Response to reviewers

We appreciate the time and effort that the reviewers have dedicated to providing your valuable feedback on our manuscript. The reviews are copied verbatim and are italicized. Author responses are in regular font. Changes made to the manuscript are blue.

Comments from reviewer 1

Comment

One issue I previously raised was that simulated land-use emissions are substantially lower than in other models, especially for the CNP runs. However, I am still uncertain how land-use emissions affect the model results. The authors now have clarified that most of the simulations are concentration-driven (Table 1) and that the net land flux (the balance between land use emissions and land sink) is reduced in the CNP configuration. Does this mean that land and ocean see the same atmospheric CO2 concentration in all configurations (C, CN, CNP) but the temperature/remaining carbon budget is computed based on a modified CO2 concentration that accounts for changes in the net land flux?

Response

Thank you for your comment. We apologize if our previous responses did not completely clarify some of the reviewers concerns. Land use change emissions in C only (209 PgC) and CN (149 PgC) are within the range of uncertainty shown in Friedlingstein et al. (2022) (205 $\pm$ 60 PgC). While CNP is lower (116 PgC), due to a reduction in vegetation biomass. Land use change emissions affect the model runs so that when forest or other vegetation is cleared for croplands, range lands or pasture, 50 % of the carbon stored in trees is released directly into the atmosphere, and the remaining 50 % is placed into the short-lived carbon pool (Mengis et al. , 2020).

The following has been added to the methodology:

Land use change emissions releases 50% of the carbon stored in vegetation directly to the atmosphere when forest or other vegetation is cleared from croplands, range lands or pastures. The remaining 50% remains in a short-lived soil carbon pool (Mengis et al. , 2020).

In regards with the concentration driven simulations, yes, the model "sees" the same atmospheric CO_2 concentration (driven by concentration) in C, CN and CNP simulations. Yes, the temperature/remaining carbon budget is computed taking into account different net land fluxes of carbon and energy.

Comment

Additionally, I previously suggested further model evaluation to build confidence in the model. I assumed the simulated biomass (456 and 525 PgC) reported in the previous study was PNV but it seems that this was for actual vegetation which would then be reasonable numbers (please confirm). However, I am puzzled by the authors claim that their model cannot reproduce regional GPP patterns, as they previously compared simulated GPP to FLUXCOM. A realistic representation of carbon stocks and fluxes beyond global numbers is essential to build trust into the simulation results. It would for example be interesting to compare maps of simulated vegetation carbon stocks to the ESA CCI biomass product or similar datasets.

Response

Thank you for your comment. We are assuming the specific to "further model evaluation to build confidence in the model" is related the vegetation biomass, GPP and model resolution representing local sites as stated in the comment. In general, we have in fact built confidence in our model performance. The new version of the model was extensively assessed in Mengis et al. (2020) and the nutrient limitation was addressed in De Sisto et al. (2023). Yes, the vegetation biomass represents the actual vegetation. Regarding the GPP and scale, the model can represent large regional scales, it is not suitable however, to be used for example in site comparison studies, the model grid cells are 400km x 400km at the equator, and the model is not designed to decouple and be forced with local meteorological observations. Yes, we have a "representation of carbon stocks and fluxes beyond global numbers" which are within the range

of uncertainty for values in literature, these can be found in the latest model version revision Mengis et al. (2020). The GPP representation and the correlation to FLUXCOM datasets can also be found in De Sisto et al. (2023). All of these values are within the range of uncertainty and show high confidence in our model performance that can be expected from a "realistic" model representation.

The following figure comparing the vegetation biomass simulated to the suggested dataset was added to the appendix:

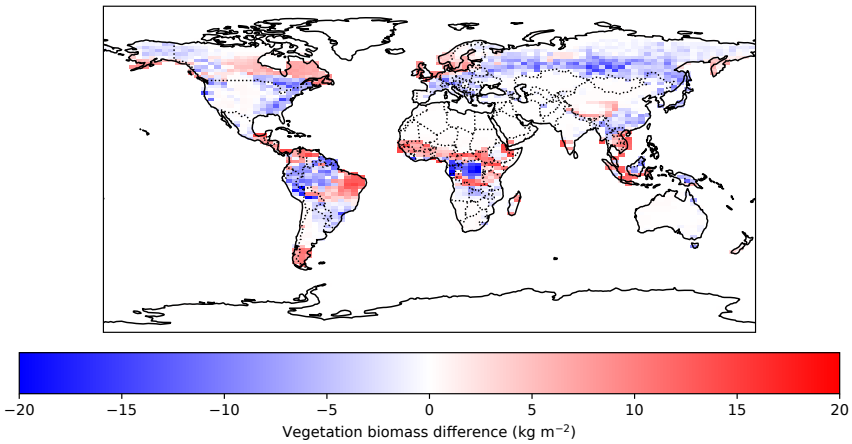

Figure 1. Above ground vegetation biomass difference between UVic ESCM CNP version 2.10 and Santoro et al. (2024) ESA CCI biomass product datasets for the years 2017-2018.

Appendix C.1 shows the above ground vegetation representation of the UVic ESCM version 2.10 with terrestrial nitrogen and phosphorus limitation. The main differences are shown to be located in tropical regions. The model both underestimates (Amazon, Borneo, Indonesian forests) and overestimated (Brazilian, Venezuelan, Colombian, central-American, Sub-Saharan and part of south east Asia forests) above-ground vegetation biomass in tropical regions in comparison with Santoro et al. (2024). However, the values estimated by the model with and without nutrients were shown to be within the range of uncertainty of literature values (Mengis et al. , 2020; De Sisto et al. , 2023).

Comment

Moreover, several of my comments and questions were addressed in the authors' responses but were not clarified in the manuscript text. While some points may have been unclear only to me, I believe other readers might often have the same questions. I encourage the authors to review the comments again and consider incorporating the explanations from their responses into the manuscript if they feel this enhances clarity.

Response

Thank you for your comment. We appreciate the suggestion to improve the understating of our work.

The following sentence has been added to the methodology:

Land use change emissions releases 50% of the stored carbon in vegetation directly to the atmosphere when forest or other vegetation is cleared from croplands, range lands or pastures. The remaining 50% remains in a short-lived soil carbon pool (Mengis et al. , 2020).

The following sentence has been added to the discussion:

In CNP, biomass reduction goes beyond CN as tropical regions are subjected to more limitations. In the UVic ESCM 2.10, tropical regions have an overestimation of broadleaf trees in the tropics. When phosphorus is modelled, the result is a substantial decrease in land use change emissions compared to the base version of the model, leading to a substantial difference with Friedlingstein et al. (2022). However, CN is still within the range shown in Friedlingstein et al. (2022) study.

References

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