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Comment on acp-2021-787

Anonymous Referee #3

Referee comment on "Spatiotemporal variations of the $\delta(O_2\square/\square N_2)$, CO_2 and δ(APO) in the troposphere over the western North Pacific" by Shigeyuki Ishidoya et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-787-RC3, 2021

general comments

This manuscript presents 8 years of $d(O_2/N_2)$ 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.

specific comments

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

Line 24: I suggest that here, and elsewhere, a space should be added between the number ± and the uncertainty value for ease of reading. E.g. "1.9±0.9" changed to "1.9 ± 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.

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

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

Line 83: What scale is the CO_2 measured on?

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.

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

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

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

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"

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 $d(Ar/N_2)$ 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?

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

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.

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

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

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

Line 155-158: I would suggest further explaining what is meant by ignoring the dAM(APO), particularly as this is frequently referred back to in the results/discussion, and I don't think this sentence fully explains this

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.

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

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 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

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

technical corrections

Line 52: change "artificial fractionation on O_2/N_2" to "artificial fractionation of O_2/N_2"

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

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

Line 126: change detail 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

Line 262: change to "is a global average"

Line 285: change Fig. 12 to Fig. 11

Line 298: Pg C, here and elsewhere

Line 431 and 440 : Formatting of references is not consistent, for all other references publication tear 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