Response to Reviewer 2

Original text is in black. Our responses are in blue text. The references are to the manuscript with changes tracked.

This manuscript describes the set-up of a new Limited Area Model for the modelling of atmospheric CO2 concentrations as part of the wider range of models at ECCC. The LAM is compared to the global model to assess the benefit of modelling at higher spatial resolution over the North American domain. The paper is mostly descriptive, although the Discussion draws some conclusions and presents some recommendations. As such, it does fit the scope of GMD. The manuscript fits also very well in the increasing debate about transport errors in the (inverse) modelling of CO2. Various groups are pushing for increased resolution to minimise the transport errors and there is also a discussion about the advantage of LAM models versus of-line models. The manuscript is well-written and everything is clearly explained.

Response: We appreciate reviewer's careful reading of our manuscript and helpful comments. We have revised the manuscript following the reviewer's suggestions.

The authors have put together a LAM with similar characteristics as their global model, which is indeed a very sensible way to go. In my view, the paper would have been more interesting, if a regional off-line model would have been included in the study as well. This would have allowed for the additional assessment of using a LAM versus using an off-line model in terms of transport errors through for instance interpolation approximations. I do realise, however, that this would have significantly increased the work, so maybe it can be considered for future work. For this paper, it would be good to have an additional paragraph on this consideration.

Response: Following the reviewer's suggestion, we have added an additional paragraph in the section 5 (Discussion and conclusions).

Page 19, lines 9-14: While this work has focused on the benefit of our higher resolution regional model over our global model for CO_2 simulation, both models are "online" in that the meteorology is coupled to the tracer transport every time step. An interesting question that was not addressed here is the impact of increased horizontal resolution in the context of an "offline" transport model which ingests meteorological analyses or reanalyses from another model (e.g. Kjellström et al., 2002; Geels et al., 2004, 2007). Additional errors arise due to spatial and temporal interpolation from another model's grid to the offline model's grid then arise.

Geels, C., Doney, S., Dargaville, R., Brandt, J., and Christensen, J.: Investigating the sources of synoptic variability in atmospheric CO_2 measurements over the Northern Hemisphere continents: a regional model study, Tellus B, 56, 35–50, 2004.
Geels, C., Gloor, M., Ciais, P., Bousquet, P., Peylin, P., Vermeulen, A. T., Dargaville, R., Aalto, T., Brandt, J., Christensen, J. H., Frohn, L. M., Haszpra, L., Karstens, U., R¨oödenbeck, C., Ramonet, M., Carboni, G., and Santaguida, R.: Comparing atmospheric transport models for future regional inversions over Europe – Part 1: Mapping the atmospheric CO_2 signals, Atmos. Chem. Phys., 7, 3461–3479, doi:10.5194/acp-7-3461-2007, 2007.

Kjellström, E., Holmén, K., Eneroth, K., and Engardt, M.: Summertime Siberian CO_2 simulations with the regional transport model MATCH: a feasibility study of carbon uptake calculations from EUROSIB data, Tellus, 54B, 834-849, https://doi.org/10.3402/tellusb.v54i5.16733, 2002.

My main issue is with the quality of the figures. Some of them are difficult to read (e.g., Figure 7), have washed-out colours (e.g., Figures 8 - 10), or contain too many curves or points (e.g., Figures 12 and 13). I encourage the authors to look at these figures again to see if they can be simplified or made clearer.

Response: Following the reviewer's suggestions (reviewer #1 also had similar concerns), we looked at figures again and have improved the quality of figures (Fig. 7 – 10, 12 and 13).

- Figure 7: The figure was enlarged and lines were made thicker.
- Figures 8, 9 and 10: The range of colours (including label bar) was narrowed down in order to vivify colours. Of course, some dots are still transparent since their values are close to zero, i.e. small differences between two results.
- Figure 12: This figure was enlarged and the light green numbers was replaced by darker green to make the green numbers more visible.
- Figure 13: Some lines were replaced by shading to make them clearer.

Some minor comments:
Section 4.1, first paragraph: while I can fully understand why the STDE would be reduced with increased resolution, it is not directly obvious why the bias should be different between the different resolutions. It would be useful to comment a bit more on this in this paragraph.

Response: To clarify why the bias is reduced. We have revised the first paragraph in Section 4.1

Page 13, lines 3-5: In JJA, the reduction in bias resulting from the higher horizontal resolution model can be seen clearly and the magnitude of reduction is higher probably due to better weather simulation (less transport errors) as shown in Figs. 3, 4, 5 and 6.

Page 15, line 20: this should be Section 2.5

Response: Yes. We have correct the typo.

Page19, lines1-5: it would be good to refer here to the 2019 Agusti paper as well, because it deals with the flux resolution problem by explicitly modelling these fluxes at the same resolution as the transport model.

Response: Following the reviewer's suggestion, we have added a statement, referring to Agustí-Panareda et al. (2019) in the proper place.

Pager 19, lines 20-22: One way to deal with this issue is to model biogenic fluxes explicitly at the same horizontal resolution as the transport model (e.g. Agustí-Panareda et al., 2019). Indeed, this is an avenue we plan to investigate in the future.

Agustí-Panareda, A., Diamantakis, M., Massart, S., Chevallier, F., Muñoz-Sabater, J., Barré, J., Curcoll, R., Engelen, R., Langerock, B., Law, R. M., Loh, Z., Morguí, J. A., Parrington, M., Peuch, V.-H., Ramonet, M., Roehl, C., Vermeulen, A. T., Warneke, T., and Wunch, D.: Modelling CO_2 weather – why horizontal resolution matters, Atmos. Chem. Phys., 19, 7347–7376, https://doi.org/10.5194/acp-19-7347-2019, 2019.