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Geoscientific Model Development Discussions

Interactive comment on "CLASSIC v1.0: the open-source community successor to the Canadian Land Surface Scheme (CLASS) and the Canadian Terrestrial Ecosystem Model (CTEM) – Part 2: Global Benchmarking" *by* Christian Seiler et al.

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Anonymous Referee (2)

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Overall assessment:

RC1: The manuscript submitted by Christian Seiler and coworkers present the evaluation of the open-source community land-surface model CLASSIC v1.0. A wide range of variables related to energy, water and carbon cycle are compared against observation-based, either site- or global-gridded, data.

An extensive evaluation and huge work have been carried out and are presented here with a high degree of clarity. The manuscript is very well organized and written, and a large and useful selection of figures and tables support this work. This manuscript is of strong interest, not only as an overview of the strengths and weaknesses of one specific model, CLASSIC, but also as a guide for the long but necessary land-surface model evaluation exercise. I detail here minor corrections and feedbacks to be considered, and I warmly recommend this manuscript for publication in GMD.

Reply: Thank you for your positive evaluation of our manuscript and the very encouraging remarks!

Corrections and feedbacks

- **RC2:** In the section 2.1 presenting the model tools, CLASSIC is among others presented as a dynamic vegetation model. However, in this work and generally, it is not clear to me if the vegetation distribution is indeed calculated "dynamically"

by the model, depending in particular on temperature and CO2 conditions, or prescribed based on land map forcings. Could the authors clarify this point in the manuscript? For a generally understanding as well: is nitrogen cycle included in this model?.

Reply: CLASSIC's biogeochemical component (CTEM) is a dynamic vegetation model. The spatial distribution of plant functional types (PFTs) can either be prescribed or simulated as a function of environmental conditions under which PFTs compete for light and water. However, it must be noted that competition is not the only dynamical aspect of vegetation dynamics. Other processes that affect vegetation dynamics include ecophysiology (allocation, turnover, mortality), disturbance (e.g. fire), and establishment, all of which are represented in CTEM. While competition can be understood as the spatial aspect of vegetation dynamics, all other processes that drive land-atmospheric fluxes present the vertical component of vegetation dynamics. The simulations presented here focus on the vertical component of vegetation dynamics. The model runs presented in this manuscript are based on a prescribed distribution of PFTs, which reduces the number of potential causes for biases. We now state that the spatial distribution of PFTs is prescribed and that the nitrogen cycle is turned off.

In section 2.1, we now write that: "In this study, the spatial distribution of PFTs has been prescribed to reduce the number of possible causes for model biases.".

Furthermore, we note that: "For the purpose of this study, CLASSIC's recently added nitrogen cycle has been turned off (Asaadi and Arora, 2021).".

- **RC2:** Correction page 4, line 114: a "c" in missing in "The protcol consists of a spin up".

  Reply: Thank you, we now replaced *protcol* with *protocol*.

- **RC2:** Correction page 17, line 493: replace "most" by "more" in "the positive biases are most evident in the NH extratropics rather than in the tropics".

  Reply: We have now replaced *most* with *more*.

- **RC2:** The authors underline both in the Abstract and in the Conclusion that "Our results will serve as a baseline for guiding and monitoring future CLASSIC development." Regarding the development monitoring, this manuscript is indeed a good guide for future other evaluation steps. Yet nothing is said regarding future developments to be carried out in CLASSIC, in terms of improvement of already existing development or in terms of implementing new developments. Could you be more specific on this point? Are there any weaknesses in CLASSIC that you suspect, or any characteristics known regarding the model responses to environmental conditions that this evaluation demonstrate they should be improved in the code?

  Reply: We now list the main issues that future model development needs to address in the conclusion section: "The main deficiencies that should be addressed in future model development are the (i) positive albedo bias and resulting SW radiation bias in parts of the NH extratropics and Tibetan plateau, (ii) out-of-phase seasonal GPP cycle in the humid tropics of South America and Africa, (iii) lacking spatial correlation of annual mean NEE measured by FLUXNET sites, (iv) underestimation of fractional area burnt and corresponding emissions in the boreal forests, (v) negative soil organic carbon bias in high latitudes, and (vi) time lag in seasonal LAI maxima in the NH extratropics. Recent model development has started addressing some of those issues already, including the improvement of LAI seasonality through the incorporation of non-structural carbohydrates, which will form part of the next model version release (Asaadi et al. 2018). Further research is required to separate the impact of observational uncertainties on biases in LAI and above-ground biomass. For LAI, we propose to add additional observation-based reference data sets and reduce the spatial coverage to high-

quality grid cells that have not been gap filled. For biomass, we propose to extend our current forest inventory database to achieve greater spatial coverage.".

We went back to the results section to ensure that all items listed above are mentioned in their respective subsections. We also inserted a similar paragraph in the abstract.

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