

Referee comments on “Combined measurement and modeling of the hydrological impact of hydraulic redistribution using CLM4.5 at eight AmeriFlux sites” by C. Fu et al.

General Comments

This study investigated the HR process and its effects on land surface water and energy cycles in a comprehensive manner by using the modeling method. The Ryel HR scheme (Ryel et al., 2002) was included in the CLM4.5 land surface model, and the new model (CLM4.5+HR) was applied at eight AmeriFlux sites with various climates, vegetation types and soil types. Quantitative analyses showed that including HR could improve the modeling of soil moisture, ET and Bowen ratio, which suggested that HR could be an important process, in many circumstances, particularly in environments where the annual precipitation was not very low and the temporal distribution of precipitation was quite uneven. Based on the numerical simulations using CLM4.5 and CLM4.5+HR at the eight sites, HR flux and the effects of HR on land surface water and energy budgets in diverse ecosystems were quantified and analyzed at different aspects. The sensitivities of model results to the important parameters of the Ryel HR scheme were also examined for the sites with varied climates.

This manuscript addresses relevant scientific questions within the scope of HESS. The methods are clearly described. The conclusions are based on well-designed numerical simulations and detailed analyses. The tables and figures are well made.

Some minor revisions are needed to make the presentation more precise or concise.

Specific Comments

1. In this manuscript, it is stated that the Ryel HR scheme (Ryel et al., 2012) is used. However, there are some differences between the Equation 1, which representing the HR process, of this manuscript and the original equation (i.e., Equation 6 in Ryel et al., 2012): (1) This manuscript: c_j , the factor reducing soil-root conductance in the giving soil layer j ; Ryel et al.: $\max(c_i, c_j)$, the larger one of the two factors in the receiving soil layer i and the giving soil layer j ; (2) In the denominator: This manuscript: $F_{root}(j)$, the root fraction in the giving soil layer j ; Ryel et al.: This parameter can be $F_{root}(i)$ or $F_{root}(j)$, which depends on the comparison between soil moisture of the layer i and that of the layer j ; (3) This manuscript: It is not explicitly stated whether HR occurs during daytime in the modeling; Ryel et al.: It is stated that HR is “turned off” during daytime in the modeling of their study. These aspects can be explained in this manuscript.

In addition, if the definition of C_{RT} here is same as that of Ryel et al., “of the entire active root system for water” needs to be added after “soil-root conductance” in Page 4 Line 19.

2. Root distribution along the vertical direction in the soil column is an important input in the HR modeling. In Page 4 Line 20, it is mentioned that the root distribution is based on Zeng (2001). More information about root distribution can be provided (e.g., how is the root distribution represented; Root-distribution differences between the eight AmeriFlux sites; etc.). This information can be helpful for the readers to understand the simulation results.

Technical Corrections

Page 1 Line 18: Add “land” between “on” and “surface water”.

Page 1 Line 19: Replace “it” with “the impact”.

Page 2 Lines 8-9: Remove “do so by”.

Page 2 Line 9: Replace “incorporating” with “incorporate”.

Page 2 Line 9: Add “e.g.,” before “Ryel et al., 2002” (because some studies listed did not use the Ryel HR scheme, for example, Lee et al., 2005).

Page 2 Line 24: Replace “CA” with “California”.

Page 2 Line 30: Replace “2m of soil” with “2-m soil layer”.

Page 3 Line 1: Replace “objective” with “objectives”; Replace “is” with “are”.

Page 3 Lines 1-2: Replace “modeling approach, the Ryel et al. (2002) approach,” with “HR scheme (*or model ?*) (Ryel et al., 2002)”.

Page 3 Line 3: Add “land” between “on” and “surface water”; Replace “it” with “the impact”.

Page 3 Line 4: Rephrase “This is done through incorporating Ryel et al.’s (2002) simple empirical equation for HR flux” to be “For these objectives, we incorporated the Ryel HR scheme”.

Page 3 Line 5: Add “(CLM4.5)” after “4.5”; Replace “applying” with “applied”; Remove “the” before “eight AmeriFlux sites”.

Page 3 Line 20: Replace “degrees C” with “°C”.

Page 4 Line 12: Replace “quantify” with “represent”; Replace “Ryel et al.’s (2002) equation” with “the Ryel HR scheme (Ryel et al., 2002)”.

Page 4 Lines 12-14: Rephrase “This equation has been widely used in HR modeling studies (Lee et al., 2005; Zheng and Wang, 2007; Wang, 2011; Li et al., 2012) and its variations (e.g. Yu and D’Odorico, 2015).” to be “Many HR modeling studies used this HR scheme (e.g., Zheng and Wang, 2007; Wang, 2011; Li et al., 2012) or its variations (e.g., Lee et al., 2005; Yu and D’Odorico, 2015).”.

Page 4 Line 25: Rephrase “The relationship between root hydraulic conductivities and soil moisture in equation (2) is similar to ...” to be “The relationship of Equation 2 is similar to ...”. (because the description is not accurate)

Page 4 Line 28: Replace “equation 1” with “Equation 1”.

Page 5 Line 1: Replace “MPb” with “MPa”.

Page 5 Line 2: Replace “ “Ryel et al. 2002” equation” with “Ryel HR scheme”.

Page 5 Line 6: Add “Clapp and Hornberger” between “influences of” and “B” ’.

Page 5 Line 6: Replace “based on” with “in the”.

Page 5 Line 11: Replace ‘ “B”s ’ with ‘ “B” values ’; Replace “lower” with “deeper”.

Page 5 Lines 12-13: Rephrase “... identical parameter “B” tuned ...” to be “... the identical “B” value tuned ...”.

Page 5 Lines 16-17: Remove “for the sites”.

Page 5 Line 23: The meaning of “conservatively” is not clear.

Page 5 Lines 25-26: “... in surrounding portions of the signal trace ...” is not clear.

Page 5 Line 26: Add “existence of” before “HR”.

Page 6 Line 4: Replace “increment” with “soil layer”.

Page 6 Line 12: Add “ – ” after “the models”.

Page 6 Lines 20-21: Remove the comma “ , ”; Remove “US-SRM”; Add “at this site” after “... 90-100 cm depths”.

Page 6 Line 22: Replace “rain” with “soil water”; Replace “surface” with “shallow”; Rephrase “it could be delivered by percolation alone” to be “the percolation process”.

Page 6 Line 31: The “hydrological effect” was “far lower” than what?

Page 7 Line 14: Add “flux” after “HR”.

Page 7 Line 16: Replace “... the magnitude of ...” with “... the magnitude in the ...”. (to make this sentence more readable)

Page 7 Line 19: The hydraulic descent magnitude (12 – 38 mm/day and 35 mm/day) seems to be very large. Please verify these values.

Page 7 Line 25: “..., the maximum depth of HR-induced soil moisture increases ...” is not clear.

Page 7 Lines 28-29: “... used soil suction to roughly control the magnitude of HR ...” is not clear.

Page 8 Line 3: Remove “+HR” after “CLM4.5”; Replace “percent” with “percentage points”.

Page 8 Line 5: Add “those of” before “decreased soil moisture”.

Page 8 Line 8: Remove “at the six Southern California US-SC sites”.

Page 8 Line 11: Add “in” before “2011”.

Page 8 Line 13: Replace “Ryel et al.’s (2002) HR model” with “the Ryel HR scheme”.

Page 8 Line 14: Remove “up to 1%”; Add “ (up to 1%) ” after “soil moisture”.

Page 8 Line 15: Remove “up to 4%”; Add “ (up to 4%) ” after “soil moisture”.

Page 8 Line 16: Remove “%”; Add “ (in the unit of %) ” after “soil moisture change”.

Page 8 Line 18: Switch “site” and “US-Wrc”.

Page 8 Line 19: Switch “HR” and “downward”.

Page 8 Lines 23-24: “... , a gradient in the depth and temporal extent of HR on modeled soil moisture was clear.” needs to be rephrased.

Page 8 Line 27: Add “range” after “depth”; Replace “influence of HR” with “HR influence”.

Page 8 Line 29: Add “H₂O” between “mm” and “d⁻¹”. (to be consistent with the same unit in this paragraph)

Page 8 Lines 30-32: It is not clear these results are from a specific year, or average values of multiple years?

Page 9 Line 4: Replace “varying” with “various”.

Page 9 Line 7: Remove “also improvement”.

Page 9 Line 9: Remove “ (hourly) ”.

Page 9 Line 9: These results are average values of one year, or multiple years?

Page 9 Line 10: Replace “tends” with “tended”.

Page 9 Line 10: Remove “observed mid-day”. (These words are redundant.)

Page 9 Lines 10-11: Fig. 6 shows that, for most circumstances, the modeled high ET values from CLM4.5+HR are closer to the observations, as compared to those from CLM4.5. This point can be put forward around here.

Page 9 Lines 17-18: “... was subsequently taken up from deeper layers by plants during transpiration.” – But soil water in deep layers could also be transferred to the shallow soil via the upward HR process when plant transpiration rate is low.

Page 9 Line 21: Move “(0.47 mm H₂O d⁻¹)” to after “US-SCf site”; Remove “corresponding ET increase is”.

Page 9 Line 22: Add “site” after “US-SRM”.

Page 9 Line 25: Replace “Ratio” with “ratio”.

Page 9 Line 32: Rephrase “synthesizes” to be “reflects the integration of”.

Page 10 Line 5: Rectify “hear” to be “heat”.

Page 10 Line 8: “... beyond those studied here” is not clear.

Page 10 Line 10-11: Rephrase “... HR-induced increases in ET are maximal at sites with mid-range soil moistures” to be “ ... HR-induced large increases in ET primarily occur at sites with mid-range soil moistures”. (because in Fig. 8, for sites of moderate soil moisture, some HR-induced increases of ET are small)

Page 10 Line 14: Replace ‘ “Ryel et al. 2002” equation ’ with ‘Ryel HR scheme’.

Page 10 Line 17: “at the height of HR” is not clear.

Page 10 Line 17: Add “during the periods with high HR flux”. (because in Fig. S10, hydraulic lift magnitude could double when HR flux is moderate or low)

Page 10 Line 27: Add “as” after “considered”.

Page 11 Line 7: Replace “yr” with “year”.

Page 11 Line 13: Replace “dominated” with “primarily caused”.

Page 11 Line 14: Replace “H2O” with “H₂O”.

Page 11 Line 17: Add “soil” before “water content”.

Page 11 Line 20: Replace “is” with “was”.

Page 11 Line 25: Add “missing representation of” before “hydraulic lift”.

Page 11 Line 31: Remove “the monitored”.

Page 12 Line 2: Rephrase “, including at sites modeled here” to be “including those conducted at sites of this study”.

Page 12 Line 3: Replace “contributed” with “supplied”; Replace “to” with “of”; Rephrase “upper 2 m of the soil” to be “top 2-m soil layer”.

Page 12 Line 5: Replace “similar” with “comparable”. (The meaning of 28% is different from that of 32%: 28% = HL / ET from the top 2-m layer; 32% = HL / ET from the whole soil column.)

Page 12 Lines 6-7: Add “transpiration of the” after “estimated”; Remove “transpiration” before “in 2004”.

Page 12 Line 21: Replace “are” with “were”.

Page 12 Line 28: Replace “idea” with “hypothesis” or “assumption”.

Page 13 Line 3: The reference “Quijano and Kumar, 2015” is missing in the reference list.

Page 13 Lines 8-10: These hydraulic lift results are maximum values in a time period? Or mean values of some periods?

Page 13 Line 14-16: These ET increases are maximum values in a time period? Or mean values of some periods?

Page 13 Line 23: Replace “Ryel et al. 2002 equation” with “Ryel HR scheme”.

Page 13 Line 25: Add “during the periods with high HR flux” after “hydraulic lift”.

Page 13 Lines 25-26: Add “larger change of” before “hydraulic descent”; Remove “was more sensitive”.

Page 13 Lines 29-31: “HR has been confirmed in many ecosystems” does not convincingly support the argument that “HR should be included for all ecosystems”. Need some revising here.

Page 13 Line 32: Replace “a large number of” with “eight”. (Eight is not a large number.)

Page 18 Lines 3, 6: Replace “Ryel et al.’s 2002 equation describing HR” with “the Ryel HR scheme”.

Page 19: Columns 1 and 2: it is better to align left.

Page 20: Column 5 Row 3: Add “m” after “0.25-5”.

Page 22 Line 1: Replace ‘ “Ryel et al. 2002” HR model ’ with “Ryel HR scheme”.

Page 22 Line 2: Add “of the entire active root system for water” after the first “conductance”, if the definition of C_{RT} is same as that in Ryel et al. (2002).

Page 22 Line 3: Remove the quotation marks “ ” around b .

Page 23: Need to specify the results of Table 5 are mean values of one year or mean values of multiple years.

Page 23: The last column: these values need to be multiplied by 100.

Page 24: The 4th line from the bottom: Replace “soil moistures” with “soil moisture data”.

Page 24: The 2nd line from the bottom: Remove “RMSE for”. (They are redundant.)

Page 24: The last line: Rephrase “improved model fit to data” to be “a better fit between model results and observed data”.

Page 25: The 2nd Line from the bottom: Replace “at 0-30 cm depth” with “at different depths in the top 30-cm soil layer”.

Page 25: The last two lines: “Results were shown for the last two years only for the above 30 cm depth at US-SRM site for clarity.” is not clear. This sentence seems to mean that: “For the top 30-cm soil layer at the US-SRM site, only the results of the last year (Year 2012) were shown for clarity.”

Page 25: The last line: “The rectangular box” is missing in the figure.

Page 27: The last line: Remove the first “soil moisture”.

Page 28: The units are missing in Fig. 4.

Page 29 Lines 1 and 2: Remove “(mm)” in the legend.

Page 30: In the ET plots, the meaning of the thin vertical lines is not described.

Page 30: The 2nd line from the bottom: “dry season and wet season” are from one year or multiple years.

Page 31: The results of Year 2004 at the US-SRM site are contrary to the other results, which can be discussed in the text.

Page 33: Replace “ ϕ_{50} ” with “ $|\phi_{50}|$ ”.

Page 33: Units of C_{RT} and ϕ_{50} are missing.

Page 33: The last two lines: Replace “Ryel et al.’s 2002 equation describing HR” with “the Ryel HR scheme”.