

Responses to Referee 3

general comments

This manuscript presents 8 years of $\delta(\text{O}_2/\text{N}_2)$ and CO_2 observations and calculated APO values from aircraft flights over the North Pacific. The data were corrected for significant fractionation effects on O_2 and N_2 . The data were then well-analysed to find latitudinal and altitudinal, seasonal and secular trends in APO and the authors have demonstrated the influence of inter-hemispheric mixing on the seasonal APO cycle through comparison to model data. This manuscript is well-designed and well-written, and the discussion and interpretation of results contributes to the understanding of global atmospheric carbon and oxygen processes. I can recommend this manuscript for publication in ACP, with some minor comments below.

Thank you very much for your significant and useful comments on the paper “Spatiotemporal variations of the $\delta(\text{O}_2/\text{N}_2)$, CO_2 and $\delta(\text{APO})$ in the troposphere over the Western North Pacific” by Ishidoya et al. We have revised the manuscript, considering your comments and suggestions. Details of our revision are as follows. The line numbers denote those of the revised manuscript.

specific comments

Line 24: Units are usually written as Pg C a⁻¹, if this is what is meant by C equivalents

We recognize the unit you suggested are more familiar with our research field, however, I have used the unit considering the Editor’s comment.

Line 24: I suggest that here, and elsewhere, a space should be added between the number \pm and the uncertainty value for ease of reading. E.g. “1.9 \pm 0.9” changed to “1.9 \pm 0.9”. I would also suggest removing the brackets around all of your quoted values, especially as the units are stated outside of the brackets.

A space has been added between the number \pm and the uncertainty value throughout the paper, as suggested. As to the brackets, I understand your suggestion, but we followed the Editor’s comment.

Line 31: Here, and throughout, you have referred to CO_2 amount fraction – this is usually referred to as CO_2 mole fraction

We recognize the phrase you suggested are more familiar with our research field, but we followed the Editor’s comment.

Line 81: Although the sampling methods are described in full in the stated references, I think a brief summary of a few lines would be helpful to the reader here and then direction to the references for a full detailed description

Lines 80-91: The sentences have been added to show a brief summary of the sampling methods and related information, as suggested.

Line 83: What scale is the CO₂ measured on?

Lines 93-95: The sentence has been modified to show the scale of CO₂, as suggested.

Lines 88-90: at some point here, or in the figure 1 caption you could include how many air samples were collected in total. You have said that 17-20 are collected per flight, but not how many flights total.

Figure 1 caption: We have added the information about the number of air samples collected and analyzed.

Lines 93-97: While these equations are correct, I would suggest writing them in full i.e. (sample-standard)/standard. The form shown here is a mathematical simplification and results in some loss in understanding of the principal behind the equation

Lines 104-108: The equations have been rewritten, as suggested.

Line 99: Which scale have each species been calibrated to?

Lines 112-113: We have added the information about the scale.

Line 116: how was this overall uncertainty calculated? Is this from the measurement uncertainty and the stated uncertainties in the coefficients from equation 6?

Lines 130-135: The sentence has been added to show the overall uncertainty, as suggested.

Line 117: I found the phrase “was not therefore excluded in this study” difficult to comprehend. I would suggest rewording to “was therefore not excluded in this study”, or “was therefore included in this study”

Line 131: The phrase has been changed to “was therefore not excluded in this study”, as suggested.

Figure 3: The legend on 3(a) shows this studies data as an open red circle, whereas in the figure I am assuming that they are coloured by altitude (as they are in 3b), I would suggest adding the altitude colour bar to 3(a) also. The bottom panel of 3(b) is not referred to in text and is showing the same data as the bottom panel on 3(a) so could be removed if the red reference point line were added to the bottom panel of 3(a). Is the red line reference point of d(Ar/N₂) the annual mean value from Tsukba in 2013? If so this information could be added to the figure caption for further clarification, if not, what is it?

Figure 3: We have made substantial revision of Fig. 3, considering your and the other reviewers' comments.

Line 123: I don't think "but" is the correct word here, as that implies that the reduction in fractionation since 2018 is linked to the larger fractionations at higher altitudes before 2018 – unless this is the case, and if so this should be reworded to make this clearer

Lines 187-188: The sentence has been modified to make the meaning clearer, as suggested.

Line 124-125: The word "however" implies that the lack of systematic data gaps across 2018 mean that the change in aircraft may not be the cause of the reduction in fractionation, I don't understand this. If this is the case, could you suggest another cause of this reduction in fractionation - is the change in aircraft the only change that occurred in 2018? The reduction in fractionation is substantial so further discussion of this would be useful.

Lines 190-192: The sentence has been rewritten as "No systematic data gaps were found in the $\delta_{\text{cor.}}(\text{O}_2/\text{N}_2)$ time series across 2018, so that we successfully corrected the fractionation of O_2 and N_2 both for C-130H and C-130R". Unfortunately, details of the air sampling line from the inlet to flask sampler have not been informed to researchers from Japan Ministry of Defense, which makes it difficult to add further discussion.

Line 153: A value of 1.35 for fossil fuel OR is not given in Keeling and Manning (2014) or in Keeling (1988) which is referenced therein, where is this value from? Typically, the value used for the weighted global average for fossil fuel consumption is higher than this

Lines 170-172: We have corrected the global OR for fossil fuel combustion to 1.37 calculated based on fossil emission by category summarized in GCP (Friedlingstein et al., 2020).

Figures 4 and 5: I think the scale differences between panels (a) and (b) in each of these figures needs to be explained explicitly in the methods section when discussing NICAM-TM. I would also suggest adding to the figure caption to note that the x-axis scales differ

Lines 172-173, Figs. 4 and 5 caption: The sentence has been added to denote the scale difference between the observed and simulated data, as suggested.

Figure 5: Add reference to different altitudes in the figure caption e.g. observed in the troposphere over MNM at various altitudes

Figure 5 caption: The figure caption has been modified, as suggested.

Line 155-158: I would suggest further explaining what is meant by ignoring the $\text{dAM}(\text{APO})$,

particularly as this is frequently referred back to in the results/discussion, and I don't think this sentence fully explains this

Lines 176-182: The sentences have been added to explain what is meant by ignoring the $\delta^{AM}(APO)$, as suggested.

Line 175: To avoid confusion I would suggest referring to “the figure” by figure number, it is not immediately clear which figure you are referring to as in the previous sentence you referred to both figures 4 and 5.

Line 214: The words “the figure” have been changed to “Fig. 5(a)”, as suggested.

Figure 8: figure caption states “relative to the corresponding values at 6 km” but in text it says “relative to surface values”?

Figure 8 caption: The words “values at 6 km” in the caption have been corrected to “surface values”, as suggested.

Line 235: Why are these values from figure 9(b) relative to the corresponding values at 6 km, but the values in figure 8(b) are relative to the surface? If there is no reason for this, I would suggest being consistent between the figures

Figure 9 caption: The words “corresponding values at 6 km” have been changed to “corresponding values at 1.3 km”.

Figure 10: the scale size for the bottom panel (12 per meg a^{-1}) is smaller than that for the top and middle (-14 per meg a^{-1}). I would suggest changing this so they are visually comparable

Figure 10: The scale sizes have been adjusted to make them easy to compare visually.

Line 301: why has 1.37 been used as the OR here, but 1.35 above?

We have corrected the global OR for fossil fuel combustion to 1.37 throughout the paper, calculated based on fossil emission by category summarized in GCP (Friedlingstein et al., 2020).

technical corrections

Line 52: change “artificial fractionation on O₂/N₂” to “artificial fractionation of O₂/N₂”

Line 52: The words “artificial fractionation on O₂/N₂” have been changed to “artificial fractionation of O₂/N₂”, as suggested.

Line 69: I don't think western should be capitalised here, should read “western North Pacific”

Line 69: The word “Western” have been changed to “western”.

Line 71: "heigh-altitude" to "height-altitude", or "altitude-latitude" as you have referred to altitude throughout the text

Line 71: The typo "heigh-latitude" have been corrected to "height-latitude".

Line 126: change detail to detailed

Line 143: The word "detail" has been changed to "detailed".

Line 130 – 132: this sentence is hard to comprehend due to the number of and's, I suggest rewording

Line 132: Change have to has

Lines 147-149: The sentence has been rewritten, as suggested.

Line 262: change to "is a global average"

Line 307: The words "as a global average" have been changed to "is a global average".

Line 285: change Fig. 12 to Fig. 11

Line 331: "Fig. 12" has been changed to "Fig. 11".

Line 298: Pg C, here and elsewhere

We recognize the unit you suggested is more familiar with our research field, however, I have used this considering the Editor's comment.

Line 431 and 440 : Formatting of references is not consistent, for all other references publication year is at the end of the reference. These two references also say "and co-authors", rather than having a full author list which should be present

Lines 487-498: The formats of the references have been corrected. Thank you for pointing that out.

Other changes

Lines 146-147: The sentence has been modified and Tohjima et al. (2005) has been added to reference since we have noticed that we used X_{O_2} of 0.2094 in their study to calculate the observed $\delta(APO)$.

Lines 201-203, Figs. 4 and 5: The sentence has been added to note the data selection in the digital filtering technique, and the observational data deviated from the best-fitted curves more than $\pm 3\sigma$ have been excluded from Figs. 4 and 5.

Figure 8 caption: The sentence to show the method to calculate the amplitude of seasonal APO and

CO₂ cycles have been added.