Response to Referee #2

We are grateful to the reviewer for their time and energy in providing helpful comments and guidance that have improved the manuscript. In this document, we describe how we have addressed the reviewer's comments. Referee comments are shown in black italics and author responses are shown in blue regular text.

The paper addresses the trends in carbon and BVOC fluxes in the YIBs model. Although the research methods are sound and the topic one of general interest to the community, at the end of the paper, it was unclear what the guiding scientific question was. If the goal of the paper was to provide an improved accounting of carbon fluxes beyond what other models could provide, the paper did not put the YIBs results in the context of other models or previous works. This is a major deficit.

If the main science question relates to what does YIBs predict for carbon fluxes, the authors don't tell the reader why s/he should care about this specific model. The paper is a length description of simulations that test the trends in carbon fluxes using two different reanalysis driver data sets, but also conduct experiments with climate change alone, CO2 fertilization, and land use change, before isolating LAI as a driver of carbon fluxes. Separating these drivers is important, but the paper as a result is very unfocused. Many of the figures needed to support their results are supplementary, and this diminishes the main text. The authors should revise this paper to make it clear what the science questions are and structure the results in a more organized fashion.

→ The main purpose of this study is to quantify the drivers of 30-year trends in land carbon flux and BVOC emissions. We agree that some of the analyses and discussions are not well organized, leading to distractions from this major goal. In the revised paper, we have made changes in the following four aspects:

(a) We clearly narrated that: "The major goals of this study are to identify: (1) the dominant drivers of the 30-year trends in carbon fluxes and BVOC emissions from elevated CO_2, changes in meteorology (temperature, radiation, and soil moisture), and human land use change; (2) the feedback of biosphere, including changes in phenology and leaf area index (LAI), to the trends of land carbon uptakes and BVOC emissions; and (3) the discrepancies in BVOC trends due to application of different isoprene emission schemes."

(b) We changed subtitles of section 3 as follows: "3.1 Drivers of trends in LAI", "3.2 Drivers of trends in land carbon fluxes", "3.3 Drivers of trends in BVOC emissions", "3.4 Feedback of biospheric changes to the trends". These changes emphasize that we are exploring the drivers of trend, instead of the trend itself.

(c) We moved all inter-model comparisons to a new discussion section 4.2. In this way, we avoid misleading readers that we are performing inter-model comparisons or model evaluation studies.

(d) We removed all simulation results using MERRA. The changes include the revision of Figure 4 and removal of Figure S1, S3, S4, and Table S1. We also deleted long paragraphs in section 3.2 and original section 4.3 (now 4.4). In the original manuscript, we compared model results driven with two reanalyses, WFDEI and MERRA. We meant to assess the model uncertainties due to meteorological forcings. However, such comparison may mislead readers that we are trying to improve the trend prediction, instead of examining the drivers behind the trend.

The paper states that the YIBs model is "well-validated", but the authors owe it to their readers to describe the methodology and results of their previous validation exercises, which is merely cited here. Given that the YIBs model is not perfect, the authors should identify both the areas where YIBs had largest disagreement with their validation data and where it was in best agreement.

→ We presented more descriptions about the YIBs model in the revised manuscript.
(a) In the introduction section, we added: "In this study, we use the Yale Interactive Terrestrial Biosphere Model (YIBs, Yue and Unger, 2015) driven with long-term reanalysis meteorology to study the global trends of land carbon fluxes and BVOC emissions over the past three decades. The YIBs model is a process-based vegetation model including complete land carbon cycle (photosynthesis, plant/soil respiration, carbon allocation, and tree growth), plant phenology (Yue et al., 2015), and two independent schemes of BVOC emissions (Zheng et al., 2015). Simulated carbon fluxes has been fully validated with carbon fluxes from 145 flux tower sites and multiple satellite products (Yue and Unger, 2015)."
(b) In the last paragraph of method section 2.2, we added: "At the site level, YIBs simulates reasonable seasonality (correlation coefficient R>0.8) of GPP at 121 out of 145 flux-tower sites with biases in magnitude ranging from -19 to 7 % depending on PFTs. On the global scale, the offline model simulates an annual GPP of 125 ± 3 Pg C and net ecosystem exchange (NEE) of -2.5 ± 0.7 Pg C for 1982-2011, with seasonality and spatial distribution consistent with both satellite observations and benchmark synthesis products (Yue and Unger, 2015). However, the model does not include a fully coupled carbon-nitrogen cycle, which may overestimate CO_2 fertilization effects. In addition, phenology of evergreen trees is set to constant value of 1, leading to underestimation of phenological feedbacks to flux trends."

On p21471, the authors state that "Our results show the large climate-driven uncertainties in the estimate of long-term trends... indicating the necessity of forcing inter-comparisons in addition to model inter-comparisons". The authors have not provided much analysis on whether there is some switch in the YIBs model that has a non-linear sensitivity to a small change in reanalysis observations used.

→ This sentence has been deleted as we have removed the comparisons of modeling results with two meteorological reanalysis datasets, which is not closely related to the main focus of the study.

The authors describe the GPP product as an observation, but it is not an observation. Perhaps it is more accurate to call it a "benchmark" than an "observation".

→ We have changed the GPP “observation” to “benchmark product”.

The multi-panel figures with maps have too much white space and tenerally the maps are too small.

→ The reason why there is white space on these figures is that we plot only the statistically significant changes ($p < 0.05$). We do not wish to distract readers’ attention by showing changes that are not statistically robust. We have modified the display structure (from 3 columns by 2 rows to 2 columns by 3 rows) of Figures 1, 2, and 6 to enlarge maps.

Reference

Yue, X., and Unger, N.: The Yale Interactive terrestrial Biosphere model: description, evaluation and implementation into NASA GISS ModelE2, Geosci. Model Dev., 8, 2399-2417, doi:10.5194/gmd-8-2399-2015, 2015.

Yue, X., Unger, N., Keenan, T. F., Zhang, X., and Vogel, C. S.: Probing the past 30-year phenology trend of U.S. deciduous forests, Biogeosciences, 12, 4693-4709, doi:10.5194/bg-12-4693-2015, 2015.

Zheng, Y., Unger, N., Barley, M., and Yue, X.: Relationships between photosynthesis and formaldehyde as a probe of isoprene emission, Atmos. Chem. Phys. , 15, 8559-8576, doi:10.5194/acp-15-8559-2015, 2015.