Dear Anonymous Referee #1,

Thank you very much for this comprehensive review. We appreciate the level of detail and your effort very much. All the comments are useful and help improving this work. We answered all questions and implemented your suggestions. Your comment is repeated underneath in **bold font**, answers are written in *italics*, changes regarding the manuscript are written in *blue italics*. In some cases, you referred to specific pages, lines or equations. In the revised version these references might have changed. If applicable we have inserted the new reference in red brackets **[]** with respect to the revised version in change mode.
Please note that the "Data availability" has been moved after the Appendix A.
New references were added in the revised version, as well as in our response here. You can find them at the end of the document.

1. **Abstract, line 8, sentence "Due to the large number of point sources and their global spatial distribution, a mobile measurement approach with fast spatial coverage is needed": Unclear, why a "mobile measurement approach with fast spatial coverage is needed"? Why mobile? Why spatially fast? Regular on-site monitoring could be even better. Please consider to revise this sentence.**
*We agree, at this point our phrasing is misleading. What we are aiming at is a satellite-based observation system. Referring to the high number of point sources and their global distribution, it is evident that on-site monitoring would entail the use of a high number of measurement instruments, and/or an enormous work effort. Being of course also challenging, satellite missions are convenient for remote monitoring on a global scale. Which is why we rephrased as follows: "Due to the large number of point sources and their global spatial distribution, the implementation of a satellite-based observation system is convenient. Airborne active remote sensing measurements demonstrate that the deployment of lidar is promising in this respect."*

2. **Abstract, line 15 [now line 16], sentence "emission rates can be derived in terms of the cross–sectional flux method". I recommend to replace "in terms of" by "via" or equivalent.**
*The suggested replacement has been incorporated: "From the resulting enhancement in the $CO_2$ mixings ratios, emission rates can be derived via the cross–sectional flux method."*

3. **Page 2, line 37 [now line 39], sentence "However, at the moment no operating satellite mission is able to reliably quantify emissions from large power plants." Unclear what exactly is meant here taking into account publications such as Nassar et al., 2017, and Reuter et al., 2019, which need to be cited (details see below in "References").**
*We agree and have cited the references in the revised version. We have rephrased as follows: "Under particularly favorable conditions, it is already possible to detect $CO_2$ emissions of power plants from space, as is done with data from NASA's OCO-2 mission (Nassar et al., 2017; Reuter et al., 2019). However, at the moment no operating satellite mission is able to quantify emissions from large power plants, on a regular basis."*

4. **Page 2, line 60 [now line 66], sentence "Albedo variations basically influence the measurement precision (statistical uncertainty), not the bias.": This is a bold statement. Is it really true that the impact of albedo variation on the bias is zero or are corresponding biases only expected to be very small?**
*Admittedly, as the retrieval involves a non-linear computational operation, the influence on the bias is still negligible, but, strictly speaking, not exactly zero. We have changed the sentence to "Albedo variations basically affect the measurement precision (statistical uncertainty), whereas the influence on the bias is negligible (Amediek et al., 2009)."*

5. **Page 3, line 67 [now line 75], sentence "This principle has been applied for : : :". The cross-sectional flux method has also been applied to satellite data, see Reuter et al., 2019. Please add this missing information.**
   *The suggested reference has been added*

6. **Page 2 [now page 5], eq (2): Reader may wonder why delta sigma, the absorption cross section difference, does not depend on altitude. Later this aspect is addressed but I recommend to add some details on this aspect when presenting Eq 2.**
   *To simultaneously address a comment from Reviewer #2, we have merged Eq. (2) with the former Eq. (5). Eq. (2) itself now reads: "$DAOD = DAOD_b + \Delta DAOD = DAOD_b + \frac{1}{M}\int_0^{fl} \Delta\sigma(z) \cdot \Delta c(z)\, dz \approx DAOD_b + \frac{\overline{\Delta\sigma}}{M}\int_0^{fl} \Delta c(z)\, dz$"*
   *Subsequent to Eq. 2 [now line 115], we have rephrased as follows: "Δσ(z) is the difference between the absorption cross section of the two laser pulses given in square meter (cf. Fig. 1). It is referred to as the differential–absorption cross section. Generally, Δσ(z) is not constant over the plume's vertical extension, due to the decreasing pressure with altitude. However, the decreases in pressure associated with typical vertical plume extensions are small. As an approximation we use the mean value over the vertical extent of the plume $\overline{\Delta\sigma}$ . This aspect is discussed in more detail in Sect. 3."*

7. **Page 6 , line 129 [now page 7 line 143]: Reference to Strandgren et al., 2020: Unclear to which statement or fact the reference refers to. Please also add space between "2020)driven".**
   *The reference was inserted by accident. It has been removed.*

8. **Page 7, line 154 [now page 9 line 173], sentence "For the definition of the plume's limits a running mean with such a width must be used that the plume enhancement is blurred." Not mandatory but please consider to improve this sentence.**
   *In this passage we have changed a little more for better readability. The two previous sentences have been moved up to where the running mean width of 0.2 km is first mentioned [line 166 and preceding]: "For this we examine a 0.2 km running mean of the DAOD dataset (Fig. 3a). The choice of 0.2 km is made because it corresponds to the diameter of the pixels of the simulation (see Sect. 4)."*
   *In line 173 and subsequent we now write: "Applying a running mean broadens and flattens the plume. For larger running mean widths, as for example 4 km, the flattening is so severe that the plume is only distinguishable from the background as a raised plateau (see Fig. 3b)."*

9. **Page 7, line 156 [now page 10 line 177], sentence: "Further on the data within the limits : : :". Please improve this sentence.**
   *The sentence has been removed.*

10. **Page 9, Figure 4, [now page 11] right (photo): I wonder if the authors have the appropriate right to use the photo. Please confirm.**
    *The photograph was taken by Co-Author Andreas Fix.*

11. **Page 10, line 213 [now page 12 line 236]: What is "surface scattering elevation"? Just the surface elevation of the ground scene?**
    *Yes, in this context it is simply the height of the ground. In general, it refers to the elevation of the backscattering surface, which could for example also be clouds. For better comprehensibility we have changed the sentence to: Consequently the differential-absorption cross section at the height of the ground (70 m a.s.l.), corresponds to Δσ(z = 0 m) = 7.10652·10-27 $m^2$.*

12. **Page 10, line 214 [now page 12 line 237]: Please add the unit for the reported delta sigma value.**
    *The unit has been added in page 12 line 237, as well as in Eq.(8) page 12 line 235.*

13. **Caption Fig. 5 should be directly below the figure, not on the next page. Same for Fig. 1A.**
    *Fig. 5 and Fig. A1 were merged with their respective caption on one side. To do so, Fig. 5 and Fig. 6 were repositioned within the text, and Fig. A1 was reduced in size.*

14. **Fig. 2A: Nice figure but please add information why "2 plumes" are visible in certain snapshots (is this related to different wind directions in different altitude?).**
    *Precisely. We've appended an explanation to the caption: "Some snapshots show disjointed exhaust plumes. This is due to vertical wind shear and the resulting different vertical advection directions."*

**References:**


Amediek, A., Fix, A., Ehret, G., Caron, J., and Durand, Y.: Airborne lidar reflectance measurements at 1.57 mu m in support of the A-SCOPE mission for atmospheric CO2, Atmos Meas Tech, 2, 755-772, https://doi.org/10.5194/amt-2-755-2009, 2009.

Nassar, R., Hill, T. G., McLinden, C. A., Wunch, D., Jones, D. B. A., and Crisp, D.: Quantifying CO2 Emissions From Individual Power Plants From Space, 44, 10,045-010,053, https://doi.org/10.1002/2017GL074702, 2017.

Reuter, M., Buchwitz, M., Schneising, O., Krautwurst, S., O'Dell, C. W., Richter, A., Bovensmann, H., and Burrows, J. P.: Towards monitoring localized CO2 emissions from space: co-located regional CO2 and NO2 enhancements observed by the OCO-2 and S5P satellites, Atmos. Chem. Phys., 19, 9371-9383, https://doi.org/10.5194/acp-19-9371-2019, 2019.