Response to Reviewer #1

R1. This article looks at methods for partitioning changes in the rainfall-runoff relationship between vegetation changes, climatic variation, and non-stationarity in runoff generation.

Response: Thanks very much for your great efforts to assess our manuscript. We have studied your and reviewers' comments carefully and will make corrections/revisions as suggested. In the following, we have detailed how these comments (in black) are raised and our responses (in deep sky blue).

R2. The three acronyms PCM, TTM and SBM are introduced and explained in parentheses by the second sentence of the Abstract, but not until the third paragraph of the Introduction and then after the acronyms are already used. Please use and explain them as soon as they are mentioned in the main text of the paper.

Response: We apologize for these oversights. The lines will be modified to "Three commonly used methods for separating the impacts of vegetation change on catchment water yield are the paired-catchment method (PCM), the time-trend method (TTM), and the sensitivity-based method (SBM)."

R3. Is the Pettitt (1975) method used in this work? It is mentioned once (p4 L101) where the authors state that the Mann-Kendall test is used for ranking tests of non-stationarity then never again.

Response: Thanks for bringing this to our attention. In the revised manuscript, what kinds of time series will be analysed using these two methods and the purposes of the applications will be mentioned in section 3.1, section 4.1 and Table 1.

The Pettitt (1979) method is mainly used to solve two problems in this study. One is to analyse the abrupt change points of annual rainfall, runoff and potential evapotranspiration (refer to Table 1). The abrupt change point of annual runoff is used to divide the calibration period and the prediction period. And the other one is to analyse the abrupt change points of the slope of the rainfall-runoff cumulative curve (refer to Figure 4). The existence of the abrupt change points of the slope of the rainfall-runoff cumulative curve means that the relationship between rainfall and runoff become non-stationary.

The Mann-Kendall test (Kendall, 1975; Mann, 1945) is used to analyse the change trend (increase or decrease) of annual rainfall, runoff, and potential evapotranspiration (refer to Table 1).

R4. Question of equilibration between rainfall-runoff process within catchment and between paired catchments? The catchments must be small enough and the changes of a suitable scale that either both equilibrate quickly, or at the same rate so that cumulative fluxes still appear as a straight line.

Response: Thanks for your constructive comment. In the revised manuscript, the principle and the purposes of the applications of double mass curve will be described in more detail in section 3.1.

The double mass curve is the simplest, but is most intuitive and most widely used method to analyse the stationarity or multiyear evolution trend of hydrometeorological variables. It is true that cumulative fluxes can still appear as a straight line when both hydrometeorological variables equilibrate quickly, or at the same rate under the condition of stationary changes. It can be seen from the straight line of the period before October 2001 in Figure 4 (b). However, when catchments are affected by non-stationary changes (such as multiyear drought, vegetation change, etc.), the amount and rate of changes to reach new equilibrium of both hydrometeorological variables (rainfall-runoff process within catchment or runoff-runoff process between paired catchments) will be different. For example, the same rainfall will lead to less runoff after multiyear drought and afforestation (refer to Figure 4 (a)). These different changes will lead to the abrupt change points of the double mass curve, and there are different equilibrium states before and after the abrupt change points (the slope of curve during different periods is changed). The double mass curve in this study is used to explore the impact of multiyear drought and vegetation change on the non-stationary changes of rainfall-runoff relationship of paired catchments.

R5. Do the authors think that having a single effect occur with reasonable gaps is necessary to analyse the data? In the case of Red Hill/Kileys Run the catchments were paired (hydrologically) well then had the afforestation and years of data, then the drought with years of data, then the post-drought conditions and again with years of data. Is there a risk if changing climate conditions inducing a non-stationary response would interfere with the land-use response if they occurred closely chronologically? Could a method determine the changes and separate them?

Response: Thanks for your constructive comments. We will add discussions regarding to your concerns in the revised manuscript.

We agree that one of investigated effects (i.e. multiyear drought) was occurred part of the study period (2000 – 2009). We think it is still necessary to analysis the impacts of drought as we have demonstrated that multiyear drought has induced rainfall-runoff relationship changes in the control catchment. Negligence of such effect can result in significant differences in estimated effects of vegetation change as shown in Figure 6, which is also reported by Zhao et al. (2010) using about 16 years data.

Only two years of rainfall was above the average after 2000 and drought lasted from 2000 to 2009 in the Red Hill paired catchments. After 2009 (post drought), the slope of double mass curve is still very close to that during the multiyear drought period. Thus the single effects of drought are considered to have similar effects as vegetation treatment and are evaluated between two periods (i.e. pre- and post-change periods).

We agree the risks of interferences between drought and land-use response are existed. Several studies have reported that not only land use types but also soil and catchment properties may lead to different effects of drought on runoff (Saft et al., 2015; van Dijk et al., 2013). Here, one of the assumptions of the new framework is that the effects of three factors (vegetation change, hydroclimatic non-stationarity and climate variability) are independent of each other. We have to make this assumption to enable us to separate three effects with the help of paired catchments. The sum of the contribution of three factors to runoff change is 111.4% in Red Hill catchment and it is close to 100%, which proves that the assumption is basically reasonable and valid. However, considering the complexity of the interaction amongst different factors and the values that are difficult to quantify, the new framework cannot separate the interaction of three factors under the current experimental conditions and data. The research about how to estimate the interactions amongst different factors need to be carefully observed and investigated in the future.

References:

Kendall, M. G.: Rank-Correlation Measures, Charles Griffin, London, 202 pp., 1975.

Mann, H. B.: Nonparametric tests against trend, Econometrica, 13, 245-259, https//doi.org/10.2307/1907187, 1945.

Pettitt, A. N.: A non-parametric approach to the change-point problem, Journal of the Royal Statistical Society: Series C (Applied Statistics), 28, 126-135, https//doi.org/10.2307/2346729, 1979.

Saft, M., Western, A., Zhang, L., Peel, M., and Potter, N.: The influence of multiyear drought on the annual rainfall-runoff relationship: An Australian perspective, Water Resour. Res., 51, https//doi.org/10.1002/2014WR015348, 2015.

van Dijk, A. I. J. M., Beck, H. E., Crosbie, R. S., de Jeu, R. A. M., Liu, Y. Y., Podger, G. M., Timbal, B., and Viney, N. R.: The Millennium Drought in southeast Australia (2001-2009): Natural and human causes and implications for water resources, ecosystems, economy, and society, Water Resour. Res., 49, 1040-1057, https//doi.org/10.1002/wrcr.20123, 2013.

Zhao, F., Zhang, L., Xu, Z., and Scott, D. F.: Evaluation of methods for estimating the effects of vegetation change and climate variability on streamflow, Water Resour. Res., 46, https//doi.org/10.1029/2009WR007702, 2010.