Comment on essd-2021-210
Anonymous Referee #2


An accurate grided global terrestrial ecosystem carbon flux data is of great importance in global carbon cycle research. This study presents a global CO\textsubscript{2} flux dataset (2015–2019) inferred from OCO-2 retrievals using the Tan-Tracker inversion system, which uses a dual-pass inversion strategy and the nonlinear least squares four-dimensional variational data assimilation (NLS-4DVar) method. The characteristics of the dataset, including annual and seasonal variations, and spatial distribution at global and regional scales, and over Tibetan Plateau, are analyzed, and the evaluations against unassimilated XCO\textsubscript{2} retrievals and TCCON observations are performed. The validation showed that posterior carbon fluxes significantly improved the modelling of atmospheric CO\textsubscript{2} concentrations, with global mean biases of 0.33 ppm against OCO-2 retrievals and 0.12 ppm against TCCON measurements. However, actually, the observation data used for evaluations is not completely independent from the assimilated XCO\textsubscript{2} data, the unassimilated and assimilated XCO\textsubscript{2} data are obtained by the same satellite and the same inversion algorithm, and there is a great correlation between adjacent data. The TCCON data has also been used during the inversion and deviation correction of the XCO\textsubscript{2} retrievals. Moreover, the CO\textsubscript{2} mixing ratios and CO\textsubscript{2} fluxes are optimized synchronously with the dual-pass scheme, thus the improvement in atmospheric CO\textsubscript{2} concentrations does not entirely represent the improvements in CO\textsubscript{2} fluxes. In addition, the difference between the posterior flux and the prior flux in the regions outside Europe is very small, and the interannual variations (IAV) are almost the same in all 11 Transcom regions, indicating that the dataset presented here basically does not improve our understanding of carbon fluxes in different regions. In summary, I think the reliability of this dataset needs to be further verified, and its usefulness in global and regional carbon cycle research needs to be further elucidated.

Other issues:

- Line 64, the response of carbon fluxes in the Tibetan Plateau ecosystems play an important role in global carbon cycle. This description is inaccurate, because the carbon source or sink of the Tibetan Plateau is very small compared with those of global ecosystems.
- Section 2.2, "fossil fuel emission and biospheric inventories used to count CO\textsubscript{2} precursor species (CO, CH\textsubscript{4} and other carbon gases) as direct CO\textsubscript{2} emissions at the surface", How is this item considered? How was that adjustment performed? The author needs to describe it clearly. In addition, the inventories of fossil fuel emissions, biomass
burning emissions, ship emissions, aviation emissions, biofuel burning emissions also need to be introduced, including the name, source, time range, and spatial resolution, etc. Moreover, as shown in Table A1, there are no IAVs in the biofuel burning emissions, ship emissions, and chemical source, which are inconsistent with the real situation, therefore, the impact of these assumptions on the inverted CO$_2$ fluxes also needs to be discussed in depth.

- Line 141, “The prior NEE was obtained from CarbonTracker CT2019B”, CT2019B released its prior flux (i.e., CASA simulations) and posterior flux, which one is used in this study?
- Section 2.3, XCO$_2$ data thinning and filtering were conducted in this study. It is necessary. However, “differences between OCO-2 XCO2 and corresponding model-simulated XCO2 were considered. The observation was discarded when the absolute difference exceeded 2 ppm”. This step is unreasonable and unfounded. The essence of inversion is to correct the flux error based on the deviation between simulation and observation. Now that the observations with large model-data mismatch errors are discarded, the effect of observation on flux is significantly reduced. In addition, with the accumulation of errors, the deviation between simulation and observation may become larger year by year (Figure 11), which may result in very few assimilated observations in the last few years.
- Section 2.4, the uncertainties used in this system may be too small, as show in Figure 5 and Table 5, the monthly uncertainty and uncertainty in each region are very small. This setting may be one of the reasons why the fluxes of each area in this study have little changes.
- Section 2.5, the TCCON data was used in this study, but almost no references are cited. It is recommended that the author carefully read the TCCON data usage.
- Section 4.4.1, It is not appropriate to directly compare the inverted NEE with GCP and JCS results, because there are large differences about the rest fluxes in the terrestrial ecosystems among these studies. This study considers the biomass burning and biofuel emissions, GCP considered the land use change emissions and had unbalanced item, while in JCS, only biomass burning emission was excluded. Additionally, the inverted ocean sink is too large, which exceeds the uncertainty range of the GCP estimate.
- Figure 4, Why is the NEE of CT2019 not given?
- Section 4.1.2, This study only reduces carbon sinks in summer and carbon emissions in winter, which means that it reduces the seasonal amplitude of NEE. The author needs to provide evidence to show that this reduction in amplitude is reasonable. In addition, 2015/2016 have a strong El Niño event. Many studies have shown that the carbon sinks in 15/16 have been significantly reduced, but from this result, the carbon sinks in the summer of these two years are almost the same as in other years, and even larger. The author needs to demonstrate it.
- Section 4.1.3, The URs in this study is significantly lower than the results of previous studies (40~70%), and the URs on the ocean is greater than that on land, which is contrary to the results of others. Such a low UR (<10%) shows that the system that the system has a limited effect on the reduction of carbon flux uncertainty, which reduces the feasibility of the results of the paper.
- Section 4.3, The author analyzed and discussed the inverted carbon sinks in the Qinghai-Tibet Plateau (QTP) in detail. Usually, in plateau areas, due to the influence of complex terrain and high albedo, the retrieve error of XCO$_2$ may be relatively large, and the amount of observation data may be relatively small. The author needs to check the data amount and errors in this area. As shown in Figure 9, the difference between the prior and posterior are very small, suggesting that the constraint of XCO$_2$ on the NEE of QTP is very weak. Therefore, this result may not make much sense.
- Section 6, till now, there are other NEE datasets inferred from OCO-2 retrievals, like the CMS-Flux NBE 2020 (Liu et al., 2021@ESSD) and the OCO-2 v9 MIP (https://gml.noaa.gov/ccgg/OCO2_v9mip/). I suggest that the author make a comprehensive comparison with other existing results.