Answers for Referee 1

We thank reviewer #1 for his/her review, valuable comments and suggestions, that we took into account to improve the paper. Our replies are in blue.

Comments

P8 line 16: The averaging kernel plot is not very helpful. You should distinguish the kernels for each level somehow.
As Figure 1 is presenting CO total column distributions, the averaging kernels are also plotted for total columns. The caption for this plot was misleading, we have clarified that the averaging kernels are also for total columns. For a sake of completeness kernels for each levels are now plotted on Fig. 9.

P11 line 9: Clarify what you mean by DOFS here. For a column retrieval, the DOFS cannot be greater than unity, because there is only one variable. I presume you are plotting the monthly average of the DOFS for the profile retrieval at each location.
Yes, we are plotting the monthly average of the DOFS for the profile retrieval at each location. We modified the sentence: "The top and middle panels of Fig. 3 show the monthly average for CO total column distribution (daytime data) for April 2010 along with the monthly average of the DOFS for the profile retrieval, for each instrument."

P11 line 12: I notice that the reduced CO in North and South America corresponds to the location of mountains. Also the Himalayas. Is the surface height likely to be the main reason for the reduction?
Yes. We added the following sentence: "Note that reduced CO total columns at the location of mountains in North and South America, as well as in the Himalayas, are due to surface height."

P11: What differences would you expect between MOPITT and IASI on the basis of their respective averaging kernels for total column?
As MOPITT and IASI differ, their associated averaging kernels differ too. When using the same a priori, the difference in total column reflects this, but the different auxiliary parameters such as temperature profiles and cloud filtering also impact. Also the difference in time and location will be seen. This is further discussed later in the paper when the vX1 retrievals are discussed.

P12 line 13: "except over Antarctica" where MOPITT DOFS are close to zero, indicating that it is returning just a priori.
We removed "(except over Antarctica)" and added the following sentence at the end of the paragraph: "Note that over Antarctica, MOPITT DOFS are close to zero, indicating that the retrieved profile is close to the a priori profile."

P13 lines 14-17: Please explain in more detail how the grid conversion is carried out. E.g:
-MOPITT uses pressure levels. I presume you interpolate log(VMR) linearly in log pressure. You should say so.
We modified the sentences:
"Since the Sa matrix cannot be extrapolated or interpolated and has to fulfill necessary properties (it has to be positive definite and the sum of its elements has to be conserved), a challenging step in this process was to convert the IASI Sa matrix expressed in altitude and partial columns into a MOPITT-compatible matrix, expressed in pressure levels and log(VMR). This was achieved by building a new profile and matrix from the original profiles in VMR used for the Sa matrix generation in FORLI, on a common 35-pressure layer grid."
to

"It is not possible to exactly convert the IASI Sa matrix (expressed in altitude and partial columns) into a MOPITT-compatible matrix (expressed in pressure levels and log(VMR)) since the IASI and MOPITT retrieval algorithms exploit mathematically inconsistent formats to express the vertical distribution of CO molecules. Schemes for interpolating or extrapolating Sa may also violate basic properties of covariance matrices, such as positive definiteness. Therefore we built a new a priori profile and covariance matrix from the original profiles ensemble used for the Sa matrix generation in FORLI, on a common 35-pressure layer grid (The MOPITT algorithm uses a priori information on a 35-level pressure grid to produce 10-level a priori profiles used in the actual retrieval algorithm)."

-IASI uses 1 km layers. Is the mixing ratio assumed constant within each layer?
Yes. We added "constant within each layer" in Table 1.

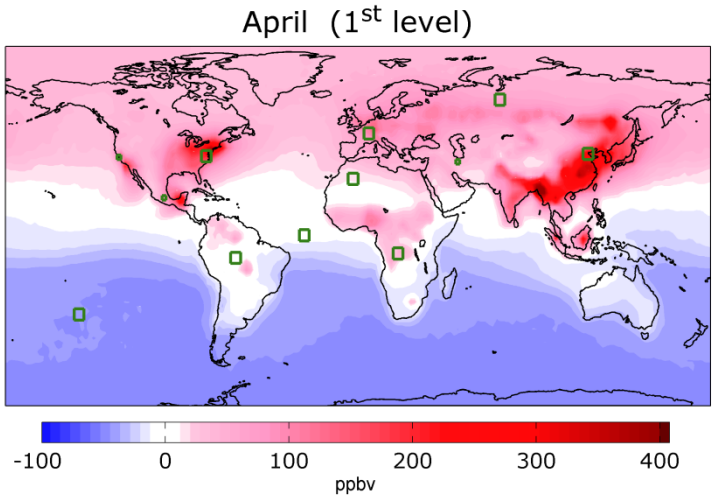
-I see that the temperature profiles come from different sources. Does this matter?
Yes. The following sentences were added in the conclusion section: "Our analysis is limited to the study of the impact of the a priori assumptions (probably the dominant factor for discrepancy), whereas other variables are known to contribute to the observed differences, in particular cloud content and temperature profiles. For long term records and trend analysis it should be envisaged to reprocess the whole MOPITT-IASI series using auxiliary data coming from the same source, e.g. ECMWF (European Centre for Medium-Range Weather Forecasts) Reanalysis (ERA) for winds, cloud cover and relative humidity (Dee et al., 2011)."

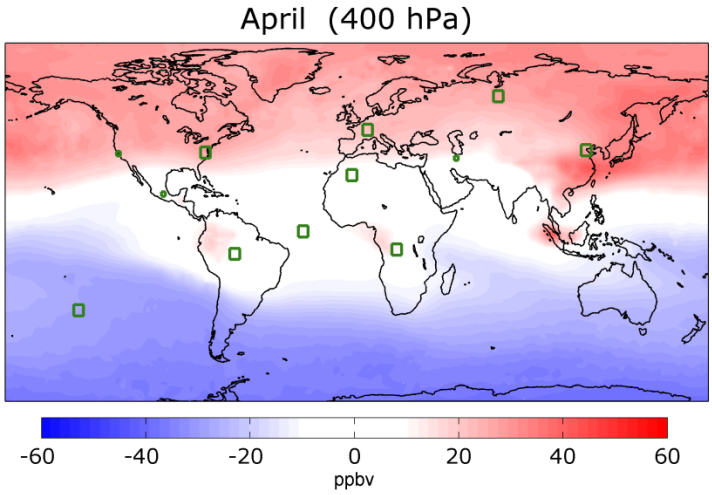
Do you take the IASI prior ensemble of profiles, convert them to the MOPITT 10 level grid using an intermediate 35-level grid, and then compute their mean and covariance matrix?
We computed the mean and covariance matrix from the IASI prior ensemble on the 35-level grid used by the MOPFAS algorithm. The algorithm uses a 35-level grid and provides outputs on a 10-level grid. We added the sentence: "(The MOPITT algorithm uses a priori information on a 35-level pressure grid to produce 10-level a priori profiles used in the actual retrieval algorithm)."

I don't understand the point of division by (ln(10))^2 at all.
We removed the sentence: "As the MOPITT Sa matrix is expressed in (delta log(VMR))^2, all elements of the IASI Sa matrix were divided by (ln(10.))^2." As it was confusing. This is done to fit to the Sa matrix used by the MOPITT algorithm as it should be expressed in (delta log(VMR))^2.

P14 para ending line 4: Is this behaviour as expected on the basis of the a priori and averaging kernels?
We added "some" in "above some emissions sources". We added the sentence: "This can be explained by the MOPITT v5T climatology-based a priori, which is closer to the real atmospheric state, including higher levels of CO above emissions sources."

As can be seen in the following maps that illustrate the a priori differences in April (Same as for Fig. 8 but for the month of April), most of the observed differences are linked to the a priori.





P16 line 12: A similar question applies here - what is expected on the basis of the averaging kernels?

See answer to previous comment. We modified “for which we have no clear explanation” by “for which an in-depth analysis of averaging kernels would be needed for a complete understanding.”

P17 line 14, re fig 9: As a general indication it would be helpful to have the error variance plotted on these figures, for comparison with the profile scatter. Maybe plot noise and smoothing error separately.

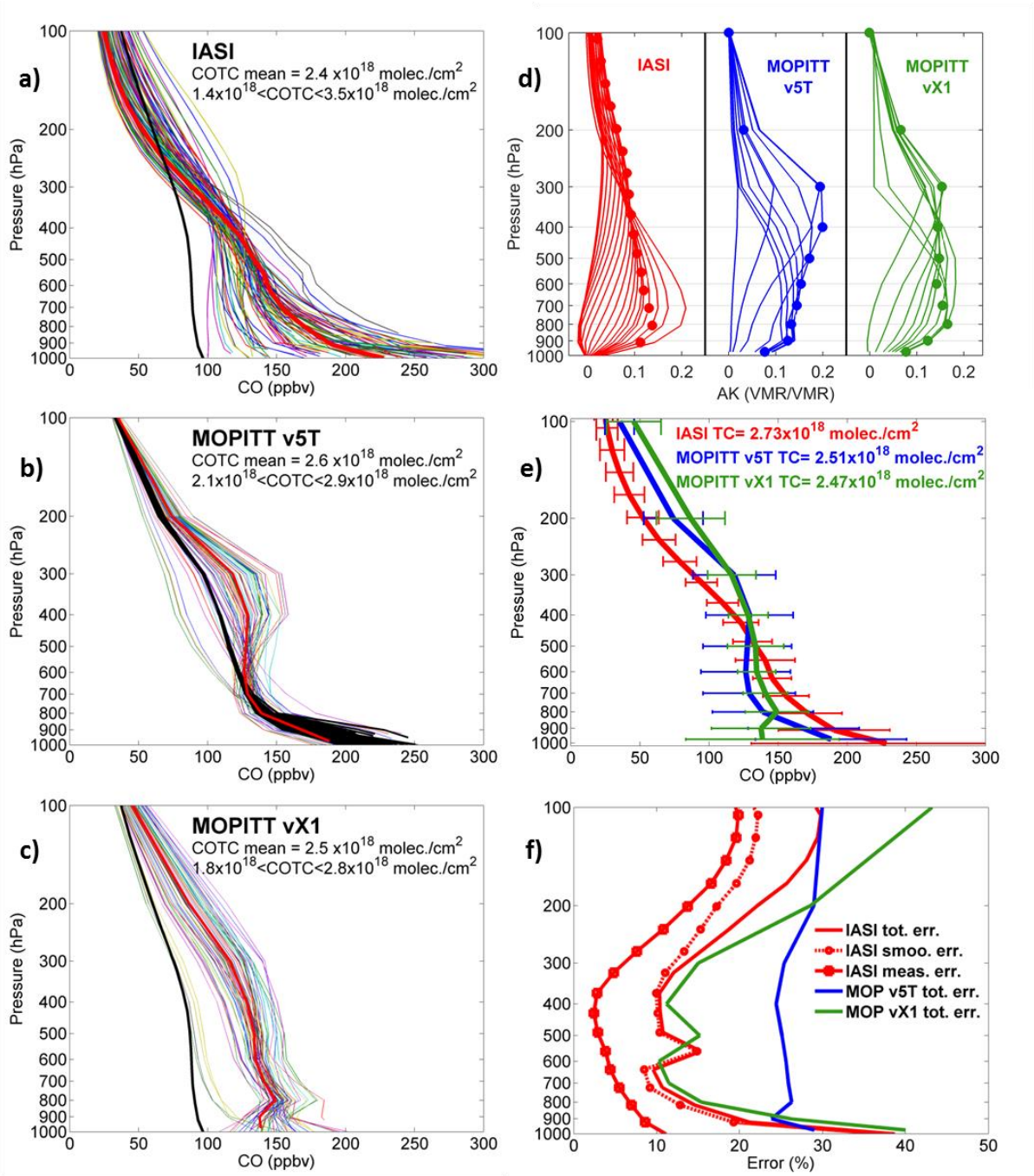
P18 lines 1-4: Examining the averaging kernels would help.

We added 3 subplots to Fig. 9 to address these comments. Figure 9 (hereafter) is now also presenting the averaging kernels for IASI, MOPITT v5T and MOPITT vX1, for one example case. The second subplot shows the total error associated with the retrieved profiles. The third subplot shows the total error in % for IASI, MOPITT v5T and MOPITT vX1, as well as the smoothing and measurement errors for IASI. For MOPITT, these 2 errors are not available separately.

We changed “This could point to a weaker sensitivity of MOPITT retrieval to surface CO concentrations” by “If we look at the averaging kernels of one collocated case chosen within this ensemble (Fig. 9d), we see that this could not be attributed to a weaker sensitivity of MOPITT retrieval to surface CO concentrations.”

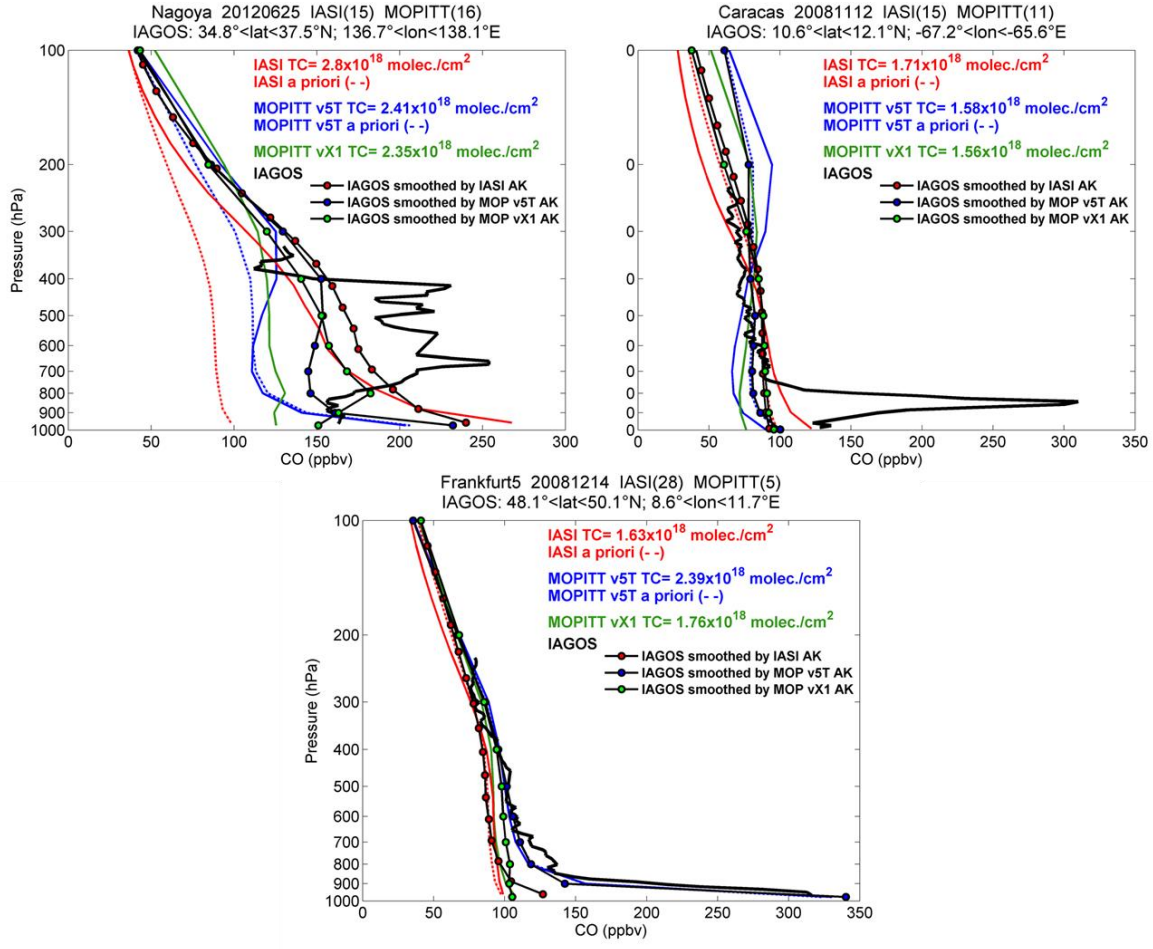
We added: “Looking at the total errors associated with each retrieved profiles (Fig. 9e), we note that the three profiles are within the errors of each other, which indicates the consistency of the datasets. The errors in % are plotted in Fig. 9f. The MOPITT vX1 total error profile is close to the IASI one because the smoothing error dominates.”

The new caption of Fig. 9: (a to c) Ensemble of retrieved profiles in the ‘Europe’ box for one day (20100409), for IASI, MOPITT v5T, and MOPITT vX1. The corresponding a priori profiles are plotted in black. For each subplot the CO total column value is also provided. (d) provides the averaging kernels (the altitude of each line is indicated by a dot) for one example case (see red profile plotted in (a), (b) and (c)), (e) Retrieved profiles with corresponding total error (horizontal bars) and (f) Error profiles in %. The smoothing, measurement and total errors are plotted in red for IASI. For MOPITT, only the total errors are available.



P18 lines 13-14: It would be helpful to see the profile smoothed by the averaging kernel as well, to see if the behaviour of the retrievals is as expected.

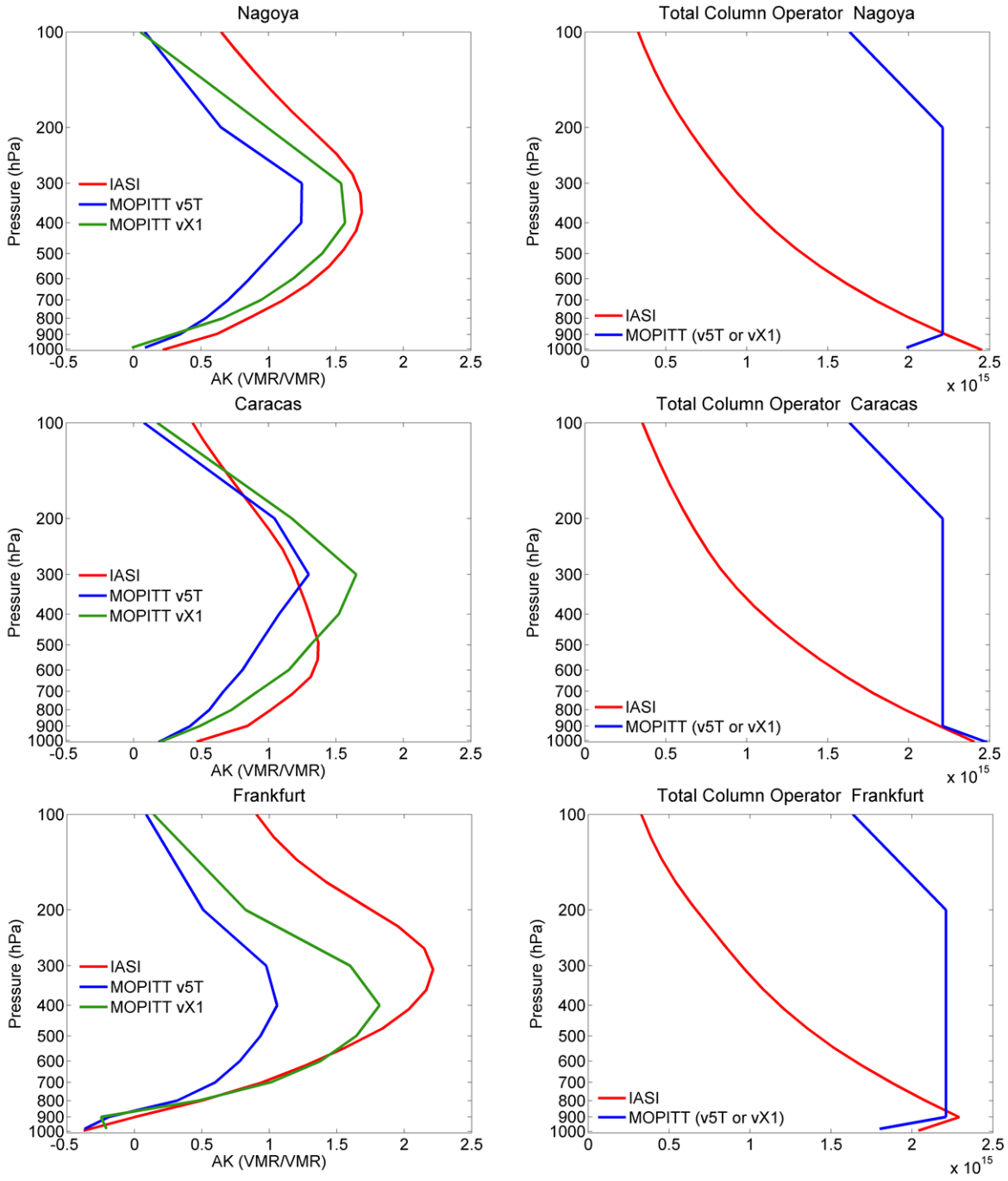
We smoothed the MOZAIC-IAGOS profiles by 1) the IASI averaging kernels and 2) the MOPITT averaging kernels. The plots are available hereafter. As we expect it, the MOZAIC-IAGOS profiles smoothed by the IASI averaging kernels are closer to the IASI retrieved profiles. Same thing for MOPITT. As we explained in the text, by presenting MOZAIC-IAGOS profiles, we "wanted to represent the actual altitude of the pollution plume if any." As this paper is not a validation paper, we would rather not present the smoothed profiles, as the plots would become difficult to read.



Figs 10-13: It would be helpful to have the total column operator plotted to compare with the column averaging kernel.

Hereafter are the plots showing the total colum averaging kernels as well as the total column operators for MOPITT in blue and for IASI in red, for the three cases (Nagoya, Caracas and Frankfurt). As the MOPITT (v5T and vX1) retrieval levels between 900 and 200 hPa are constant within each layer of 100 hPa, the total column operator is constant as well between 900 and 200 hPa. On the contrary the IASI layers are constant on a 1-kilometer altitude grid. As a consequence the IASI total column operator follows a decreasing exponential.

For clarity purpose, the total column averaging kernels has been removed (from Fig. 10, 11 and 12) since these are not discussed in the text (only full matrices are discussed).



P21 line 12: It leads to clear improvements in the comparison of MOPITT with IASI. This is not necessarily the same as an improvement in the quality of the retrieval. It conceivably could be better to carry out IASI retrievals with the variable MOPITT a priori.
"Clear improvement" is indeed misleading. We meant "better agreement" and changed the sentence: "For total columns we found that it leads to a better agreement for source regions…"

P21 line 18: how about: "but as expected the shape of the profile differs"?
We agree, we completed the sentence with "as expected": "We show that when the sensitivity is good, both instruments detect CO concentrations but as expected the shape of the profiles differs."

Section 4: On the basis of this study have you got any conclusions/suggestions about how to proceed to establish a long term data set?
We added some sentences in the Conclusion Section. The last part of the Section is now:

"On a longer term/climate perspective, Essential Climate Variables (ECVs) are needed for all climate related gases. This requires continuous and unbiased long-term data records. MOPITT initiated a record of more than 15 years, which is being continued for the next >30 years by the IASI series of instruments, with the launch of MetOp-C currently scheduled at the end of 2018, and the IASI-New Generation instruments to be embarked on the MetOp-SG plateforms (Clerbaux et Crevoisier, 2013; Crevoisier et al., 2014). A systematic processing of both datasets using the same a priori assumptions is foreseen in the framework of the EU-FP7 projects QA4ECV, and this work is paving the way for establishing such a long term CO compatible record. Our analysis is limited to the study of the impact of the a priori assumptions (probably the dominant factor for discrepancy), whereas other variables are known to contribute to the observed differences, in particular cloud content and temperature profiles. For long term records and trend analysis it should be envisaged to reprocess the whole MOPITT-IASI series using auxiliary data coming from the same source, e.g. ECMWF (European Centre for Medium-Range Weather Forecasts) Reanalysis (ERA) for winds, cloud cover and relative humidity (Dee et al., 2011). Regarding the differences in time and location, as well as in vertical sensitivity, only data assimilation can process each dataset accordingly."

Trivia

P2 line 11: "Invariant" is a technical term with a standard mathematical meaning, which is not the meaning intended here. "Fixed" or "constant" would be preferable.
We replaced "invariant" by "constant".

P2 line 20: remove one of "and" or "also".
We removed "also".

P4 line 17: x_a is and "expected" profile rather than a "mean" profile.
We replaced "mean" by "expected".

P9 line 2: The tense of "accumulate" is wrong, and "respectively" is in the wrong place:
"The MOPITT and IASI missions have now accumulated 15 and 7 years respectively of…"
Done: "The MOPITT and IASI missions have now accumulated 15 and 7 years respectively of near-continuous global data for tropospheric CO."

P9 line 10: "amount of information" is the wrong quantity — it implies "information content". It should be "degrees of freedom", or "number of independent pieces of information".
We replaced "amount of information" by "number of independent pieces of information".

P18 line 13: "where" should be "were".
Done.