HESSD

Interactive
comment

Interactive comment on "Controls on root zone storage capacity in boreal regions" *by* Tanja de Boer-Euser et al.

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The manuscript by de Boer-Euser presents an application of root zone storage (S) derived from hydro-climate data for the boeral region of Finland. I am in favor of the idea that climate, soil and vegetation are co-evolving and that the plant available water storage is an outcome of this interdependence and not just a fixed parameter determined simply from soil / vegetation lookup tables. In boreal regions we also expect that snow cover, high water tables, low soil depths, and frozen soils are important constraints on root zone storage. de Boer-Euser explicitly implement this through a snow component driven by observed changes in snow water equivalent. The other constraints are not explicitly modeled but somehow implicitly included through the observed long term water balance closure ($E = P - R$) which is an input to the method – if I understand this

correctly.

I really like the motivation to compare the derived S with independent data, such as forest characteristics and land cover type. The results show that S increases towards the south, increases with biomass, but decreases with area of peatlands due to high water tables. Since root biomass is used as a metric for verification, more details are required on how this was derived.

The statistical analysis is presented in a way to suggest that root zone storage is independent of the climate variables (P, Ep, T, SWE), while indeed it is derived from these data. Actually the analysis of climate controls is performed like an uncontrolled sensitivity analysis of a bucket model with different inputs. The outcomes of this sensitivity analysis (Fig 6, Sect. 3.2, 4.2) are difficult to interpret since the influence of the other input parameters changes from one catchment to the next. I also wonder why there is no precipitation frequency / drought index be used to correlate with S?

An interesting point is the influence of drainage of peatlands on S. Although the authors claim to identify an effect, I could not identify the mentioned influence of drainage in Fig 7. Unfortunately, the analysis lacks a reference to compare drainage with pristine peatlands. Here a stratification of the data could be useful means to assess this point.

I do not understand how the method can be applied in climate or land-use change analysis. To my understanding an estimate of transpiration is required to estimate S and both are unknown for a given change scenario. Please explain.

Apart from these major remarks the authors did a very good job in writing and presentation of the results. The topic is of high scientific interest and after revisions well suited for publication in HESS.

Detailed comments:

P1L17: Check the causal order of the mentioned processes "Retreating . . . "

P2L2: add references

P2L7: "but so far none have studied changes in transpiration (patterns) at the catchment scale in boreal regions." Please check (Jaramillo et al., 2018; van der Velde et al., 2013).

P2L17: "Thus, climate (or the balance between precipitation and transpiration) has a large influence on the developed S r ." Doesn't transpiration depend on the root zone storage (and not the other way around)?

P4L3ff: To my knowledge there is a significant undercatch of precipitation, especially in winter. It is not clear if the undercatch was corrected for, but if not, then I disagree with the choice of the authors to correct SWE with P.

Sect 2.3 climate derived root zone storage capacity. Since the results show how climate variables correlate with S, I recommend to repeat the key equations to show how climate input is used in the method. Then also the choice of a return period of 20yr may become more clear.

P5L12: wording "transpiration demands" is unclear to me

Results / Discussion: report correlation and significance in text. For example in Sect. 3.1

P8L21: check argument: "The presented results show that climate derived root zone capacities are related to vegetation characteristics, climate variables and vegetation cover, which strongly indicates that the S r -method can be used for boreal regions containing seasonal snow cover." Since S is computed from climate data, the relationship is not a verification of the method!

P9L2: unclear from results "This seems to indicate that in case of low transpiration demands the plant's resources between below and above soil elements are more equally divided than for areas with higher transpiration demands."

P9L6f: unclear argument "However, for pine in mid- and south-boreal regions a negative correlation was observed, which means that the vegetation is able to create a

larger storage capacity with fewer or thinner roots." Please calculate the significance of the correlation and possibly use a bootstrap to check the influence of outliers. Please check/report how root biomass was calculated. Also check for other influencing variables.

P9L12: please provide references for shifting management activities

P10L5: please provide references

P10L8: "Peatland drainage for forestry changed this pattern: higher S r values were observed in areas with larger cover of drained peatlands (Figure 7)." I could not see this effect!?

Sect. 4.4: Explain how the method is applied to a change scenario when data on transpiration is required a priori?

Figure 1: Missing y-axis labels; Add points to the boxplots. Panels of Fig1 are insightful, but hardly touched in text. Add relevant topographic info to the map.

Fig 2: use white text in dark boxes

Fig 6c, Fig 8: Julian date for snow off in Fig.6 and Julian Date for max SWE in Fig 8. Please be consistent.

Fig 7c,d: Peatland area per catchment? Why does the number of points change?

Fig 8: show correlation as text in one of the diagonals

Fig. 9: What is the ordering in y-axis? Coloring: black lines are hardly seen on darkblue background. Why is PET always the same?

References:

Jaramillo, F., Cory, N., Arheimer, B., Laudon, H., van der Velde, Y., Hasper, T.B., Teutschbein, C., Uddling, J., 2018. Dominant effect of increasing forest biomass on evapotranspiration: interpretations of movement in Budyko space. Hydrol Earth Syst

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van der Velde, Y., Vercauteren, N., Jaramillo, F., Dekker, S.C., Destouni, G., Lyon, S.W., 2013. Exploring hydroclimatic change disparity via the Budyko framework. Hydrol. Process. https://doi.org/10.1002/hyp.9949