Interactive discussion on "Temporal-Spatial Variations based on OCO-2 observations" by Yifan Guan

Summary: This manuscript assesses the IAV (interannual variability) of the column-averaged carbon dioxide (CO_2) dry air mole fraction of OCO-2 satellite data (ACOS version 10) at a global scale for September 2014 to June 2021 and associates its variability to El Niño/Southern Oscillation (ENSO) conditions. The IAV assessment was performed at different latitudinal bands (20-60S, 0-20S, 0N-20N and 20-60N) and a grid-cell spatial scale of 5x5 degrees. The main finding suggests that positive OCO-2 anomalies in 2015-2016 are associated with ENSO conditions, and similar results are found when analysing TCCON and MLB observations. Although OCO-2 IVA patterns are similar to based-ground observations, the amplitude of the IVA is much larger for MBL sites and TCCON.

In general, the manuscript is organized and well-written. However, some parts in the results sections need clarification. Therefore, I would recommend this paper for publication once the authors have addressed all the questions described below.

General comments:

Given that the IVA at MBL sites is almost double the IAV in the OCO-2 time series (Fig. 4a and 4b), Has the author tried to estimate XCO2 at the lower layer of the troposphere? Some studies (e.g., Kulawik et al., (2017)) split the XCO2 GOSAT column into two partial columns (lower <25 km elevation) and above 25 km., and found that the lower tropospheric CO2 partial column compares well to the independent surface CO2 data at oceanic sites. I wonder whether doing something similar here could improve the IVA comparison between OCO-2 and MLB. I also agree with reviewer 1, and a comparison with GOSAT XCO2 satellite data will also be beneficial.

Specific comments:

Line 221: When averaged into broad zonal belts representing the tropics and mid-latitudes, the OCO-2 XCO2 IAV time-series anomalies range between -0.5 to 0.75 ppm (Fig. 4). Does the author mean Fig.4a? Please indicates the results of Figs 4b and 4c are described in 3.2. For a moment, I thought that author was going to include the findings of MLB and TCCON in this section.

As an opinion, I believe that it would be better to only have one figure in this section (Fig 4a), and later in Section 3.2, I would include Fig 4a-4c as 4 different panels. For example, (a) (20-60S), (b) 0-20S, (c) 0N-20N and (d) 20-60N, where each panel should only contain the IVA time-series of OCO-2, MLB and TCCON together. By doing this, it would be easy for the reader to see how different the temporal-spatial variation is between these products.

Line 225: The Southern Hemisphere extratropical regions have larger and more rapid response in the IAV associated with ENSO compared to other zones, especially for a second. What does the author mean by saying: especially for a second?

The author also mentions that TCCON has a similar IAV amplitude to OCO-2. Is this true? Looking at Fig 4. c, TCCON has more IVA than OCO-2 (zonal belt (20-60S)). What happened in 2019? It seems that TCCON has an IAV of about 1.5 ppm compared to OCO-2 (no variability).

We note a slight low bias in OCO-2 relative to TCCON for all five sites in the Southern Hemisphere, which lie below the one-to-one line. How does the author know that OCO-2 has a lower bias than TCCON? I am a bit confused here; the author calculated standard deviations in Fig.10 and then discussed biases. Please clarify.

Line 427: When using IAV time series for flux inference, it will be crucial to account for non-flux imprints on the time series since spurious attribution of IAV will lead to biased fluxes. What does the author mean when he says: non-flux imprints on the time series? Flux or XCO2? Spurious attribution of IAV in XCO2 data?

Editorial comments:

Table 1 and Table 2 should also be included in the appendix and not in the main text.

Please be aware that TCCON locations must be placed correctly on the map. For example, reunion Island is over the Australian continent.

Line 227: that of other latitude belts. Remove 'that of' from the text; it seems unnecessary in this sentence.

EL niño instead of El nino. Please be aware that el niño is a Spanish word that must be written with 'Ñ'.

References

Kulawik, S. S., O'Dell, C., Payne, V. H., Kuai, L., Worden, H. M., Biraud, S. C., Sweeney, C., Stephens, B., Iraci, L. T., Yates, E. L., and Tanaka, T.: Lower-tropospheric CO2 from near-infrared ACOS-GOSAT observations, Atmos. Chem. Phys., 17, 5407–5438, https://doi.org/10.5194/acp-17-5407-2017, 2017.