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Interactive comment on "Regional CO$_2$ Fluxes during 2010–2015 Inferred from GOSAT XCO$_2$ retrievals using a new version of Global Carbon Assimilation System" *by* Fei Jiang et al.

Anonymous Referee #2

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General comments: In this study, Jiang et al. upgraded the Global Carbon Assimilation System (GCAS) with new assimilation algorithms, a localization scheme, and a higher assimilation parameter resolution, namely GCASv2. The global terrestrial ecosystem (BIO) and ocean (OCN) carbon fluxes from 2009 to 2015 were constrained by the GOSAT ACOS XCO2 retrievals. Following this, the posterior carbon fluxes from 2010 to 2015 were evaluated using 52 surface flask observations. The errors in the posterior carbon fluxes in the new inversion system were compared to those in a previous version. The authors indicated that the pattern of regional carbon sinks was significantly different from previous studies (CT2017). The inter-annual variations of carbon fluxes in most land regions, and the relationship with the changes of severe drought area the

plant indexes, and drought were re-visited. These results are interesting. However, the improvement of the inversion methodology is not presented, and the reduction of the uncertainty by the inversions remains unclear (Figure 3) in the current paper. I, therefore, recommend that this work cannot be published before the following comments are addressed.

Specific comments: Figure 3: What is the source for error bars in these two plots? Are they coming from the uncertainty in the prior and posterior estimates? If yes, it seems that the uncertainty is not reduced from the prior estimates to the posterior estimates. One main purpose of inversion is to reduce the uncertainty in the prior estimates. If the uncertainty is not reduced, the effectiveness of the inversions should be evaluated.

Figures 4/5: Evaluation of the reduction of the uncertainty from the prior estimates to the posterior estimates is more important than evaluation of the bias itself for an inversion system.

Tables 2/3: What is the uncertainty for the prior and posterior estimates?

Line 473-488: What is the uncertainty for the estimates from this study? To evaluate the effectiveness of an inversion system, the uncertainty of the posterior estimates is more important than the central value. Such information is missing in the current manuscript, which is better considered / discussed in previous studies (e.g. the literature cited in line 586).

Figures 7/9/10: What is the uncertainty for the prior and posterior estimates?

Figure 1: The authors suggested that a new assimilation scheme is developed in this paper. Why not directly compare the flow charts between the GCAS and GCASv2 systems and show the difference?

Line 124: It seems that a major advance of GCASv2 against GCAS is that "In the second step, the MOZART-4 model is run again using the optimized fluxes of Xa, to generate new CO_2 concentrations for the initial field of the next DA window. This DA

flow chart is different from the previous version of GCAS, which runs the MOZART-4 model only once, and optimizes the fluxes and the initial field of the next window synchronously." However, I do not understand how this improves the inversion system. The old GCAS system produces the posterior global gridded carbon fluxes, which were used as prior fluxes as input to any other forward models to simulate the CO2 field. If the difference of GCASv2 was just that the posterior global gridded carbon fluxes were used by MOZART-4 to simulate the CO2 field, I cannot see how and why the inversing methodology is improved.

Line 143: It seems that the carbon emission from cement production, a large part of CO2 source, is missed in this inversion system. This could be a big weakness of the current system.

Line 143: What is the relationship between BIO and FIRE? Biomass sequestrates carbon from the atmosphere, and releases CO2 in biomass burning. Should FIRE be a part of BIO?

Line 147: "FOSSIL and FIRE fluxes are assumed to have no errors, only BIO and OCN fluxes are optimized in an assimilation system". I do not think that this is the case in other inversion systems: (1) It needs clear justification by summarizing and tabulating the methodology in the literature. (2) The difference relative to a system with errors considered for FOSSIL and FIRE need to be calculated to show how much the conclusion of the present study are sensitive to this assumption.

Line 209: How does GCASv2 consider the spatial representativeness errors in the inversion system?

Line 238: How many sites are subject to this spurious noise? Are these sites excluded from the inversion system? How much does removing data at these sites influence the inversion fluxes?

Technical corrections:

Line 38: "BIAS" is not defined before it is used.

Line 63: "However, their carbon uptakes have significant spatial differences and inter-annual variations." References are needed.

Line 95: "However, so far, on the one hand, most studies focused on the impact of GOAST XCO 2 retrievals on the inversion of surface carbon fluxes, but in many regions, there are still large divergences for carbon sinks between different inversions with the same GOSAT data or between inversions with GOSAT and in situ observations (Chevallier et al., 2014)". Is only one study considered and cited?

Line 102. References are needed.

Line 255: The references for the two emission inventories of FOSSIL and FIRE are out of date. ODIAC and GFEDv4 have been updated recently.

Line 270: "The BIO carbon flux, which is the most important prior carbon flux". Why is the prior carbon flux of BIO more important than FOSSIL and FIRE to an inversion system?

Line 340: When the averages of the modeled and the observational values/retrievals are equal, BIAS is zero, even if all data are distant to the 1:1 line in the comparison. BIAS cannot effectively evaluate the performance of the model by showing how much the modeled values/retrievals agree with the observational values/retrievals. The average of absolute difference between the modeled and the observational values/retrievals is needed.

Line 360: Does the study of Wang et al. (2019) account for the uncertainty in FOSSIL and FIRE?

Line 448: What is "impact of accumulation"?

Figures 3/4: "Biases" in the caption is easily confused with "BIAS" defined in equation 10.

Table 1: BIAS cannot evaluate the performance of the model by showing how much the modeled values/retrievals agree with the observed values/retrievals.

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Discussion paper