Author’s Response

“A process-oriented evaluation of CAMS reanalysis ozone during tropopause folds over Europe for the period 2003–2018”

Dear Editor

Please find below our responses to the Reviewer’s #2 comments.

In addition, to make our Figures more color-blind friendly (suggestion from the editorial support), we have modified Figure 3 (quality of red color), Figures 4 and 5 (quality of red color, green is replaced with pink), and Figures 6 and 10 (new color schemes).

Sincerely,

Dimitris Akritidis (on behalf of all the co-authors)

Note: Reviewer's comments are presented in black font; authors' responses are presented in blue plain font; manuscript text quotations are presented in blue bold font.

Anonymous Referee #2

We would like to thank Reviewer #2 for her/his time devoted and the constructive and helpful comments.

Thank you for carefully answering and taking into account most of my comments. The figures that have been included in the supplementary material are really an added value for the paper and some figures (figures R1 and R4/R5) might even deserve to be included in the main manuscript, I would say. The authors have now provided the essential information about the methods and tools used in their analysis and the findings are also much more interpreted in the revised version of the manuscript.

We would like to thank Reviewer #2 for the positive comments. Our point-by-point responses to the Reviewers comments are presented below.

I only have two minor comments:

1. The reason you gave in your response why you concentrate on Europe (project related) is not very scientific. Please include some scientific arguments (can also be data availability) why the region of interest was Europe, and not other regions in the world with more SST or tropopause fold events.

Since for the European region the observational data exhibit relatively higher data availability (following our selection criteria) compared to other regions around the world, we have included the following sentence in the Revised Manuscript (RM) (L63-64): **"Compared with other regions worldwide, the European region exhibits relatively higher observational data availability for the examined period."**

2. I think you could do better in explaining the spatial variability of the O3S/IAGOS-CAMSRA ozone differences: "The differences seen in the comparison between the observed and CAMSRA O3 concentrations among the examined sites are subject to the uncertainties introduced by the ozonesonde instrument measurements, as well as the proximity of the selected grid points to the

respective ozonesonde sites, and the CAMSRA 3-D spatiotemporal representation of the IAGOS take-off landing routes. “ As all the considered sites use ECC sondes (it should also be written in capital letters in the manuscript, not ecc), except Hohenpeissenberg, the ECC ozonesonde uncertainties should be rather modest and very similar for the different ECC sites (so no explanation for the site to site variability). BM sondes experience a higher challenge for measuring tropospheric ozone, but, on the other hand, the Hohenpeissenberg people have a long experience with it. Also the IAGOS instruments at the different airports should be traceable to the same standard, so this cannot explain why the Paris observed profiles deviate much more from CAMSRA than the ones at other airports. The CAMSRA model output should give you an idea about the spatio-temporal variability of tropospheric ozone around the sites/airports: is this higher around Hohenpeissenberg and Paris compared to the other sites? In this context, how are the sites ordered in Fig. 6 and Fig. 10? Making a geographical ordering (e.g. increasing latitude or longitude) might make sense for those figures.

The annual mean (2003-2018) CAMSRA O3 concentrations over the examined sites indicate small spatial variability. In more detail, the CAMSRA O3 concentrations at Hohenpeissenberg and Paris are not higher than that of the other sites, but rather similar, as also indicated by Figure 3. As discussed in the paper the CAMSRA O3 overestimation in the upper troposphere is a feature seen in the majority of examined stations. The overestimation seen at Hohenpeissenberg and Paris in the middle and lower troposphere is on average ~3 ppb (between 450 and 850 hPa) which is slight amount comparable with the precision of sonde measurements and within the range of the standard deviations in ozone profiles for observations and CAMSRA. Similar O3 overestimations in the free troposphere over Hohenpeissenberg are also reported for previous ECMWF atmospheric composition reanalysis products such as the MACC reanalysis (see Figures 7 and 8 in the evaluation study by Katragkou et al. (2015)).

Moreover, CAMSRA O3 representation is also subject to regional differences and uncertainties in ozone precursor emissions affecting modeled local net photochemical ozone production rates. In addition, differences seen in the comparison between the observed and CAMSRA O3 concentrations among the examined sites are also related to the spatiotemporal representativeness of WOUDC vertical profiles and IAGOS aircraft take-off/landing routes by the selected CAMSRA grid points and time steps. In the RM we have replaced the respective sentence with the following (L185-189): **“The differences seen in the comparison between the observed and CAMSRA O3 concentrations among the examined sites are presumably related to regional differences and**

uncertainties in O3 precursor emissions affecting modeled local net photochemical O3 production rates, as well as the spatiotemporal representativeness of WOUDC vertical profiles and IAGOS aircraft take-off/landing routes by the selected CAMSRA grid points and time steps."

Finally, as suggested, in Figures 6 and 10 in the RM the sites are ordered with increasing latitude, and "ecc" is replaced with "ECC".

References

Katragkou, E., Zanis, P., Tsikerdekis, A., Kapsomenakis, J., Melas, D., Eskes, H., Flemming, J., Huijnen, V., Inness, A., Schultz, M. G., Stein, O., and Zerefos, C. S.: Evaluation of near-surface ozone over Europe from the MACC reanalysis, Geosci. Model Dev., 8, 2299–2314, https://doi.org/10.5194/gmd-8-2299-2015, 2015