Reply to the editor:

Dear authors,

thank you very much for submitting a revised version of your work. I have now received the evaluation of one reviewer. The reviewer commends the efforts you invested to address his/her previous comments. I agree with that and think that the manuscript has strongly improved. The reviewer provided a few additional suggestions, which I strongly encourage you to address in a second revision.

I am looking forward to receiving the revised manuscript soon.

best regards,
Markus Hrachowitz

Dear editor,

Thank you very much for your second evaluation of our manuscript. We incorporated the remaining remarks of reviewer #1 in a new version as outlined below.

(1) We placed more emphasis that our focus is on agricultural regions
(2) We added additional model evaluation and show, amongst other things, that there are no systematic biases related to the available water-holding capacity of the root zone.

Kind regards,

Erik Tijdeman and Lucas Menzel

Reply to the comments of reviewer #1:

General comments

"This manuscript investigates the role of soil characteristics in the root zone and climate properties in determining the probability of occurrence and characteristics of agricultural drought. Although I was very critical towards the initial submission and even recommended rejection with a resubmission, I would like to complement the authors with the way the managed to improve this manuscript. In my opinion only a few issues remain."

We would like to thank the reviewer again for the helpful and critical remarks during two rounds of review. They challenged us to significantly improve the previous versions of the manuscript. Below, we reply (in blue), to the remaining remarks of the reviewer (which are shown in black). The line numbers refer to the track-changed version of the manuscript.

- "The authors write in their reply that their main focus is on agriculture, hence justifying a purely soil-based (and not climate-based) metric for $S_{rootzone}$. Yet, I do think that the focus on agricultural regions should be mentioned more explicitly at the end of the introduction where they introduce their objectives (end of Section 1), in the description of the study region (Section 2.1), in the description of their modelling approach (Section 2.3) and in the conclusions (Section 5). Also, it should be made clear why some areas that hardly have any agriculture were not left out of the analysis. "

- We emphasized our focus on agricultural grid cells at the points suggested: Introduction (Line 98), Section 2.1 (Line 114) and Conclusion (Line 588). It was already stated in Section 2.3 (line 178). The considered agricultural grid cells all have agriculture as their major land use class. These grid cells include areas known for their agricultural production (e.g. Rhine Valley) but also exist in some regions that are not known for their agriculture e.g. some more-local agricultural activities.

- "I am happy to see model performance analysis of the TRAIN model, yet, I think this can be taken some steps further in order to rule out the possibility that the conclusions about the importance of AWC are based on systematic errors in estimating the available water to plants (i.e., AWC). Some suggestions: "

- We evaluated the model based on the suggested evaluation criteria.

  - "In Figure 5 it would be interesting to see whether there is a relationship between over- or underestimation of the observed flow with AWC. The authors could, for example, include a color scale with AWC and give each dot a color corresponding to the average AWC in that catchment to show, hopefully for the authors, that AWC is not systematically associated with an over- or underestimation."

- We changed Figure 5a according to the suggestion. We noted that there are no systematic biases associated with the AWC (Section 3.1, Line 292-293). Thanks for the idea on how we could include this information in the Figure.

  - "The same analysis as Figure 5 could also be performed on monthly basis. In case this just confirms Fig. 5 just as supplement, but in case significant problems occur, the authors might need to reconsider the fact that AWC in the TRAIN model is not calibrated."

- We evaluated the monthly performance of TRAIN. However, as outlined in the revised manuscript, TRAIN does not directly simulate river flow but rather percolation and runoff (Section 2.3, Fig. 2). The delay in groundwater response to streamflow in not considered in the percolation signal. To evaluate monthly model performance, we used the following approach to consider differences in catchment response (inspired from Barker et al. 2016; described in Section 2.4, Line 226-232).

  (1) Accumulate the sum of catchment average percolation and runoff over n-month periods (1-12 months), i.e., percolation in the current month, percolation in the current and previous month etc. (similar to the accumulation of the Standardized Precipitation Index).

  (2) Correlate all accumulated time series with monthly streamflow for each catchment and calendar month

  (3) Identify the accumulation period with the maximum correlation for each catchment and calendar month.

  Given that the found maximum correlation coefficients are of the same magnitude as Fig. 5b, the corresponding Figure is added to the supplementary material (Fig. S2), as suggested, and described in Section 3.1 (line 292-293).

- “Include a figure that answers the question: What is the performance of TRAIN in specific drought years and does or does that not relate to AWC? “

- We compared for prominent drought years 2003 and 2018 observed streamflow anomalies with anomalies in the sum of simulated percolation and runoff accumulated over the n-month period with the strongest correlation with observed streamflow (Fig. S3). Their anomaly distributions across all catchments were similar (Fig. S3, a-d). The differences between percolation- and streamflow- percentile time series were generally small and unsystematic (Fig. S3, g-h). Finally, biases were not related to the catchment average AWC of the root zone (Figure R1). Because we now already show that biases are not related to the AWC of the root zone (Fig. 5a), we suggest not to include this Figure. Finally, Fig. S2 in the previous version, showing that periods with below normal river flow coincide with periods of below normal soil moisture, has been integrated in Fig. S3 of the current supplementary material.

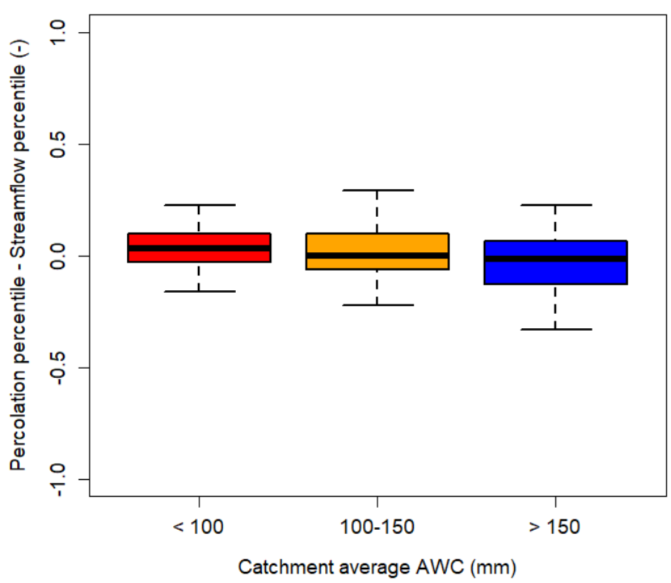

Figure R1. Difference between observed streamflow percentiles and percentile of the sum of simulated percolation and runoff accumulated over the n-month period that has the strongest correlation with streamflow. Shown for the growing season of prominent drought years 2003 and 2018 for all catchments, i.e. all values shown in Fig. S3g-h, grouped by catchment average AWC.

Technical corrections

“Fig. 7. One of the y-axes still has ‘likelihood’ instead of probability. Please correct.“

Corrected as suggested.

Reference:

Barker, L. J., Hannaford, J., Chiverton, A., and Svensson, C.: From meteorological to hydrological drought using standardised indicators, Hydrol. Earth Syst. Sci., 20, 2483–2505, https://doi.org/10.5194/hess-20-2483-2016, 2016.