1. The reason is that filtering the waypoints to "Y_{Camera} > 2 minutes" would reduce the evaluation to only two outcomes (Y_{Camera} & Y_{Sim}, and Y_{Camera} & N_{Sim}), whereas Table 1 presents four different outcomes (Y_{Camera} & Y_{Sim}; Y_{Camera} & N_{Sim}; N_{Camera} & Y_{Sim}; and N_{Camera} & N_{Sim}). This creates an inconsistency. Additionally, applying a lifetime-based filter would also reduce the sample size that were previously listed in Table 1.
    - We have now included this analysis in the revised manuscript (below). Our results align with the reviewer's hypothesis, showing that the simulation becomes more capable of predicting contrail formation when the observed contrail lifetime is greater than two minutes (Y_{Camera} > 2 minutes):
        - [Main text: Lines 273 – 285] "Unlike with the SAC, the percentage of false negative waypoints (Y_{Camera} & $N_{Sim=CoCiP}$ = 21.2%) is nearly four times

higher than the false positive waypoints (N_{Camera} & $Y_{Sim=CoCiP}$ = 5.7%) (c.f. Y_{Camera} & $N_{Sim=SAC}$ = 1.1% vs. N_{Camera} & $Y_{Sim=SAC}$ = 23.1%). **False negative waypoints also tend to occur at lower altitudes (35100 ± 2600 feet at 1σ) and at sub-saturated RHi conditions (0.68 ± 0.19 at 1σ) relative to those with true positive outcomes (37500 ± 2700 feet and 1.02 ± 0.29) (Fig. 5b). Notably, on 14-Jan-2022, correct contrail predictions dropped sharply from 83.8% to 42.9%, with no persistent contrails predicted in the simulation, because the ERA5-derived RHi at all waypoints were well below ice supersaturation (0.07–0.79, Fig. 6).** The~~is~~ **difference in accuracy between the SAC and CoCiP's definition** ~~underprediction~~ of persistent contrail formation is most likely due to contrail model simplifications~~, where adiabatic heating from the wake vortex downwash is assumed to occur~~ **(i.e.,** instantaneous~~ly~~ **wake vortex downwash)** which can underestimate the simulated contrail lifetime**s, particularly** ~~compared to observations~~ for short-lived contrails. **Indeed, when waypoints are segmented by the observed contrail lifetime, the simulation correctly predicted contrail formation for only 55% of waypoints with short-lived contrails (Y_{Camera} < 2 minutes & $Y_{Sim=CoCiP}$). However, correct predictions increased significantly to 96% for waypoints with observed lifetimes between 2 and 10 minutes, and to 86% for waypoints with observed contrails persisting beyond 10 minutes.**"

- [Abstract: Lines 16 – 17] "**When evaluating contrails with observed lifetimes of at least 2 minutes, the simulation's correct prediction rate for contrail formation increases to over 85%.**"
- [Conclusions: Lines 401 – 403] "**When waypoints with Y_{Camera} are segmented based on their observed contrail lifetime, the simulation accurately predicted contrail formation for only 55% of short-lived contrails (Y_{Camera} < 2 minutes & $Y_{Sim=CoCiP}$), while correct predictions rose to over 85% for contrails with observed lifetimes exceeding 2 minutes (Y_{Camera} ≥ 2 minutes & $Y_{Sim=CoCiP}$).**"

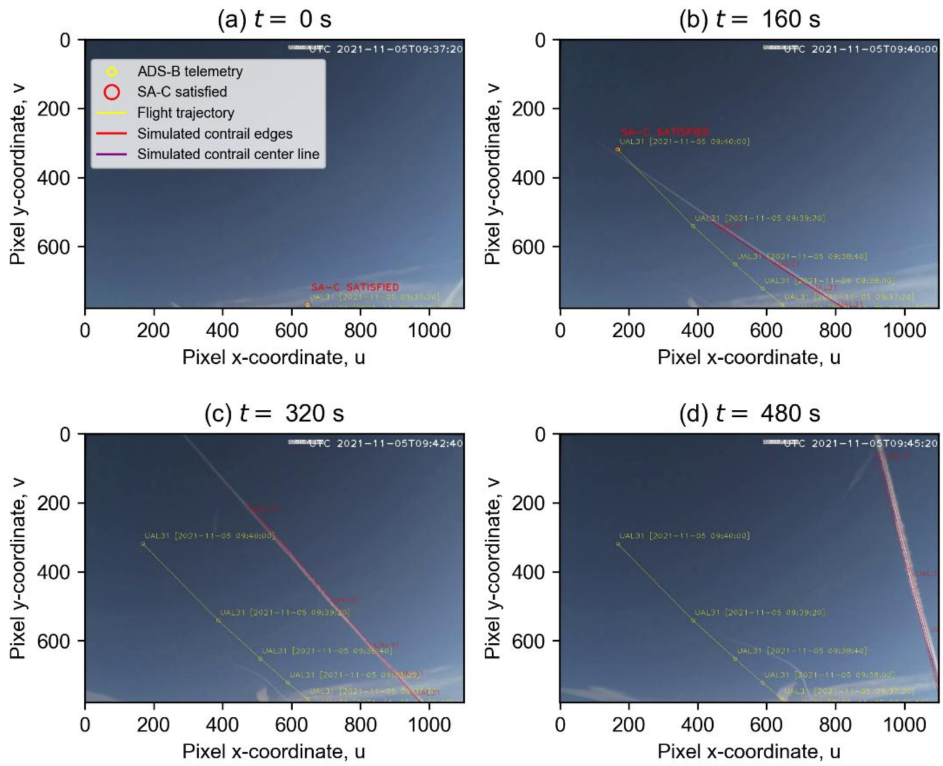
3. <u>*Figs. 2 & 3*</u>*: The intention behind showing Figs. 2 and 3 is good and the plots should be kept in the manuscript. However, the description, explanation and interpretation are left to the readers. A single sentence is insufficient to convey the full meaning of the plots; additional clarification is necessary ("Figures 2 and 3 provide examples of the superimposed flight trajectories and/or simulated contrail properties to the video footage.").*

   Moreover, please ensure that the legend lists only items that do appear in the plots. The inserted text is readily legible. It would be preferable to produce plots with enhanced quality and to focus on the content that is intended to be conveyed. For instance, it is not evident why multiple black lines intersecting the contrails have been plotted. I do not see the added value of plotting all the black lines (I do not motivate them either).

   - Thank you for this feedback, we have made the following changes in the revised manuscript to better describe Figures 2 and 3:
     - [Main text: Lines 159 – 168] "After correcting for distortions, we project the **ADS-B** ~~simulated contrail~~ waypoints and **simulated contrail** dimensions onto the video footage using a camera transformation model that

follows a two-step process**. First,**~~: (i)~~ the real-world 3D positions (i.e., ADS-B ~~flight~~ waypoints and the simulated mid-point and edges of the contrail plumes) are mapped **in**to a 3D camera coordinate system (X, Y, Z) using an extrinsic (rotation) matrix**. Next,**~~; followed by (ii) transforming~~ the 3D camera coordinates (X, Y, Z) **are transformed in**to a 2D pixel coordinate system (u, v) using an intrinsic (camera) matrix. **Using this two-step process, Fig. 2 shows the ADS-B waypoints and simulated contrails superimposed onto the video footage, specifically young contrails less than 6 minutes old that were formed within the camera's field of view. Similarly, Fig. 3 projects the simulated dimensions of aged contrails (i.e., those initially formed outside the camera's field of view and subsequently advected into it) onto the footage and compares them with the observed contrails.** Further details of the camera transformation model can be found in Appendix A3. ~~Figures 2 and 3 provide examples of the superimposed flight trajectories and/or simulated contrail properties to the video footage~~."

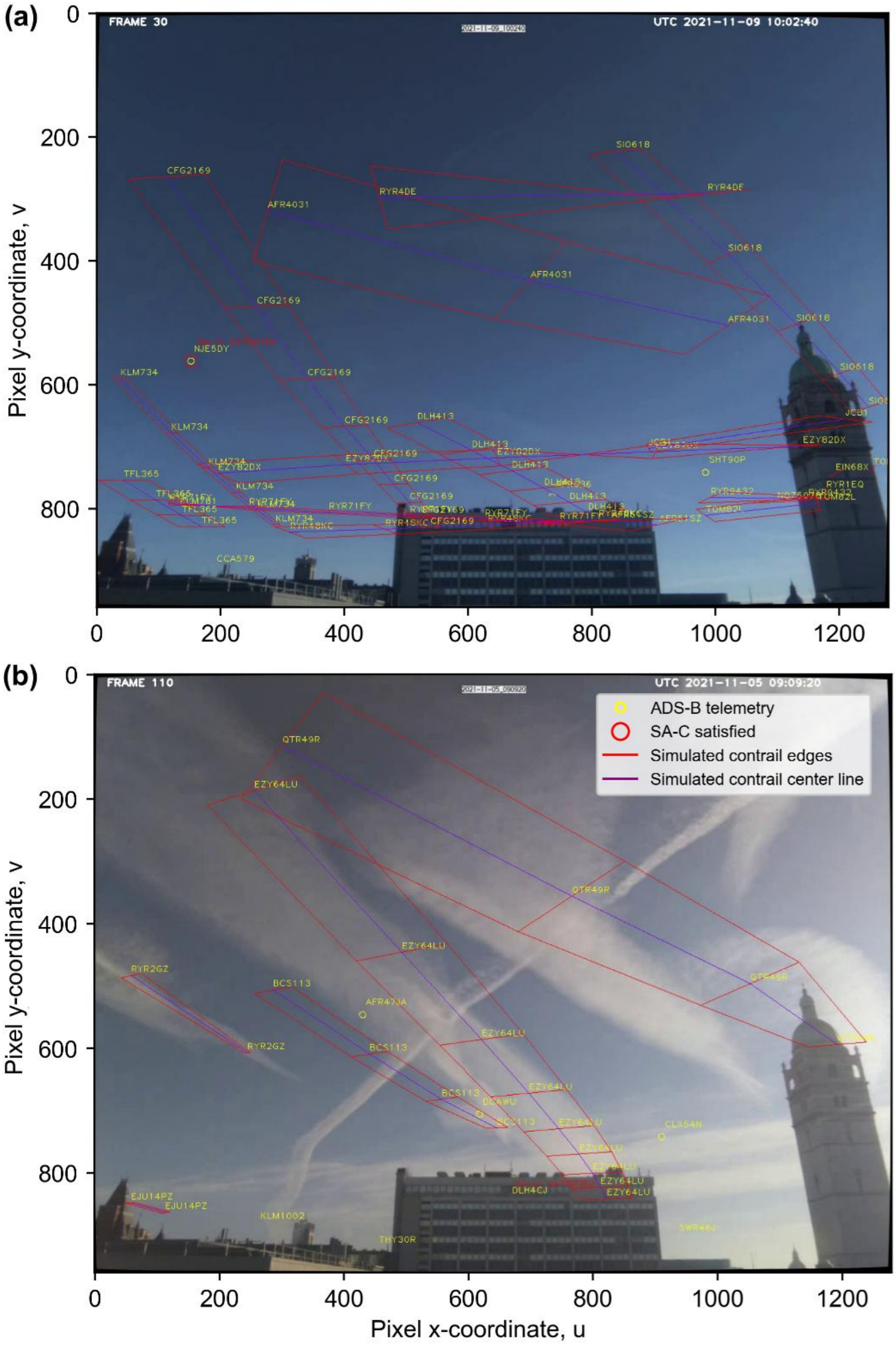
- Additionally, we have re-plotted Figures 2 and 3 to enhance the image resolution.
- In Figure 2, the updated sub-plots now focus specifically on the flight trajectory and contrails formed by a single flight (callsign "UAL31"), rather than multiple flights, to improve clarity. We also removed: (i) items in the legend that were not visible in the sub-plots; and (ii) the black lines perpendicular to the contrail waypoints, which were previously used to sample the RGB pixel intensity and estimate the observed contrail widths (refer to Figure 4 in the revised manuscript).
    - [Main text: Lines 169 – 172] Updated Figure 2:



"Figure 2: Example of the flight trajector**y**~~ies~~ and simulated contrail dimensions from **the flight with callsign "UAL31", both of which** ~~CoCiP~~

~~that~~ are superimposed onto the video footage using the camera transformation model (detailed in Section 2.3). The flight trajector**y**~~ies~~ and **persistent** contrails were observed on 5-Nov-2021 between 09:**37:20**~~16:40~~ and 09:**45:20**~~22:40~~ (UTC). ~~Note that the persistent contrails visible in the top right and lower right of panels (a) and (b) were formed outside the observation domain and subsequently drifted into the camera's field of view, and the absence of labels on these contrails suggests that they were most likely false negative outcomes (Y_{Camera} & $N_{Sim=CoCiP}$).~~"

- [Main text: Lines 173 – 179] Updated Figure 3:



"Figure 3: Examples of the simulated contrails that were initially formed outside the camera's observation domain and subsequently drifted into view on: (a) 9-Nov-2021 at 10:02:40 UTC; and (b) 5-Nov-2021 at 09:09:20 UTC. The CoCiP-simulated contrail dimensions are superimposed onto the video footage using the camera transformation model (detailed in Section 2.3). ~~Note that~~ **In panel (a), the faint signals and absence of observed contrails suggest that they could be false positive outcomes (N_{Camera} & $Y_{Sim=CoCiP}$). In panel (b),** the absence of labels on some ~~of the~~ observed contrails ~~in panel (b)~~ indicates that they were most likely false negative outcomes (Y_{Camera} & $N_{Sim=CoCiP}$)."

4. *Fig. 5: I am unable to understand the right panel of Fig. 5. The title indicates that only true positives are displayed, yet the legend lists all four combinations. In my opinion, the information content of the present plots is not overly high as most aspects are straightforward to interpret. For instance, the fact that all grey and blue symbols in Fig.5 are to the right of the vertical line, while the green and red ones are to the left.*

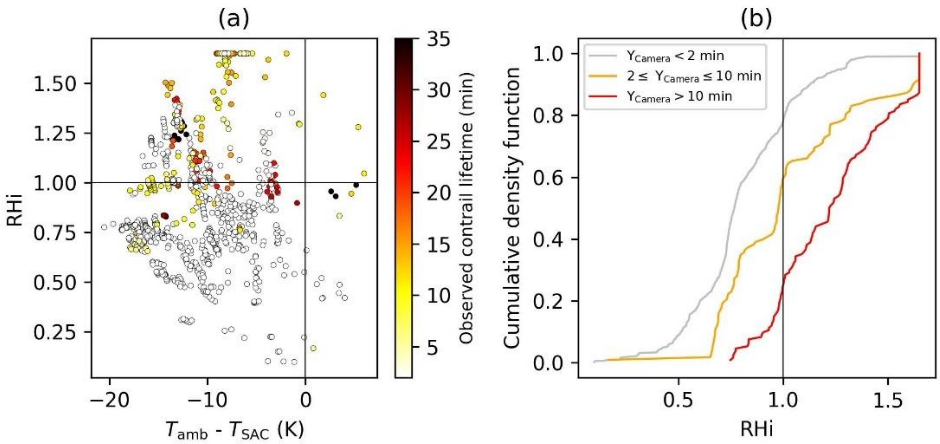
   - Thank you for identifying the mistake in Fig. 5b. We want to clarify that the data points included in Fig. 5b filter only for waypoints that satisfied the SAC ($Y_{Sim=SAC}$), rather than true positive outcomes (Y_{Camera} & $Y_{Sim=SAC}$). Additionally, we note that the data points presented in the updated Fig. 5b differ slightly from the earlier version due to a minor bug in our code, where we inadvertently filtered for data points with Y_{Camera} **or** $Y_{Sim=SAC}$.
   - We have also updated the caption of Fig. 5 to clarify the definitions of false negative and true negative outcomes in panel (b):
     - [Main text: Lines 263 – 268] "Figure 5: Joint plot of the aircraft barometric altitude versus the: (a) difference between the ambient (T_{amb}) and SAC threshold temperature (T_{SAC}) across all flight waypoints; and (b) ~~the~~ corrected RHi from the ERA5 HRES for waypoints that satisfy the SAC in the simulation ~~and have contrails observed from the camera~~ (~~Y_{Camera} &~~ $Y_{Sim=SAC}$). In both **panels** ~~figures~~, green data points represent true positive outcomes (Y_{Camera} & Y_{Sim}), red for false positive outcomes (N_{Camera} & Y_{Sim}), blue for false negative outcomes (Y_{Camera} & N_{Sim}), and grey for true negative outcomes (N_{Camera} & N_{Sim}). **In panel (b), the false negative (Y_{Camera} & $N_{Sim=CoCiP}$) and true negative outcomes (N_{Camera} & $N_{Sim=CoCiP}$) correspond to waypoints that satisfied the SAC in the simulation but did not persist beyond the wake vortex phase.**"
   - While we agree with the reviewer that most aspects in Fig. 5 are straightforward to interpret – specifically that all grey and blue symbols are positioned to the right of the vertical line, while green and red symbols are to the left – we have included it to emphasise two key takeaways from this figure:
     i. False positive (N_{Camera} & $Y_{Sim=SAC}$) and false negative outcomes (Y_{Camera} & $N_{Sim=SAC}$) occur closer to threshold conditions ($T_{amb} \approx T_{SAC}$ and RHi ≈ 100%) compared to true positives (Y_{Camera} & $Y_{Sim=SAC}$) and true negatives (N_{Camera} & $N_{Sim=SAC}$), and
     ii. False negative waypoints (Y_{Camera} & $N_{Sim=CoCiP}$) also tend to occur at lower altitudes (35100 ± 2600 feet at 1σ) relative to those with true positive waypoints (Y_{Camera} & $Y_{Sim=CoCiP}$) (37500 ± 2700 feet).

These points are already discussed in the manuscript (see Lines 258 – 260 and Lines 275 – 277).

5. *<u>Figs. 5 & 6</u>: Fig. 5 and 6 only uses the binary information whether or not contrail formation was observed. I strongly recommend that you show analogous plots for observed lifetimes > 2 min and > 10min, which can be compared to similar CoCip categories. As previously stated in my review of the original submission, it is recommended that the fact that individual contrails are observed over time be exploited to a greater extent.*

   This is the excerpt from the previous review round: "In general, I realize that you do not really exploit the fact that you observe the evolution of specific contrails despite this sentence in the conclusion ("Ground-based cameras provide a cost-effective way to observe contrails, and unlike satellite imagery, their higher relative spatiotemporal resolution enables effective tracking of the formation and evolution of young contrails."). This should be better exploited.

   - Thank you for this feedback. We note that the observed contrail lifetimes have been compared with the ERA5-derived RHi and temperature at the point and time of their formation, albeit on a continuous spectrum rather than using the three lifetime categories (see Fig. 7 in the revised manuscript).
   - To address this comment, we have now included additional analysis in the revised manuscript that utilises the three lifetime categories (< 2 minutes, 2 – 10 minutes, and > 10 minutes):
     - [Main text: Lines 305 – 310] Updated Figure 7:



"Figure 7: Evaluation of the observed contrail lifetime relative to the ERA5-derived **meteorology at the point and time of their formation for all waypoints with observed contrails (Y_{Camera}). Panel (a) compares the observed contrail lifetime with the** RHi (y-axis) and the difference between the ambient temperature (T_{amb}) and SAC threshold temperature (T_{SAC}) (x-axis)**. Panel (b) shows the cumulative density functions of the initial RHi, with the data points segmented into three groups based on their observed contrail lifetimes, i.e., those lasting fewer than 2 minutes (gray), between 2 and 10 minutes (orange), and more than 10 minutes (red)** ~~at the point and time of contrail formation. This analysis includes all waypoints with observed contrails (Y_{Camera})~~."

- [Main text: Lines 299 – 304] "For waypoints with Y_{Camera}, we compared their observed contrail lifetimes against the ERA5-derived meteorology at the **point and** time of **their** formation (Fig. 7). Our analysis shows that: (i) 98% of the~~se~~ **observed** contrails ~~met~~ **fulfilled** the SAC ($T_{amb} < T_{SAC}$) in the simulation; (ii) 78% of short-lived contrails **(Y_{Camera} < 2 minutes)** ~~with observed lifetime under 2 minutes~~ were formed under ice sub-saturated conditions (RHi < 100%)**, with a mean RHi of 81 ± 25% (1σ); (iii) 59% of contrails with observed lifetimes of between 2 and 10 minutes also formed under ice sub-saturated conditions, but the mean RHi is higher at 103 ± 32%**; and (i**v**~~ii~~) 75% of persistent contrails **(Y_{Camera} > 10 minutes)** ~~with observed lifetime exceeding 10 minutes~~ were formed in ice supersaturated conditions (RHi > 100%)**, with a mean RHi of 124 ± 26%**."
- [Conclusions: Lines 403 – 406] "Notably, **among the waypoints with Y_{Camera}: (i)** 98% of **them**~~ waypoints with Y_{Camera}~~ fulfilled the SAC~~,~~**; (ii)** 78% of ~~waypoints with~~ short-lived contrails (observed lifetimes < 2 minutes) initially formed at RHi < 100%~~,~~**; (iii) 59% of contrails with observed lifetimes ranging between 2 and 10 minutes also formed at RHi < 100%; while (iv)** ~~and~~ 75% of persistent contrails (observed lifetimes > 10 minutes) formed at RHi > 100% (Fig. 7)."

- In addition to the analyses mentioned here and in Comment 2, we also note that the contrail evolution over time has also been exploited when comparing the observed and simulated contrail geometric width in Section 3.3 (Fig. 9). However, this analysis was conducted on a continuous spectrum and did not necessitate the use of three lifetime categories.

Minor specific comments

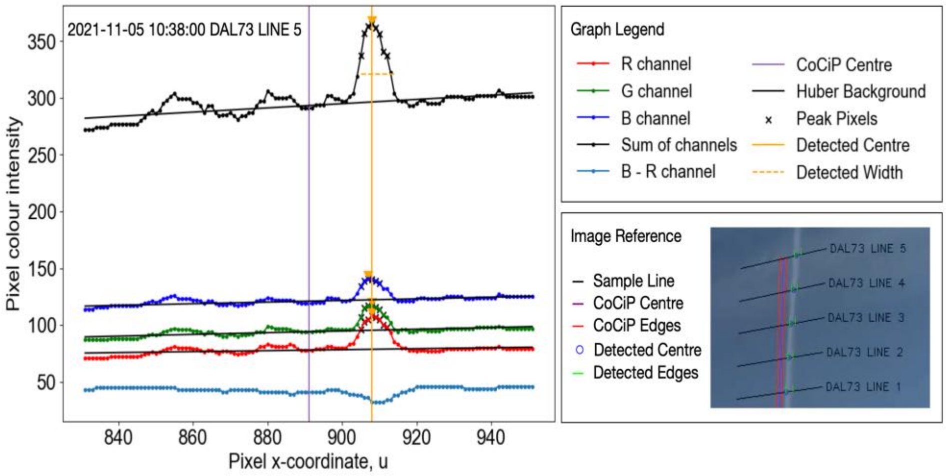
6. *Line 40: Märkl et al (2024) focuses on measurements and the climate impact of SAF contrails. The Bier & Burkhardt (2022) paper, which you cite a few lines below, would be a better reference, as it deals with classical contrails from kerosene and the main topic of the paper is about GCM results.*

- Thank you for this suggestion. Both studies (Bier & Burkhardt, 2022; Märkl et al., 2024) use the same modelling approach to simulate contrails globally. We agree that Bier & Burkhardt (2022) may be a more relevant reference, as it focuses specifically on contrails formed by conventional jet fuel. We initially selected Märkl et al. (2024) because: (i) Bier & Burkhardt (2022) only reports the global annual mean contrail net radiative forcing for 2006; while (ii) Märkl et al. (2024) provides more recent estimates (i.e., 2018 global contrail net RF), which aligns with the 2018-2019 period mentioned in this sentence. Nevertheless, we also acknowledge that Märkl et al. (2024) derives its 2018 estimates by scaling air traffic activity from 2006 to 2018 levels.
- To address this comment, we have decided to include Bier & Burkhardt (2022) alongside Märkl et al. (2024), rather than replacing the latter reference in this sentence:
    - [Main text: Lines 38 – 41] "Recent studies suggest that the global annual mean contrail cirrus net radiative forcing (RF) in 2018 and 2019 (best-estimate of between 61 and 72 mW m^{-2} across three studies) (**Bier and**

Burkhardt, 2022a; Märkl et al., 2024; Quaas et al., 2021; Teoh et al., 2024a) could be around two times greater than the RF from aviation's cumulative CO_2 emissions (34.3 [31, 38] mW m^{-2} at a 95% confidence interval) (Lee et al., 2021)."

7. *Around line 60: Iwabuchi et al (2012) is worth to be mentioned.*
   - Thank you. We agree with this suggestion and have included the Iwabuchi et al. (2012) reference in this sentence:
     - [Main text: Lines 57 – 62] "While satellite observations can partially address some limitations of in-situ measurements by enabling a large number of contrails to be measured, matched with specific flights and tracked over time (Duda et al., 2019; Gryspeerdt et al., 2024; **Iwabuchi et al., 2012;** Marjani et al., 2022; Tesche et al., 2016; Vázquez-Navarro et al., 2015), they still face challenges in detecting young contrails with sub-pixel width, aged contrail cirrus that has lost its line-shaped structure, instances of cloud-contrail overlap, and contrails with small optical depths (< 0.05) (Kärcher et al., 2010; Mannstein et al., 2010; Meijer et al., 2022)."

8. *Fig. 4: the two red lines in the picture are not explained. Moreover, DAL73 is not explained. Would it suffice to just draw the one black line for the intersection that is depicted in the left panel?*
   - Thank you for this feedback. We have updated this figure to enhance the clarity of its legend in response to Comment 3, as well as revising the caption to address this comment:
     - [Main text: Lines 192 – 198] Updated Figure 4:



"Figure 4: Pixel colour intensity profiles of the contrail waypoint at Line 5 (shown at the bottom right **panel**). **The contrail observed in the bottom right panel was formed by the flight with callsign "DAL73"**. **In the left panel, the black** ~~L~~linear trendlines ~~(in black) indicate~~ **represent** the **best-fit** background colour intensity for each RGB channel. The solid ~~vertical~~ yellow **vertical** ~~and purple~~ line~~s~~ **marks** ~~represent~~ the mid-point of the observed ~~and simulated~~ contrail plume~~, respectively~~, while the dashed (horizontal) yellow line indicates the estimated contrail pixel width. **In both**

the left and bottom right panels, the purple line indicates the centre of the simulated contrail plume from CoCiP, and in the bottom right panel, the red lines show the simulated contrail edges."

- After further consideration, we decided to retain the five black lines in the plot to demonstrate that the observed and simulated contrail widths were compared at each flight waypoint.

9. *Explanation of Table 1 starting from line 263: It would be worth mentioning that $Y_{Sim=CoCiP}$ cases are a subset of the $Y_{Sim=SAC}$ cases. Hence, it is trivial that the values in the first two lines of the CoCiP block are smaller than the analogous entries the SAC block. Likewise, the values in the third and fourth line are smaller in the CoCiP block.*
   - Thank you for this suggestion. We have made the following changes in the revised manuscript to address this comment:
     - [Main text: Lines 269 – 273] "~~Using~~ CoCiP~~'s~~ defin**e**~~sition of~~ persistent contrail formation **as occurring when the** ~~(i.e.,~~ post wake vortex contrail IWC **exceeds** ≥ 10^{-12} kg kg^{-1} **($Y_{Sim=CoCiP}$**), ~~where~~ **and adiabatic heating from the wake vortex downwash is assumed to occur instantaneously at the time of contrail initialisation. As a result, waypoints with $Y_{Sim=CoCiP}$ are a subset of $Y_{Sim=SAC}$. Using CoCiP's definition of persistent contrails,** the overall **accuracy of** ~~correct~~ contrail predictions ~~across~~ **over** five days decreased slightly from 75.8% (SAC approach) to 73.1%, with significant variability between individual days (Table 1)."

10. *Fig. 8: I appreciate that you mention a "poor visual agreement", which is indeed the case. Nevertheless, I suggest to spend a few more lines on describing on what can be seen in the plot (cases with y=0, y=35min or x=0). Currently, the plot is described in only two lines 298-300, before starting with the plot interpretation in line 300 spanning over many lines.*
    - Thank you for this suggestion. We agree with this and have made the following changes in the revised manuscript:
      - [Main text: Lines 311 – 317] "Fig. 8 shows a poor visual agreement between the observed and simulated contrail lifetime, with the simulat**ed**~~ion~~ **lifetimes being strongly influenced by the ERA5-derived RHi. Specifically, the simulation always predicts contrails with lifetimes below 5 minutes** ~~generally underpredicting contrail lifetime~~ when the ~~ERA5-derived~~ RHi is ~~below~~ **less than** 100%**, often underestimating the observed contrail lifetimes. Additionally, the simulation consistently predicts contrails with lifetimes exceeding 2 minutes** ~~and could overestimate it~~ when the RHi ~~exceeds~~ **is above** 100%**, even though around half of these waypoints were observed with short-lived contrails (< 2 minutes). It also tends to predict contrail lifetimes longer than 35 minutes when the RHi exceeds 120%, though evaluating these predictions is challenging as the maximum observed contrail lifetime can be limited by the contrail drifting out of the field of view or becoming too small or faint to be tracked (Fig. 3a).**"

- For data points where y = 35min, the maximum simulated contrail lifetime has been capped to 35 minutes to align with the longest observed contrail lifetime. This was previously noted in the caption of Figure 8.

11. *Fig. 9: In the figure caption, you mention that the black lines represent the "temporal evolution …". These are only the thin black lines. The thick black line is the 1:1 line.*
    - Thank you identifying this mistake. We have made the following changes in the revised manuscript to rectify this:
        - [Main text: Lines 336 – 341] "Figure 9: Comparison between the observed and simulated contrail geometric width for waypoints with true positive cases **and with observed lifetimes exceeding 2 minutes** (Y_{Camera} > 2 minutes & $Y_{Sim=CoCiP}$) ~~and with observed lifetimes exceeding 2 minutes~~. Panel (a) shows a parity plot between the observed and simulated widths at single point in time, with the black line~~s~~ representing the **1:1 line** ~~temporal evolution of the contrail width for each waypoint~~. Panel (b) illustrates the difference between the observed and simulated geometric widths as a function of the observed contrail age**.**~~, with~~ **For panels (a) and (b),** individual lines **connecting different data points** represents~~ing~~ the temporal evolution of **the contrail width at** each contrail waypoint. The observed contrail pixel width is converted to the observed geometric width using the reverse camera transformation model (see Section 2.3)."

12. *Lines 305-306: For me, an analysis using a smaller study is even more affected by sub-grid scale variations. Hence, "because of the small study domain" sounds a bit awkward. I would have expected "despite of…"*
    - Thank you. We have made the following changes in the revised manuscript to address this comment:
        - [Main text: Lines 321 – 326] "Secondly, the spatial resolution of the ERA5 HRES (0.25° longitude × 0.25° latitude ≈ 18 × 28 km) is insufficient to capture the sub-grid scale RHi variabilities **that have been observed from in-situ measurements** (Wolf et al., 2024). ~~Here, we do not evaluate the effects of sub-grid scale RHi variabilities because of~~ **Given** the small study domain, where the camera's field of view fits within 10 grid boxes of the ERA5 HRES (Fig. A2), **our simulation would be particularly impacted by these sub-grid scale effects. However, we do not evaluate these effects due to our small** ~~and the limited~~ sample size (n = 942 for waypoints with Y_{Camera} **distributed** over 14 h **and 10 grid boxes**)."

Technical corrections

13. *Line 29: reaches -> exceeds?*
14. *Line 127: remove ","*
15. *Line 151: its*
16. *Line 343: " ."*

17. Line 360: Missing full stop.

- Thank you for identifying these technical errors, the necessary corrections have been applied to address Points 13 to 17.

REFEREE 2 (RC2)

18. While the authors have made a good effort to acknowledge the limitations of this study in terms of representing only clear-sky contrails, they leave out any quantification of the representativeness. A good reference to that effect was provided in the original review, Bedka et al., Geophysical. Res. Lett., 2013. Given that there is knowledge available on this subject, the authors should inform their readers about how much of the contrail phenomenon this study addresses.

- Thank you for highlighting this. We overlooked this comment in the original review. We have now incorporated the findings of Bedka et al. (2013), which estimate that contrails form under clear sky conditions only about 15% of the time:
  - [Main text: Lines 414 – 419] "Nevertheless, we acknowledge the potential limitations of our study, including the small sample size and an inherent bias toward selecting contrails formed under high-pressure systems (i.e., clear sky conditions), **which is estimated to account for only 15% of all contrails in the Northern Hemisphere (Bedka et al., 2013). This selection bias** ~~while~~ exclud~~esing~~ **a significant portion of** contrails formed in low-pressure systems associated with storms or overcast weather. ~~This selection bias could be significant, as different~~ **Such discrepancies in** synoptic weather conditions could introduce varying error patterns in NWP models, which may **propagate and affect** ~~lead to differences in~~ the accuracy of the simulated contrail outputs."

REFERENCES

Bedka, S. T., Minnis, P., Duda, D. P., Chee, T. L., & Palikonda, R. (2013). Properties of linear contrails in the Northern Hemisphere derived from 2006 Aqua MODIS observations. *Geophysical Research Letters*, *40*(4), 772–777. https://doi.org/10.1029/2012GL054363

Bier, A., & Burkhardt, U. (2022). Impact of Parametrizing Microphysical Processes in the Jet and Vortex Phase on Contrail Cirrus Properties and Radiative Forcing. *Journal of Geophysical Research: Atmospheres*, *127*(23), e2022JD036677. https://doi.org/10.1029/2022JD036677

Iwabuchi, H., Yang, P., Liou, K. N., & Minnis, P. (2012). Physical and optical properties of persistent contrails: Climatology and interpretation. *Journal of Geophysical Research: Atmospheres*, *117*(D6). https://doi.org/10.1029/2011JD017020

Märkl, R. S., Voigt, C., Sauer, D., Dischl, R. K., Kaufmann, S., Harlaß, T., Hahn, V., Roiger, A., Weiß-Rehm, C., Burkhardt, U., Schumann, U., Marsing, A., Scheibe, M., Dörnbrack, A., Renard, C., Gauthier, M., Swann, P., Madden, P., Luff, D., … Le Clercq, P. (2024). Powering aircraft with 100 % sustainable aviation fuel reduces ice crystals in contrails. *Atmospheric Chemistry and Physics*, *24*(6), 3813–3837. https://doi.org/10.5194/ACP-24-3813-2024