Reviewer 2

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We thank the reviewer for the useful comments. In the following, we answer the specific comments (included in **"boldface"** for clarity) and, whenever required, we describe the related changes implemented in the revised manuscript. Page and line numbers indicated refer to the revised version of the paper. The text added in the revised version of the paper to address the reviewers' comments is highlighted in blue.

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General Comments

- **The description of the vectors in Section 2.3 could be support with a diagram to highlight the difference between the retrieval products from the limb measurements and from the nadir measurements. It would also be good in this section or earlier to specify what your retrieval targets are.**

We specified the retrieval target in the introduction and at line 127 (Sect. 2.3) and we added a graphical representation of the retrieval products of 1D and 2D tomographic retrieval (Fig.1) in accordance with the reviewer request.

- **Section 3.1 requires references for the instrument details. While all the relevant information is there, this section is hard to follow as the instruments are introduced and key information about them is then merged in the second paragraph. I would recommend that this section be separated as follows: introduction to why CAIRT (aims, details, advantages etc), introduction IASI-NG (aims, details advantages etc.), why the synergy is useful (similar to your current last paragraph).**

We rewrite the instruments section following the reviewer's request.

- **In Section 3.2 it is unclear why the ERS are being introduced, how many simulations you are performing, and what was performed in Erera, 2023 vs in this work. It would be better to include an introduction paragraph for this section to describe the use of these simulations and to justify why two different radiative transfer models are being used. Figures of the ozone profiles should also be included.**

We simulated the IASI-NG and CAIRT for only one ERS scenario (line 207), we introduced the ERS datasets to describe how these scenarios are built. The citation Errera, 2023 refers to the published complete database, so that the reader could access directly to the data with the corresponding documentation.

The complete data fusion algorithm is an a posteriori method to combine Level 2 products supplied by the individual retrieval processors of the independent measurements. It is common that different Forward Models (FMs) are used in the independent retrievals. We describe and clarify this in the text. Different forward models (FMs) were used for practical reasons: limb and nadir observations were simulated by two separate groups within the project framework, each employing its own FM. However, this difference is not relevant to the objectives of the present study.

We added an introduction paragraph to Section 3.2:

To evaluate the performance of the extended CDF algorithm, we conducted a series of simulations based on synthetic measurements from the CAIRT and IASI-NG instruments. These simulations were necessary due to the unavailability of IASI-NG and CAIRT real data. The simulated datasets reproduce realistic observational scenarios and allow us to test the algorithm under controlled conditions. In the following, we describe the

simulation setup, including the forward models, instrument characteristics, and the atmospheric scenario used for generating the synthetic measurements. The CDF algorithm combines Level 2 products provided by the individual retrieval processors of the independent measurements. It is common for different Forward Models (FMs) to be used in the separate retrievals.

A new figure (Fig. 2) shows the ozone profile for the selected ERS scenario, along with the a priori profile.

- **Section 6: While the results look promising, it is difficult to interpret the improvements in DFS and the AKMs without information about the ozone profiles. It is not explained why the measurements in these three cases are suspected to be representative of the CAIRT and IASI-NG fusion. More detail is needed about the acquisitions themselves and why they have been averaged in this way. In this section you also refer to the IASI-NG and CAIRT measurements, please be specific that these are synthetic measurements or simulations.**

We added a figure with the true profile of the ERS scenario (Fig. 2), in order to better evaluate the improvements in the AKMs and DFS. The aim of this study is to describe the extension of the Complete Data Fusion (CDF) algorithm to two-dimensional (2D) retrieval products and to assess its performance, particularly in comparison with its application to one-dimensional (1D) products. To this end, we analyse the diagonal elements of the averaging kernel matrices and the total retrieval error, and we quantitatively evaluate the synergy between measurements using the Synergy Factors.

The three test cases presented are representative of the configurations described (in terms of objectives and specific measurements characteristics) in the three subsections of the Results section (from lines 289 to 313). To facilitate understanding, we have also included schematic figures illustrating the geometry of each case, as requested by Reviewer 1 (Fig. 3, 5, 8).

We modified the text in order to clarify in each sentence that we are using synthetic measurements.

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Technical Comments

- **Line 21: It's not necessary to cite all of these references, only cite the key ones.**

The selected scientific articles report on studies that are particularly relevant to the investigation of synergies among different remote sensing measurements, each addressing different aspects of the synergy. If the reviewer has suggestions regarding which references should be considered as key, we are open to revising our selection accordingly. Otherwise, we would prefer to retain the current set of references.

- **Line 35: It is not initially clear what the features (that you explain in the next sentence) are. Please combine these two sentences and rewrite.**

We modified the sentence as suggested (lines 36-40):

The CDF is termed "complete" because it accounts for all features of the combined measurements, namely the retrieval errors of the fusing profiles and their correlations (represented by the covariance matrices, CMs) and the sensitivity of the retrieved profiles to the true profile (described by the averaging kernel matrices, AKMs), and can be regarded as a generalization of the weighted mean for cases where AKMs differ from the identity matrix.

- **Line 47: Can you define what Multi Target Retrieval is?**

We added the definition of Multi Target Retrieval in the text.

- **Line 90: Define Sn,I and Ss,i**

We modified the text accordingly to the reviewer comment.

- **Line 113: This looks like the same citation twice.**

The cited papers are different:

Ceccherini, S.: Comment on "Synergetic use of IASI profile and TROPOMI total-column level 2 methane retrieval products" by Schneider et al. (2022), Atmospheric Measurement Techniques, 15, 4407–4410, https://doi.org/10.5194/amt-15-4407-2022, 2022.

Ceccherini, S., Zoppetti, N., and Carli, B.: An improved formula for the complete data fusion, Atmospheric Measurement Techniques, 15, 7039–7048, https://doi.org/10.5194/amt-15-7039-2022, 2022.

- **Line 127: Equation 14 and the description above could be better explained. If my understanding is correction, this could be rewritten like the below.**

  X^t = [pjk] where j=[1,m] and k=[1,n]

The correction suggested by the reviewer does not fully reflect the structure of the state vector as defined in Equation 14, since it overlooks the precise ordering of parameters, which is rigorously specified by the original formulation. For this reason, we recommend retaining the original equation.

- **Line 137: I would suggest moving this to the supplementary or removing it. This does not seem particularly important for the paper.**

The description of the averaging kernel matrix (AKM) arrangement is crucial for a proper understanding of how the CDF algorithm is applied to two-dimensional products. A rigorous and detailed explanation is therefore essential to support the methodological focus of this paper.

- **Line 163: Change your definition of ranges to '…645 to 2760 cm1 (15.5 to 3.6 microns)' for easier reading**

We modified the text as requested.

- **Line 185: Please specify if KLIMA is a line-by-line or fast rt model here, what version of the model you are using, and what HITRAN database it is based on.**

We added the information about KLIMA as requested:

KLIMA is a line-by-line model and for these simulations we used the AER v3.8.1 spectroscopic database.

- **Line 220: It would be good to see a plot of the NESR and target ARA for this and IASI-NG in Section 3.1.**

We have added references to the NESR specifications for both CAIRT and IASI-NG in the Simulations Section. ARA is not defined for CAIRT. Instead, a Radiometric Scaling Error is defined, which is an error proportional to the radiance, and a Radiometric Additive Error, which accounts for error contributions that are independent of the radiance level. We added a reference to a Figure in Ridolfi et al. (2022) showing the ARA

of IASI-NG. We believe that a detailed discussion of the technical characteristics of the two instruments goes beyond the scope of this paper, which focuses on the application and evaluation of the CDF algorithm.

- **Line 277: This information should be presented more clearly in a table in Section 4.**

We added Table 1, with these information.

- **Figure 1/3: The light blue is hard to see and the blue is not clear on the figure. Where has your aprori error come from? What do the profiles look like? (lines 227 for the apriori description)**

We changed the cyan colour in the plots with green. We modified the caption of Figure 1, adding a reference to McPeters and Labow for the a priori error profile.

The blue line is not visible in Figure 1 as the AKM diagonal elements profile for the fused product is superimposed to that of CAIRT as written in line 325-327 and the total error profile of the fused product is overlapped to that of CAIRT (lines 333-334).

The true profile on which the analysis is performed is reported in figure 2.

- **Line 351: The description of a synergy factor should be moved to Section 5 where you introduced other quantifiers of performance.**

We moved the description of the synergy factor in accordance with the reviewer's request.