Review of Tijdeman and Menzel: Controls on the development and persistence of soil moisture drought across Southwestern Germany

General comments

This manuscript investigates the role of soil characteristics in the root zone and climate properties in determining the probability of occurence and characteristics of agricultural drought. The manuscript is well written albeit sometimes rather lengthy and repetitive. Analyses are systematic as is the presentation of the results. The main conclusion to my understanding is that root zone storage characteristics are important for agricultural drought assessment and people should not only look at meteorological metrics. Although I fully agree with that statement irrespective of the results in this study, I do not think that this statement is justified based on this study's findings. My main issues are:

- The data used for the available water-holding capacity (AWC, i.e., the amount of plant available water in the root zone at field capacity), might not be representative for the actual amount of water available to vegetation at all and could be significantly biased as climate and land cover types are in reality the main controls on root zone storage capacity and not the soil type. This would be fine, however, if we would accept that AWC is simply a soil characteristic, but then the definition of soil moisture stress occuring at 30% AWC might be biased instead.
- Conclusions are drawn on AWC being a control of reaching 30% AWC. This is clearly circular reasoning and those findings can hardly be considered surprising.
- This study evaluates the soil moisture within a hydrological model (TRAIN), however, there is no information shown on the setup of the model and whether this model performs well at all based on streamflow or other measurements. This might be shown in the papers that are referred to, but I would find it useful here as well. Neither is it evaluated how crucial information/parameterization affects the results. Does the in- or exclusion of the AWC data vs. a fixed value improve model performance? Is the vegetation water stress formulation in TRAIN really the best and would other parameters lead to worse or better streamflow predictions?

Conclusion: although the research is systematic and well presented, and I do not have a lot of comments, I personally do not see how the authors would be able to address these comments without adding new analyses. Doing so, would make the revision deviate considerably from the original submission and, therefore, I would recommend a rejection with the encouragement to resubmit, rather than major revisions. I believe that although this is a harsh recommendation it would also be in the interest of the authors themselves to have a revised manuscript evaluated starting from the public discussion phase.

Specific comments

L38: "Droughts are often defined as a below normal water availability"

I would have expected some critical reflections on this directly in or directly after this paragraph and not by the end of the introduction.

L75: "which is indicative for low soil moisture levels causing drought stress for plant"

Given the fact that at this point in the introduction drought has only be described to be defined as an anomaly and not as an absolute measure, low soil moisture levels can occur without having a drought, so the plants in this example just experience water stress and not drought stress.

L109: "Vectorized soil property data (field capacity and wilting point of the root zone soil) were derived from the BK-50 (scale of 1:50,000) dataset provided by the Federal State Office for Geology Resources and Mining (LGRB, 2019)."

Is this the available water-holding capacity in the rootzone? Does it include thickness as well as soil type? This is not clear. More importantly: how do you know that plants' roots really access all this water? There have been many studies showing that the root zone storage capacity is not a characteristic of the soil, but mainly that of the climate and the plant (e.g., de Boer-Euser et al., 2016; Fan et al., 2017; Gao et al., 2014; Guswa, 2008; Kleidon, 2004; Nijzink et al., 2016; Speich et al., 2018). Therefore, it should be made clear in the manuscript that AWC is a soil property within a part of the rootzone, but not necessarily a characteristic of the rootzone itself, and may even be completely unrelated to root zone water storage capacity.

L145-146: "Thus, the root zone soil is not subdivided into different layers but understood as one uniform soil column."

Does it have a specific pre-defined thickness? Was it calibrated on something? This is a crucial parameter, so a more comprehensive description would be useful to the reader.

L218-L220: "The latter suggests a stronger influence of root zone soil characteristics, over the influence of the climatological setting, on whether or not SM drought stress developed. SM drought stress was further found to be more likely to develop in soils that have a lower AWC (Fig. 5a), as the likelihood of Socc increases with decreasing AWC."

Yes, obviously this is the case. The probability of occurrence of SM drought stress (defined as <30% of AWC!) is related to AWC. It's extremely obvious that these variables are related, so it's not surprising at all to find a strong relation, especially as this is an entirely model-determined results. This is clearly circular reasoning and can hardly be considered surprising.

L302-L303: "SM drought stress was generally more likely to develop, and evolved faster and earlier in the year, in shallow root zones with a lower AWC."

Yes, obviously this is the case as SM drought stress is defined as <30% of AWC! This is again clearly circular reasoning and can hardly be considered surprising.

L305-L306: "Results also confirm that AWC of the root zone is an important factor to determine the vulnerability to agricultural drought"

In your model that is and with a definition where agricultural drought is defined as a percentage of AWC. This conclusion is, therefore, overstated and should be withdrawn in case it cannot be backed up with any observations (crop yields, vegetation observations, etc.) or hard proof that the hydrological model is a reliable descriptor of true states and fluxes.

L352: “However, roots do not necessarily utilize the water in the entire soil column”
Exactly! Or they are able to access more water than what you think based on the soil map and model parameterization. There would likely be great differences between forests, grasses and crops and the roots would develop differently under different climates. Therefore, what you define as soil moisture drought stress could be far from reality.

L357: “However, by analyzing a large sample of grid cells, we cover most combinations of root zone characteristics and climatological settings that occur within the study region”
Even if we accept that the rootzone characteristics and climate to be wrongly represented in individual grid cells, you have no basis to claim that the probability distribution function of root zone vs. climate is representative of reality.

Technical corrections

L34: “aerial overview”
What does this mean? Aerial in the literal sense or as a figure of speech? Perhaps just use overview.

L71: “it’s”
its

Fig 1. The numbers on the side are probably some kind of coordinates, but not defined. Moreover, all text is really small and difficult to read.

L114: “watt/m^2”
Just an example, but notation should be W m^{-2} (please look at HESS Mathematical requirements)

L123: “T, Uspeed, RH and RG”
Just an example, please avoid acronyms where a single symbol could easily be used and use italic notation for physical quantities (please look at HESS Mathematical requirements)

Fig. 3. Units missing in the legend.

L204-L205: “For ease of notation, we omit the grid cell and year identifiers (i and y) from the variable subscripts in the remainder of this paper.”
I don’t think it was necessary then to introduce i in the first place. Moreover, y is used in the remainder of the manuscript making the statement incorrect.

Fig. 5 and beyond. What is defined here as likelihood should be probability. There is no hypothesis testing or anything that would justify using the term likelihood.

L229. “at least once in a year (Socc = 1)”
The symbol of at least once is ≥ and not =

L330: “vegetative stress”
Water stress for vegetation

References

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