

## ***Interactive comment on “Divergent predictions of carbon storage between two global land models: attribution of the causes through traceability analysis” by R. Rafique et al.***

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Comments from Reviewer 2 The manuscript submitted by Rafique et al entitled "Divergent predictions of carbon storage between two global land models: attribution of the causes through traceability analysis" is an interesting work on the behavior of land models. The authors used an analytical approach (traceability framework) to decompose model predictions of ecosystem carbon (C) storage into a set of common parameters. The authors also made good attempt in writing the manuscript, however, there are few concerns (mentioned below) those can help in improving the manuscript. I believe that after considering below mentioned concerns, this manuscript can be suitable for

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publication in Earth Syst. Dynam. Discuss journal.

Major Comments (i). The traceability framework used in this study can be discussed in more detail to make it more compelling. This can be done through the better articulation in the objectives section. In the Results section, the text mainly focusing on detailing the differences in models which is good but should not be stretch too much and rather authors should focus on the key differences and the importance of those differences in modeled NPP and carbon storage.

Response: This study mainly focused on the application of traceability framework. Therefore, the detailed explanation of the traceability was avoided. We have cited the following reference, which has developed and explained the framework. However, in order to accommodate reviewer's concern we have also revised the objective section of the manuscript.

Xia, J. Y., Y. Q. Luo, Y. P. Wang., E. S. Weng and O. Hararuk.: A semi-analytical solution to accelerate spin-up of a coupled carbon and nitrogen land model to steady state, *Geosci. Model Dev*, 5, 1259-1271.

The minor details from the results section have been removed. The current version of manuscript shows the key differences between two models, CLM-CASA' and CABLE, in estimating carbon storage capacity. (ii). The discussion section is reasonably organized and describes a summary of the differences in the models. However, this section needs to focus on the model performance, and why this approach is most useful than previously studied. Also, what are the model uncertainties?

Response: We appreciate reviewer's concern about the models performance. However, the objective of this study was to implement the traceability framework for the relative comparison of the two models in estimating their carbon storage capacities. Evaluation of models performance against any benchmark was not the aim. We acknowledge reviewer's idea in evaluating these models and verifying the applicability of traceability framework. We would consider this idea in future research.

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(iii). The summary section of should focus on key findings and take away message rather than repeating most of the results.

Response: The summary section has been revised to highlight the key findings. The repeating results, if found unnecessary, have been removed from the summary section.

#### Specific Comments

(i). Abstract: The abstract is well written, however, it can be further improved by more focusing on the take away message. Also, highlight what we learned from this study.

Response: Takeaway: The following takeaway message has been highlighted the manuscript. "Overall, the traceability analysis showed that the major causes of different carbon storage estimation were found to be parameters setting related to carbon input and baseline residence times between the two models." What we learned: The biggest challenge to model diagnostics is model intractability. The more processes incorporated; the more difficult it becomes to understand model behavior. As a result, uncertainty in predictions among global land models cannot be easily attributed to their sources. The framework used in this study analytically decomposes complex land models (CLM-CASA' and CABLE) into traceable components, which are helpful in attributing the models variations to their respective sources. This study showed that the models predictions were mainly controlled by the parameters differences. These messages have been mentioned in the manuscript.

(ii). Introduction: Authors mention that the future CO<sub>2</sub> concentrations depend on the balance of C uptake and C loss from ecosystems. Why is "in simulations" used? The future of CO<sub>2</sub> concentration depends on how the terrestrial carbon cycle will (actually) respond to various external factors, not on how we simulate it. Further, the sentence needs work...Many studies have evaluated and compared the carbon cycle components of ESMs...Also you focus on ESMs here, but the analysis presented in the paper is using land models (not ESMs). This distinction is not clear. Response: The word "simulation" has been removed from the revised manuscript. Also, the word "earth

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system model" has been replaced with "land models" in the revised manuscript.

(iii). Materials and Methods: Again, here referring to ESMs, when analysis is focused on land models. If CLM-CASA' and CABLE are forced with different climate drivers? If so, this needs to be made clear. Somewhat glossed over here.

Response: The word "ESM" has been replaced with "land models" in the revised manuscript. The detailed analysis of climate forcing, used in this study, is given in the section 3.4 of manuscript. This analysis shows that the two climate forcing data sets were not substantially different at global level. However, at biomes level, few biomes show some differences.

(iv). Results: The statement "In general, biomes with higher carbon storage capacity of models, showed moderate NPP and higher ecosystem residence times" does not seem to accurately describe the relationship between  $U_{ss}$  and  $\tau_E$ . This only seems to describe ENF. Please check it again. The sentence "Three biomes, evergreen broad leaf forest, C4G . . ." is unnecessary and too wordy. "similar diverse"??? This needs to be fixed. Majority of the text is describing figures only. Please shorten the text (as commented above in the General Comments) to highlight the main points and their importance.

Response: We agree with reviewer on the statement "In general, biomes with higher carbon storage capacity of models, showed moderate NPP and higher ecosystem residence times". After careful observation, we found a complex pattern (shown in Figure 1). Therefore, we have removed the statement from revised manuscript. The too wordy sentence "Three biomes, evergreen broad leaf forest, C4G . . ." has been also removed from the revised manuscript. The sentence starting with "similar diverse ..." has been fixed in revised manuscript. Overall, text has been shortened, as much as possible, to highlight the main results of this study.

(v). Summary. See response in above General Comment section.

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Response: Summary section has been revised in manuscript (see earlier response).

(vi). Figures: Figures can be improved by mentioning in the caption about the black circle and the open square symbols. These things have not been mentioned in the figure 1. Same apply for the Figure 2. Further, in Figure 4, the time period of the weather data should be mentioned.

Response: Figures' captions have been updated in revised manuscript, where necessary. The weather data description and analysis has been give in the method and results sections of manuscript.

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Interactive comment on Earth Syst. Dynam. Discuss., 6, 1579, 2015.