

## ***Interactive comment on “Can a regional-scale reduction of atmospheric CO<sub>2</sub> during the COVID-19 pandemic be detected from space? A case study for East China using satellite XCO<sub>2</sub> retrievals” by Michael Buchwitz et al.***

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Many thanks for taking the time to review our manuscript and for providing very useful feedback. Your comments and the comments from the other two referees have been carefully taken into account when generating the revised version of our manuscript. Please see below our response to each of your comments.

Referee: This paper endeavors to characterize the impacts of COVID-19 pandemic on atmospheric CO<sub>2</sub> by estimating the fossil fuel emission from satellite observations

C1

(OCO-2 and GOSAT). This is an inverse estimation, so a model is needed to establish the relation between observation and model variables (Fossil fuel emissions (FF)). The authors did not use a physical model, but use the posterior CO<sub>2</sub> field and input fossil fuel emissions from CarbonTracker – a inverse model of atmospheric CO<sub>2</sub>, to construct a linear regression model, to calculate FF emissions from the change of XCO<sub>2</sub>, and this relationship was then used to estimate emissions from satellite XCO<sub>2</sub> observations. The authors did get an estimation of a small change in fossil fuel emissions, but the change is so small comparing to its uncertainty and possible variations caused by other factors. Even so, this referee suggests that manuscript should be published after major revision, as suggested below.

Major comments:

Referee: 1. The paper is too long comparing to its contents. For example, the lengthy abstract, and a couple of paragraphs (part of) quoted from other documents, and other redundant description and analysis.

Author's response: We have carefully checked the paper for unnecessary redundancy and have shortened the paper where possible. We have significantly shortened the abstract and have removed the quotes from other documents. However, we think that a certain level of redundancy helps readers to more easily and faster understand what has been done and what has been concluded from this and why. We have aimed at reducing repetition to a minimum while at the same time writing the paper such that it is easy to read and understand without the need go frequently back and forth. Furthermore, we have improved the structure of our paper to also better meet this goal.

Referee: 2. Reduction algorithm is the core of the method using in the paper, and in the same time the authors did not get a significant change as a result of COVID-19 pandemic. Therefore, if we need to justify the result of this research, the authors should assess the consequence of a possible signal lost of the original observations as a result of the reduction algorithm used, and this could be the most important contribution of

C2

this paper to our research community.

Author's response: It would quite challenging (if not impossible) to reliably quantify a possible information loss due to our admittedly quite simple analysis method. One way to assess this could be to use one or several more traditional inverse modelling method including detailed transport modelling and use of a priori information on CO<sub>2</sub> surface fluxes. This however would be a major exercise including detailed transport modelling etc. (which we consider out of scope of our study) and also would not guarantee that significantly more information can be extracted. There are several reasons for this including transport modelling errors, uncertainties of a priori fluxes (fossil fuel, biogenic and other), the need to consider (unknown or not well enough known) error correlations of the satellite retrievals, etc. Ideally, when trying to uncover a tiny signal, one should attempt to remove all other competing/confounding signals. We use two methods, but these are not the only possibilities and there may be other methods to more effectively remove the confounding signals of biology, transport, satellite sampling, etc. After submission of our manuscript other publications appeared using different approaches to find out to what extent satellite XCO<sub>2</sub> retrievals can provide COVID-19 related CO<sub>2</sub> emission reduction information (see Chevallier et al., 2020, Tohjima et al., 2020, and Zeng et al., 2020, now also cited in the revised version of our manuscript). The findings of these studies are consistent with the conclusions drawn in our manuscript. This is not a proof that the limit has already been achieved via our analysis, but this is a strong indication that a significant information loss due to the simple data-driven analysis method used in our publication is not very likely but also not entirely impossible.

Minor comments:

Referee: The abstract is way too long.

Author's response: Agreed. The abstract has been considerably shortened, see also above.

Referee: Line 138-139: "assimilates: : :as well as: : :". Does the model assimilate

C3

emissions? Line 142-149: Is it necessary to quote a whole paragraph to describe CT?

Author's response: We have revised the entire paragraph along the lines suggested.

Referee: Line 154: "The DAM method is essentially identical with the" and Line 159: "Our approach is very similar". If you think "essentially identical" and "very similar" are identical, then "very similar" in Line 159 is redundant.

Author's response: We have revised the sentence by removing "very similar".

Referee: Line 156-159: Hakkarainen et al., 2019, explain their method as follows: " : : :". Is it necessary?

Author's response: We have removed the quote as suggested.

Referee: Line 163: How about change "but" to "and"? you already have a "but" in line 162.

Author's response: Agreed. We will improve the sentence by splitting it into two: "Our investigations showed that the width of the latitude band is not critical. The band needs to be wide enough to contain a statistically significant sample, but narrow enough to resolve large latitudinal gradients in CO<sub>2</sub>".

Referee: Line 164: how about remove "as contained"?

Author's response: Yes, we removed this.

Referee: Line 168: what is "The good agreement"?

Author's response: We will replace "The good agreement confirms" with "The degree of agreement confirms".

Referee: Line 208:  $\Delta XCO_2^{FF}$  is misleading. It is FF estimated from  $\Delta XCO_2$ , and  $FF\Delta XCO_2$  could be more intuitive.

Author's response: Agreed. We will change the notation.

C4

Referee: Line 361: “This single observations uncertainty”. Is “This single uncertainty of observations” better?

Author’s response: What we mean is the uncertainty of single observations (rather than the uncertainty of averaged observations). We will write: “The uncertainty of single observations, which is typically around . . .”.

#### References

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