

Divergent water balance trajectories under two dominant tree species in montane forest catchment shifting from energy- to water-limitation

Nikol Zelikova et al.

Author's response to Reviewer#1

Comment #1

There seems to be no consideration of the difference in the phenological phases between the beech stand and the spruce stand and their influence on the transpiration.

Response #1

Yes, you are right. The utilized modelling approach did not take into account phenological phases of particular vegetation. Hence, we have newly incorporated crop growth phases based on the seasonal variation of leaf area index in the beech forest. The approach originates from the FAO56 manual and adjusts the rate of potential evapotranspiration based on the crop coefficient (K_c). In our case, it is expressed as a ration of LAI_{actual} to LAI_{max} , hence varying from 0 to 1. This enables the gradual increase in transpiration of beech with the onset of growing season as the PET will be multiplied by increasing value of K_c .

It inevitable led to the new calibration of the model at the beech site (new model parameters in Table 2), which resulted in slightly different values of water fluxes and therefore changes in Table 3 and Figure 6,7 and 8. The seasonal values remained nearly the same but there is more pronounced difference in summer/winter rates of transpiration and drainage between both sites.

Comment #2

Since data for the Penman-Monteith (P-M) method has only been available at this location since 2008, it might be reasonable to extend the time series with this simple approach. However a comparison with a more refined method should be shown in the manuscript or at least in the supplementary.

Response #2

We newly present the comparison with Penman-Monteith approach (that was a part of responses to reviewers) in the supplementary material (Fig S6).

Comment #3

The relative homogeneity of vegetation is not a strong indicator for the representativity of the soil moisture measurements. The convenient placement of the sensors is also only a necessary condition but not sufficient. Soil structure, particularly in soils with a high skeleton content, is much more important for water drainage, root penetration and finally plant-available water.

The additional measurements with the UMS T8 indicate a reasonable correlation with the Thies sensors. Please, put the graphics also in the supplement.

Response #3

Unfortunately, I am afraid that we cannot add the required plot into supplementary material as it was already published in another journal (eventhough also in the supplementary material). Hence, in this case, we would prefer to keep only the reference to our previous manuscript where the plot is easily accessible.

Comment #4

I still miss a graphical presentation of the soil moisture changes observed over time. Could you add the average values of soil moisture and runoff to Figure 2.

Response #4

We have newly modified Fig 2 so that it contains average seasonal soil water content and runoff.

Comment #5

Thank you for the exceedance probabilities of pressure head (Fig. 3). I am wondering why the probability for the entire period does not run in between the dry and the wet years. Why is the pressure head by 100 % probability of exceedance not the same for entire period and for wet years? Likewise, why is the pressure head by 0 % probability of exceedance not the same for entire period and for dry years? This should be the minimal and maximal value contained in both datasets respectively.

Response #5

Thank you for the thoughtful comment, we have constructed the average exceedance probabilities for the entire period in the wrong way. Originally, we made an average daily pressure head for each particular day (as it is usually done in streamflow analysis) instead of taking the entire dataset in consideration without averaging, which lead to the fact that the probabilities for the entire period did not run in between the dry and wet years. Now it is constructed correctly so that the exceedance probabilities for the entire period run in between wet and dry years and similarly pressure head of 0 %/100% probability of exceedance is the same for entire dataset as for dry/wet years.

Comment #6

Please, place a concise description of the categories directly after L293 "... seasonal development of their measured pressure heads.", i.e. move the part after L314 up to L293 and complete it with values (L314 is not a sum up, but a qualitative definition of the categories).

Response #6

The description was moved.

Comment #7

- The description of the model parameterisation and validation has improved with subsection 2.4, but it still needs some clarification. Please, make short sentences and use tables or lists for description of parameters. Clearly indicate which parameters are calibrated using which data and quality criteria.
- If you use the runoff for calibration you need to define the areal distribution of beech and spruce in the catchment.
- L230 You state "4 sub-periods for cross-validation". Cross-validation is a statistical technique used to evaluate how well the results of a model or analysis will generalize to an independent, unseen dataset. It involves partitioning the available data into subsets, training the model on some of these subsets, and testing it on the remaining ones. This process is repeated multiple times to ensure that the model's performance is robust and not just tailored to a specific portion of the data. ... It is not clear what is the unseen dataset which you use for the cross-validation.
- I would assume that there is a difference in the parameter set for summer and winter, at least at the spruce site.
- L240: "forward modelling"? Did you start with a known model and predict observations? It is more "inverse modelling", where you derive the model parameter, i.e. the model, from observations.
- L241 "Besides the model run in the period of available soil water potential measurements (2000–2021), the model was run also from 1975 to 1999 using the calibrated model parameters and available air temperature and precipitation sums to quantify annual AET for the entire observation period." This description is not really reproducible.

Response #7

- The first paragraph of the 2.4 section was rewritten and the list of model parameters was newly added to Table 1.
- The area distribution of beech and spruce is mentioned in the 2.1. Study site section (line 114)
- We have newly made clearer what were those unseen datasets in line 241-242
- Although, it is a very tempting approach, which we have already explored (Sipek and Tesar, 2017) we did not use different parameter sets for summer and winter in this study.
- It was an improper phrase, which was deleted.
- The section was rewritten (lines 236–239).

Comment #8

How is the influence of tree type regarded?

You respond "The influence of tree type is reflected through different parametrization of the effective wetness (θ_E) restricting the rate of PET." However, the parameters θ_S and θ_R depend only on the soil type and soil structure, not on the tree type.

Response #8

You are absolutely right that the mentioned parameters depend on the soil type, but in reality, they also reflect the vegetation properties as the slope of the PET reduction in Feddes function (given by the difference in θ_S and θ_R) varies among both sites. Additionally, as we implemented the crop growth phases based on the seasonal variation of leaf area index in beech forest (which influence both transpiration and interception), the tree type influence is incorporated in the model.

Comment #9

These are indeed a complex relationships; one could also investigate the dependence on the soil moisture of the previous year or the runoff.

Response #9

Yes, we did that originally as well but the correlation was very low (correlation coefficient was -0.11) as for the snow cover and air temperature; hence we did not include the information.

Comment #10

Fig. 7: Budyko plots are interesting. Please, compare the slightly changed form in Renner et al. (2014). In my opinion it is somewhat clearer.

It is also to consider that in this study PET is only a linear function of the air temperature. A trend in PET is therefore initially a trend in temperature. AET is then the relative filled soil water storage times "Temperature" plus interception.

For $PET/P < 1$ the system is just energy limited, crossing the line of $PET/P = 1$ the system is additionally water limited. Instead of Fig 5 a) with the 5 year sums I would prefer a time series of AET/PET it might be that the shift between the two spaces in time is better visible using this relation.

Response #10

Thank you for the reference to the article of Renner et al. (2014) which we did not know. We newly modified the Fig 7a in order to express AET in the relation with PET as it better represents the long-term shift from energy to water limited environment (than the 5y averages) by the decline of AET/PET ratio and occurring divergence between beech and spruce site.