

Interactive comment on “Modelling CO₂ weather – why horizontal resolution matters” by Anna Agustí-Panareda et al.

Anonymous Referee #1

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This manuscript considers the benefit of high horizontal resolution for the simulation of CO₂ transport. The article uses the CAMS model at a variety of resolutions with grid sizes ranging from 80 to 9 km. The performance of the models validated against CO₂ surface and column observations from TCCON reveals improved performance with higher horizontal resolution. In addition, the forecast error is smaller with higher resolution, at all forecast ranges (from 1 to 10 days). Finally, the high resolution model is used to quantify subgrid scale variability of surface and column mean CO₂ for a coarser (1x1 degree) grid. Overall, the article is well written, with a clear and well-supported message. The nuances of the issue (such as the nonlinearity of forecast error growth with forecast range) are also discussed. The question of the optimal horizontal resolution needed for CO₂ transport depends on the goal of the assimilation

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problem and the observations used to constrain the inversion system. With the rapid expansion of the global observation network and the desire to resolve fluxes at finer spatial scales, the flux estimation question is shifting to one of anthropogenic attribution so the question of model error sensitivity to horizontal resolution is both important and timely.

Minor comments

1. P2, L2-4: These 2 sentences seem contradictory. Please resolve the conflict.
2. P3, L6: “being” should be “whether”
3. P4, L8: Figure 3 is referenced before Figure 2 (P6, L21), therefore please reorder these figures.
4. P4, L15: Table A3 is referenced before Table A2. Please reverse the order of these Tables.
5. P5, L17: “semi-lagrangian” needs a capital L
6. P6, L1- 4: Do the net sources and sinks of biogenic fluxes have the same value across horizontal resolutions? Are the global net fluxes the same for all resolutions? An example showing biogenic fluxes from different resolutions would be helpful in this regard.
7. P6, L14: “Semi-Implicit Semi-” doesn’t need any capitals.
8. P8, L12-13: “Since most low resolution models used in atmospheric inversions tend to use the model sampling ASL at mountain sites. . .” Please add some references here to back up this statement.
9. P9, section 3.1 and Fig. 4: Care must be taken when interpreting meteorological forecasts at 1000 hPa because this level frequently requires extrapolation (below mountains and at locations with surface pressure below 1000 hPa). Some caveats regarding the use of this level should be mentioned.

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10. P9, L15-16: Diagnostics computed with observations at screen level are mentioned but not shown. It would be worth showing these figures because of the issues with observations at 1000 hPa mentioned in point 9, and because there are far more observations from surface stations than there are radiosonde observations at 1000 hPa.

11. P9, L32: “reflect on” should be “reflect”

12. P10, L2: “Figs. 5c and 5d” should be “Figs. 6a and 6b”

13. LP11, L17: “summer (winter)”. Should this be “boreal summer (winter)”? There may be similar issues occurring elsewhere, for example on P14, L15. Please review the entire manuscript to ensure clarity when discussing seasons in regard to global results.

14. P13, L13: “an” should be “and”.

15. P14, L33 and P15 L1: please keep consistency between “sec.” and “section”.

16. P16, L26: “at least 4 km”. Do you mean “at most 4 km”? Also it would be clearer to talk about grid spacing rather than resolution.

17. Tables S3, S4: It would be helpful for the reader to provide the difference in bias and possibly also for standard error, as it is for RMSE. Also, it would be better to order the stations by latitude rather than by name, to better see if there are any patterns with respect to latitude.

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