Review of Borsdorff et al. "Vertical information of CO from TROPOMI total column measurements in context of the CAMS-IFS data assimilation scheme"

This study developed a posteriori profile retrieval method to estimate the mean CO vertical distribution from an ensemble of standard TROPOMI CO column retrievals by incorporating the profile sensitivity from column averaging kernel. The column averaging kernels and retrieval precisions are used to relate the column and the profile, as expressed in equation (2). An optimization scheme was deployed to "retrieve" the mean CO profile. The CO profile is then used to compare with model simulations and field measurements to show that the TROPOMI CO column retrievals contain satisfying vertical distribution information that may not be in the model simulations. For the CAMS-IFS to assimilate TROPOMI CO columns, besides using IASI and MOPITT data, such assessment on the information content from TROPOMI CO column retrieval as reflected in its column averaging kernel is important. Nevertheless, I have two major comments and some specific ones as detailed below. Moreover, the writing of this manuscript, including formatting and simple punctuation, should be improved and double checked through the manuscript.

Major comments:

(1) Assumptions on formulating Equation (2) that relates CO profile and column
The matrix A is the total column averaging kernel from TROPOMI CO column retrieval. As I understand it:
$x\_hat - x0 = A*(x - x0) + e$
where "x_hat" is the retrieved CO profile (its integration is the retrieved total column "c"); "x0" is the a priori in the retrieval algorithm; "x" is the "truth"; "e" is the error term.
Then,
$x\_hat + (A-I)*x0 = A*x + e$
Since the a priori "x0" or "(A-I)" is not zeros in the TROPOMI column retrieval algorithm, this term cannot be omitted. I would like to know the theoretical basis and assumptions made on formulating equation (2), which is the key equation for the profile retrieval method.

(2) Effectiveness of the a posteriori profile retrieval method should be evaluated using simulation spectra
The way to infer the profile from column and column AK is interesting. However, simulation study (so called OSSE) should be carries out to make sure the method works properly. In this way to make sure the retrieval results are not significantly biased, and to quantify the error budget from the a posteriori profile retrieval algorithm.

Specific comments:

Line 9: change "individual … retrievals"

Line 11: remove "the" before date.

Line 38: rephrase "are supplied **by** the data product"

Line 50: comma before "respectively"

Line 81: correct the citation format

Line 125: left hand side of Equation (3) should be the cost function value, not x_ret.

Equation (3): Which is used for x_apr in the retrieval algorithm? Is it TM5 simulations? Please add that in the paragraph.

Line 138: in better agreement with TROPOMI CO columns retrieved using profile scaling?

Results section: I would suggest to separate this one big section into 3 parts based on the three different cases.

Line 158: CAMS-IFS assimilates IASI and MOPITT only. The reason the pollution pattern does not show up in the simulation may be because both satellite data failed to capture the anomalies. Please see the images of IASI CO below:
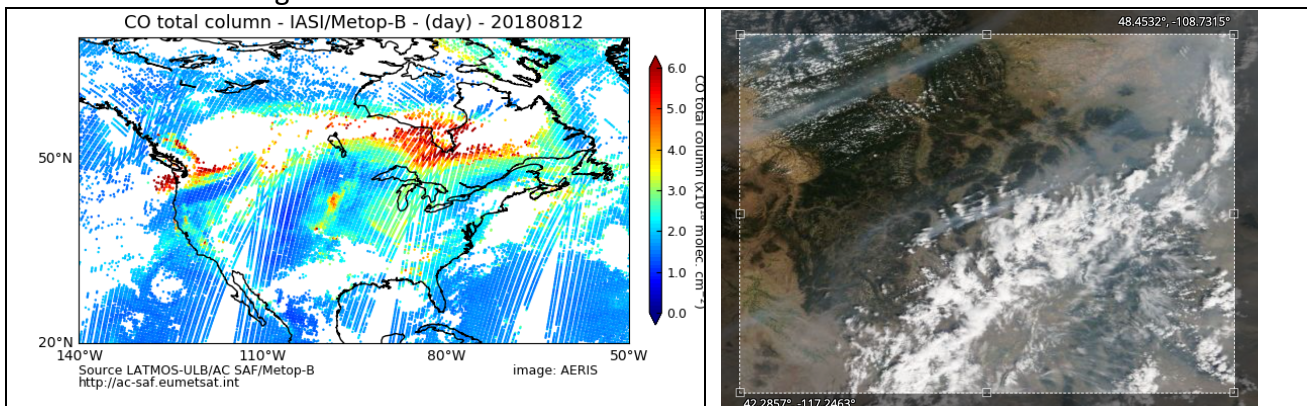

Figure A: (left) IASI CO; (right) MODIS Terra true clor image.
Source 1: https://iasi.aeris-data.fr/co/
Source 2: https://worldview.earthdata.nasa.gov/?v=-124.38027857717674,37.98995560270401,-101.18322922255078,50.78515346100961&t=2018-08-12-T08%3A04%3A01Z

Very likely due to clouds over the fire plume (seen from the MODIS image on the same day), IASI did not make the retrieval. Therefore, it is not reflected in the CAMS-IFS. Adding this background information may help readers to understand the discrepancy between TROPOMI and CAMS-IFS.

Line 159: "This can be either due to missing emissions of the fire in the model or a time delay of the emissions used in the forecast run of the model." You can easily check that by looking into the temporal changes of CO simulations in CAMS-IFS. Or, as I point out above, this is because the IASI data feeded into CAMS-IFS failed to capture the high CO plume.

Line 184, comma before "respectively"

Figure 1:
Do the different colors have meaning? The column averaging kernels differ largely, what are the primary cause? There is an outlier in light blue, which has AK values close to 1.0 for all layers, representing a very ideal case. Why does this one look so peculiar? Also, please rewrite the x-axis label.

Figure 2: please correct the subscript formats for x-axis and y-axis labels

Figure 3: Please explain the difference of the physical meaning of AK columns and rows.

Figure 7-9: Is a way to add error bars for the CO profile retrievals to show if the difference is significant or not?