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Interactive comment on "River Breezes for Pollutant Dispersion in GoAmazon2014/5" *by* Adan S. S. Medeiros et al.

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Response to Review #2 General Comment: The manuscript shows the effect of river breezes for the city of Manaus using data from a field campaign and WRF-Chem modeling. I believe this is the first study to analyze the effects of river breezes on pollutant transport at the city scale using models, which makes it very valuable. The paper is well written and the topic is relevant and in the scope of the Journal. I have a few comments and suggestions outlined below, mainly requesting additional complementary analysis.

1 – Comment from Referee: Given that this is the first study of its kind, it would be great to see additional analysis performed by including sensitivity simulations. Given that river breezes are being studied, it would be helpful to see what's the model re-

sponse to the representation of river breezes when the grid-spacing is changed. I recommend adding simulations (with and without rivers) going down to 1 km horizontal resolution and by refining the vertical resolution in the region where the breeze develops. Including the 10km domain into this analysis (if two-way nesting is not used) would be helpful too. Analyzing the changes in meteorology and pollutant concentrations as a function of the grid-spacing would provide great insight into the subject.

1 – Author's response: We thank the reviewer for this perspective. We agree that sensitivity simulations to grid spacing can be interesting and helpful to understand atmospheric processes. In the study design, we adjusted the grid to 2 km in the central region of the simulation in an around the rivers. Internally (i.e., without mention in the manuscript), we also carried out simulations at 3 km and 5 km while scoping the project. The rivers have a width of 5 to 10 km, so the model at 2 km resolution captures the major features of the river breezes, specifically as related to penetration of the river breeze to higher altitudes (in which 19 vertical levels were used in the first 500 m) and possible pollutant dispersion of the nearby urban area (scale of 20 km). Other scientific questions could require different scales. The revised text includes this caveat, as follows:

1 - Author's changes in Manuscript: Line 103: "The inner domain represented an area of 302 km x 232 km, had a horizontal resolution of 2 km x 2 km, and had 38 vertical layers from ground to 160 hPa. The first 14 levels were below 200 m in altitude. With this grid configuration, the major features of the river breeze could be represented."

2 - Comment from Referee: Another sensitivity simulation that comes to mind has to do with changes of the river properties. Fig. 1 shows a very distinct albedo difference between the Rio Negro vs the Amazons. Adding a simulation where this contrast is added by changing the reflective properties of one of the rivers could be useful to see if this has any effect.

2 - Author's response: We thank the reviewer for this perspective. This suggestion is

very interesting in a scientific perspective geared toward understanding weak versus strong river breeze effects. The focus of our study, however, was to understand the effects of river breezes as they are now around Manaus on possible regional pollutant dispersion and/or channeling. The study of reflective properties of the rivers would be a good effort for a future manuscript focused more on the physics of river breezes than the effects of the presence of the rivers on pollution plume dispersion, as herein.

3 - Comment from Referee: Finally, the manuscript should be revised more carefully for English by a native English speaker.

3 - Author's response: The revised manuscript has been carefully reviewed by a native English speaker

4 - Comment from Referee: Line 19. You could include the % of change associated with these concentrations

4 – Author's response: We thank the reviewer for this perspective. After consideration, however, we think that the values shown in line 19 are associated with single events and the proposed insertion of percentage values can confuse the reader. In addition, Figures 5, 6, and 7 show the time series of pollutant concentrations at T3, R1, and R2, so the reader can have an idea of how much these individual events are significant at mean basis for March 2014.

5 - Comment from Referee: Intro. Additional information of the effect of lake breezes on air quality could be included together with expected similarities and differences to river breezes;

5 - Author's response: The following sentence is added to the manuscript.

5 – Author's changes in the Manuscript: Line 39: "RiverÂăbreezes arise from the unequal heating of land and water bodies. In the morning, land heats fasterÂăthan water, inducing an ascendancy of air over the land and a corresponding subsidence over theÂăriver. In this way, surface winds go from the river toward the land. At an altitude

of a fewÂăhundred meters, the circulation cell is closed, and the winds go from the land to the river, with subsidence over the central portion of the river. The height of the cell depends on the thermal characteristics of the circulation. At night, the opposite behavir occurs (i.e., the cell reverses) because the river cools more rapidly than land. At the size scale of the regional rivers, these processes are similar to lake breezes that also arise from the thermal gradient between land and water, especially in the Amazon region where there are expansive wetlands during the wet season (Walter, 1973;Hess et al., 2015;Moura et al., 2004)."

6 - Comment from Referee: Line 99. Provide the vertical grid-spacing in the first layers up to 200m, as this is the region where the largest sensitivities occur due to river breezes;

6 - Author's response: The authors agree with the reviewer. To address the point, the following sentence is added to the manuscript. Author's changes in Manuscript: Line 103: "The inner domain represented an area of 302 km x 232 km, had a horiziontal resolution of 2 km x 2 km, and had 38 vertical layers from ground to 160 hPa. The first 14 levels were below 200 m in altitude."

7 - Comment from Referee: Fig S1. It would be helpful to add the data for both simulations in this plot, to have an idea of the changes (if any) in the performance of modeled meteorology due to river breeze;

7 - Author's response: The authors thank the reviewer for this suggestion. We think that these kind of analysis is out of the scope of the article because we intend to focus on the effects of the presence of the rivers on pollution plume dispersion.

8 - Comment from Referee: Line 133-135. You mean that every 72h meteorology was initialized from CFSv2? If this is the case, did you leave some spin-up time for meteorology after every initialization? This would be recommended given that you are studying river breeze effects.

8 - Author's response: We thank the reviewer for this observation. The simulations were performed in groups of 96 h, with 24 h of spin-up, and using 72 h of valid run. The text is clarified as follows:

8 - Author's changes in Manuscript: Line 136: "Simulations of the wR and woR cases were carried out for all days in March 2014. Other characteristics between the two simulations remained the same. This approach aimed to isolate the river breeze effects on the transport of pollutants downwind of Manaus. For time zero, the inner and outer domains were both initialized to CFSv2 and MOZART-4. The simulations were performed in groups of 96 h, with 24 h of spin-up followed by 72 h of valid run, as described in Medeiros et al. (2017)"

9 - Comment from Referee: Fig. 2. Maybe you can add a column showing the mean surface values at noon, which is where your maximum changes occur.

9 - Author's response: The authors thank the reviewer for the suggestion. We think that the variability of the horizontal wind speed is shown and discussed in Figure 3.

10 - Comment from Referee: Line 147-165. This analysis is great but could be complemented with the addition of changes of wind direction and vertical winds. Maybe adding arrows representing horizontal (in the A-C axis) and vertical winds (differences?) in the profiles could help. In the intro you mention that the breezes happen due to temperature gradients, so including temperature differences would also contribute.

10 - Author's response: We thank the reviewer for this valuable input. We did the analysis of the changes in vertical winds and wind direction while scoping this project, but conclusive results were not possible from monthly means. For the temperature gradients, a Figure S2 is added to the manuscript. The manuscript is clarified as follows:

10 - Author's changes in Manuscript: Line 163: "The strongest differences were at noon corresponding to maximum daily solar irradiance, as expected, because of the largest

thermal gradients between land and river at these times (Oliveira and Fitzjarrald, 1993, 1994;Silva Dias et al., 2004;Fitzjarrald et al., 2008;dos Santos et al., 2014;de Souza and dos Santos Alvalá, 2014;de Souza et al., 2016). Monthly mean surface temperature are shown in Figure S2 for wR and woR cases. The thermal gradient is higher at noon rather than midnight."

11 - Comment from Referee: Line 166-182. Here you only discuss the flight observations. I recommend adding the simulated values over the flight track for both simulations on the time series in Figure 4, so is visually clear that there are no differences at this altitude and also to have an idea of the model performance.

11 - Author's response: The authors thank the reviewer for this recommendation. However, we think that a full evaluation of the model performance is out of scope of this manuscript. The focus of the manuscript is to describe the effects of the presence of the rivers on Manaus plume dispersion. A different manuscript with this kind of evaluation is the topic of some current work and might be forthcoming later. The model configuration used in the simulations is based in Medeiros et al. (2017), which compares the observed and simulated ozone concentrations for Manaus region.

12 - Comment from Referee: Figs 5-7. It would be great to have an idea of model performance by adding the observed T3 concentrations to the upper-left panel

12 - Author's response: We thank the reviewer for this suggestion. We think that this comparison is highly valuable, yet it is out of the scope of the manuscript. In this regard, please see the answer for point 11.

13 - Comment from Referee: Line 184-195. CO seems to present a high frequency variability coming from Manaus while there is a long frequency probably because of background air changing, could you elaborate on this? Is this also seen in the observations at T3?

13 - Author's response: The reviewer is correct that there is low-frequency variability

because of changing background air. The same variability is seen upwind at the ATTO tower. This variability must be addressed in the context of a global model because of CO outflow from biomass burning in Africa as well as CO production from VOC photo-oxidation (i.e., isoprene). For purposes of our regional study, the background CO concentration is a boundary condition, i.e., CO has a relatively long atmospheric lifetime.

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