I answer the comments of reviewer #1 (included in "**boldface**" for clarity).

It is unclear to me what this paper adds. It appears that the paper is a continuation of a discussion in the paper by Ridolfi et al (2022) which is more complete than the current document.

This paper defines new variables to represent the retrieval products that have several advantages with respect to the standard quantities used so far. Furthermore, it describes how to calculate these new variables and discusses their advantages. This objective is clearly stated in the abstract and in the introduction of the paper and the result is completely new.

The paper by Ridolfi et al. (2022), of which I am coauthor, compares the performances of the synergistic retrieval and of the complete data fusion in the case of combining simulated FORUM and IASI-NG measurements, therefore, the subjects of the two papers are quite different.

The terminology is confusing: the author is using a term data fusion. maybe i do not understand this but if i look at how the Ridolfi et al is defining data fusion it looks more like a data combining - averaging than fusion. I would understand data fusion more as a combining two different data sets from totally different sources (e.g. model and observations) than combining two different observational datasets. When combining observations with model simulations, reference is made to data assimilation, which is a different topic then discussed here.

Averaging and data fusion are different processes applied to observational datasets. The first one can be rigorously applied only in the case of consistent retrieved profiles that have the same vertical resolution (the same averaging kernels) and the second one is a more sophisticated algorithm that can also be used when the retrieved profiles have different vertical resolution.

However, this terminology is not introduced in this paper. I have been using this terminology since 2009, when I faced this problem for the first time in Ceccherini et al. (2009). Since then several papers (see the list of papers reported at the end), where I am coauthor, have been published on this subject using this terminology and the difference among averaging, fusion and assimilation has never been considered to be a confusing issue.

Here the author discusses a method to combine two different observational datasets.

In this paper I do not discuss a method to combine different observational datasets. This topic has been discussed in previous papers (see the list of papers reported at the end).

Here, as I have already indicated in the answer to the first point, I discuss a new representation of the retrieval products that has several advantages.

The abstracts suggests something new. However, already for decades there are instruments mounted on the same satellite platform, making observations in different spectral regions of the same atmospheric properties: vertical profiles of T, q, O3, etc. For iinstance IASI-MHS or HIRS and AMSU etc. So there is already a wealth of real data where new ideas can be tested. We do not have to wait for future missions like FORUM or IASI-NG, before the value of a new approach can be demonstrated.

I agree with the reviewer that it is already possible to find measurements of different instruments of the same atmospheric profile. Indeed data fusion has already been applied to real measurements and the advantages of this approach have been discussed, see e.g. Ceccherini et al. (2010b) and Cortesi et al. (2016). With the increase of satellite instruments the occurrence of the same profile being measured by more instruments will become more likely and in the abstract I address the increase in the requirement for data fusion operations. In order to underline this concept in the abstract I have replaced "very likely" with "more frequent".

What is new in this paper are the suggested new variables to represent the retrieval products.

The use of averaging kernels to mitigate the difference in vertical resolution and to mitigate issues with the mean state of the background has been reported. Rodgers has published several papers on this. And this is thus an accepted procedure to compare retrievals from different instruments. And for sure can used to derive new products which enables an more comprehensive way to combine products from different sources as discussed by the author.

But i believe there are some more fundamental problems then vertical resolution when combining similar products derived from semi simulateous observations by different instruments. Each instrument has different characteristics, viewing geometry, spatial sampling, Point Spread Functions etc. How these problems affect the final product is not addressed in the paper.

As already said above, the purpose of this paper is not to discuss the problems connected with the combination of measurements of different instruments by means of data fusion, but the discussion of the advantages of the proposed new variables for the representation of the retrieval products.

The author should demonstrate the approach he is advocating on real data.

The validation of these variables by means of application to real cases is something that requires the involvement of data provider and data user communities and should be a follow up of this paper. As stated in the conclusions: “The communities of data providers and data users are invited to test and validate the efficiency of this new interface”.

My read from the paper is that the data producers should not only distribute the products, but also averaging kernell information. This is only possible if the product is generated using the methods based on OE.

Actually, the averaging kernels are distributed also with approaches different from optimal estimation, for example when the constraint is different from an a priori profile with its covariance matrix as in the case of Tikhonov regularization. However, the hypothesis of optimal estimation approach is indispensable for the estimate of the first term of the expansion in Eq. (8). Consequently, it is true that the results of the paper are valid only for products obtained with the optimal estimation approach. This limitation is clearly stated in the paper.

If observations are not nearly coincidence in space and time, some sort of assumptions about the time/space evolution of the derived products needs to be made. It can be expected that the more complete the assumption the better the combined product will be. In that case Data Assimilation is around the corner and we would not need the new products proposed by the author as level 2 data assimilation introduces different problems, in particular correlated errors. Level 2 data assimilation is possible, but requires a different set of products.

A significant distinction between data fusion and data assimilation is that data fusion includes only experimental results and does not include any model. On the other hand, the description of the atmospheric state given by the data assimilation products comes from both experimental data and a model. I agree, therefore, that the two products have different characteristics and can be used in different contexts according to the purpose of the study that is performed. However, this is not an issue addressed in this paper.

In summary: to bring the proposed methodology to the attention of the target user community, the author should spend time to apply the method to some practical examples and then re-submit.

As already said above, in order to be significant the testing of the new variables is something that requires the involvement of data provider and data user communities and should be a follow up of this paper.

A final consideration. This review is focused on the discussion of the utility and of the problems of the data fusion, which have been already addressed in previous papers and are not the subject of this one. The subject of this paper is the new proposed variables to represent the retrieval products and their advantages. Only one of the three discussed advantages is connected with data fusion, the new variables can also be used to obtain the representation of the vertical profile with an a priori information selected by the user and allow to reduce to about one third the stored data volume with respect to the standard products. In particular, this last characteristic can be very useful considering the large data increase expected with the future missions.
I want to thank the reviewer for the time and efforts spent in this review, although I cannot agree with his/her final conclusion. The paper is a theoretical paper and, given that no errors or incoherencies have been reported in the analytical derivation by the reviewer, this theoretical result can be brought to the attention of the user community.

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