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Geoscientific Model Development Discussions

Interactive comment on "Addressing Biases in Arctic-Boreal Carbon Cycling in the Community Land Model Version 5" *by* Leah Birch et al.

Anonymous Referee #2

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This manuscript aims to correct the biases in representing circumpolar carbon cycling by the CLM5.0 model. The authors did a good job pinpointing model deficiencies in CLM5.0 responsible for these biases. To address these deficiencies, they focused on point-based simulations and compared directly with PFT-specific seasonal cycle of carbon fluxes in the model development. The paper is well-written and easy to follow, and their model recommendation show significant improvement in its capacity in capturing the mean seasonal characteristics of Arctic-Boreal carbon cycling.

As many terrestrial biosphere models show poor performance in simulating the seasonal cycle of CO2 exchange, especially in the high latitudes, this paper could potentially offer important insights to the wider modeling and scientific community. The authors faced a challenging task as observations are sparse in the ABZ, and they im-

plemented the model improvements following clear and logical steps. However, there are two major issues limiting the broader appeal (i.e., contributing to a future stock version of CLM or motivating changes in other models) of this research.

Firstly, although mean seasonal carbon cycle is important, other features such as the magnitude change of carbon fluxes, their interannual variability, and the mean carbon sink, are also essential. It would reassure the readers if the authors could demonstrate in more detail that other aspects of the model do not become worse after the changes. Currently the authors rely heavily on FLUXCOM data in validations, how reliable is the PFT-specific output of FLUXCOM? Could other observation-based datasets, such as atmospheric inversions, and observed phenology data be used in the comparison as well in the benchmarking? If any of the proposed changes are not limited to ABZ, it would make sense to also show results for a global-scale benchmarking. Otherwise, it would be helpful to quantify the contribution of updated ABZ carbon fluxes to global carbon fluxes.

Secondly, it was not always clear how the authors arrive at their proposed changes. For phenology onset, was there any attempt to improve the scheme based on growing degree days? Were any quantitative criteria (in addition to visual inspection of Fig. S2) used in determining the environmental metrics used? For temperature acclimation, why was Kattge and Knorr used over Leuning in previous CLM development? Was there any sensitivity testing in the updated parameters (i.e., carbon allocation)? As only four sites were used in model development, and that the mechanisms changed show compensating effects in changing the seasonal carbon cycle, the new model parameters might be poorly constrained and could introduce new biases in the model.

Minor points: - Figure 3, the label "Temp. Scaling"is potentially misleading as it also include daylight scaling, and some of the line colors are hard to differentiate. - Why did the model still perform poorly in Figure 4 a) and c) despite the changes? - The discussion could be more succinct and repeat less information from previous sections. It would interest potential readers if the authors could discuss if other TBMs also have

similar deficiencies as identified in CLM5.0.

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