

Comment on the “Investigating the limiting aircraft design-dependent and environmental factors of persistent contrail formation” by Liam Megill and Volker Grewe

General Comments:

The study by Megill & Grewe examines the limiting factors related to aircraft design and environmental conditions in the formation of persistent condensation trails. The aircraft design factors considered include propulsion efficiency in relation to the type of fuel used (Sustainable Aviation Fuels - SAFs, hydrogen - H₂ fuel cells and combustion, hybrid electric aircraft, and the Water-Enhanced Turbofan - WET). The environmental conditions studied are ice supersaturation, droplet formation, and droplet freezing. The dataset used to calculate the environmental conditions is the ERA5 data set. The analysis is performed in a 3D dimensional framework using data from the decade of 2010. To limit computation cost and autocorrelation, the authors randomly selected data from a certain number of hours per season. The authors developed climatological relationships describing potential persistent contrail formation as a function of pressure level and Schmidt-Appleman mixing line slope G , and found that the influence of aircraft design on persistent contrail formation decreases with increasing altitude. They found that ice supersaturation is the most limiting factor for all aircraft designs considered. They also found that, on the one hand, globally averaged persistent contrail formation could increase by 13.8% for next-generation conventional aircraft, or by 71.4% if all aircraft were replaced with hydrogen combustion or fuel cell equivalents. On the other hand, water vapor extraction technologies, such as the Water Enhanced Turbofan concept, have the potential to reduce persistent contrail formation by 53.6% to 85.6%.

This is an excellent study, carefully produced and well-written. It fits perfectly within the CPA framework. I therefore recommend publication of this article once the authors have responded to the major and minor comments listed below.

Majors comments:

1. The authors investigate the limiting factors related to aircraft design and environmental conditions in the formation of persistent contrails using ERA5 data. Consistent with a previous study that reported biases in ERA5 relative humidity, the authors apply a bias correction approach to address this deficiency. However, previous studies have also reported biases in ERA5 temperature data (e.g. Wolf et al. 2023), in the upper troposphere and lower stratosphere. Since temperature is an essential parameter in the Schmidt-Appleman criterion, I recommend that the authors discuss the

potential impact of these biases on their results, since they didn't correct them as in Wolf et al. (2023).

2. The authors conducted their study over the decade of 2010. To limit computational costs and reduce autocorrelation, they randomly selected 10 % (one-year duration data) of the total data. It is questionable whether the study can be considered a climatological framework study, especially at the regional scale, where the limited number of sampling points may raise concerns about statistical robustness. The authors should perform a sensitivity test on the sample size (number of hours or percentage) to assess the robustness of the results (e.g., variation in the fraction of persistent contrails with fuel change) and the conclusions of the study.

Minors:

L18: Even if persistent contrails quickly dissipate, they can still be expected to have localized and short-term small impacts on the climate. It is preferable to use terms like "small" or "negligible impact", etc. instead of suggesting "no impact."

L18: Please start a new sentence from "In certain conditions"

L22: Please, cite the references in chronological order and ensure this is consistently applied throughout the manuscript.

L205: Please specify what RH_i is.

L89-90: Please split the sentences into two for easier understanding, starting the second sentence for example with "but in total prevents".

L95: Please define the acronym ERA5

L240 : Typos, please change the second "that" before the word "factor" to "the".

Reference:

Wolf et al. 2023. Correction of temperature and relative humidity biases in ERA5 by bivariate quantile mapping: Implications for contrail classification.