Interactive comment on "Development and evaluation of CO$_2$ transport in MPAS-A v6.3" by Tao Zheng et al.

Anonymous Referee #1

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This paper compares newly implemented CO2 output from variable resolution runs of the MPAS model to observations and two other modeling systems. The high-resolution region of the MPAS runs was centered over North America so most of the comparisons are made in this region but global comparisons with the relatively low resolution region of the model are also made. The MPAS CO2 output generally compares well with both the observations and other model output in the variety of known sharp gradient features, such as across cold fronts. The results suggest a successful implementation of CO2 into the MPAS model and the possibility to do focused high-resolution model runs in regions of interest.

The techniques and methodology are clearly described and the results are well supported by the figures and discussion. There are many grammatical errors and I have

tried to list some of them here but there are certainly more. My main comments are regarding figure clarification and are minor. I recommend publication with consideration of the specific comments below.

Specific comments:

Figure 6: You should add a label to the y-axis on at least the left column of plots. It's apparent that you are plotting CO2 mole fraction in ppm but the labels should still be included. Also, I would recommend adding the labels 'ACT', 'MPAS', 'WRF-Chem' and 'CT2019' in the appropriate regions on at least one of the plots in the top row, or all of the top row plots to make it clear without reading the caption what is being plotted. Red 'warm sector' and blue 'cold sector' labels somewhere in the figure would also help. In line 3 of the caption 'measurement' should be 'measurements'. In line 5 I think you mean 'quartiles' instead of 'percentiles'.

Section 3.3.3: It would be helpful to include a summary of the warm-cold sector differences for each season and each model or measurement system. This could either be included in Table 4 or just in the text.

Figure 9: It's not clear if you intended to have a Figure 10 on Pg. 36 or continue Figure 9 onto two pages. In the caption of Figure 10 and 11 you refer to 'Figs. 9 and 9', which should either be 'Fig. 9' or 'Figs. 9 and 10' if you've split the figure into two. I would actually recommend moving Figure 9 into the supplement. 48 individual plots are too many for a single figure, or even two figures. One option to summarize the information in Figure 9 is to make normalized composites for each season. These could just emphasize the mole fraction differences across the fronts so that the measurements and models are each subtracted from their respective values at the front location. As the figure is now, the absolute value offsets are most visible rather than the differences across the front. The RMSEs calculated for Fig. 10 could also be based on the normalized mole fractions.

Technical comments:

Pg. 6, line 24: 'first set of simulations. . .'

Pg. 7, line 14: A question mark appears to be inadvertently left in parentheses.

Pg. 7, line 19: Did you mean 'reanalysis' instead of 'analysis'? Here and in the next line.

Pg. 8, line 16: Should be 'subscript k' instead of 'subscript j' for the vertical level.

Pg. 8, line 18: Should be 'hI,k' not 'hI,j'

Pg. 8, line 20: Should be 'rhoi,k' not 'rhoI,j' and 'qI,k' not 'qI,j'

Pg. 9, line 3: Add comma after 'MPAS'

Pg. 10, line 26: Why is this information in Table 6 instead of Table 3 since at this point in the text Tables 3-5 haven't been referred to yet? It seems to make sense to switch Tables 3 and 6 so they coincide with where they are discussed in the text.

Pg. 11, line 32: change 'he' to 'the'

Pg. 12, line 9: change 'resulted in' to 'had'

Pg. 12, line 10: 'accuracy than MPAS, likely because it applied. . .'

Pg. 12, line 12: change 'large' to 'larger'

Pg. 21, line 12: 'compared'

Pg. 12, line 31: 'in the next two sections. . .'

Pg. 13, line 5: add 'the' before 'warm'

Pg. 13, line 10: remove the second 'well' in this sentence.

Pg. 13, line 27: 'represents'

Pg. 13, line 32: One of the 'BL' subscripts should be changed to 'FT'

Pg. 14, line 2: 'observations'

Pg. 14, line 4: 'are a substantial. . .'

Pg. 14, line 5: 'majority of cases. . .', 'the rest of the three. . .'

Pg. 14, line 15: 'shows'

Pg. 14, line 22: 'seasons'

Pg. 14, line 34: should be 'Fig. S2'

Pg. 15, line 7: 'flights'

Pg. 15, line 30: 'MPAS performs. . .'

Pg. 16, line 24: 'this results in. . .'

Pg. 16, line 33: 'mean sea level. . .'