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Earth System
Dynamics
Discussions

Interactive comment on “Studying the large-scale effect of leaf thermoregulation using an Earth system model” *by* Marvin Heidkamp et al.

Anonymous Referee #1

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In their manuscript “Studying the large-scale effect of leaf thermoregulation using an Earth system model”, the authors explore the role of leaf thermoregulation (vegetation’s control on leaf temperature that can result in substantial differences between the radiative skin temperature of a leaf and the canopy air surrounding the leaf), by utilizing a canopy temperature and moisture scheme implemented into a land surface model.

The authors perform 3 distinct sets of simulations. The first solves the equations relating to canopy air space in steady-state assuming ample soil moisture. The second forces their canopy air space model with atmospheric data from FluxNet sites. The third set of simulations are coupled with an atmospheric model using MPI-ESM. They find that their simulations reproduce the expected relationship from observations, where

when air is cold, leaves are warmer than air, and when air is warm, leaves are cooler than air. They explore how this relationship (and the temperature at which leaves and air at the same T) changes for non-water-stressed vegetation based on incoming solar radiation and relative humidity. Their model predicts a lower temperature at which leaves and air are the same T compared to observations when forced with flux tower data, but this can likely largely be explained by differences in what the observations measure (top of canopy leaf temperature) and what the model simulates (temperature of vegetation across the canopy). For water-stressed forcing data and over much of the land area in the AMIP-style simulations, they find a positive (rather than negative) relationship between leaf and air temperatures. That is, while their idealized model and non-water-stressed test sites show a negative relationship, most regions in the AMIP-style simulations are actually experiencing some degree of water stress; leaf thermo-regulation should be strongest in non-water limited systems, but even the simulated leaf thermo-regulation in the AMIP simulations results in a 3-5% increase in global GPP.

The manuscript is clearly written and the study well thought out. I particularly applaud the authors on their detailed but easy-to-follow methods section. I have only minor comments on the manuscript, which are outlined point-by-point below. This manuscript is suitable for publication in Earth System Dynamics.

General comment: It might be nice to include some discussion on how much including LT modifies global evapo-transpiration and temperatures, broadly (in addition to carbon impacts)

Specific comments:

- Line 106: there are a lot of reasons that non-transpiring parts of the canopy (bark, branches/trunks) should be much hotter than transpiring leaves. Could the authors please include a discussion about if Tc here includes this and thus overestimates Tleaf, or if instead Tc really is Tleaf, and the canopy instead is estimated to all have leaf-like temperatures? (Just make it clear if CEBa is skipping the woody-bit or of Tleaf is including the T of woody-bits in this study)

- Line 149: because the authors mention snow, what *does* happen if there is snow on the ground? Is it effectively on "top" of the vegetation, or under the vegetation but on top of the ground?

- Line 165: Do the authors mean the RH of the air space in the top soil layer? (Pardon my ignorance here, soil moisture physics are not my strongest suite). Just clarifying that they're calculating RH of air in soil vs how saturated the soil is (i.e. measuring water as a gas vs a liquid).

- Line 248-249: Might be useful here to say how much area / how much of the time the land surface isn't experiencing any water stress.

- Line 250: please give a brief explanation of the oasis effect here. (Authors do explain this near line 460, but this is the first place they mention it so it would be helpful to briefly sketch in words what it is).

- Figure 7: I assume the authors checked for all of the figure 7 cases that the negative relationship in figure 6 holds, but might be worth explicitly stating that (sorry if you did and I just missed it)

- Figure 7: clarify in legend of (d) that RH = 20% and Sin = 1000 W/m2 (and so on for other colours)

- Line 260: ie latent cooling isn't very effective when it is humid – it may be useful to reference Vargas Zepetello et al 2020. Specifically I'm thinking of figure 8 (showing changing LH has minimal effect when water flux is already large). They were more interested in soil moisture in that study, but the same general physics is at work as what I think the authors are getting at here - if you're already cooling a lot via latent cooling, and the atmosphere is really humid, it is hard to get "extra" cooling via the latent heat pathway. https://doi.org/10.1175/JCLI-D-19-0209.1

- Line 273: what do the authors mean by "vegetation period" - growing season?

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