Referee #1

We would like to thank the anonymous referee for his/her comprehensive review and valuable suggestions. These suggestions help us to present our results more clearly. In response, we have made changes according to the referee's suggestions and replied to all comments point by point. All the page and line number for corrections are referred to the revised manuscript with tracked changes, while the page and line number from original reviews are kept intact.

This study presents an NEE dataset based on flux inversion analysis that assimilate 10 years of ACOS GOSAT v9 XCO2 retrievals. To my knowledge, this is the first published flux dataset using the full ACOS GOSAT v9 XCO2 retrievals and believe it to be a signficiant contribution to the community. I find that the dataset is well described and evaluated, and recommend publication after addressing several generally minor comments.

My most significant comment is that the atmospheric growth rate reported here seems to deviate substantially from that reported by GCP2020. From line 227 it is stated that the bias (GCAS2021 minus GCP2020) is 0.25 PgC/yr. Over the 10 year inversion, this amounts to 2.5 PgC or 1.2 ppm (using 1 ppm / 2.086 PgC from https://acp.copernicus.org/preprints/12/C8465/2012/acpd-12-C8465-2012.pdf). I would expect such a difference to be evident in the comparison against independent CO2 data (which does not appear to show this bias). It would be useful to also compare the growth rate with that reported by NOAA (https://gml.noaa.gov/ccgg/trends/gr.html) and discuss this difference some more. For the comparison against independent CO_2 data, it would be useful to show whether these mismatches are decreased relative to the prior (would be fine to have this in the supplement).

Response: Many thanks for this suggestion. We have checked the AGR of GCP2020, which was estimated directly from atmospheric CO_2 concentration measurements, and provided by the US NOAA Earth System Research Laboratory (NOAA/ESRL, http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html) (Friedlingstein et al., 2020). Therefore, the growth rates reported by NOAA and GCP2020 are exactly the same. The growth rate reported in GCP2020 is in units of GtC yr^{-1}, which was converted from the report of NOAA in units of ppm yr^{-1} by multiplying by a factor of 2.124 GtC ppm^{-1}. In this study, the mean bias of AGR between GCAS2021 and GCP2020 during the 10 years is 0.25 PgC/yr, accordingly, over the 10 years inversion, the accumulated bias in atmospheric CO_2 concentration should be 1.18 ppm (converted using 2.124 GtC ppm^{-1}). Such an accumulated bias could be found in the comparison against independent CO_2 data (Figure 10), however, since we only show the time series of monthly averaged observations and simulations, this error accumulation problem is not clearly presented in that figure. In the revised manuscript, we have added the time series of the biases between observations and simulations in the revised supplement (Figure S11), which is also given in this text as Figure R1. Clearly, there is an upward trend in the biases between simulations and observations in all regions except East Asia, as well as at the MLO site. For a clearer presentation and to compare with the AGR bias, the inter-annual variations of the global averaged (74 surface flask CO_2 measurements selected for independent evaluation in this study, Section 3 and Figure 1) annual mean bias is showed in Figure R2. There is negative bias in 2010, with value of -0.36 ppm, and significant positive bias in 2019, with value of 0.75 ppm, that is, the bias increases by 1.1 ppm from 2010 to 2019. The slope of this uptrend is 0.115 ppm/yr, indicate that over the 10 year inversion, the accumulated bias reaches 1.15 ppm (0.115 ppm/yr × 10 yr). Both the biases calculated based on the difference between 2010 and 2019 (1.1 ppm) and estimated from uptrend slope (1.15 ppm) are very close with the one estimated from the mean bias of AGR between GCAS2021 and GCP2020 (i.e., 1.18 ppm). Figure R2 has also been added in the revised supplement, and named as Figure S12.

In Figure S11 (Figure R1), we also show the biases between observations and prior simulations. Clearly, the mismatches are significantly decreased relative to the prior. In the 7 regions, for the prior simulations, the biases and RMSE are in the range of 1.88~3.35 and 2.13~4.07 ppm, respectively, after constrained using XCO_2 retrievals, they are decreased to 0.1~0.56 and 0.52 ~ 1.68 ppm, respectively.

The following sentences are added in the revised manuscript.

In section 5.1 (see page 9, lines 248-251):

"… Additionally, GCP2020 also reported atmospheric growth rate (AGR) of CO_2 in the atmosphere, which was estimated directly from atmospheric CO_2 concentration measurements provided by the NOAA Earth System Research Laboratory (Friedlingstein et al., 2020). Ideally, the inverted global net carbon flux (i.e., AGR) should agree with the observed AGR. As shown in Figure 4,"

In section 6.1 (see page 16, lines 471-478):

"…Figure S11 shows the time series of biases in the 7 regions and at the MLO site, for comparison, the biases of prior CO_2 concentrations are also shown in this figure. Clearly, the biases of the simulated CO_2 concentrations are significantly decreased relative to the prior. It also could be found that there is an upward trend in the biases of the posterior CO_2 concentrations in all regions except East Asia, as well as at the MLO site. On global average (74 sites), the annual mean biases increase from -0.36 ppm in 2010 to 0.75 ppm in 2019, with uptrend slope of 0.115 ppm yr^{-1} (Figure S12). By multiplying by a factor of 2.124 PgC ppm^{-1} (Ballantyne et al., 2012), this bias accumulation rate is equal to 0.244 PgC yr^{-1}, which is very consistent with the 10-year averaged bias in the inverted global AGR given in Section 5.1 (0.25 PgC yr^{-1})."

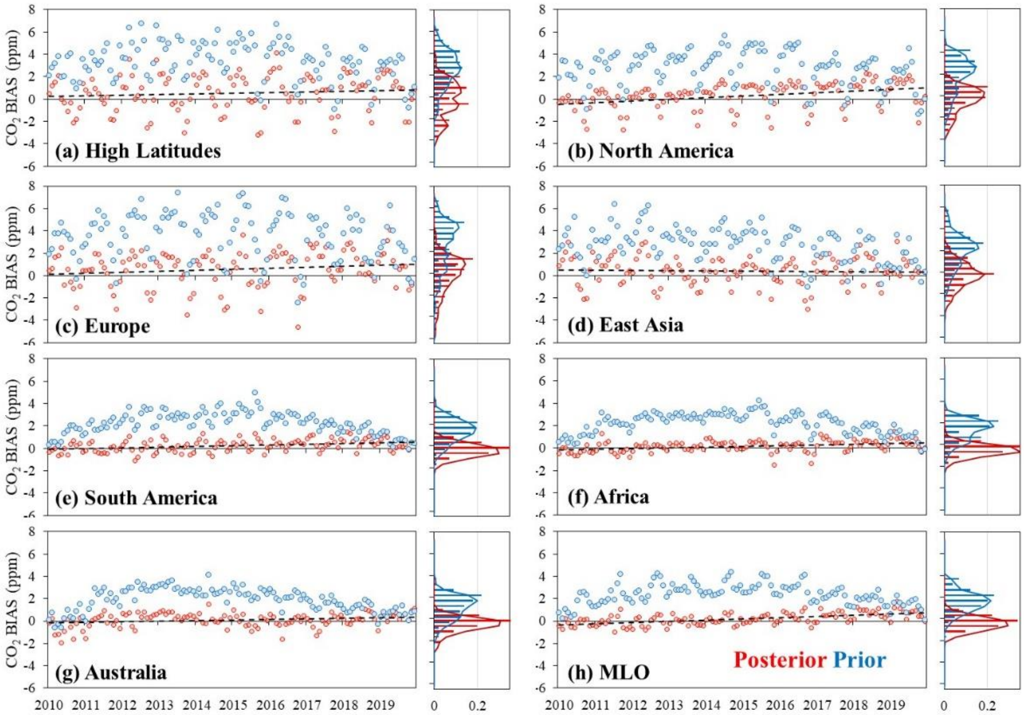

Figure R1. Time series of monthly averaged biases between observations and simulations and the frequency distribution of the biases in the 7 regions and MLO site (the black dotted line represents the linear trend of the biases between the observations and the posterior simulations)

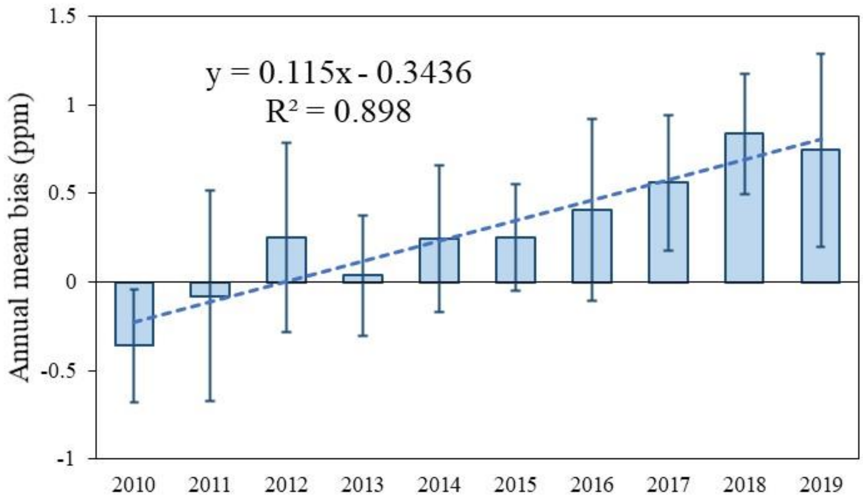

Figure R2. Inter-annual variations of the global averaged annual mean bias (error bar represents standard deviation of monthly mean biases in one year; the dotted line is its linear trend)

L35: remove "could" in "ecosystems could uptake"

Response: we have removed “could” in the revised manuscript, see page 2, line 35.

L40: remove "," in NBE, = NEE + wildfire carbon emission

Response: we have removed "," in the revised manuscript, see page 2, line 40.

L77-78: Please double check wether Liu et al. (2021) actually optimizes fire emissions. I think they just optimize NEE but report NBE because errors in fire would alias into NEE.

Response: Thank you! We have checked the method of Liu et al. (2021). Their prior CO_2 fluxes include NBE, air–sea carbon exchange, and fossil fuel emissions, and only fossil fuel emissions were prescribed (i.e., assuming no uncertainty). The prior NBE was constructed using the CARDAMOM framework, which included fire emissions. In both their inversion framework and data product, the data of fire emissions are not independently presented.

L128: What is the data assimilation window length?

Response: The length of DA window is 1 week. We have added this information in page 5, line 140 in the revised manuscript.

L141: I did not see the qauntity "BIO" or "FCC" explicitly defined. Please make sure that these and other abbreviations are explicitly defined in the text.

Response: Thank you! We have changed "BIO" and "FCC" to "NEE" and "FFC" in that sentence in the revised manuscript (see page 5, lines 148-149). We also checked the full text to make sure all abbreviations are explicitly defined.

L162: "pfp" should be "PFP"

Response: Thank you. We have changed "pfp" to "PFP" in the revised manuscript, see page 6, line 172.

L210: "low latitudes (30 S ~ 30 N, TL)" should be "tropical latitudes (30 S ~ 30 N, TL),"

Response: Thank you! We have changed "low" to "tropical" in the revised manuscript, see page 8, line 220.

L238: "NEE constraint with" should be "NEE constrained with"

Response: Thank you! We have changed "constraint" to "constrained" in the revised manuscript, see page 10, line 269.

L254-261: "strongest NEE" should be "strongest sink". Similarly, "weakest NEE" should be "weakest sink"

Response: Thank you! We have changed “strongest” and “weakest” NEE to “strongest” and “weakest” sink in the revised manuscript, see page 10, lines 289-290.

L287-289: In general, OCO-2 XCO_2 or GOSAT XCO_2 flux inversions find northern sub-saharan Africa to be a strong source of CO_2, while in situ CO_2 inversion do not (e.g., https://doi.org/10.5194/acp-22-1097-2022). However, due to the lack of validation data for XCO_2 and few in situ CO_2 measurements, it is hard to know for sure which is more accurate.

Response: Thank you for this suggestion. There are big differences in top-down estimates of African NBE in different studies. Generally, the estimates based on surface in-situ measurements show carbon sinks or weak source, while the estimates from satellite XCO_2 retrievals report strong carbon sources. We strongly agree that due to the lack of validation data for XCO_2 and few in situ CO_2 measurements, it is hard to know for sure which is more accurate. We have added the following sentences in the revised manuscript (see page 12, lines 340-342, and lines 349-351).

“... Peiro et al. (2021) also found a similar phenomenon by comparing the carbon fluxes constrained using in-situ observations and OCO-2 retrievals within the same inversion frameworks. Although the estimates based on surface measurements”

“… thus probably resulting in an overestimation of the surface flux. Peiro et al. (2021) found that the version of OCO-2 retrievals also had a significant effect on the inversion results in Africa. However, due to the lack of validation data for XCO_2 and few in situ CO_2 measurements, it is hard to know for sure which is more accurate.”

L324-325: I would be careful about calling this a "trend". It appears that this is primarily coming from Australia (Fig. 8j) which had very wet seasons at the start of the record (during 2011 La Nina) and has had drought for the last few years. So the "trend" might be strongly impacted by these events at the end points. Interestingly, the variability for Australia in this study looks very similar to the variability for southeast Australia reported in Fig 5 of https://doi.org/10.1029/2021AV000469.

Response: Many thanks for this comment. We strongly agree with you that this decreasing trend is primarily coming from Australia (Fig. 8j), which had very wet seasons at the start of the record (during 2011 La Nina) and had drought during the last few years. We also compared the interannual variations of NEE in Australia and in southeast Australia in our dataset, their interannual variations are indeed consistent. Southeastern Australia's carbon sink accounts for about 40% of Australia's carbon sink.

We have added the following sentences in the revised manuscript (see page 13, lines 377-383).

"… It could be found that there is a continuous decreasing trend. This trend is basically consistent with that in Australia (Figure 8j), indicating that the IAV of NEE in SL is dominated by that in southern Australia, especially in southeastern Australia (Byrne e t al., 2021). Previous studies have revealed that the enhanced carbon uptake in Australia from 2010 to 2012 was associated with the La Niña phase from the end of 2010 to early 2012 (Detmers et al., 2015), while the significantly increased carbon loss in 2019 was due to extreme drought (Byrne e t al., 2021) associated with the Indian Ocean Dipole event (Wang et al., 2021b), indicating that the decreasing trend of carbon sink in SL was caused by the extreme climate events occurred in the start and end years of this decade, respectively, thus this downtrend is just a coincidence."

L326: "global land NEE" should be "global land sink"

Response: Thank you! We have changed "global land NEE" to "global land sink" in the revised manuscript, see page 13, line 384.

L326-237: It is unclear which regions are being correlated for each of these numbers. Please state explicitly.

Response: We have revised that sentence to "The correlation coefficients between the IAVs of NEE in these three regions (NL, TL, and SL) and the IAV of global terrestrial NEE are 0.57, 0.86 and 0.37, respectively, indicating …" in the revised manuscript, see page 13, lines 385-386.

L368: "Unite States" should be "United States"

Response: We have changed "Unite States" to "United States" in the revised manuscript, see page 15, line 427.

L368: "Unite States in 2011-2012 (He et al., 2018; Wolf et al., 2016)". There are several more studies that used atmospheric CO_2 to study this event that could be cited:

Liu, J., Bowman, K., Parazoo, N. C., Bloom, A. A., Wunch, D., Jiang, Z., Gurney, K. R., & Schimel, D. (2018). Detecting drought impact on terrestrial biosphere carbon fluxes over contiguous US with satellite observations. Environmental Research Letters, 13(9), 095003.

Byrne, B., Liu, J., Bloom, A. A., Bowman, K. W., Butterfield, Z., Joiner, J., et al. (2020). Contrasting regional carbon cycle responses to seasonal climate anomalies across the east-west divide of temperate North America. Global Biogeochemical Cycles, 34, e2020GB006598. https://doi.org/10.1029/2020GB006598

Response: Thank you! We have added these two citations in the revised manuscript, see page 15, line 427, and page 20, lines 578-580.

L375-377: Could cite some previous studies that use atmospheric CO_2 to study NEE over Russia in 2010:

Guerlet, S., Basu, S., Butz, A., Krol, M., Hahne, P., Houweling, S., Hasekamp, O. P., & Aben, I. (2013). Reduced carbon uptake during the 2010 Northern Hemisphere summer from GOSAT. Geophysical Research Letters, 40, 2378–2383. https://doi.org/10.1002/grl.50402

Ishizawa, M., Mabuchi, K., Shirai, T., Inoue, M., Morino, I., Uchino, O., Yoshida, Y., Belikov, D., & Maksyutov, S. (2016). Inter-annual variability of summertime CO_2 exchange in Northern Eurasia inferred from GOSAT XCO_2. Environmental Research Letters, 11(10), 105001.

Response: Thank you! We have added these two citations in the revised manuscript, see page 15, line 435; page 23, lines 686-689; page 24, lines 713-715.

L434: “on extreme climates” should be “to climate extremes”

Response: We have changed “on extreme climates” to “to climate extremes” in the revised manuscript, see page 17, line 508.

Figure 7 caption: Give the latitude range of these regions in the caption. Rename “low latitudes” to “tropical latitudes” to be consistent with the abbreviation “TL”

Response: Thank you! We have given the latitude range of these regions and renamed “low latitudes” to “tropical latitudes” in the revised manuscript, see page 36, line 992.

Figure 10: It is hard to see the difference because the trends are so large. Please either add panels showing the data-model differences or add a plot to the supplement showing these differences.

Response: Thank you for this suggestion. We have added a plot to the supplement showing these differences (see Figure S11 in the revised supplement).

Supplementary figure S2: This caption is incomplete. What are the individual dots? Different Years?

Response: Thank you! We have changed the caption as “Comparisons between this study and GCP2020 for the estimates of annual (a) NBE and (b) AGR from 2010 to 2019” in the revised supplement.

Reference:

Liu, J., Baskaran, L., Bowman, K., et al.: Carbon Monitoring System Flux Net Biosphere Exchange 2020 (CMS-Flux NBE 2020), Earth Syst. Sci. Data, 13, 299–330, https://doi.org/10.5194/essd-13-299-2021, 2021.

Friedlingstein, P., O'Sullivan, M., Jones, M. W., et al.: Global Carbon Budget 2020, Earth Syst. Sci. Data, 12, 3269–3340, https://doi.org/10.5194/essd-12-3269-2020, 2020.