Comment on acp-2021-16

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Referee comment on "Was Australia a sink or source of CO_2 in 2015? Data assimilation using OCO-2 satellite measurements" by Yohanna Villalobos et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-16-RC2, 2021

The manuscript is a clear and straightforward presentation of the Australian NBP derived from OCO2 XCO☐☐ retrievals in 2015. The inversion methodology and the analysis of results is sound, and I would recommend publication once the authors have addressed the following questions.

- Line 48: Is the anomaly of 0.40-0.61 PgC/yr positive or negative? It is presented as a positive anomaly, but that goes against an expected negative anomaly in 2011.
- Line 57: What is the "BoM, 2015" reference?
- Figure 1: The uncertainty in the top right yellow box should be R^{-1}, not B^{-1}
- Line 119: ODIAC certainly has bunker fuels, including aviation and marine transport. For at least the past five years, ODIAC files have had a variable called 'intl_bunker' containing bunker emission estimates. Since the authors assumed that ODIAC did not have bunker fuels, are they double counting that category by adding EDGAR bunker emissions?
- Line 123: Which version of EDGAR did you use? And which sectors of EDGAR did you sum up to get just the marine and aviation sectors? Can you be specific?
- Line 128: Why were small fires excluded? And why was version 4 used instead of 4.1s? The latter has been out for at least 4 years now.
- Line 148: Can you say exactly how you chose "good" quality soundings? OCO2 quality flags are 0 and 1, not good and bad, and I am asking for specifics because earlier this year I reviewed another manuscript that used the wrong value of the quality flag to select their soundings.
- Line 172: "Monthly daily mean averages" denotes a lot of averaging. Why not compare the observations with the model co-sampled at exactly the correct times?
- It is customary for satellite inversions to do an in situ only inversion as a "baseline", to compare OCO2 inversions with and assess the added information content and possible biases in the OCO2 data. Why was no in situ inversion performed in this study?
- Line 199: Why is the correlation calculated between the flux correction and MODIS EVI? It would make more sense (to me) to calculate the correlation between MODIS EVI and just the posterior flux.
- Line 233: I think the cost function being too high is a symptom of uncertainties that are too low, not too high.
- Lines around 245: What is the uncertainty in the Australian fossil CO☐☐ emission? Say the range between different inventories?

- Lines around 365: My impression from the TCCON plots is that the posterior sticks pretty close to the prior and does not necessarily approach the TCCON data in most months. Given that two of the three TCCON stations are exactly where the largest flux adjustments are (northern and south-eastern Australia), isn't that bad news for the reliability of your flux estimates? Or can you show that these TCCON mismatches are primarily due to boundary conditions at the edges of your CMAQ domain?
- Figure 10: Looking at JJA at Barncluith and Ironbark, I get the impression that some of the deep JJA winter sink is an artifact, because the posterior is too low compared to in situ CO□□. Correct?
- Line 412: The -0.30 ± 0.09 PgC/yr is the prior, not the posterior, correct?
- Lines around 415: Not all global inverse models are made equal. If you have the models' mole fractions, you can check how well these five models fit the in situ data you have over Australia, which indicates how well you can trust their fluxes in that region. I strongly suspect that the realistic "model uncertainty" or range you will get out of that exercise will be smaller.
- Table 4: Of the models listed here, I understand that ORCHIDEE or CASA may have the wrong seasonality over Australia, since most of the ecosystem data used to evaluate those models do not come from Australia. Why would BIOS-CABLE3, a model built specifically for Australia, also have the minimum in the wrong month?
- General question about error bars: Are the error bars reported here the analytical errors from flux and measurement uncertainty, or do they also contain the uncertainty due to the boundary condition at the edges of the CMAQ domain?