

Interactive comment on “Do changes in climate or vegetation regulate evapotranspiration and streamflow trends in water-limited basins?” by Q. Liu et al.

Anonymous Referee #2

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The paper by Liu et al. addresses the important question on the cause of trends in streamflow within water-limited basins. The authors use Budyko's conceptual model (incorporating ecohydrological influences following Donohue et al. 2011), to attribute hydrological change to changes in climate or changes in rooting depth (Z_e). The authors state that changes in Z_e had a greater overall response to changes in hydrological processes than climate change only. In general, the study could provide an interesting contribution to the heavily debated question on the importance of vegetation changes related to hydrological change. However, some technical and methodological issues give rise to concern if the study is suited to be published in HESS in its present form. Furthermore, the title is very promising, but from my point of view slightly overstated.

General Comments

1. As far as I understand, the rooting depth Z_e is parametrized as a function of precipitation only. The authors further found a general decrease in P for the YRB, resulting in a corresponding decrease in Z_e . Decreasing Z_e results in a smaller n -parameter in the BCP, causing the alteration of the hydrological conditions. However, two aspects, which are essential to understand and reproduce their results are not given and discussed in the manuscript: (i) The function of how Z_e is calculated from P and (ii) a map (or at least the basin wide average) of the particular aridity values (E_p/P), since the sensitivity of the n -parameter on E is a function of E_p/P (see Zhang et al. 2004) and is much larger in transitional climates compared to dry or wet climates.

Response: Broad generalizations, based on empirical evidence suggest that, under water-limited conditions, the higher the precipitation (or the lower the E_p/P) the deeper the rooting depth and the higher the precipitation intensity and/or seasonality under a given P , the deeper roots become in order to maintain the same E . Most models of rooting depth generally capture the first of these generalizations. In this study, we used the equation provided by Guswa (2008) to calculate Z_e in the Yellow River Basin.

$$Z = \frac{\alpha}{\kappa(1-W)} \ln X \quad (1)$$

where Z is the rooting depth for different vegetation.

For $W \geq 1$, X is calculated as

$$X = W \left(1 + \frac{\kappa (1-W)^2}{\alpha \cdot 2A} - \sqrt{\frac{\kappa (1-W)^2}{\alpha \cdot A} + \left(\frac{\kappa (1-W)^2}{\alpha \cdot 2A} \right)^2} \right) \quad (2)$$

And, for $W < 1$, X is

$$X = W \left(1 + \frac{\kappa (1-W)^2}{\alpha \cdot 2A} + \sqrt{\frac{\kappa (1-W)^2}{\alpha \cdot A} + \left(\frac{\kappa (1-W)^2}{\alpha \cdot 2A} \right)^2} \right) \quad (3)$$

The physiological parameter, A (mm^{-1}), for a given vegetation type is

$$A = \frac{\gamma_r D_r}{L_r W_{ph} T_p f_s} \quad (4)$$

γ_r is the root respiration rate, D_r is the root-length density, L_r is the specific root length, W_{ph} is the water use efficiency of photosynthesis and f_s is the growing season. T_p for which we used the long-term daily average potential evaporation rate. Effective rooting depth of trees (Z_t , mm) and of grasses (Z_g , mm) is apportioned areally according to the fractional cover each respective vegetation type, as derived from the separation of the green fractional cover data of Donohue *et al.* (2009) into the persistent and recurrent cover fractions, respectively. Considering the large area of YRB, the growing season is estimated by the daily air temperature above 3 °C (Editorial Committee for Dictionary for Atmospheric Sciences, 1994). The growing season (f_s), combined with the other physiological parameter, estimated Z_e for the Yellow River Basin. Z_e can be calculated by the following equation:

$$Z_e = \frac{F_t Z_t + F_g Z_g}{F_t + F_g} \quad (5)$$

In this study, the method for calculating Z_e was omitting in order to get a simple version. The average of E_p/P were also was omitted, it also used to definite the water-limited conditions. The average of E_p/P is < 1 in most regions of the Yellow River Basin.

2. Is using 1961 to set the base condition for Z_e really appropriate? Would you consider 1961 to be a rather 'normal' year? Why not using the first 10 years to set the base conditions?

Response: In this study, we set 1961 as the base state for calculating the static Z_e . The static and dynamic Z_e were used to calculate the E and Q , which used to assess the impacts of climate change and Z_e on E and Q . Due to Z_e reflecting the combined effects of P , E_p and physiological processes of the vegetation, dynamic Z_e obtained from the method provided by Donohue *et al.*, (2012). Maybe the 1961 was not the normal year, while Z_e change with climate change in the dynamics scenarios. On this context, impact of static and dynamics Z_e on E or Q can be showed.

3. How realistic is the assumption of fixed vegetation type and fraction under climate change? A

discussion on this is definitely needed.

Response: Combined effects of climate, vegetation, soil and terrain impacts of E and Q . Especially, changes of vegetation type and fraction regulate the partitions of P into E and Q , which also has been assessed in many regions, e.g., in this paper “Degradation in vegetation influenced by decreasing P has been reported in YRB (e.g., Xin *et al.*, 2008). In particular, changes in vegetation extent and type (mainly resulting of human activity) are major causes of Q change (Li *et al.* 2007; Liu *et al.*, 2009). For example, changes in vegetation pattern as a result of land use changes (e.g., such as determined by the Grain for Green program in the Loess Plateau) inevitably alter hydrological processes and result in a decrease in Q (McVicar *et al.* 2007; Cao *et al.*, 2011)”. As it is expected, vegetation also can change with climate changes in physiological characteristics, such as Z_e , that should also can regulate the hydrological processes. In this study, we fixed the vegetation type and fraction and assessed impacts of Z_e on E and Q with static and dynamics. The results should be outlined the response of E and Q to changes in Z_e from the other aspect besides the vegetation type and fraction.

4. From my point of view, the model description and dataset section is far too short. How do you calculate Z_e (see first comment)? How do you calculate κ and α ? Which data are you using for their calculation? How do you calculate the trends? Which data are you using to calculate E_p ?

Response: OK, in order to address a simple version of manuscripts, model description and dataset section were addressed in a simple way. According to your comments, some more detail information was added in the revised version. For example, Z_e was addressed as “ Z_e is hardly observed at catchment scale (Gao *et al.*, 2014). According to conclusions that state that the higher the P the deeper the Z_e (Schenk and Jackson, 2002; Donohue *et al.*, 2012), Z_e was calculated for YRB using the effective rooting depth model of Guswa (2008), a large water-limited basin. Fraction of vegetation for tree and grass calculated from the NDVI (obtained from <http://ecocast.arc.nasa.gov/data/pub/gimms/3g/>), which used to calculate the Z_e , furthermore the fraction of vegetation also used to reflect the extent of vegetation in the whole basin.” Storm depth (α) were addressed as “Due to no basin wide, long-term, sub-daily precipitation data existing to calculate α , storm depth was estimated by the daily P during 1961-2010 (Porporato *et al.*, 2004).”. Furthermore, In this study, the average fraction plant-available soil water holding capacity (κ) was set as static state, which was obtained from the Harmonized World Soil Database (version 1.0) (FAO/IIASA/ISIRC/ISS-CAS/JRC, 2008). Monthly E_p was calculated by means of monthly wind speed, daylight hours, relative humidity, and average air temperature using the Penman equation (Shuttleworth

1993).

5. You should discuss the influence of human activities (river damming, land use change, diking) somewhere in the manuscript.

Response: Yes, it is expected that river damming, land use change, diking can regulate hydrological processes. In this paper, we assess the impacts of climate changes and vegetation on E and Q in long term at basin scale. The objectives of the paper is to assess impact of climate changes and vegetation on E and Q in relative static state. Furthermore, the sensitivities E and Q to changes in different parameters also were addressed using the partial derivative method at BCP model. On this context, the influences of human activities were cut down. Of course, we also gave some example for human activities, e.g., Green for Grain Program in China.

6. Please state throughout the manuscript, if (i) computed trends in and (ii) differences between the dynamic and static experiments are significant.

Response: The computed trends in and differences between static and dynamic Z_e were not significant at 95% confident level.

7. From my point of view, the conclusions in its present form are not really conclusions, but more a summary of the main findings. The whole section could be incorporated in the discussion section.

Response: Yes, the conclusion in its present form mainly addressed a summary of main findings. In the improved version, conclusion addressed at two aspects: one is temporal trends in E and Q ; the other is relative contribution of climate and vegetation changes on E and Q , which consistent with the objectives of this study.

8. It would be beneficial to provide a map indicating the location of YRB within China or East Asia.

Response: The map for Yellow River Basin was added in the improved version. It presented in the Fig. 1.

9. In general, the paper is well written. Nevertheless, there are some phrasing issues. Maybe, it would be beneficial to get some input from an English native speaker.

Response: Thanks for your comments. The paper has been improved by the native English speaker.

Specific Comments

P.11184, l.2: Please provide some basic information on YRB already in the abstract.

Response: The Yellow River Basin also has been added in the revised version.

P.11185 l. 2: Please provide some basic information on the 'Grain for Green' program, since many people outside China are probably not aware of it.

Response: The Grain for Green program has been explained in the improved paper, as “GGP was established by the Chinese Central Government for ecological restoration by re-vegetating the farming and grazing land with perennial species in 1999”.

P.11185, l. 22: Please reference some of these numerous studies.

Response: Some references also have been added here.

P.11187, l. 25: Why is it '-0.96 mm a⁻²' and not just '-0.96 mm a⁻¹'?

Response: Annual P or E_p can presented mm a^{-1} , here the slope of P or E_p were addressed as mm a^{-2} .

P.11188, l. 18-19: Please state if these trends are significant.

Response: Z_e series showed insignificant decreasing trends in this study.

P.11189, l. 6-12: It would be nice if you could maybe illustrate these results with e.g.histograms.

Response: The histograms should be more clearly, while in this study trends of Z_e presented for whole at each cell. The average of slope for static and dynamic Z_e was presented in this form.

P.11190 l. 18-19: You probably meant: '(with an average decrease of -0.96 mm/a)'

Response: Here, decreasing trends in P (with an average increase of -0.96 mm a^{-2}), the average increase means the slope of P , -0.96 refer to the negative trends for P . According to your comment, the sentence has been improve as “decreasing trends in P (with an average trend of -0.96 mm a^{-2})”

P.11198 Fig. 2: Any idea on what causes the great difference between the static anddynamic Ze in the Northeast of the YRB?

Response: The Fig. 2a showed the Z_e in 1961, while Fig. 2b showed the average Z_e resulted from the influenced of climate change.

P.11199 Fig. 3: The blue and the black line are rather hard to distinguish.

Response: OK, the figure has been improved.

P.11201 Fig. 5: Please provide the information on the method used to quantify the

significance in the text as well.

Response: In this study, the Mann-Kendal method used to test the significant trends of E , the method has been added in the caption of the figure.