

We thank the reviewers for their valuable and useful comments on this manuscript. We believe that their suggestions will further improve our manuscript and we can address these comments in the revised manuscript. These comments are in line with the complexity of the problem this paper seeks to discuss, and we feel highlights the importance of the paper as a means of adding clarity on how hydrologic models change in the changing world we live in. Please see below our response to each of the reviewers' comment.

## **Anonymous Referee #2**

I am very interested in the analysis and discussions about the different influences of vegetation cover and climate changes on runoff in the manuscript. But in my opinion, some analysis is unconvincing and some conclusion is arbitrary. So, I suggest the authors conduct further improvement on the manuscript. Major comments are given below.

1. I suggest that the authors change the usage of “non-stationary catchment”. Significant increasing or decreasing doesn't mean that the catchment is not stable. On the contrary, non-significant trend also does not mean stationary.

Thank you for providing this comment. The term “non-stationary catchment” is used for a matter of brevity in the manuscript. In some cases, we have used the term “catchments with non-stationary hydrologic response” in the manuscript. We will clarify the above usage further in the revised manuscript.

2. What I am most interested are figure 3 and figure 4. For figure 3b, the authors state that “In catchments with positive precipitation fractional vegetation cover relationships, fractional vegetation cover sensitivities decline with increases in annual precipitation across the catchments”. But I would argue that, fractional vegetation cover sensitivity increases significantly with increases in annual precipitation across the catchments when precipitation is smaller than 700 mm; Authors also concluded statement “Fractional vegetation cover sensitivity is highest in the xeric (arid) catchments with lower mean annual precipitation compared to the rest of the non-stationary catchments” from figure 3b. But I cannot see any direct index reflecting “arid”. I would suggest that authors plot  $dF_{tot}/dP$  against with  $PET/P$  in figure 3b, as well as in figure 4a.

We will revise this statement in the revised manuscript to state that “across catchments with positive precipitation fractional vegetation cover relationships, fractional vegetation coverage sensitivity approaches zero in catchments with higher mean annual precipitation”.

We will incorporate reviewer comment to show aridity-index with  $dF_{tot}/dP$  in the revised manuscript and similarly for figure 4a. Catchment 7 with the lowest amount of mean annual precipitation has the largest aridity-index among non-stationary catchments.

3. For figure 3c, the authors should point out: what ranges of HI values mean dry and what HI values mean wet? It is also interesting that in wet regions (low HI), vegetation cover increases when the climate becomes dryer (HI increases)? Authors should give reasonable explanations.

In arid and semiarid catchments, quick flow constitutes most of the total streamflow ( $S$  is almost equal to total runoff in equation 3). Therefore, we expect HI to approach 1 in arid catchments. In humid catchments, quick flow runoff is smaller than the total stream flow and HI is less than 1. In catchments with limited storage, HI is undefined (0/0) (Troch et al., 2009). We will clarify these ranges in the revised manuscript. Please see Troch et al. (2009) for additional details.

The second question is a very important point and it is a subject of further investigations to identify the exact cause of vegetation increase under dryer conditions in group B catchments. One plausible mechanism as discussed here and in an earlier paper by Brooks et al. (2011) is nutrient limitation as similar behavior is also observed in some of the MOPEX catchments located in the humid climate. In this paper, we hypothesize that nutrient, light and temperature limitations may contribute to the observed response. With limited data on sunshine hours, we were able to show that in some of these catchments light limitation contributes to the observed pattern. However, no information about nutrient content is available to test this hypothesis. We also used various remote sensing datasets to make sure the observed pattern is not the artifact of remote sensing data. The next step is to use ecohydrologic models that can incorporate nutrient limitation in simulating carbon dynamics and vegetation growth.

4. For figure 3d, because high  $F_{tot}$  always locates in wet regions. So, according to figure 3d, in dryer regions (low  $F_{tot}$ ), runoff coefficient always increases as vegetation cover increases? This is conflict with the conclusion that reforestation and forest growth usually significantly decrease the runoff in dry regions.

To clarify this point, we refer to Figure 5b where interactions between precipitation-fractional vegetation cover and runoff ratio are outlined. As can be seen in Figure 5b, positive correlations between precipitation and fractional vegetation cover exist in water limited catchments (Group A). This means that higher precipitation increases productivity and  $Q/P$ . As can be seen in Figure 3a and 3b, sensitivity of runoff ratio to fractional vegetation cover is positive in drier catchments (water limited catchments based on our classification). As period of higher productivity coincides with higher precipitation (positive precipitation-fractional vegetation cover relationship) in these catchments, runoff ratio increases in years with higher precipitation. It should be noted that the percentage of tree cover in these drier catchments are more than 60% with a few exceptions (Table S1, supplementary Information). In Group B catchments percent tree cover is higher than water limited catchments. Overall, mean annual runoff ratio and its variability (standard deviation) are smaller in drier catchments with smaller mean fractional vegetation cover (Figure 2). We will clarify this point in the revised manuscript.

5. For figure 4b, the authors concluded that “: in catchments where groundwater constitutes significant component of stream flow, fractional vegetation cover exhibits smaller variability: :”. I would also suggest that the authors used the ratio of base flow to total runoff to replace the mean based flow as the x axis.

We will use baseflow index instead of mean baseflow in the revised manuscript.

6. The authors only analyze the vegetation cover besides climate factors. Former studies showed that catchment area and slope etc. are also very important factors, which might significant influences the changes of runoff to climate and vegetation cover changes. The areas of selected

catchments ranges from 6.6 to 232846 km<sup>2</sup>, which might bring unexpected influences on the analysis about figure 3 and 4. That is also probably the reason while only 20/166 catchments showed significant trends in runoff coefficients. So I suggest the authors should consider other catchment factors and explain the underlying reasons.

We will explore the impact of slope and area in the revised manuscript. However, within non-stationary catchments no significant differences in catchment mean slope exist and catchment area ranges from 18.7 to 5158 km<sup>2</sup> (Table 1).

7. Lack specific data and method descriptions. For example, authors didn't explain how ET and PET were calculated etc.

Thank you for your comment. We will include detailed descriptions of ET and PET computations in the revised manuscript.