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Comment on acp-2021-998

Anonymous Referee #1

Referee comment on "A process-oriented evaluation of CAMS reanalysis ozone during tropopause folds over Europe for the period 2003–2018" by Dimitris Akritidis et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-998-RC1, 2022

In the manuscript, CAMS reanalysis tropospheric ozone profiles are evaluated during folding events using ozonesonde and IAGOS aircraft data in Europe. A control run without data assimilation is then also used to understand the differences, especially in the upper troposphere, between the modelled and observed ozone concentrations.

The manuscript is well written and gives a nice overview of the current knowledge about STT and tropopause folding. The scope of the manuscript is very focused, and the methodology very clear, although the knowledge of earlier studies by the authors is almost a must in the description. The results are interesting, but I had the feeling at several places that the authors could go more in depth. The authors observe, but do not interpret their findings enough. I will give examples here below.

- In the introduction, you might refer to the work by Zhao et al. above Asia as well https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JD033955 , https://doi.org/10.1016/j.atmosres.2020.105158, and Luo et al. (https://www.hindawi.com/journals/amete/2019/4375123/).
- Why did you restrict your evaluation of the CAMS reanalysis ozone during tropopause folds to Europe? This is clearly not the region with the highest number of tropopause fold events, so I guess the availability of the ozonesonde and IAGOS profile data has driven the choice of the study area. Please clarify your choice for Europe in the introduction (lines 38-44 are not that convincing for the current focus of the manuscript).
- It would also be nice to give some additional climatological information on tropopause frequency, spatial and temporal variability of STT events over your study domain (Fig. 1) in Europe.
- It is not clear to me which selection criteria have been used for the ozonesonde and IAGOS sites. For instance, the Prague ozonesonde dataset, which you have been using in an earlier study, is absent. If the data criterion for using ozonesonde time series is number of observations available throughout the 2003-2018 time period (line 71), I do not understand why, for instance, Observatoire Haute Provence (OHP), Sodankylä, Valentia (?) data were not selected. The same question arises for the IAGOS airports:

what is the data temporal coverage (line 77) criterion used to include data from an airport or not?

- As you included a control run without data assimilation, please specify the sources (which satellites? which products? during which period of the 2003-2018 time frame) of partial column and profile ozone retrievals that are assimilated in CAMS reanalysis.
- In section 2.3, I would expect more details on the fold detection algorithm. Now, the summary is very limited. Major clarifications: how is the stratospheric source of air identified, what is the weight of the specific humidity content, and are the ozone concentrations used in the detection (I guess not, but please confirm clearly).
- The selection of STT events (section 2.4) in ozonesonde and IAGOS profile data seems to be rather indirect , based on your database of STT events detected in CAMSRA (with 3D-labeling algorithm). I assume this algorithm is not directly applicable to ozonesonde and IAGOS "2D" data? Please specify. However, algorithms exist to detect tropopause folds in ozonesounding data as well (e.g. Van Haver et al., https://doi.org/10.1029/96GL00956), so how did you confirm the presence of an STT event independently from CAMSRA in the ozonesonde and IAGOS data? Details are missing how a fold is found in the ozonesonde profile (line 126) and in the IAGOS profiles (lines 131-135).
- At the end of section 2.4, it would be nice to include some statistical information: how many of the CAMSRA STT events are also identified in the coincident ozonesonde and IAGOS profiles? Are the detection rates site dependent? Dataset (ozonesonde vs. IAGOS) dependent? What are the relative ratios between the STT events and rest of events? Again: site or dataset specific? Consistent?
- In section 3.1 and 3.2, you mention some spatial differences between the CAMSRA and observational ozone profile differences, e.g. in lines 145-148, in lines 157-159. But, you do not give any explanation why features in the differences arise at some sites, and not at other sites. Is this related to data quality issues at some sites, instruments used, differences in the spatial representativeness of the tropospheric ozone observations at some sites compared to others, etc? Some discussion and/or thoughts would be helpful here.
- My previous comment was on the spatial fingerprint of the CAMSRA ozone evaluation. But what about the temporal fingerprint? Is there a temporal evolution in the figures 3 to 10 that is smeared out by considering only the full 2003-2018 period? There might be a temporal component due to a change of the data quality of the observations, change of data assimilation source data, etc. Can you comment if you detected a temporal fingerprint?
- There is no clear explanation given in section 3.3 why chemical data assimilation deteriorates the comparison with the observations above 350 hPa. Only in the conclusions, a list of possible improvements in the data assimilation is given, which might explain the larger inconsistencies between model and observations at those pressure levels.
- Please reformulate the expression "with a bias increase close to O3 increases closes to the upper troposphere"; its meaning is not fully clear to me.