Geoscientific Model Development Discussions

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Comment on gmd-2022-203

Kieran Tait (Referee)

Referee comment on "A Python library for computing individual and merged non-CO_2 algorithmic climate change functions: CLIMaCCF V1.0" by Simone Dietmüller et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-203-RC1, 2023

This paper provides an excellent contribution to the field of climate-optimal aircraft routing, with a focus on the spatio-temporal sensitivity of the atmosphere to non-CO2 emission species. The first-of-a-kind ClimaCCF tool is presented, which enables its user to investigate the potential variability in atmospheric response to aircraft emissions, through rapid calculation of algorithmic climate change functions.

The delivery of this manuscript is aptly timed, as the industry becomes increasingly aware of the vast potential to reduce climate impact through operational means, in the interim to fully zero-emissions flight. ClimaCCF is a prime example of a useful tool to communicate complex climate science to the aviation industry, policymakers, and the wider public. In particular, the use of K/kg(fuel) as a metric to distinguish the climate impact of individual flights could be a more useful performance indicator than say, total emissions per flight.

The paper begins with an introductory literature review, which succinctly explains the concept of weather-dependent trajectory planning. It is evident from literature cited, that this project largely builds on the works of FlyATM4E and REACT4. Whilst these research groups have been the driving force behind progress on this topic in recent years, more background information on the fundamental science of non-CO2 climate forcing could be beneficial here. For example, the less experienced reader may appreciate a more comprehensive explanation of (or references to) chemical reactions that lead to NOx-based effects, or the basis of contrail formation and persistence. A clearer explanation of these fundamentals in the beginning of the paper may help to justify decisions made later on regarding parameters used in aCCFs.

The formulation of aCCFs is well presented in section 2. However, the discussion around the use of NOx EI and flown distance per kg fuel is not immediately obvious, based on wording. It took a good few reads to understand that these metrics were introduced purely to change units for the merged aCCFs. Better explanation around this unit conversion for both NOx aCCF and contrail aCCF might help to minimise confusion. See attached pdf for suggestions. In the discussion on climate efficacy conversions, some more detail on how and why RF from different climate forcers results in different levels of warming could help too.

In section 3, the technical details of ClimaCCF are covered in great detail. Figure 1 is a very useful schematic to help understand the process flow of the tool. A reference/link to the exact ECMWF ERA5 dataset used could aid the reader, should they decide to implement the tool themselves.

It is good to see that the science underpinning non-CO2 climate forcing is better presented in section 4, along with the associated example aCCF maps. My research team and I do however, have one major area of concern in the technical implementation of the ozone aCCF: It is stated outright that the photochemical ozone formation does indeed increase with available sunlight. However, ozone aCCF does not take into account irradiance (table 2 states only temperature and geopotential are required to calculate ozone aCCF). How therefore, would these effects be captured in the generated maps? Note, this is less of a point about your findings, and more about drawing attention to the fact that ozone aCCF formulation does not include solar radiation as input. The photolysis reactions pertaining to the formation of ozone are highly sensitive to solar radiation, so more information explaining why the derivation did not identify this sensitivity would be useful.

Sections 5 and 6 round off the paper sufficiently, with discussion around technical implementation and conclusion to highlight key points and findings. One final area that has led to confusion in this paper is the aCCF limitations. Why is it stated that aCCFs are only configured for use in the North Atlantic Flight Corridor region, when all of the maps generated as examples are over mainland Europe? This contradiction between what is stated and what is shown in examples may lead to reader uncertainty.

In general, the findings of the paper were very interesting and engaging, and the tool is an excellent addition to the field. However, technical details need to be addressed such as punctuation, wording and hyphenation, as there were lots of minor technical issues found in the manuscript, hence why presentation quality is given as "fair" in this round of the review. The attached pdf attempts to address the specific areas that may need a second look, so that corrections can be made where deemed necessary.

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2022-203/gmd-2022-203-RC1-supplement.pdf