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Comment on amt-2021-31

Anonymous Referee #3

Referee comment on "Synergetic use of IASI profile and TROPOMI total-column level 2 methane retrieval products" by Matthias Schneider et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-31-RC3>, 2021

The paper by Schneider et al. presents an interesting approach to derive tropospheric methane retrievals by synergism of IASI and TROPOMI level 2 products. The presented method is an a posteriori combination of the two level 2 products, using methane total columns from TROPOMI and profiles from IASI. The theoretical basis of the synergism is presented as well as comparisons with in situ measurements and ground-based retrievals. While previous work on fusion or synergism of level 2 products have been done, the present study shows an application of this kind of approach for methane retrievals, including the application and comparison with real data.

However, major revisions are needed in order to make the paper publishable. The present manuscript lacks some key elements to demonstrate the real contribution and validity of the combined retrieval and in some cases of criticism. Moreover, I disagree that the authors demonstrate the equivalency between this combination of level 2 products and a synergism of level 1 measurements. I strongly recommend modifying the manuscript with respect to the following major issues:

- Performance of the TROPOMI only approach vs the combined product: figure 3, 4 and 5 show that the TROPOMI total column retrievals are more sensitive (between 5 and 15 km), have less contribution of the a priori and less error than the combined product. How is this possible that the combination degrades the total column retrieval, both in sensitivity and the error? How is it possible that the IASI product does not really provide additional information according to the averaging kernels (except for a small change between 2-3 km of altitude, which is much smaller than the loss above) and it even slightly increase the error? Other synergetic satellite approaches show a very clear gain in total column retrievals, for example in total column degrees of freedom, as compared to single-instrument products. Why in the case of the combined product shown in this paper we do not see such gain and we even remark a small degradation? It is important to clarify the reason for this degradation and clearly indicate it in the manuscript. The manuscript should also point out limitations of the combined approach.
- Since the gain of the combination for the total column retrieval is not clear (even a

small degradation is seen), what is the actual information provided by IASI measurements? And what would the advantage of the combined product as compared with a profile retrieval using TROPOMI measurements only?

- In Lines 8, 63-64 and 491-492, the authors strongly claim an equivalence between the level 2 combination and a level 1 synergism. I disagree that this statement is demonstrated in the paper. Such a strong statement can not only be based in theoretical estimations of appendix A2, but a practical comparison with real data should be given. The only way to demonstrate it is to fully develop and implement a full synergism of level 1 measurements of TROPOMI and IASI and then compare its performance with that of the a posteriori combination of level 2 products. However, the authors do not show such level 1 synergism product in their paper. I strongly suggest removing these statements, unless such thorough practical demonstration is provided.
- Global daily maps: The authors claim their product enables the generation of global daily maps of combined data (line 60), however the manuscript does not provide any map of the combined product. The validation of a satellite product in specific locations (figure 6) does not imply the capability to derive global daily maps with a satellite product. In order to provide such a general statement, it should be demonstrated by showing the capacity of this approach to map tropospheric methane distribution.
- Co-location of TROPOMI and IASI products: the authors arbitrary propose co-location criteria in section 2.2. Such criteria should be geophysical justified by comparison between the time-space variability of methane. What is the influence of the difference in the overpass time? How does it compare with the diurnal evolution of methane? The same in terms of space variability. It should also be clearly specified the horizontal resolution of the combined product and the coarser resolution of this product as compared to TROPOMI should be explicitly indicated as a limitation. Moreover, section 4.2 on data inconsistency should also deal with heterogeneity and time evolution of methane as observed by IASI and TROPOMI, and in addition to their biases.
- Title: "Synergetic use of IASI and TROPOMI space borne sensors .." calls for ambiguity when it comes for the use of the IASI and TROPOMI spaceborne sensors measurements. I recommend to clearly indicate in the title "level 2 products" or "level 2 retrievals" instead of only the sensors.
- The authors claim that the major contribution of the combined product is a tropospheric column of methane that is not obtained with the individual single-instrument product. However, this statement should be more moderate since Figure 12 only show an increase in correlation R^2 from 0.245 (IASI only) to 0.346 (combined product), which remains a rather moderate gain.

Other important points:

- A UTLS partial column retrieval from TROPOMI: in Figure 5c, black marks are drawn that would correspond to a TROPOMI retrieval. Does this partial column retrieval exist?
- The "correlation plots" or scatter plots of figures 7, 10 and 11 are very difficult to understand visually (biases and slopes) due to the change in the scales (vertical and

horizontal). I recommend changing them to have the same range in both axes.

- The use of % for correlation coefficient is not the most common practice. I recommend expressing correlation coefficients as values between -1 and 1.