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Discussions

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

Anonymous Referee #1

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Overall Comments:

The authors have produced a nice study that attempts to find correlations between a climate derived root zone water storage (Sr) and aspects of vegetation distribution among 64 drainage basins in Finland. This topic is of interest to the readers of HESS and the general findings are useful and well presented. My recommendation is that revisions are necessary but that the potential for eventual publication is strong.

A weakness in the analysis is that Sr is derived at the basin scale, and then assessed against vegetation type and attributes, but different vegetation types prefer different soil texture and moisture conditions. A diverse catchment likely has a diverse soil and an Sr value that may not apply very well to any of the vegetation types in the particular catchment. Conversely, I would expect stronger correlations and more valid

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Discussion paper

Sr values in catchments containing a dominant vegetation type. From looking at Figure 3, I suspect that peatlands never make up enough of the catchments for the Sr value obtained to be applicable to them, and this would also be the case for many of the agricultural areas. Forest is usually the dominant vegetation type and this is shown by its close agreement with the broad boreal zone plot.

There appear to be inconsistencies in the data that are presented in subsequent plots. These need to be corrected or explained. In Figure 3a there are two points with relatively low leaf cover and Sr values of about 230 and 110 mm. These points show up in the boreal regions plot (3d) as northern points, so they are northern forests. Based on Figures 3e and 3h, the 230 mm Sr value is also associated with a large tree length of about 210 m while the 110 mm Sr value is associated with a medium tree length of about 100 m. I'm wondering if there is something about these two basins that makes them different. Why is the leaf cover low and yet one of them has the largest observed tree length? Was there a defoliation event? When I look in Figure 4, I see no northern forests with an Sr value anywhere near 230 mm. At first I thought that perhaps it wasn't pine, spruce or deciduous, but it doesn't even appear in figure 4d. What happened to this forest that stands out in Figure 3? Figure 3 shows two northern catchments with Sr values not far from 110 mm, one is mostly forest with some peatland and the other has a bit less forest but still more forest than peatland. Figure 4 only shows one northern catchment with Sr values close to 110 mm. What happened to the other catchment? Figure 3 shows two northern catchments with Sr of 70-80 mm and one at about 50 mm, and these appear to be forests or mostly forests, but in Figure 4 the Sr values do not fit the same distribution of two in the 70-80 mm range and one at 50 mm but instead it appears that two are at about 70 mm and one at about 85 mm. These plots appear to be derived from somewhat different datasets with respect to Sr values. The data used in the figures needs to be made internally consistent, or explanations provided for data appearing in some figures and not in others.

From my experience, some pine species like to grow in sandy well-drained soil, and here contribution to discharge is likely high and transpiration low. In such a catchment the estimated T should be low and there will not likely be large deficits, even though the soil can get quite dry. Spruce trees like to grow in moist soil, often in poorly drained areas. Such areas don't often dry out and contributions to discharge also likely follow precipitation quite well, except following a drought when there is recharge; again such areas may not see very large deficits. So we have pine in dry areas with small deficits and spruce in wet areas with usually small deficits. Deciduous trees tend to have larger transpiration demands and can grow in poorly or well drained soils. If deciduous trees exist more often in areas with larger deficits and adjust their root mass accordingly, this may explain why the best correlation is for deciduous trees in Figure 4. However, much of this detail would be smeared out because each basin contains multiple tree and other vegetation types and probably a combination of wet and dry areas. With this in mind, I understand why the correlations and patterns are not as strong as one might hope for.

Some of the relationships appear to be curvilinear rather than linear, so it might be more informative to try fitting some nonlinear relationships (exp, log, polynomial) to see which correlations increase and whether the relative importance of parameters changes. Perhaps a flexible generic nonlinear model could be used.

More specific comments:

P4 line 4-7: Are the authors aware of the type of precipitation gauges used to measure snowfall, whether they were shielded and whether they were corrected for undercatch based on coincident wind speed measurements? Precipitation gauges always measure less than the true snowfall amount, but if properly located, shielded and adjusted using established correction factors based on wind speed, one can arrive at an accuracy that is comparable with a snow survey.

P4 line 22-23: I am somewhat perplexed that canopy interception is included for rain but not for snow, when it is well known that boreal forests can store close to an order of magnitude more mass of snow versus water on the canopy, and interception losses on the order of 30% or more are common over a winter.

P5 Section 2.4: I think an explanation of the specific method used to obtain Sr is required. I looked at de Boer-Euser et al. (2016) and based on that, I think I understand what was done, but a brief overview would be helpful.

In Figure 3 are the values of leaf cover and tree length basin values or are they specific to each vegetation type? I see for example the two northern basins with Sr near 70-80 mm and leaf cover near 24-28% in Figure 3d, and these appear to have corresponding large forest fractions, small peatland and smaller agricultural fractions with the same leaf cover values. This suggests that these values are basin-scale and are not specific to each vegetation type. Since most of the basins are forest-dominated, when we look at the peatlands or agricultural plots, in most cases when the fractions of these vegetation types are small, we are not looking at leaf cover or tree length values that have anything to do with the peatland vegetation or crops other than they happen to be in the same basin. This should be made more clear.

P6 line 19: The statement "…and this correlation decreases for higher percentages of peatland…" is a bit misleading. There hasn't really been an analysis of correlation for basins with high and low peatland cover. When I look at Figure 3f, it does appear that there may be some correlation between Sr and tree length in pristine peatlands for the basins with small fractions of pristine peatlands (because the correlation is coming from the larger forest fractions) and the pattern looks more scattered (implying a lower correlation) for the larger circles or basins with a larger peatland fraction. It should be made clear that these are just visual interpretations, not a comparison of calculated correlation coefficients.

P6 line 20: The variability in leaf cover and tree length is small within the boreal regions but appears greater when the three regions are examined together. It appears that factors affecting tree length and leaf cover act largely but not exclusively along the latitudinal gradient such that the correlation is weak within each region.

I think the strong relationship between Day of Year (date of snow-off) and Sr has more to do with the fact that the snow-off date is correlated with both maximum SWE and air temperature than a special relationship with the phase of snowmelt. For example, the timing of maximum SWE is probably determined almost exclusively by temperature, whereas the amount of maximum SWE is a combination of snowfall amount and temperature (and other factors).

P7 line 22: While it is true that the clearing of land for agriculture increases soil exposure (more evaporation) and crops tend to have high transpiration demands (more transpiration), there is also the likelihood that croplands are more prevalent in the south because of the longer growing season and increased likelihood of a successful crop. So did the crops in the south cause larger Sr values because of their higher water demands or were they planted in a warmer area because it is beneficial for the crops and that just happens to coincide with larger Sr values (warmer, more evaporative demand)? I would say it works in both directions.

P8 lines 1-3: Peatlands generally develop in areas where the soil does not dry out very often, either because of cold temperatures and low evaporative demand, or a combination of positive P-E and poor drainage. Since the soil does not tend to dry out, the Sr value calculated will be small because large deficits of P-T are rare.

P8 line 11-12: Maximum SWE and mean annual temperature and the snow off date are likely highly correlated within a small region. A regression model that attempted to include all three would almost certainly show that all three are not necessary. I would be inclined to predict that mean annual temperature and maximum SWE are the most important, but maximum SWE is partially dependent on mean annual temperature based on the length of the snow period and when melt starts. Perhaps mean annual temperature and winter precipitation would do better.

P9 line 6: I have read that jack pine have a tap root to access deeper water. If this is true of the pines in the Finland catchments, it may be that deeper water is accessed without a large increase in root density and this may lessen correlations between Sr and root biomass. The authors would want to find an appropriate citation before using this point as an explanation.

P9 lines 1-3: Yes, peatlands develop in places where the decomposition rates are slower than the annual increment, due to a combination of cold temperatures and/or poor drainage and anoxic conditions. Peatlands are created by the same conditions that cause the estimated Sr to be low, but I doubt that peatlands cause the small Sr values.

Minor comments and corrections:

Sr,20 is never defined in the text. It is stated in Section 2.3 that a drought return period of 20 years is used, but the symbol Sr,20 is not introduced here; it simply appears in figures but not in the text.

P4 line 21 and elsewhere: Why is SSWE used for Snow Water Equivalent instead of SWE?

P5 line 14: “Tree length” is never defined. It is certainly not tree height, but I don’t see the term in the literature.

P7 line 24-25: In Fig. 7c I might view the southern boreal region as showing a negative correlation between Drained peatland % and Sr with two outliers.

P9 line 24: I would change “. . .. for example indicates that. . ..” to “. . . for example may indicate that. . ..”

Figure 1: Add a North Arrow. Perhaps outline Finland so as to make the study area boundaries more clear.

Figure 3: The letters need to be on the plots (e.g. a, b, c . . .. h).

Figure 6: Change Julian date to Day of Year. Julian date or Julian day is not the same

as Day of Year.

Figure 8: What do the size of the boxes represent? There is no scale provided to interpret this.

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