Authors' Response to Reviews of

Using statistical models to depict the response of multi-time scales drought to forest cover change across climate zones

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Hydrology and Earth System Sciences (HESS)

RC: Reviewers' Comment EC: Editor' Comment AR: Authors' Response

Dear Prof. Dr. Genevieve Ali,

We hereby submit the second revised version of our paper entitled "Using statistical models to depict the response of multi-time scales drought to forest cover change across climate zones".

We would like to sincerely thank the editorial office and the reviewers for the efficient handling of our manuscript and the constructive suggestions that helped to improve the quality of the paper. We have carefully addressed all the comments and a produced a revised version of the manuscript where they are considered. Changes following the comments of reviewers are marked in an independent file with track changes.

To address the reviewers' comments, we provide a more detailed explanation regarding grid-point-wise training and detrending analysis methods, and highlight the distinctions between these two methods in the revision manuscript. To clarify this aspect of our study, we also have adjusted the text accordingly.

Please do not hesitate to contact me should you need any more information.

Yours sincerely,

Yan Li

(On behalf of the co-authors)

Editor

EC: Two reviewers have assessed your revised manuscript. They appreciated the changes that you made, which add up to a more robust manuscript, but still raised a few comments for you to address, especially when it comes to **methodological approaches/statistical analyses**. Because at least one of the suggestions made by reviewers would require **a data re-analysis for comparison purposes**, I am returning your manuscript for moderate revision. Please note that upon reception, your revised manuscript will be sent back for review.

AC: We would like to sincerely thank your efficient handling and suggestion to improve this manuscript. Regarding the comment on grid-point-wise training and detrending analysis, we provide further answers and explanations on statistical methods. We use a generalized linear model (Eq. (5)), not a traditional linear model, which has an analysis of interaction (more explains in Line 235-238) and therefore cannot interchange averaging and model building. The grid-point-wise training work can be served as an extension of the present work (discussed in the text L501- 505). For detrending analysis, we focus on a statistical description of drought indices as functions of temperature, precipitation and forest cover, independent on external drivers of these variables. Figure B1 help us identify any underlying trends over time that may not be accounted by the existing predictor variables (temperature and precipitation) (more explains have been added in Line 288-292).

Anonymous referee #1

RC: The authors tried to answer all my concerns point by point. However, I was expecting more in detail analysis.

AD: Thanks for the useful feedbacks to improve the quality of the manuscript and we add more details in the analysis.

RC: show that the grid-point-wise training and the averaging over the categories lead to the same results (at least for one category);

AC: For the linear model in Eq. (5), it is not possible to interchange averaging and model building as there are interaction terms (more explanation about the interaction in L235-238). Hence the result from first building a grid-point-based model and then averaging the result will in general not yield the same result. The interpretation for these two approaches differ: The result from our approach quantifies the effect of aggregated forest cover change, temperature and precipitation on an aggregated drought index for a given climate zone.

Modelling individual grid-points is a lot more difficult as there are -- as you say -- very heterogeneous influences which we cannot grasp with the model presented. We focus on large scale effects here. (As an outlook, one could split up the climate zones into large regions and look for differences.)

And we also add some explanation "In our research, to simplify the initial study, we chose to aggregate data across different climate regions. This approach helps to smooth out localized variations and complexities. Going into a more detailed spatial analysis would be a deeper level of investigation. However, it's important to note that the conclusions might not be entirely consistent when transitioning to a grid-point-wise training approach. This inconsistency arises due to interaction terms in the model building process." (in L501-505)

RC: show that the detrending would lead to the same results as in the original time-series,

AC: For the detrending: the purpose of our model is to quantify changes in drought indices as results of changes in forest cover, temperature and precipitation. If we remove trends in the target variable (drought index) and the covariates (temperature, forest cover, precipitation), we would change the relation between the drought index and our covariates. For a more elaborated answer on detrending, see our last reply page 15.

Anonymous referee #2

RC: I would be happy to accept the manuscript. We thank the authors for their careful revisions to address my comments. I am overall satisfied with the authors' revisions and responses. The manuscript is much clearer than the original one, particularly for the Method section. I acknowledge that I do have a bias against using linear regression model to address the issue with multiple physical processes being fully coupled. Nevertheless, I think that the linear model used here is perhaps a useful tool to examine the effects of forest cover changes, as well as temperature and precipitation, on drought. I appreciate the authors' effort to add some explanations on their findings in the revised manuscript, but some results are still not sufficiently explained. Please see my detailed comments below.

AC: Thanks for the appreciation of our work and the useful feedbacks to improve the quality of the manuscript.

RC: Line 356-361: It sounds plausible that afforestation reduces PET via an increase in air humidity when precipitation is higher than above. However, I still cannot understand why afforestation increases PET when precipitation is lower than above. The authors attribute the increased PET to the water supply restriction. It is true for actual ET but not necessarily for PET. I am wondering whether the increased PET is linked to higher net radiation (according to the Penman–Monteith Equation), with the latter being further attributed to the lower albedo of higher forest cover.

AC: In this context, it's important to note that the temperature remains constant throughout the analysis (in the first and second rows of Figure 6). The change of net radiation is not involved. Consequently, the variations in drought conditions are solely influenced by changes in water supply. To clarify this aspect of our study, we have adjusted the text accordingly (Line 366-382).

We can see that the influence of forest cover on drought conditions varies depending on precipitation levels and geographical regions. For SPEI03, it appears that forest fraction has a relatively modest impact across various levels of precipitation (lines are close to be horizontal). This suggests that precipitation does not significantly modulate the influence of forest cover on the short-term drought index (the first row in Fig. 6). However, when we examine SPEI24, a different pattern emerges. There is a strong influence of precipitation on the forest fraction effect (the second row in Fig.6), particularly in arid regions (as seen in Fig. 6F). In general, as precipitation increases beyond the median level, the drought index tends to rise with increasing forest cover. This phenomenon can be explained by increased transpiration associated with larger amounts of precipitation, resulting in a reduced vapor pressure deficit (VPD) and, consequently, lower PET. This leads to higher SPEI24 values when forests are denser. Furthermore, forests have the capacity to intercept precipitation and diminish ground-level wind speeds. These combined effects contribute to a reduction in PET as forest cover increases. If precipitation is lower, this effect decreases and the slopes in Fig. 6F get smaller. There is not sufficient water to be evapotranspirated, even if the forest fraction increases. For a specific amount of precipitation (about the median) the slope is 0. When the precipitation is less than this amount, we see a negative slope suggesting the interpretation that for restricted water supply, an increase of trees leads to an increase of PET and hence to a decrease of SPEI24. An opposite effect can be observed in snow region (Fig. 6N). Here, with minimal forest cover, precipitation directly affects the SPEI24 leading to a more humid situation with higher precipitation. However, with forest cover increases, this direct effect vanishes. It's worth noting that for snow regions, the model captures less than 30% of the total variability, indicating the complexity of this relationship.

RC: Line 371-374: The authors find that higher temperature leads to negative responses of SPEI03 to forest cover increases. Their explanation is that "rising temperature leads to increasing transpiration from trees, and if there are more trees, more water will be taken away, and the drought indices will decrease". This explanation is not complete as the authors uses PET and P, instead of soil moisture, to measure drought. I think the full explanation should be more trees->higher evapotranspiration->less soil water->less evapotranspiration->higher VPD->higher PET->lower SPEI.

AC: Thank you for your suggestion. The precipitation remains constant throughout the analysis (in the bottom two rows of Figure 6). Yes, rising temperature leads to increasing transpiration from trees, and increasing transpiration will increase PET, then conducting a decline of drought indices. We revised the manuscript according your comment. “Elevated temperatures trigger greater transpiration rates from trees. When there is an abundance of trees, they collectively draw more water from the soil. This depletes the water content in the soil, and when soil moisture becomes insufficient, it results in reduced evapotranspiration. This decrease in evapotranspiration leads to a higher vapor pressure deficit, and subsequently, an increase in PET. This shift toward higher PET values often corresponds with a decrease in drought indices.” (L390-394)