Referee #3

Many thanks for your comprehensive review and valuable suggestions, which 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.

Comments for essd-2022-15

This manuscript introduces a new global top-down NEE data from 2010 and 2019 produced by GCASv2 assimilating with a new ACOS GOSAT XCO2 L2 data. The data has been well validated by ground based and aircraft in-situ measurement that provide from OBSPACKv6. Further studies on comparison with GCP data descripts clear in this manuscript. The detail of dataset, e.g. interannual variations, trend, and profile performance is introduced. This manuscript, overall, is well written and organized, and detail is enough for potential readers and data users. I recommend it for publication, but a minor revision is required.

Line 100, the griding method is not clear, would suggest adding some equation description.

Response: Thank you for this suggestion. We have given more details about the griding method in the revised manuscript (see page 4, lines 100-107), which are shown as follows.

"… we re-grid the XCO_2 data into 1°×1° grid cells. The pixel level XCO_2 data are filtered with xco2_quality_flag, which is a simple quality flag denoting science quality data (0=Good, 1=Bad), and provided along with the XCO_2 product. In each 1°×1° grid and each day, only the XCO_2 with xco2_quality_flag equals 0 are selected and averaged according to Equation (1).

$$C_{G,T} = \frac{1}{W}\sum_{l=1}^{W} C_{l,t}\,,\ T = \frac{1}{W}\sum_{l=1}^{W} t \qquad (1)$$

where $C_{l,t}$ denotes the selected pixel level XCO_2 located in grid G of one day, l is the identifier of the record, t is the observation time, and W denotes the number of $C_{l,t}$. T is the averaged observation time, and $C_{G,T}$ is the re-grided XCO_2 concentrations. The other variables in the XCO_2 product like column-averaging kernel …"

Line 155, please state the 'a global ocean circulation and biogeochemistry model'

Response: Thank you! We have added the following sentences in the revised manuscript (see page 4, lines 119-122).

"… Following Jiang et al. (2021), the fluxes in 2009 modeled using a combined global ocean circulation (OPA) and biogeochemistry model (PISCES-T) (Buitenhuis et al.,

2006) is used to fill the no data areas. The sea-air CO_2 fluxes simulated using the PISCES-T model have been used in many studies of ocean carbon cycle dynamics (e.g., McKinley et al., 2006; Valsala et al., 2012; Le Quéré et al., 2007), and also used as a priori ocean fluxes in previous inversion studies (e.g., Jiang et al., 2014; Deng et al., 2011; Chen et al., 2017)."

Line 225 and Global carbon budgets, the different between top-down estimation NBE and AGR of GCASv2 and GCP2020 comes from LULUC. I would like to indicate the average significant on this different, otherwise the improvement compared a prior and posterior is not clear.

Response: Thank you for this comment. Since the LULUC carbon emissions have been included in the NBE, the difference in NBE between GCASv2 and GCP2020 mainly comes from the imbalance item of GCP2020. After including the imbalance item in the NBE like Liu et al. (2021), the difference of NBE between this study and GCP2020 could be significantly reduced, especially for the year of 2016. For the difference in AGR, it may be mainly from the biases in the GOSAT XCO_2 retrievals. We find that the inverted AGR in 2019 in this study is significantly higher than that of GCP2020, and it is also higher than that in 2015, which is a year with extreme El Niño event. The higher AGR in 2019 is mainly due to the abnormally low carbon sink in the tropical latitudes (TL, 30° S ~ 30° N) in 2019. We find that after detrending, in TL, the GOSAT XCO_2 in 2019 is higher than that in 2015, which is unreasonable.

To make it clear, we have added the following sentences in the revised manuscript (see page 9, lines 253-259).

"… The difference in NBE between this study and GCP2020 is partly due to the imbalance item in GCP2020, especially in 2016. It also should be noted that in this study, the AGR in 2019 is higher than that in 2015, and significantly higher than the observed value, which is mainly due to the abnormally low carbon sink in the tropical latitudes (TL, 30° S ~ 30° N) in this year (Figure 7). The reason may be related to the biases in the GOSAT XCO_2 retrievals in TL. We analyze the monthly changes of GOSAT XCO_2 in 2015 and 2019, and compare them with the OCO-2 XCO_2 retrievals (OCO-2 v10). We find that after detrending, in TL, the GOSAT XCO_2 in 2019 is higher than that in 2015, while OCO-2 is the opposite (Figure S3)."

Line 237, 'In N. America, the distribution of NEE constraint with GOSAT XCO2 agrees well with a recent regional inversion using surface CO2 and 14CO2 measurements, which also shown significant sources over western US and sinks over central and eastern US (Basu et al., 2020).' Please revise this presentation to avoid over-estimation on the ability of your inversion and GOSAT XCO2 measurement.

Response: Thank you for this suggestion. We have revised this description and changed 'agrees well with' to 'exhibits a similar pattern to that of' in that sentence in the revised manuscript (see page 10, line 269).

Line 265, it seems CMS-Flux using two satellites measurement in their study, incl. GOSAT and OCO-2 comes from different retrieval. The statement of measurement is not clear, e.g. satellite, retrieval algorithm and version, please revise.

Response: Thank you for this suggestion. Both GOSAT and OCO-2 retrievals are from the ACOS team, the versions are v7.3 and v9, respectively. They were created using the same retrieval algorithm and validated using the same strategy (Liu et al., 2021). We have added a sentence to make it clear in the revised manuscript (see page 8, lines 236-237), which is shown as follows.

"…in which the results of 2010-2014 was inverted from the GOSAT XCO2 v7.3, and the rests were inverted from the OCO-2 XCO2 v9 retrievals. Both GOSAT and OCO-2 retrievals were from the ACOS team, created using the same retrieval algorithm and validated using the same strategy (Liu et al., 2021)."

Line 387, what is that 'absolute errors' mean?

Response: Thank you! We have changed 'absolute errors' to 'absolute biases between the posterior CO_2 concentrations and CO_2 measurements' in the revised manuscript (see page 15, lines 447-448).

Fig.9, this comparison method is not clear.

Response: Many thank for this comment. Yes, the comparison method is not clear here, we have modified the caption of Figure 9 to "Spatial distributions of the (a) BIAS and (b) MAE of the posterior CO_2 concentrations at each site (simulations minus observations, unit: ppm)" in the revised manuscript (see page 38, line 1000).

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.