

Referee report: Manuscript titled “Temporal-Spatial Variations based on OCO-2 observations”, by Yifan Guan et., al.

I am satisfied with the author's responses to the questions raised from my initial review. I am pleased the author used GOSAT data as an independent assessment to provide robustness around findings found by OCO-2. Although the author added GOSAT in the results section, no discussion of GOSAT findings was added in the discussion or conclusion sections. It is worth adding this information given that both satellites showed agreement (Fig.4) in northern and southern hemisphere tropical zones (0-20°), with relatively small differences in Northern Hemisphere/Southern Hemisphere extratropical zones (20-60°) compared to TCCON and MBL.

I suggest the author re-write some parts of the abstract to convey main findings in the manuscript better. In line 40, the author says that 'similar zonal patterns of OCO-2 XCO₂ IAV timeseries compared to ground-based in situ observations and with column observations from the Total Carbon Column Observing Network (TCCON) and the Greenhouse Gases Observing Satellite (GOSAT) provide validation that OCO-2 observations can be used reliably to estimate IAV'. Here the author uses the word "validation" when comparing OCO-2 and GOSAT. GOSAT is not used in this study to validate OCO-2 but to show robustness of the IVA of OCO-2. Here, I would say that assessment with independent satellite data, such as GOSAT, provides similar seasonal patterns with OCO-2 IVA and provide robustness to this study. Comparison with TCCON and MBL is more variable and suggests the largest variability of these estimates is related to poor sampling across zonal bands.

In the discussion, the author starts this section by saying: the good agreement among the OCO-2 XCO₂ IAV timeseries, TCCON XCO₂ IAV timeseries and the MBL surface CO₂ IAV timeseries in broad zonal belts improves our confidence that we are able to quantify reasonable IAV timeseries from the satellite record. I can't entirely agree here with the author. Looking at Fig.4, I can clearly see that OCO-2 IVA is much smaller than TCCON and MBL surface data. I suggest to say that the OCO-2 show similar seasonal patterns to TCCON and MBL, but there is still a large amplitude difference between them. However, despite these differences, OCO-2 can still capture ENSO-driven variations and likely represent the IVA better due to the better spatial coverage compared to TCCON and MBL.

As mentioned at the beginning, there is no discussion about GOSAT here or in the conclusion section. Looking at Fig.4b and Fig4.c OCO-2 and GOSAT seems to agree well in the northern (20N-0) and southern hemisphere (0-20S), but with some differences in the northern (60N-20N) or southern extratropic (20S-60S). How well GOSAT compares to TCCON and MBL surface measurements at site level? I couldn't find this analysis in the result section or supplementary. Suppose GOSAT shows a poor agreement with TCCON in the extratropical bands. In that case, OCO-2 better characterize the IVA in these zonal bands compared to GOSAT and provides more accurate results to study IVA.

Minor editorial changes:

Add to Fig.4 the description of the zonal bands. For example, (a) northern hemisphere extratropical (60N-20N), (b) northern hemisphere (20N- 0), (c) Southern hemisphere (0-20S), (d) Southern hemisphere extratropical (20S-60S). I would also suggest to change the black colour of the OCO-2 time series to a more notorious colour.

Line 252. Which figure? I would write: the southern hemisphere extratropical region (Fig.1d). Remove the 's' at the end of regions. Here, I guess the author is referring to one zonal band.

Line 255. Why refer to Fig.4 only. If you are comparing Fig.4d to the other panels, you should write (fig.4a to c)

The caption of Figure 8 needs to be clarified. Is this figure showing lag correlations? If so, please indicate and add the description to label (a), (b) and (c) panels.

Line 257, We assess the spatial correlation patterns... should it says, we assess the spatial 'lag' correlation patterns.

Line 440, 452 : Again. El niño instead of El ñino. 'Ñ' goes in the second n. Check throughout the whole manuscript.

Line 273 the high XCO₂ in early 2020 around 60°S. Which Figure?

Figure 10: (page 15) I suggest to indicate that the IAV timeseries come from XCO₂ OCO-2.

Line 431. Fix typo in the word timeseries^are

Line 124 fix typo (1sigma) to 1-sigma

Please recheck the manuscript for typos and grammatical errors