We would like to thank the referee for their feedback and relevant comments. We will address every point in blue, between the referee's comments.

General comments:

The manuscript entitled, "*The Adaptable 4A Inversion (5AI): Description and first XCO2 retrievals from OCO-2 observations*" presents a description of the 5AI retrieval, designed for use with OCO-2 but adaptable to other current and future GHG satellites. They show that, although there is a small offset of a few ppm, 5AI agrees in many ways with the B8/B9 ACOS XCO2 retrieval. The manuscript is very well-written and I recommend publication in AMT after the authors address comments below.

The primary weakness I see is that this is a non-scattering retrieval, which isn't mentioned until page 8 of the manuscript. This is important to discuss and likely contributes to the especially large differences seen between 5AI and ACOS in Africa, South America, India, etc. (Fig. 7) and the general lack of data in typically aerosol- or cloud-laden areas (Fig. 2). All other major near- infrared XCO2 retrieval algorithms include a scattering component because no scene is truly "clear sky" and you'll end up with unacceptably high biases unless you heavily filter the data. Annoyingly, the places we care about most regarding the carbon cycle are also cloudy and full of aerosols, so a retrieval needs to be able to at least get quality XCO2 for slightly contaminated scenes.

We thank both reviewers for stressing the importance of this discussion that was missing in the first submitted manuscript and gave a false impression regarding the capability of 5AI to include scattering parameters in its state vector. In the revised version, we have included 5AI retrievals that take into account scattering particle parameters in the state vector for a sub-sample of the selected OCO-2 target data, and we now discuss the impact on 5AI results and how they compare to ACOS in a dedicated subsection (Sect 5.1).

As 5AI does enable to take into account the impact of scattering particles in XCO2 retrievals, we took the opportunity of this necessary discussion to perform XCO2 retrievals while taking into account scattering particles, and thus try to assess the forward and inverse consequences of our initial hypothesis. As XCO2 retrievals take longer when considering the impact of scattering particles, especially for OCO-2 that requires using the coupling with VLIDORT, we only processed a few hundreds OCO-2 measurements of our target sounding selection. Because we are interested here in the impact of scattering particles, we focused on 15 target sessions that have collocated TCCON, OCO-2 and also available AERONET data. The independent AERONET information regarding scattering particle optical depth can thus help to discuss the retrieved total aerosol optical depth.

For these retrievals, we took into account two layers of aerosols: a coarse mode layer and a fine mode layer for which we added their respective optical depths in the 5AI state vector. We compared these new 5AI retrieval results to those obtained without considering scattering particles and identified several impacts:

1- reduction or even removal of the 5AI surface pressure airmass dependence, that can be explained by forward and inverse modeling arguments (see Fig. 2, Fig. 8)
2- shift in the averaged 5AI retrieved surface pressure, compared to the prior (see Fig. 8). This partly translates into an averaged XCO2 difference to ACOS that is reduced when taking into account scattering particles (see Fig. 9).

Both 5AI and ACOS retrieved optical depths show a large scatters compared to AERONET data (0.07 and 0.05, respectively).

Regarding the revised manuscript, we separated the Results (Sect. 4) and Discussion (Sect. 5) sections. Subsection 5.1 gives all the details regarding the discussion of the impacts of neglecting scattering particles in 5AI XCO2 retrievals. Of course, the inverse setup choices made for the sub-sample of 5AI retrievals that consider the impact of scattering particles are not exactly identical to ACOS. Differences remain and result in remaining systematic average differences between 5AI and AOCS. We thus kept the averaged – calculated spectral residual discussion, detailed in subsection 5.2, that enables to show that those systematic differences can be compensated.

Specific comments:

- Maybe too many details in the introduction. E.g. listing all the HITRAN/ABSCO versions. Suggest moving elsewhere.

Our intention was to underline the multiplicity of approaches that could be designed to retrieve XCO2 from infrared spectra, from the choice of inverse method, state vector setups, forward model choices and speed-ups and spectroscopic database.

We have adapted the introduction to reflect this great diversity of methods, design and spectroscopy choices without enumerating all of them.

- P2 L64: S5P doesn't measure XCO2, so maybe not relevant here.

  We restricted to carbon dioxide observing instruments in the introduction (lines 61-63)

- P4 L121: which version of ACOS? B10 is the current version.

  We use version 8 of the Full-Physics ACOS results. We added the version number here (lines 115-116), and repeated it in the Data section (lines 244-245)

- "*In this work we assume a slow variation of the Jacobian matrix along the iterations and therefore choose not to update it in order to save computational time... We performed a sensitivity test and assessed that this approximation does not significantly change the retrieval results (not shown).*" Is this because not solving for a scattering component makes the retrieval much more linear?

  That is right. Trying to estimate XCO2 while taking into account scattering particles makes the retrieval way less linear and keeping the 1st Jacobian matrix in this case leads to unrealistic results. However, when we neglect the impact of scattering particles, as it is the case here (but for Sect. 5.1), the retrieval problem is more linear, making it possible to only work with the Jacobian matrix computed for the a priori state.

- "*(O'Dell et al., 2018) explains that this uncertainty is 0.0005 /cm-1 but B8r data release uses*

1.0 /cm-1 in the 'apriori_covariance_matrix', in 'RetrievalResults', in Diagnostics files."

Appears to be a typo in O'Dell 2018. 1.0 is correct for B8r.

Thank you for confirming this uncertainty value, we removed this comment from the revised manuscript.

- "*its most recent version is distributed within the B8 retrospective (B8r) ACOS data release*" B10 is the latest version, as of a few months ago. But B8/B9 is fine for an analysis like this.

We updated the text that was written just before summer 2020 (lines 244-245).

- "*we apply a simplistic empirical correction on 5AI*"

Have you thought about what you'll do for a more complex bias correction in the future?

An operational large scale processing of OCO-2 data is out of the scope of this paper. To reach this goal, the question of empirical bias correction would be seriously considered, and different approaches would need to be investigated. The sole purpose of this simplistic empirical bias correction was to try to be more consistent when comparing to FOCAL. Following the advice of referee #2, we have removed this sparse and less consistent comparison from the revised manuscript.

- "*0.05 ppm difference between 5AI and ACOS*"

Are you comparing 5AI lat bias corr to ACOS lat bias corr? Don't you want to compare 5AI lat bias corr to ACOS official bias corr (so, 1.17 – 0.98, not 1.17 – 1.12)?

For this case, intersecting with available FOCAL data, we indeed compared lat bias corr results, because it appeared to be the less inconsistent comparison, with a standard deviation difference also similar to 5AI and ACOS raw. Comparing 5AI lat bias with the official ACOS bias corr appears less consistent as the simplistic lat bias correction did not have the ambition of an operational one such as the official ACOS bias correction. Following referee #2 advice we have removed this discussion.

- "*and account for cirrus clouds or aerosols in the retrievals.*"

This is critical. Figure 7 clearly shows the disadvantages of a non-scattering retrieval. Your algorithm differs substantially from ACOS where there are high levels of dust (e.g. Sahara), pollution (e.g. India), etc. And probably is suffering from an inability to do anything about unscreened thin clouds in general

We reflected this comment when describing results of Fig. 7 (now Fig. 5 in the revised manuscript).

Technical comments:

P4 L120: "target mode" instead of "target session" P6 L169: "many projects" instead of "many work". The sentence is a bit clunky. P6 L188: Would recommend something like: "Moreover, as the forward model for this retrieval is highly non-linear..."

We have corrected these points in the revised manuscript as per your suggestions:

- "OCO-2 best flag target mode soundings between 2014 and 2018" (line 106)
- "Being the base of many projects since the beginning in the astronomical" (line 155)
- "Moreover, as the forward model for this retrieval is highly non-linear, it is practical to use a local linear, approximation, here expressed around the a priori state" (line 176-177)