Response to Referee #2 report

Dear Referee,

We thank to Referee #2 for re-assessing our manuscript and for additional suggestions and corrections to improve our manuscript. Our detailed responses to each comment and suggested correction can be found below (in blue):

The manuscript "Carbon dioxide plume dispersion simulated at hectometer scale using DALES" by Karagodin-Doyennel et al. presents a well-executed study using the LES model DALES at 100×100 m resolution to simulate CO2 mole fractions over a region in the Netherlands. The model includes both anthropogenic and biogenic fluxes, with a clear method for downscaling emissions and CAMS forecasts providing the CO2 background. Model results are evaluated at three Dutch sites—Cabauw, Slufter, and Westmaas—using tagged tracers to analyze variability drivers and the contribution of specific flux components to measurements. I think the paper can be accepted after revising the following:

1. The short discussion (L724-727) about the perspective of using this set-up in an atmospheric transport inversion should be expanded. At the moment the these lines are quite vague and miss the chance to provide more details on what are the main challenges for achieving a high resolution emission estimate based on a top-down approach using LES that can be a benchmark for bottom-up estimates. For example, what is now the bottleneck to achieve this? Would an analytical inversion be feasible? I think a little more substance to this part can be added just with a few sentences.

Response: We agree with reviewer that it makes sense to expand this paragraph to clarify the potential and limitations of using LES in atmospheric transport inversions. Here is the revised version (L722-733):

In addition, LES can optimize emissions for specific SNAP categories by integrating top-down atmospheric observations with bottom-up inventories. This approach refines the spatial and temporal distribution of emissions, providing a high-resolution benchmark for validating and adjusting reported estimates. However, the use of LES in atmospheric transport inversions poses several challenges. This includes the limited spatial and temporal extent of LES domains that constrains inversion to local or short-term events. This requires careful nesting within larger-scale models to capture background conditions accurately (see, e.g., Barlow et al., (2011), Lauvaux et al., (2016)). Besides, high computational costs also constrain the ensemble size and averaging periods required for robust inversions. Although analytical inversions may be feasible for a limited number of tracers or emission parameters, the high dimensionality and inherent nonlinear dynamics of LES simulations generally require ensemble-based methods (e.g., Brunner et al., (2019)). Despite these challenges, LES-based inversions offer a valuable framework for process-level understanding and can serve as a benchmark for evaluating bottom-up inventories under well-constrained conditions.

2. I suggest the authors to perform another proofreading to correct some grammar typos or wording of some parts of the text, for example:
- Abstract title is repeated

Respose: Agreed. Redundant “Abstract” word has been deleted.

- L182. latheral -> lateral
Respose: Agreed. “Latheral” has been replaced with “lateral”.

- L363, merge this sentence with previous paragraph
Respose: Agreed. This sentence has been merged with previous paragrath.

- Figure 6. Horisontal -> Horizontal

Response: The Figure 6 has been corrected and updated (see L450-451).

- L640. Distinct compounds -> individual flux components

Response: Agreed. The “Distinct compounds”has been replaced with “individual flux components”

- L683. To achieve this -> Achieving this will require..

Response: Agreed. “To achieve this “ has been replaced with “Achieving this”

- L699-L701. Merge with previous paragraph
Response: Agreed. This sentence has been merged with previous paragrath.

- L720. First sentence sounds repetitive, deals with the same topic as the paragraph above.
Response: Agreed. This sentence has been removed.

- L740. I suggest to remove this sentence. Already clear from the discussion above.
Response: Agreed. This sentence has been removed.

Additionally, as suggested, we reviewed the manuscript and made several revisions to improve language and phrasing.