

Response to reviewer 1

There are numerous instances of question marks in place of Table or Figure numbers that need to be corrected.

Thanks for pointing this out. The missing Table/Figure numbers (question marks) were generated by the LaTeX in the deleted/replaced portions of the change-track document. The errors have been fixed and they are not in the current version of change-track document, point-by-point response, or the revised manuscript.

Response to reviewer 2

I appreciate that the authors made a great effort to improve the manuscript significantly, especially running the model for a longer period of time to obtain a robust result. Many comments are addressed appropriately. However, it was able to find out some minor issues remaining. Plus, although many typos are corrected as the authors declared, still some (or the same) typos can be found again. Nevertheless, I believe that these can be addressed easily.

We appreciate the reviewer's insightful comments and suggestions.

Specific comments:

[1] P7L7-L18: This paragraph explains the sampling method used in the paper nicely. However, I am still curious about the sentence "MPAS simulated CO₂ fields are interpolated in time and space to match each 5-second airborne data points" at P15L4-5. Because it looks inconsistent with the method explained here (interpolation in space vs. selecting nearest grid point overland). For ACT campaign data, is the sampling method used in section from 3.4.1 to 3.4.3 the same as the method used for sampling near-surface CO₂ observations (section 3.3.3)? If they are the same, it needs to revise the sentence. If they are different, then please clarify why they are different.

All the horizontal samplings (including for ACT campaign, near-surface observations, and TCCON XCO₂) use the same "selecting nearest grid point overland" as described in P7L7-L18.

To avoid the possible confusion, the sentence at P15L4-5 has been revised to "*MPAS-A simulated CO₂ fields are sampled as described in the second paragraph of Section 3 to match the 5-second airborne data points.*" (P15L11-12 of the revised manuscript)

[2] P8L3: the sentence "CO₂ mixing ratio is kept unchanged during the meteorology re-initializations" is in contradiction with the CO₂ mass conservation method in section 3.2.2. Please clarify it.

Thanks for pointing this out. Since CO mass conservation method during meteorology re-initialization has been described in Section 3.2.2, this sentence (P8L3) is deleted to avoid possible confusion.

[3] P12L2-3: It is hard to understand what is "evident". Please rephrase the sentence.

This sentence has been revised to "*For instance, the difference in horizontal resolution between MPAS-A and CT2019 can be clearly observed in XCO₂ in July over both northeast and southern China.*" (P12L10-12 of the revised manuscript)

[4] P12L5-7: Maybe it is better to remind it for readers that both model used the same CO₂ fluxes so the difference is only caused by the different model transport.

Agreed. The sentence at P12L6-7 has been revised as to “*Because both models used the same surface CO₂ fluxes, the difference in the simulated CO₂ fields is caused by the difference in transport: spatial resolution, dynamics, and physical parameterizations.*” (P12L14-16 of the revised manuscript).

[5] P13L1: Is it possible to add 60 km uniform grid result over 15 km cell area (data in Table 3) in the table 6, in order to support the benefit of high-resolution? If you don’t have the result for CO₂, it is fine with leaving it as is because I don’t ask an additional experiment.

Adding CO₂ result from the 60-km uniform resolution will require new experiments. Therefore, we choose to leave Table 6 as it is.

[6] P14L31-P15L1: This paragraph looks redundant. Please consider to move it to earlier part (section 3.1 or other proper place).

Thanks for pointing it out. This paragraph has been moved to Section 3.3.2 where CT2019 CO₂ fields is used for the first time in the manuscript. (P11L31-34 of the revised manuscript).

[7] P15L6: Which version of ObsPack dataset did you use? Please specify it.

ObsPack v5.0 was used for validation. The version number has been added. (P15L14 of the revised manuscript).

[8] P17L15: Since paired t test is also used in Table 5. The explanation can be moved earlier part of the paper (section 3.3.3), if the same method is used.

The explanation of using paired *t* test for model comparison has been moved to section 3.3.3 (P13L17-18).

[9] P18L30: In summary section, please consider to mention briefly about an additional experiment using 60 km uniform-resolution presented in section 3.3.1.

The following sentence has been added to the summary section “*The horizontal wind fields of the 60-15 km variable-resolution MPAS-A simulation are evaluated at four pressure levels at 457 radiosonde stations. Furthermore, a comparison with an additional 60 km uniform-resolution MPAS-A simulation shows that the accuracy of the horizontal wind fields is substantially higher at the 15 km cells.*” . (P20L7-9 of the revised manuscript).

[10] P44: Table 2. What does “IGRA” stand for? Since it is not mentioned/explained in the main text. It would be better to add its full name or remove it.

“IGRA” stands for the Integrated Global Radiosonde Archive. “IGRA” has been removed from Table 2 since it is not mentioned in the main text.

Technical corrections:

[1] P1L2: CTM -> CTMs

Fixed.

[2] P2L1: CTM -> CTMs

Fixed.

[3] P2L35: model(FV2) -> model (FVS) (add space)

Fixed.

[4] P4L9: If the variable V here is the same one in eq. 1, then you can move this explanation to just after eq. 1.

The explanation of V has been moved from after Eq. 2 to after Eq. 1.

[5] P4L22L: YSU -> YSU scheme

Fixed.

[6] P5L8: YSU ->scheme

Fixed.

[7] P6L1: KF ->scheme

Fixed.

[8] P6L17: It is difficult to understand what “simulation experiments” is. Please revise it.

The sentence has been revised to “In this section we evaluate the newly developed MPAS-A CO₂ transport model by comparing its simulation results with observations and other models.” . (P6L21-22 of the revised manuscript).

[9] P6L22: ACT -> ACT campaign

Fixed.

[10] P8L7: “The four CT2019 fluxes” -> “The four components of CT2019 fluxes”

Fixed.

[11] P8L29: Their model name is actually GEM-MACH-GHG, please check their paper.

GEM has been replaced by GEM-MACH-GHG in all three places in the manuscript.

[12] P9L12: “the model’s initial and current time step global CO₂ mass” -> “the global CO₂ mass at the initial and current time step.”

Fixed.

[13] P9L27: “To restore the CO₂ mass conservation” -> “To keep the total CO₂ mass”

Fixed.

[14] P9L27: MPA-A’s -> MPAS-A’s

Fixed.

[15] P10L19: CO₂₂ (remove redundant 2)

Fixed.

[16] P10L19: XCO₂ (2 for subscript)

Fixed.

[17] P12L6: GEM -> GEM-MACH-GHG

Fixed.

[18] P12L30: “(11.77” -> “(11.77” (remove space)

Fixed.

[19] P12L31: “a accuracy level” -> “a level of accuracy” or other else

Fixed. It has been changed to “a level of accuracy”.

[20] P14L25: project -> campaign

Fixed.

[21] P14L29: analysis -> reanalysis

Fixed.

[22] P14L31: CarbonTracker -> CT2019

[23] P14L33: free troposphere -> FT

Fixed.

[24] P15L6: CarbonTrack -> CT2019

Fixed.

[25] P15L6: CarbonTrack ObsPack -> CarbonTracker ObsPack (or CT2019 ObsPack, depending on the version of dataset you used)

CarbonTrack ObsPack has been replaced by CarbonTracker ObsPack.

[26] P15L14: free troposphere (FT) -> FT

Fixed.

[27] P15L30: boundary layer -> BL

Fixed.

[28] P15L30: free troposphere -> FT

Fixed.

[29] P16L6: boundary layer -> BL

Fixed.

[30] P16L30: boundary layer -> BL

Fixed.

[31] P16L30: free troposphere -> FT

Fixed.

[32] P19L28: CarbonTracker -> CT2019

Fixed.

[33] P19L31: Maybe TCCON dataset information is necessary

TCCON dataset information has been added (P20L13 of the revised manuscript).

[34] P20L14: Maybe proper acknowledgment for TCCON dataset is necessary, depending on their data policy

TCCON acknowledgement has been added (P20L23 of the revised manuscript).

[35] P30: Figure 2.

- 1) Please make red solid lines in both panels have the same thickness. It would be good for better visualization.

Fixed.

- 2) “number of hours” looks wrong. Please correct it.

“number of hours” has been corrected to “the days of 2014”

[36] P31: Figure 3.

- 1) Please make the red solid lines in both panels have the same thickness. It could be good for better visualization.

Fixed.

- 2) “number of days” looks wrong. Please correct it.

“number of days” changed to “the days of 2014”

[37] P32: Figure 4. XCO₂ -> simulated XCO₂

Fixed.

[38] P34: Figure 6. Please add period at the end of the caption.

Fixed.

[39] P35: Figure 7.

- 1) “MPAS-A simulated hourly XCO₂” -> “Simulated hourly XCO₂ of MPAS-A”.

Fixed.

- 2) please add period at the end of the caption.

Fixed.

[40] P40: Figure12. level-leg flight -> “constant altitude flight segments”

Fixed.

[41] P42: Figure14. “for create” -> “for creating”

Fixed.

[42] P43: Table 1. Please revise the caption.

Fixed.

[43] P44: Table 2. add bracket for the unit (degree) in the 4th column.

Fixed.

[44] P45: Table 3. 1) speed(m/s) -> speed (m/s) (add space), 2) add bracket for the unit (degree) in the 4th column

Fixed.

[45] P50: Table 7. Please revise the caption

The caption has been revised to “TCCON stations used for model evaluations”.

[46] P51: Table 8. RMS -> RMSE

Fixed.

[47] P53: Table 10.

1) MPAS -> MPAS-A,

Fixed.

2) “MPAS simulated horizontal wind” -> “simulated horizontal wind of MPAS-A”,

Fixed.

3) Add a comma after “1000”,

Fixed.

4) speed(m/s)-> speed (m/s) (add space),

Fixed.

5) add a bracket for the unit (degree) in the 4th column

Fixed.

[48] P54: Table 11. “2017 winter” -> “Winter 2017”

Fixed.

[49] P55: Table 12. Please revise the first sentence of the caption.

Fixed.