

## ***Interactive comment on* “Harmonization and comparison of vertically resolved atmospheric state observations: Methods, effects, and uncertainty budget” by Arno Keppens et al.**

### **Anonymous Referee #2**

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The manuscript “Harmonization and comparison of vertically resolved atmospheric state observations: methods, effects, and uncertainty budget” by A. Keppens et al. presents a summary of different methods for harmonization and comparison of atmospheric profile retrievals. This paper summarizes different approaches to harmonize data using a consistent mathematical terminology, which makes it easy to contrast different methods and estimate a contribution of each manipulation to the final result.

This study fits well to the scope of the problems discussed in the ATM. This manuscript would be a good addition to the special TUNER (Towards Unified Error Reporting) issue laying a theoretical base for the atmospheric profile comparisons and error analysis.

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The results are presented in a consistent manner. The manuscript is very technical, but overall it is well written. I would recommend this paper for the publication in the AMT after some technical corrections. My general and technical comments are listed below.

General comments:

-Page 4, line 5: Do you mean cross-covariances here - the covariances between different error terms? Please, re-phrase this statement.

-Page 6, lines 16-19: I am not sure if I understand this part of the manuscript. To interpolate a vertical profile from a coarser vertical scale to a finer scale, one needs to assume an underlying function (linear, quadratic etc.). This interpolation might introduce an additional source of error into the comparison results that authors did not mention and considered here. If one degrades vertical resolution of the profile reported on a finer vertical scale, then no additional information is required. Typically, it is recommended to make comparisons on a vertical scale of the measurement with a coarser resolution. There is a discussion of effect of interpolation in section 5, but it would be good if you can mention that here as well.

-Page 7, equation 13: Why do you apply two operators (max/min) simultaneously? How would these two operators work? In the original paper referenced here [Langerock et al., 2015], authors use min or max, but not a combination of the two.

-Page 19, Conclusions. Conclusions are not well written, and I would suggest you make some revision. I listed some suggestions below in the technical section.

Technical comments:

-Page 1, line 11: the reference is missing;

-Page 2, lines 1-2: there are many abbreviations here that have not been introduced earlier in the text.

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-Page 3, lines 1-10: Typically,  $X_a$  and  $S_a$  are used to define a priori profile and corresponding matrix. It might be easier for readers to follow your paper if you use the established terms.

-Page 4, line 18: It might be better to re-phrase: "a full assessment and quantification of all contributions to the difference error  $S_{\Delta}$  are necessary ..."

-Page 5, lines 6-7: I suggest to replace this phrase with "...the latter may introduce a bias and increase the spread due to uncertainties in the ancillary data. ..."

-Page 5, eq. 8 (also eq. 12): there are three equations written in one line. I suggest to have one equation in each line and have (a, b, c) labels for each equation.

-Page 7, lines 29-30: the sentence needs some re-wording, because the meaning is not clear.

-Page 19, line 1: I suggest to re-phrase with "The harmonization of a pair of atmospheric profile retrievals and their representations is required ..."

-Page 19, lines 3-4: This sentence needs some re-wording. Maybe something like "Other data manipulations are needed to reduce the error budget of the comparison by minimizing contributions due to differences in retrieval characteristics and spatiotemporal sampling."

-Page 19, lines 4-5: replace with "... have been identified and expressed in a consistent way using common matrix algebra."

-Page 19, lines 5-6: Suggest to replace with "These operations include procedures for converting the a-ante covariance and averaging kernels matrices associated to each atmospheric profile retrieval."

-Page 19, lines 7-10. It would be easy to read and understand if you simply say "In this study we discussed ..." or "Finally, we examined ...".

-Page 19, lines 8-10. I would rather say "... what terms of the error covariance are

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removed. . .”

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