Review of HESS-2017-723
Speich, Lischke, and Zappa
Testing an optimality-based model of rooting zone water storage capacity in temperate forests

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In this manuscript, the authors use eddy covariance and soil-moisture measurements from fifteen European sites to calibrate a water-balance model (FORHYTM). Root-zone storage, one of the calibrated parameters, is then compared with predictions of root-zone storage (Sr) from two theoretical models - G08, G10 – that presuppose optimality for plant-roots with respect to carbon. In the interest of transparency, I acknowledge that I am the author of the papers that originally presented those theoretical models (Guswa, 2008; Guswa, 2010).

I have seen only the revised version of the paper, and the authors seem to have addressed the comments of the previous reviewers. With respect to the results and discussion, I offer two additional comments:

1. The Mediterranean sites (IT-Sro, IT-Ro2, and IT-Col) are three sites for which the optimality-based Sr was calculated to be far less than the calibrated. Thus, it may be that "net carbon profit apparently does not appear to work so well" at those sites (as mentioned by Dr. Savenije, Reviewer #1). The authors mention that the difference between calibrated and optimal may be attributed to the fact that these sites have lower performance of the water-balance model (so the calibrated Sr values are subject to uncertainty) and that these sites have younger vegetation and may also be affected by the presence of shallow groundwater.

An additional explanation for the difference could be the inadequacy of the precipitation model; indeed, in a Mediterranean climate, the intermittency of events during the growing season is likely not as important as the lower-frequency signal of wet and dry seasons. Such seasonality is not well represented by the Poisson model of rain arrivals; it may need to be approximated by using a much lower frequency of events (see section 2.2.1 and Figure 4 in Guswa, 2008).

2. Another issue that may be confounding the results is the method by which the authors separate the root zone into understory and overstory components, which are then summed to get the total root-zone storage capacity. My understanding of the way that this is accomplished is as follows:

a. the evaporative demand (Epot) is partitioned into an overstory and understory evaporation based on LAI.

b. a wetness index for the overstory (W,o) and the understory (W,u) is computed by Peff/Tpot,o and Peff/Tpot,u, respectively. The authors acknowledge that they are ignoring competition for Peff between the overstory and the understory.

c. A root-zone storage (depth) is computed for the overstory (Sr,o) and understory (Sr,u) by applying the optimality models G8 and G10, using W,o and W,u, along with vegetation parameters.

d. The total root-zone storage is computed by summing Sr,o and Sr,u

The challenge with this approach is that the optimal root depth (or root-zone storage) for the overstory and understory is based upon wetness indices (W,o and W,u) that are not necessarily representative of the climate. By partitioning the energy between overstory and understory, but not partitioning the water, the wetness indices will be larger than they should be. In reality, not all of Peff would be available to the understory, nor would it all be available for the overstory. However, the formulation in the paper computes the wetness index presuming that all of the precipitation is available to both the understory and the overstory. Thus, the optimality models, G8 and G10, would compute a root depth for the overstory and understory based on a wetness index that is too wet. This, combined with the non-linearity of root-depth as a function of wetness, means that the total root-zone storage will be a strong function of LAI, not only because LAI dictates the partitioning of energy between overstory and understory but because it also changes the wetness index.

As an example, using parameter values that are similar to those used in the paper, the table below shows how total root-zone storage changes as a function of LAI, even when the vegetation parameters are the same in the understory and overstory. For example, with an LAI of 2, the energy is partitioned approximately equally between the understory and overstory, leading to W values of approximately 2. When LAI,o is very large or very small, however, the wetness index for the dominant vegetation type is closer to 1. This leads to root-depths that vary from 150 mm to 240 mm, revealing a potential artifact of the method.

Andrew J. Guswa	Peff =	2.5 mm/day	theta =	0.15
Review of HESS-2017-723	Epot =	3 mm/day	alpha =	15 mm
15 May 2018	k =	0.5	theta/alpha	0.01 mm^{-1}
			Beta/Tpot =	1.67E+02 day/mm

LAI,o	Tpot,o mm/day	Tpot,u mm/day	W,o -	W,u -	Beta,o -	Beta,u -	Sr,o mm	Sr,u mm	S,total mm
0	0.00	3.00		0.83		500.0	0	230	230
1	0.89	1.82	2.82	1.37	147.6	303.3	43	140	183
2	1.42	1.10	1.76	2.27	237.0	183.9	86	58	144
3	1.75	0.67	1.43	3.73	291.3	111.6	128	30	158
5	2.07	0.25	1.21	10.15	344.2	41.0	189	9.5	199
10	2.23	0.02	1.12	123.68	372.5	3.4	233	0.7	234
20	2.25	0.00	1.11		375.0		238	0	238

Beta is the beta parameter from Guswa, 2008, which combines vegetation parameters with climate and soil

Of course, I may be misinterpreting what the authors have done. I recommend that the paper be returned to the authors for revision, comment, or correction with respect to partitioning the root-zone storage between the overstory and understory. I would be happy to answer questions that the authors might have.