**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "High resolution modeling of CO$_2$ over Europe: implications for representation errors of satellite retrievals" by D. Pillai et al.

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We would like to thank F.M Breon for his comments. Authors' responses to these comments are as follows:

(1) One significant comment concerns the use of "bias" in the manuscript. The authors looked at the spatial variability of the column concentrations at a given time, but also after temporal averaging over a month. The later is given the term "bias". In the context of satellite remote sensing and the use of its observations to retrieve surface fluxes, one may fear a bias if multiple successive observations are used within a grid box at the exact same location. In practice, this would not be the case, first because

very few satellite observations will be available within a 100x100 km grid bow at the monthly scales (on different days), and also because the few observations will probably be acquired at different locations (depending on the instrument pointing). As a consequence, the "bias" does not apply to the study context. It should be made clear in which context there is realy a bias to be feared.

Response: We disagree with the definition of bias mentioned above. The error that is systematic for a given time-scale is defined as bias. The "bias" term, unlike "random" errors, do not average out when aggregating long periods. Hence we attempt to address the bias term of representation errors.

Response:Please refer to comments by 2nd reviewer as well.

(2) My other significant comment concerns the numbers that are quoted in the text and the abstract, in particular the 1.2 ppm. This is the highest value found for the representativity error, over a region of high relief. The number is quoted and compared to the accuracy objective of the satellite sensors. In most case, the accuracy objectives are expressed in RMS terms, and it is then not fair to compare such accuracy target to a maximum error. I suggest the authors provide typical numbers rather than the max error.

Response:We modified the abstract and use the median as well.

Other comments:

(3) Abstract : I suggest to provide the mean, median or 90% percentile rather than the max error. See also general comment.Abstract : I do not think that it is clear what the "bias component" is.

Response: Please See answer to previous comment above. Modified the statement by "systematic (bias) component of representation error"

(4)See also general comment Page 2, second paragraph. "Community". Which community?

Response: We removed this part of the sentence.

(5) Page 2, third line from bottom, "sampling error". What is the sampling error ? Is it the same as measurement error ?

Response: The sampling error includes both limitations in instrument precision and accuracy and uncertainty caused by unresolved atmospheric variability of CO_2 within the mixed layer due to turbulent eddies. This has been modified in the manuscript.

(6) Page 5, second paragraph, "reasonably well". R^2 is between 0.16 to 0.44, which some may find rather poor correlations

Response: We qualified the statement by saying "in comparison to other models"

(7) Page 5, last sentence of second paragraph. I could not see that from the table.

Response: Not shown in the table is the WRF-VPRM performance for the "blended fluxes" (high resolution fluxes + Transcom coarse fluxes) since we have used only high resolution fluxes for the present study (which Table 2 corresponds to). We have added "(not shown in the Table)".

(8) Please rephrase or comment Page 6, end of second paragraph, concerning stratospheric concentrations. I tend to agree, but is there any real measurement to support this statement ?

Response: We do not know of any measurement addressing horizontal variability of column CO_2 within the stratosphere. However, the only assumption that we make is that the variability on small scales in the stratosphere is not larger than in the troposphere. To clarify this, we reformulated the sentence to "Since horizontal variability of CO_2 in the stratosphere on scales below 100 km is small (at least not larger than in the troposphere), neglecting this part of the column might thus result at maximum in a 10% overestimation of the sub-grid variability."

(9) Page 6, first line of third paragraph, There is a strong need for a proper definition

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of this monthly average. Is it the monthly average of sigma_c,col, or the standard deviation of the monthly averaged column concentrations ? I tend to believe it is the second from further reading of the manuscript but it is realy not clear.

Response: The monthly average of $\sigma c,col$ (specific for a given hour of the day) represents the full representation error (random+bias) in a monthly scale. In order to exclude uncorrelated errors (random part) and find consistent sub-grid variability in a monthly scale, the column concentrations are averaged for the month (specific for a given hour of the day) and the standard deviation of this field is derived within each 100x100 km2 grid cell. We modified the description to make this clearer. In page 6, second paragraph, we write "Representation error ($\sigma c,col$) is thus estimated for every time step (hourly) . . .", and we added "specific for a given hour of the day " in brackets after sigma_c,col

(10) Page 6, end of third paragraph, see general comment concerning biases

Response: See our response above.

(11) Page 8, end of second paragraph, see general comment concerning biases

Response: See our response above.

(12) Section 4.2. I suggest to start by saying that the number provided in the previous section assume there is a single measurement per grid box. In practive, satellites provide several measurements which may be averaged and reduce the representativity error. The impact depends on the sampling, and will be discussed here. I do not think that the "corner" sampling is really of interest as it is directly related to the results of the previous section, assuming a random sampling within the box.

Response: We added the adverse sampling condition ("corner" sampling") for comparison to the Alkhaled et al. 2008 paper. It is obvious from our description of the "A-SCOPE" sampling that there usually is not a single measurement per grid box.

(13) Section 4.2.1, last sentence of first paragraph, "a factor of 2 larger". Not clear than

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what (although it is clear when looking at the table)

Response: We added "compared to those provided by A08".

(14) Summary and Outlook, last sentence of third paragraph, This sentence may be misleading. One does not realy capture the error. It provides an estimate of the error so that less weight are given to the observations is regions of high variability.

Response: We modified the last sentence to "These findings suggest a parameterization which would enable a substantial fraction of the representation error to be taken into account more quantitatively"

(15) Figure 7 caption. The blue line is not the 1:1 line but the best fit.

Response: The figure had already been changed. Please refer to the online version of manuscript.

Please also note the Supplement to this comment.

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