Dear Referee #3,

we would like to thank you for taking your time to help us to improve our manuscript. We think that your suggested comments, in particular the alternative representation of the latent heat storage (not only including a simple dependence on the surface temperature), increase the manuscript's quality significantly. Moreover, we appreciate your comment on the ground heat flux which removes some confusions concerning the unclosure of the energy balance using eddy covariance measurements.

Specific Comments

- P3, line 1-3: To my opinion, the question in bold letters relates to the reference model only and doesn't include the SkIn scheme. Or, is the SkIn scheme deemed to be correct?
  Good point! We clarified this issue by rephrasing the scientific question (page 3, line 14-16): *Does the SkIn scheme improve the performance in reproducing the diurnal cycle in comparison to the old heat storage concept in case of shallow vegetation?*

- P4, line 13: The term "offline experiment" first appears in the Introduction (line 32). Thus, the definition should already be given there.
  Changed (page 3, line 10-11) $\surd$

- P4, line 15: Up to which depth reaches the multi-layer vertical grid?
  It reaches up to a depth of 10 m (page 4, line 22).

- P6, Eq. (6): Please define, whether the relative humidity within or above the canopy is meant.
  That was one problem of the old latent heat storage. We estimated the relative humidity within the canopy as follows:

$$R_{\mathrm{H}} = \frac{q_{\mathrm{air}}}{q_{\mathrm{sat}}(T_{\mathrm{sfc}})} \tag{1}$$

  This is clearly not correct and not needed anymore in the new formulation of the latent heat storage (see next comment).

- P6, Eq. (6): Inserting Eq. (6) into Eq. (4) would lead to a time dependence of qsat which is more realistic than a simple dependence on Tsfc because qsat can also vary at constant temperature. Eq. (4) should be modified in this context.
  This is an issue that was addressed by all three referees and we agree that Eq. (6) is misleading without the derivation. The idea was to express the different types of canopy heat storages by means of heat capacities so that all heat storages could be related to the time derivative of the surface temperature. The reason behind this is that the surface temperature is the only prognostic variable to represent the processes in the canopy layer and the current scheme does not contain a prognostic

variable like the specific humidity of the canopy air space. Thus, the heat storage resulting from changes in specific humidity in the canopy layer (in short: latent heat storage) S_q was approximated by using the saturated values of specific humidity and the relative humidity within the canopy layer. In addition, we neglected the change of relative humidity within time ($\partial R_{\mathrm{H}}/\partial t = 0$). So that S_q can be written as follows:

$$\begin{aligned} S_q &= L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}\frac{\partial q}{\partial t} = L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}\frac{\partial R_{\mathrm{H}}q_{\mathrm{sat}}}{\partial t} \\ &= L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}\left(R_{\mathrm{H}}\frac{\partial q_{\mathrm{sat}}}{\partial t} + q_{\mathrm{sat}}\frac{\partial R_{\mathrm{H}}}{\partial t}\right) \\ &\approx L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}R_{\mathrm{H}}\frac{\partial q_{\mathrm{sat}}}{\partial t} \\ &\approx \underbrace{L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}R_{\mathrm{H}}\frac{\partial q_{\mathrm{sat}}}{\partial T_{\mathrm{sfc}}}}_{C_q}\frac{T_{\mathrm{sfc}}}{\partial t} \end{aligned} \tag{2}$$

where q_{sat} is the saturated specific humidity at the surface temperature, C_q the heat capacity related to humidity changes, ρ_{a} the density of air, z_{veg} the vegetation height and L_{v} the latent heat of vaporization. We have to admit that the neglection of the time derivative of the relative humidity within the canopy layer is a rather crude approximation that may not be appropriate to estimate S_q.

As you have mentioned in your review, in using this approach we only consider changes in specific humidity due to changes in surface temperature and neglect other humidity sources and sinks. Therefore, we decided to develop an alternative parameterization for the latent heat storage which produces more realistic results for our purpose. We have addressed this issue in the manuscript, see from page 7, line 15 onwards. In this approach, we take into account the heat storage resulting from changes in specific humidity of the canopy air space by defining an effective *surface specific humidity* q_{sfc} which is the best proxy for canopy specific humidity that we have. It represents a nonlinear weighted average between the specific air humidity above the canopy layer and the surface saturated specific humidity, by demanding that

$$\frac{q_{\mathrm{air}} - q_{\mathrm{sfc}}}{r_{\mathrm{a}}} \overset{!}{=} LE(q_{\mathrm{air}},\, q_{\mathrm{sat}},\, r_{\mathrm{a}},\, r_{\mathrm{c}},\, ...) \tag{3}$$

where r_{a} is the atmospheric resistance, r_{c} the canopy resistance and LE the latent heat flux as it is calculated in the energy balance. This means that q_{sfc} is calculated to represent the effective near surface specific humidity that is required to reproduce the surface moisture fluxes due to turbulent exchange processes. In principle, the specific humidity of the boundary layer q_{air} could also be used as suggested by Moore and Fisch (1986). However, we are of the opinion that the usage of q_{air} would underestimate the latent heat storage in the current scheme. This leads to the new formulation of the latent heat storage S_q:

$$S_q = L_{\mathrm{v}}\rho_{\mathrm{a}}z_{\mathrm{veg}}\frac{\partial q_{\mathrm{sfc}}}{\partial t} \tag{4}$$

Because q_{sfc} is not a prognostic variable in the energy balance, its time derivative is approximated by using values of q_{sfc} at previous time steps. This is an approximation that is inevitable in the current model framework and can only be avoided by developing an extended dual source canopy layer scheme which includes a prognostic specific humidity of the canopy air space as mentioned in the discussion (chapter 5 of the manuscript).

Due to these changes in the parameterization of S_q, it is not possible anymore to compare different heat capacities, but one has to compare heat storages of different processes (see chapter 3.2 of the manuscript). Because heat storages have the nature to compensate each other over longer time scales, we compare only positive contributions of the heat storages to estimate their magnitude. This could be interpreted as the average amount of energy that is stored in the canopy and the same amount will also be released.

Comparing the old approach of the latent heat storage (Eq. 2) with the new one (Eq. 4) on diurnal scales, we find that the old one tends to react like a common heat storage with a positive peak during the first half of the day and a negative during the second part (compare to the soil heat storage from Figure 2 of the manuscript). In contrast, the new representation of the latent heat storage does not exhibit this pattern. It shows positive as well as negative changes in heat storage during the whole daytime. This corresponds to the fact, that the specific humidity does not follow a strict diurnal pattern as the surface temperature. On the contrary, there are different kind of days representing either a positive or negative trend in humidity depending on wet or dry weather periods. The global mean over thirty years of the new representation of the latent heat storage is of the same magnitude as the old one. It reacts in slightly smaller values because the old one overestimated S_q due to the direct coupling to the surface temperature.

- P9, Fig. 2 and P10, line 3,4: In contrast to DICE, in eddy-covariance experiments the ground heat flux is usually measured. Nevertheless, eddy-covariance generally doesn't close the energy balance. To close the balance, the missed energy (frequently exceeding 200 W/m^2) is usually partitioned to the sensible and the latent heat flux according to the Bowen ratio. The full allocation of the residuum to the ground heat flux G leads to an overestimation of G which will be considerable for large residua. In turn, the green plots in Fig. 2 represent the sum of G and the residuum at daytime and G at nighttime when the residuum is close to zero. Please, comment this issue.

  We do totally agree and are aware of the unclosure of the energy balance using the eddy covariance method. However, the problem is, if the ground heat flux was not measured, there is no possibility to estimate the imbalance and therefore to divide it into sensible and latent heat flux part. Thus, in our opinion, it makes more sense to depict the ground heat flux including a possible imbalance than discarding it completely. Nonetheless, you are right that we should at least mention the imbalance to avoid confusions.

Technical Corrections

- P7, Fig. 1: The yellow color is hardly visible. I suggest the authors should use another color for the incoming sw radiation.
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