General comments

In the presented manuscript, the authors provide a comprehensive assessment of the performance of the two latest versions of the Community Land Model (CLM4.5 and CLM5.0) at a tropical montane forest in Costa Rica. A broad range of measurements are available at the chosen location including radiation fluxes, CO_2 fluxes, water vapor fluxes, leaf wetness, temperatures at different locations in and around the canopy, and the ground heat flux. The authors identify a number of discrepancies between the field measurements and the two model versions including an over-estimation of the surface albedo, the gross primary productivity, ET, the leaf wetness, and the diurnal variability of temperature. Also, they demonstrate that the overestimation of the gross primary productivity by the model could be alleviated be choosing a lower value for the quantum efficiency of photosystem II than the default value. Further, decreasing the maximum fraction of wet leaves in CLM5.0 reduced the overestimation of ET.

Overall, studies such as the one presented here provide valuable insights for further developing the model and I could learn a lot about the model from reading the study. Therefore, I think the manuscript is definitely worth publication. However, it was sometimes hard to follow. A lot of the detailed comments below address such issue and are hopefully helpful in increasing the readability of the text. Also, I wonder whether the model was challenged with an unfair comparison on some aspects:

-ET/TR: If I interpret Fig. 6 c correctly, the average TR from the sapflow measurements is as large or even larger than the average ET from the EC measurements (integrated over the entire day). This would imply that either the sapflow measurements overestimate TR (because the sampled trees are not representative? The setup described in Aparecido et al., 2016 is convincing though.) or the EC measurements underestimate ET (because the EC method is problematic on sloped terrain?), as one would expect that ET is higher than TR at a site with considerable interception by leaves. In fact, the simulated TR of the CLM versions seems to be quite realistic. Also, I wonder whether it makes sense to exclude nighttime water fluxes from the analysis with the argument that CLM does not represent nighttime TR. As the authors mention in lines 240-245, the sapflow measurements exhibit a temporal lag, where part of the daytime TR originates from plant water uptake during the night. Wouldn't it make more sense to compare values integrated over the entire day for a fairer comparison? I agree that the diurnal cycle of ET is relevant and should ideally be captured by the model. But still as a starting point, a good representation of the daily average value is already important.

-Leaf wetness: I am not sure whether I understood the normalization correctly. 0 corresponds to complete dryness of the leaves and 1 for fwet = fwetmax in the respective model configuration? If this is the case the actual maximum in the diurnal cycle of the leaf wetness in CLM5 would be ~0.7*0.05 = 0.035. This would mean that CLM5 vastly underestimates the leaf wetness compared to the measurements rather than overestimate it as Fig. 7 suggests. Also why did you not test for an intermediate fwetmax (e.g., 0.5)?

Specific comments

L17: I am not sure what the authors mean by climate cycles.
L24: Greater energy exchange than what?
L105: A brief statement about the seasonality could be of interest to the reader here.
L108: The base of which mountain. Providing a map with the location of the two sites might help the reader to get a clearer picture of the field sites.
L131: 33 or 34 m? In Fig. 1 the EC is located at a height of 33 m. Also what does IRGA stand for?
L158-160: Soil moisture could still limit stomatal conductance in the model. However, it is probably a fine choice to neglect soil moisture limitation in this study, as ET and the carbon fluxes are on the high side in the model.
L260: Are you sure you are talking of the canopy air temperature here and not the 2 m temperature? The canopy temperature Ts has a different definition if I understand correctly (see eq. 5.93 in technical documentation of CLM5.0).
L286-287: Albedo cannot explain the difference in the nighttime net radiation. Also, how is the albedo estimated?
L307: To me it is unclear what is meant by the BB parameter.
Fig. 4: Are the APAR values in panels c and d from the observations or the model? Part of the discrepancy in the alphas could also originate from differences in PAR (Fig. 3 f).
L344-345: The R^2 increased marginally for CLM5 when introducing phi=0.25. But, the slope and intercept is clearly deteriorated by this modification. So, I wouldn't really talk of an improvement here.
L390: Another relevant process could be energy storage in particular in the stem, which is missing in the default version of CLM5. This process was found to decrease the diurnal temperature range in forests and decrease the overestimation of turbulent heat fluxes in CLM5 (Swenson et al., 2019, Meier et al., 2019).
L433: A nice study supporting and concretizing your claim for accounting for terrain effects: Fan et al. (2019).

Technical comments

L19: I assume 16 % of the land area right? Also, I would reformulate ", accounting for 33 %" to "and account for 33 %".

L46: Remove balance after water.
L49-51: This sentence reads a bit awkward for me. Please consider reformulating it.
L55: Remove on before "tropical ET"
L59: Verb missing. Maybe "which implies that net radiation is highly…" or "which implies a correlation between net radiation and …"
L72: Remove "such" before complicated systems.
L82: The sentence "Therefore, site-based…" breaks the flow of the text for me. Consider removing it.
L95: Parameter choices instead of parameters?
Caption Fig. 1: Add space at "points(100 …"
L126: Remove canopy after height.
L132: As shown in which figure? Again you could show the mean wind direction nicely in a map.
L141: Consider removing "Additionally".
L146: Consider reformulating "models determining the amount of energy exchange" to "models to determine the exchange of energy".

L146-148: This sentence reads awkward for me. Please consider reformulating it.
L148: Remove “energy of”
L149: Consider rearranging this sentence to “For example the canopy energy balance can be written as a function of vegetation temperature:”
L155: Consider formulation “Using a big-leaf approach, CLM represents…”
L156: Shade**d** leaves.
L166-169: I was confused, when I read this for the first time. Consider to first mention CLM4.5 and its equation and then CLM5 and its equation.
L174: 0.1 has the unit kg/m^2 right?
L181: Consider reformulating to “...and the CO_2 concentration does not vary significantly.”
L186: Is there an alternative way to estimate the electron transport rate in the model? If not, remove “additionally”.
L188: = 0.7 **by** default)
Also consider to finish the sentence after “electron transport” and adding a “where” before the phi.
L195-197: I am confused about the units here. c_i and c_p are supposed to be concentrations right? Also consider restructuring these sentences as it reads a bit awkward.
L211: Consider changing “model if” to “model, as“.
L212: “include” instead of “included”.
L214: Maximum fractional saturated area of what? Also, add “and” before color class.
L238: I do not understand what the authors mean by “whether the model is over-parameterized”.
L239-240: Consider reformulating “To investigate water loss from the canopy”.
L249-250: Consider reformulating this sentence.
L251: by a combination **of** the Medlyn …
L257: Consider changing to active form: “it is necessary…” to “CLM requires a number of heights as input variables.
L268-269: Consider splitting into two sentences: “… soil layers. Therefore, the results …”.
L271: Consider reformulating to “cycling (through) the 6-year forcing data collected…”.
L279: Consider avoiding passive voice in last part of the sentence.
L284: Replace “CLM” with “Net radiation in CLM”.
L292: Remove extra dot.
L292-293: Consider reformulating to “, when the albedo difference between the observations and the simulation was smallest (+0.0214).”
L294: Add comma after “albedo models”.
L303: Are you talking of optical thickness here?
L308: Consider reformulating to “Disabling the plant hydraulic stress model in/of CLM5…”.
L311: possible causes of **the** discrepancy…
L315: Add comma after 0.05.
Fig. 3: I am missing a unit in panels d and f.
L332: I would suggest to just refer to Fig. 6 here.
L341: Refer to relevant figures here.
L342: Consider reformulating “and reduced change to the estimated” to “reduction of”.
L372: Consider replacing “assume” with “play”.
L380: Not sure if I understand this correctly. 3 hours of no rain would require 6 consecutive half-hourly time steps with no rain.
L414: This should read “lower in the measurements”.
L428: Studying…
L434: The formulation “are becoming more elaborate vertically and horizontally” sounds a bit awkward to me. Consider reformulating.
L439: Consider splitting into two sentences: “...2012). Such errors…”.

L450-452: Consider reformulating to “Unlike the CO_2 fluxes, which largely depend on plant-light relationships and their effect on photosynthesis, ET consists of three major components: …”. Also, the CO_2 fluxes consist of multiple components as well (i.e., photosynthesis, soil respiration, plant respiration). Therefore, consider removing the comparison to the CO_2 fluxes completely.
L480: Consider replacing “datasets” with “counterparts”.
L481: related **to** each other … canopy condition**. Therefore,** it was (the latter modification being a suggestion).
L483: during **the** daytime.
L496: Remove “with”.
L508: Consider replacing “seems too physically simplified” with “seems oversimplified”.
L524: Remove “balance)”
L535: Consider replacing “such as this” with “such as the location of this study”.
Fig. 7: Shouldn’t the unit in panels c and d be per time? Otherwise, I misunderstand these panels.

References

Fan, Y., Clark, M., Lawrence, D. M., Swenson, S., Band, L. E., Brantley, S. L., et al. (2019). Hillslope hydrology in global change research and Earth system modeling. Water Resources Research, 55, 1737 1772. https://doi.org/10.1029/2018WR023903

Meier, R., Davin, E. L., Swenson, S. C., Lawrence, D.M. & Schwaab, J. (2019). Biomass heat storage dampens diurnal temperature variations in forests. Environ. Res. Lett. 14, 084026, DOI: 10.1088/1748-9326/ab2b4e.

Swenson, S., Burns, S. P., & Lawrence, D. M. (2019). The impact of biomass heat storage on the canopy energy balance and atmospheric stability in the community land model, Journal of Advances in Modeling Earth Systems, 11, 83 98. https://doi.org/10.1029/2018MS001476