

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2022-510

Anonymous Referee #2

Referee comment on "Why do inverse models disagree? A case study with two European CO₂ inversions" by Saqr Munassar et al., Atmos. Chem. Phys. Discuss.,
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In this study, the authors have examined the leading drivers of CO₂ flux inversion by setting up an ensemble of eight inversions with different regional transport (STILT and FLEXPART), global transport (TM3 and TM5), and inversion systems (CSR and LUMIA) over Europe in 2018. The surface measurement of CO₂ dry mole fraction is used to estimate the posterior. The results exhibit a large spread of CO₂ flux estimation, majorly driven by the mesoscale transport model, rather than two other contributions. Overall, this study is interesting and worthy of investigation; however, some queries need to be addressed.

Major comments:

- I don't think the title could well represent the entire manuscript. This study quantified the impacts of regional transport, lateral boundary conditions, and inversion systems on estimating biogenic CO₂ flux. Even though the major contribution of regional transport was found and more results laid out in order to dig into details in context; still, the main part of the study is not only about atmospheric transport. Otherwise, you may want to use more regional transport models and focus majorly on the impact of atmospheric transport.
- Similar to 1), I recommend re-organizing the introduction part as well in order to give a better bridge to readers. The current introduction is mostly focusing on atmospheric transport (Line 30 – 57).
- The number of ensemble members for each suite representing mesoscale transport, global transport, and inversion system is too limited (two of each) with overlapped characteristics. For instance, TM3 and TM5 should have similar characteristics. Also, I doubt the result of differences of "meteo" shown in Figure 7. Those are all the ECMWF datasets. It would be better to use ECMWF and non-ECMWF to present the impact of using different types of meteorological data.
- Line 181-182: Why do two inversion systems use different uncertainty for the observation?

Minor comments:

- Line 25: "the largest impact seems to come from the models themselves" is too vague.
- Line 46 – 53: The accuracy of the meteorological data is not addressed in the main text.
- Equations 1-3: It's better to add equations containing a sensitivity term (calculated by STILT and FLEXPART)
- Line 228 – 231: From figure 2, major corrections appeared over western and southern Europe, not around the observational sites.