Review of "Impact of Host Climate Model on Contrail Cirrus Effective Radiative Forcing Estimates" by Zhang et al., 2024

In the study by Zhang et al., the influence of underlying climate models on the effective radiative forcing of contrail cirrus is examined. Two different climate models, both using the same parameterization for contrail cirrus but different microphysical schemes, are used. It turns out that differences in humidity in the UTLS region between the two models lead to significant variations in the fraction of contrail cirrus.

Quantifying the differences between the climate models in terms of their description of contrail cirrus' effective radiative forcing is crucial. Therefore, this paper aligns with the scope of ACP.

However, I have concerns about the overall structure of the comparison, which I will outline in more detail below. For this reason, I recommend a thorough revision of the manuscript before publication.

General Comments:

The aim of this manuscript is to address the differences in radiative forcing from contrail cirrus due to the use of different host models. The same contrail cirrus parameterization is applied to both models (CAM and UM). However, the two models differ significantly in some key parameters (as shown in the table), so it is unsurprising that the results also vary greatly. As a result, it's unclear what conclusions can be drawn from this comparison.

	UM	**CAM**
Microphysics	one-moment (Wilson and Ballard, 1999)	Two-moment (Gentleman and Morrison, 2015)
Horizontal resolution	1.9° lon x 2.5° lat	1.25° lon x 0.9° lat
Vertical resolution	85 levels (500 m @ UTLS region)	56 levels (1000 m @ UTLS region)
Time step	20 minutes	30 minutes
Nudging	ERA5	NASA MERRA-2

This raises the question of whether the title should instead be: "Impact of the microphysical scheme on contrail cirrus effective radiative forcing estimates." Alternatively, the differences in radiative forcing could be investigated by focusing on aspects such as horizontal or vertical resolution, model time step, or even different nudging datasets. After reading the manuscript, it's unclear

to me why two climate models were used. I believe the study could have been effectively conducted using a single model with different microphysical schemes.

This leads me to question what can be learned from these results. Would it not be more useful to focus initially on a single host climate model, examining the impact of factors such as microphysics or spatial resolution? Could the spatial and temporal dimensions of the models not at least be harmonized? Doing so would make it easier to assess the differences between the two host models.

Specific Comments:

- **Section 2:** Since ice supersaturation is a key prerequisite for contrail cirrus formation, it would be helpful to include a more detailed description of how ice supersaturation is treated in the host climate models. For example, is ice supersaturation allowed within clouds? What about saturation adjustment?

- **L179:** You point out the important differences in microphysical schemes here, but you also discuss differences in contrail representation. This is confusing, as both models use the same contrail parameterization. Please clarify.

- **L194ff:** The cross-sectional area of the initial volume is set to 100m x 100m for both models, despite their significantly different horizontal resolutions. How does this influence the results?

- **L210ff:** Could you comment on or estimate the expected differences due to the use of different nudging datasets? Why are two different datasets used in the first place?

- **Section 3.1:** You mention good agreement between UM and CAM ice supersaturation versus observations, but Figure 1 shows clear differences in the annual zonal mean. Could you comment on this? Which model aligns more closely with observations? Over what time period is the annual zonal mean calculated—one year or more?

- **L244ff:** Why was 2006 chosen for the seasonal cycle, and how representative is that year? Which December (2005 or 2006) was used?

- **Section 3.2:** The young contrail is defined as the contrail in the first time step of its life cycle (L258). What differences can be expected if one model has a time step of 20 minutes and the other 30 minutes? Later, it's mentioned that CAM values are normalized by multiplying by 2/3. What if CAM shows no contrails after 30 minutes, but they would still be present after 20 minutes?

- **L283:** What do you mean by "high temperature in the Northern Hemisphere"? Are you referring to temperature in the UTLS region?

- **L289:** The phrase "This may be due to…" sounds speculative. Can this be substantiated?

- **L297ff:** Differences in CAM results are discussed, showing a factor of 10 when different vertical resolutions are used. How useful is it to compare CAM and UM, which have significantly different vertical resolutions?

- **L308f:** What is the temporal and spatial resolution of ECHAM5 in this case?

- **Section 3.4:** The description of the scaling factor is brief. Could you explain how you arrived at the value of 4900? Is this value representative for regions with less traffic?

- **Figure 6 Caption:** What are the "annual mean simulated contrail-driven changes" compared to?

- **L393:** The phrase "is likely due to…" sounds speculative. Can this be substantiated?

- **Summary (L416):** You mention the use of the same contrail scheme in two different host climate models. However, disentangling the differences due to one- and two-moment microphysics is challenging enough. Including different climate models with varying resolutions seems to skip a necessary step (as mentioned above).

- **L429ff and L373ff:** You write that the contrail cirrus is misrepresented in UM for understandable reasons, but it should be shown more clearly that CAM provides a more realistic representation, especially since UM's optical depth is matched to CAM's values.

- **L443 (Future Work):** It appears that microphysics is recognized as the greatest uncertainty, and improving UM with a new two-moment microphysics scheme is suggested. If microphysics is indeed the primary factor driving differences, the title of the manuscript should reflect this focus, perhaps as “Impact of Microphysics on Contrail Cirrus Radiative Forcing.”

Typos, Format, etc.:

- **L69f:** Place the likelihood range after the unit, as in L72.
- **L77:** Avoid two parentheses directly after one another.
- **L150ff:** In LaTeX math mode, use \textrm for text and \unit{} for units. Ensure consistent typesetting and spacing between different units.
- **L123:** Omit parentheses around Wilson.
- **Figure 6:** Use "m²" for kg/m².