Interactive comments on the manuscript gmd-2017-261 entitled: Modeling canopy-induced turbulence in the Earth system: a unified parameterization of turbulent exchange within plant canopies and the roughness sublayer by Bonan et al.

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General comments

Improved and more precise evaluation of turbulent exchange of momentum, energy, and passive and active chemical compounds between the land and the atmosphere in presence of vegetation canopy is beneficial for both modeling and measurement communities. This model development report quantifies the canopy and the roughness-sublayer (RSL) induced turbulent effects on surface-atmosphere exchange properties as evaluated by comparing large observational data, Community Land Model version 4.5(CLM4.5) and multi-layer canopy model. The authors concluded that *'the implementation of the RSL improves model performances in terms of sensible heat flux, friction velocity, and radiative temperature, and additional improvement comes from modeling stomatal conductance and canopy physiology beyond what is in the CLM4.5 .'*, which is important and relevant conclusion. The paper is well written and provides the all necessary information of the modeling system.

The main drawback of the paper however, is often not clear separation of the added value of the included RSL parameterization, and the 'Leaf biophysics' incorporation in the model, when presenting and discussing the results (although figures/tables show this clearly). For example, the conclusion sentence, cited above, states that the RSL improves the sensible heat flux, friction velocity and the radiative temperature. This is only true when taken the RSL together with the leaf biophysics improvement in the multi-layer approach, but not entirely true for the sensible and the latent fluxes as seen separately only for the RSL effects (we cannot know this since the RSL here is always linked to the leaf physics of the multi-layer model, and the latter is absent/different in the CLM).

Specific comments

page 2, line 29-30 in the abstract: please see the same comment in the general note. The effective influence of the RSL on presented quantities would be by comparing the ML-RSL and ML+RSL.

page 8, Eq. 1, 2, 3, 4: The fluxes, as stated in the equations, show that they are height dependent (e.g. $\frac{dH}{dz} = f(z)$); but later (**page 15**, Eq. 18-20 are derived from $\frac{dc}{dz} = \frac{c_*}{\kappa z}\Phi_c$ (e.g. Harman and Finnigan 2008, Eq. 12) on the assumption that the fluxes above the canopy are height independent (with $c_* = F_c/\rho u_*$). This seems theoretically incorrect statement and need justification.

page 9, line 184: The scalar diffusivity (K_c) is assumed to be the same for heat and water vapor. It has to be shown that this is not always the case, especially near the canopy top (e.g. please see Shapkalijevski et al. 2016, Fig. 1)

page 12, line 242: *'... additional source fluxes'*, but during day, and sink during night?

page 17, line 348-349 similar to the comment above on **page 9, line 184:**.

page 18, line 366 Eq. 27, the roughness length for momentum and scalars are defined as invariant (fixed values), but no reference is given based on what. The RSL theory (Harman and Finnigan 2007; 2008) defines them as variant quantities, dependent on the flow/stratification and canopy properties. Further justification here would be very appreciated

page 26, line 538: The wind speed, as simulated including the RSL effects in the flux-gradient relationship of momentum has smaller magnitude compared to the wind speed from the standard MOST. Looking at the profiles provided by Harman and Finnigan (2007), the wind profiles calculated by RSL is generally stronger compared to the wind profiles calculated by MOST. Any comment in the discussion about this would be also very appreciated.

page 28, line 579 The RSL effects are expected to have larger influence on nocturnal turbulent exchange (as assumed by the theory), due to shear-driven (canopy induced in this case) turbulence dominating over the night (compared to thermal convection during day). This is excellent example that corroborates this assumption.

page 32, line 666-672 Shapkalijevski et al. (2016) used the RSL theory (Harman and Finnigan 2007; 2008) over a canopy with different sparsity/density and explicitly calculated the β and the l_m/β scale as function of stability.

page 66, Figure 1 It could be convenient for the readers if the displacement height and the roughness length are define in the schematic figure.

References

Harman, I. N. and Finnigan, J. J.: A simple unified theory for flow in the canopy and roughness sublayer, Boundary-Layer Meteorology, 123, 339363, doi:10.1007, 2007.

Harman, I. N. and Finnigan, J. J.: Scalar Concentration Profiles in the Canopy and Roughness Sublayer, Boundary-Layer Meteorology, 129, 323351, doi:10.1007, 2008.

Shapkalijevski, M., Moene, A. F., Ouwersloot, H. G., Patton, E. G., and Vil-Guerau de Arellano, J.: Influence of canopy seasonal changeson turbulence parameterization within the roughness sublayer over an orchard canopy, Journal of Applied Meteorology and Climatology, pp. 150205, doi:10.1175/JAMC-D-15-0205.1, doi/abs/10.1175/JAMC-D-15-0205.1, 2016.