**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.

Anonymous Referee #2

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This manuscript describes a nice study in which a high resolution simulation of atmospheric CO2 over Europe is used to estimate observation representation errors. The authors also present a simple error model that could be used in data assimilation or flux inversion systems to account for the representation error as a function of a few relevant variables. The study provides a new approach to the topic compared to other studies that have been published in the past. As such, I think it will provide new insight to the carbon cycle community and I recommend publication after the following comments have been addressed.

General Comments:

My first comment is actually referring to the other review. I do not agree with the reviewer about his statement about the definition of bias. A bias is a systematic error on the relevant time scale. While this leaves room for different interpretations, I think the author's use of the term bias is actually correct. It refers to the representation error that is constant over a month, which I think is a relevant time frame for flux inversions. Observations do not have to be at the exact same location to have a bias component embedded in them.

My second comment refers to section 4.3. The error model used to estimate the representation error is focused on the land area. However, in coastal zones there seems to be a significant representation error that is not related to sigma_h, sigma_f, or c. Is there another variable the authors could introduce, that would describe the error over sea?

Before applying the proposed error estimation method to flux inversions, I think we would need to know if the same error model works for other parts of the world. I would encourage the authors to apply the same study to other geographical areas, if possible. The manuscript should at least comment on this.

Finally, how dependent are the results on the size of the grid boxes? Inversion models use different grids and the modelers should know if they can apply the method regardless of their chosen grid or not.

Detailed Comments:

Page 20601, lines 13 - 14: "but after ... re-launch." I find this a bit of a strange remark for a scientific paper. The authors could replace it with something like "but unfortunately the launch of OCO failed."

Page 20601, line 17: Please, also mention the American ASCENDS mission.

Page 20601, lines 16 - 17: There are more advantages to an active mission than just being able to measure during night. For instance, it provides better control over the

estimation of the aerosol scattering. I suggest that the authors either go into more detail here or just remove this last part of the sentence.

Page 20601, lines 25 - 27: The footprint of 0.1 km for A-SCOPE is not the real footprint of the observation. Active missions need some averaging to improve the signal-to-noise ratio. While the 0.1 km FOV allows for looking in between the clouds, it will take several of these FOVs to provide a good signal. Please mention this in your text.

Page 20604, line 17: I would use "satellite-constrained" instead of "satellite-based".

Page 20607, line 17: I would use "systematic" instead of "bias" in this sentence. In the next couple of sentences it is then explained what is meant by the bias.

Page 20607, line 18: Please remove "also".

Page 20608, line 25: There is a "and" missing between the "(a)" and "(b)" description.

Page 20609, line 8: Please remove "a" before "strong".

Figures 4 and 5 are rotated by 90 degrees.