

Review of: Anthropogenic and natural controls on atmospheric $\delta^{13}\text{C}$ -CO₂ variations in the Yangtze River Delta: Insights from a carbon isotope modeling framework

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This paper describes a study of CO₂ emissions in the megacity region of the Yangtze River Delta of China, which include several major cities in eastern China. The novel contribution of this study is the WRF-STILT modeling of the emissions making extensive use of the stable isotopic composition of carbon in CO₂ ($\delta^{13}\text{C}$ -CO₂). The simulation agrees well with the CO₂ observations. The modeling of $\delta^{13}\text{C}$ -CO₂ allows investigation of the contributions of various anthropogenic and biogenic sources. The topic of this study falls well within the scope of Atmospheric Chemistry and Physics. Therefore, this paper should be published after minor revision.

My concerns include the need for clarification and further discussion of several points and the need for quantification of uncertainties in calculations resulting from the modeling runs. Particular instances of these are given below.

Specific comments:

Line 114: Replace “be used” with “been used.”

Line 188ff: Move Figure 6 here, since you are describing it here. You should refer to it here, changing the number to 2, and therefore adjusting the figure numbers for the old 2-5 to 3-6, both in the text and in the figure captions.

Lines 205-206: The lowest quintile is the lowest 20%, not the lowest 5%. You can just say “the bottom 5%” to describe the data used in this approach to background.

Lines 216-218: Give the parameters you used in the CCGCRV curve fitting calculations.

Line 231: Add (Figure 2 (perhaps changed to Figure 3)) after “YRD.”

Line 243: Replace “East China” with “Eastern China.”

Line 247: Insert “backwards” after “locations.”

Line 250: Replace “at the end of” with “for.”

Lines 263-264 and elsewhere: Replace “EDGAR v432” with “EDGAR v4.3.2.”

Line 276: Please clarify “enhancement.” Is this proportion of emissions due to source *i*? “Enhancement” sounds like it is the amount of CO₂ in excess background.

Line 286: When considering the biosphere in cities, people are starting to include the effects of human respiration and excretion (Turnbull et al., 2015; Miller et al., 2020, just published in PNAS), using information from Prairie and Duarte (2007). You might want to comment on how this would affect your analysis. The $\delta^{13}\text{C}$ of human respiration should reflect that of the average diet. Also, is any bioethanol used in the gasoline? You should confirm this, since this is common in some cities.

Line 322: Replace “blue” with “blue-red.”

Lines 333-334: Replace “below” with “to.”

Line 335: What hours did you use for daytime? Most modelers stress that mid-day to mid-afternoon hours work best, when the planetary boundary layer height (PBLH) is best simulated.

Your Figure 3 suggests that the monthly average of nighttime modeling results matches the observation best.

Line 345: What are the two months that fall far below the trend in Figure 4a? Do you have an explanation for these?

Line 359: Neither Figure 5a nor 7b is consistent with a negative average summer NEE. Indeed, Figure 5a suggests the opposite since all 2014 summer months are positive in NEE/biological contribution to the CO₂ enhancement, as are June and July 2015.

Line 363: Replace "4b-c" with "4b-d."

Lines 375-376: What are the uncertainties in the observed anthropogenic CO₂ enhancements? In general, please give uncertainties.

Lines 388-390: The absolute enhancements depend on many things, including the meteorology and the magnitude of the emissions. You can't conclude that the YRD has more emissions simply because the enhancements are higher. Modeling is critical for coming to that conclusion.

Line 392: Explicitly explain where these percentages come from.

Line 395: Where do you show that the maximum source contribution exceeded 50% on 19 September 2013?

Lines 396-399: Please explain how the "anthropogenic enhancement" is different from the "anthropogenic emissions."

Line 408: Replace "2014" with "2014-2015."

Lines 408 and 415: Express the emissions as $\times 10^{11}$ kg, the same units as in Table 1, for consistency.

Line 417: Replace "is" with "are."

Lines 430-431: A positive biological CO₂ signal during winter is consistent with a negligible role for photosynthesis, but it could be that photosynthesis is still important, just not as important as respiration. Will human respiration affect this?

Line 434: Replace "domain" with "background."

Line 435: Add "(Figure 6)" after "respectively." This may become Figure 2.

Line 454: Replace "Figures 3 and 7" with "Figures 3a and 8", but the vertical scale in Figure 8 is too compressed to be seen clearly.

Lines 465-469: Please give uncertainties. Are the seasonal increases significant? Could PBLH simulation issue explain the large discrepancies, especially since the model diurnal variations are greater than those in the observations.

Line 505: Replace "than" with "in." The baseline simulation in Figure 10b (red) is more enriched in the heavy isotope, as evidenced by its less negative values between April and October.

Lines 509ff: Are the differences of 0.08-0.20‰ significant? Please give uncertainties. Similar comment for the next paragraph.

Line 530: Add the definition of the regional source term " $(\delta_s \cdot \Delta CO_2)$."

In general, be consistent with " δ_s "

Line 544: If you use nighttime simulations, you still have respiration.

Lines 597-598: Do you need to show both 13a and b? They are almost identical. You could just show one and generally state the results for the second in the text.

Lines 600-601: Replace "relatively similar with" with "similar to."

Lines 608-609: Insert “absolute” after “1.57%.” Are the uncertainties in your calculations small enough that “a 0.013‰ – 0.038‰ change” is significant?

Lines 621-622: Add “calculated from the simulations” before “was shown” and “From the EDGAR v4.3.2 inventory” after “proportion.”

Figure 1: More information is needed in the caption – significance of the different-colored boundaries. Is the red triangle in (b) the same as the blue dot in (a) (Nanjing UIST)?

Figure 2: What is the base map in the middle of (a) – city lights?

Figure 4: Explain the Δ s – what quantities are subtracted? Is the PBLH from the model? Have you compared the simulated PBLH with data? Are the data plotted in (a) averages for all hours of the day?

Figure 5: I think the captions for (b) and (c) are switched.

Figure 7: More explanation is needed in the caption. What is the origin of the background in (a)? What are the vertical lines in (b)? The latter question can be avoided by using the same shading in both panels.

Figure 8: This figure is good for showing model/observation comparison, but the vertical scales are too compressed to show long-term temporal variations or to compare between years.

Figure 9: (a) and (b) – the yellow color is very difficult to see. How do these plots look if you only use mid-day or early-mid afternoon results?

Figure 10: “Observation” in the legend should be plural (“Observations”). What is the solid blue curve in (a) – probably the dashed blue line in the legend. This is difficult to see.

Figure 11. The 1:1 lines are not dashed in the figures, although the legends say they are. Please distinguish the 1:1 lines from the regression lines.

Figure 13. More explanation is needed in the caption. “Cement proportion” of what? Total anthropogenic CO₂ emissions? EDGAR? “Cement increase ratios” – please explain what this is. Please be explicit as to what strategies 1 and 2 are, especially since some readers focus on the figures and not on the text.

Table 1.: Explain “/”

Table 2.: Can you add rows for the average values for the model results and the observations for both CO₂ mixing ratios and $\delta^{13}\text{C-CO}_2$ for each column?