Dear Editor,

Thanks for you kind comments. According to comments of two anonymous reviewers, the paper should explain the method used to explore the impacts of climate and vegetation on evapotranspiration and streamflow trends. Especially, the ecohydrological parameters used in the BCP model should be explained more clearly.

In this context, the method used to calculate the ecohydrological parameter such effective rooting depth (Z_e), the plant-available soil water holding capacity (κ) and storm depth (α) were explained in line 83-92. Ecohydrological parameter (n), incorporated into the Budhyko hydrological model, was calculated to simulate the evapotranspiration and streamflow.

Furthermore, the methods were used to calculate the relative contribution for climate and vegetation were addressed in the caption. And the relative contribution of climate and vegetation were recalculated and presented the regions with significant trends.

Furthermore, the manuscripts also improved by the native English speaker in its language.

Thanks for your time.

With Best Regards!

Qiang Liu

2014.12.15

I share the view of the reviewers that the methodology should be explained more clearly, and that puts the scope of the paper at the right level. It's probably best to change the title to make it seem a bit less ambitious.

Response: According to comments of anonymous reviewers, BCP model were improved to explain the method used to calculate effective rooting depth (Z_e), the plant-available soil water holding capacity (κ) and storm depth (α). The title were improved as "The impacts of climate changes and vegetation on evapotranspiration and streamflow trends in a large water-limited basin".

Please provide a new version of the manuscript that clearly shows the differences to the original manuscript. Also please provide a document that lists your point-by-point replies and also shows the changes that are made to the new manuscript.

Response: The marked version for manuscript was submitted for you. Furthermore, the response note were presented one by one as followed.

(1) The title was improved as: Impacts of climate or vegetation changes on evapotranspiration and streamflow trends in a large water-limited basins.

For reviewer 1

(2) The abstract section, *Abstract and introduction: the study appears to be about the Yellow River Basin, butthis is strangely enough not mentioned here.*

Response: According to reviewer's comments, abstract and introduction sections have been improved to present the Yellow River Basin, China. Abstract section has inserted "Hydrological processes regulate by the interactions between climate, vegetation, and soil, especially in the water-limited region. In this study, we conducted to investigate the causes for the changes for evapotranspiration and streamflow in the water-limited regions, the Yellow River Basin, China."Introduction section also presented the study basin.

11184 - L3: "In this study, it was assumed : : : " I would expect the authors first to explainwhat they are doing in the paper, rather than beginning with the assumptions. Thisassumption, by the way, has to be defended as I expect rather big land-use changes inthe Yellow River Basin in the study period.

Response: Thanks for your comments. According to your comment, "In this study, we conducted to investigate the causes for the changes for evapotranspiration and streamflow in the water-limited regions, the Yellow River Basin, China" has been inserted in theintroduction section to explain the objective. Followed by the method, it was assumed.

11184 - L5: "Budyko's hydrological model" I would in first instance rather call it theBudyko framework or Budyko curve, but later it appears to be the Budyko-Choudhurry-Porpato model, so why not call it that?

Response: "Budyko's hydrological model" was used to highlight the model, and contrast with spatial distributed model. That should be more specific using the Budyko framework in the first instance. That has been improved in the revised version.

11184 - L15-L17: "Ze scenarions were able : : : on water resources" It is quite logical than changing an important parameter affects the partitioning of precipitation into evaporation and runoff. For that conclusion it was not necessary to perform the study. I agree that rooting depth should be able help to regulate climate change impacts. However, in contrast to what is shown in this paper, I would expect plants to root deeper when precipitation goes down.

Response: Generally, under water-limited conditions, the higher the precipitation the deeper 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. mostly model captures the first in calculating the effective rooting depth.In our study, we also calculated effective rooting depth using the model provided by Guswa (2008), that also mainly reflect the first condition. BCP model incorporated the ecohydrological parameter can used to reflect the sensitivity of Q and E to changing in climatic and ecohydrological parameter. Using the different Z_e scenarios, we also can reflect the causes for the changes in Q and E.

11185 – L3-L4: "which the Grain for Green program has shown to exist." Is there aproper reference for *this claim?*

Response: The reference has been added.

McVicar, T.R., Van Niel, T.G., Li, L.T., Wen, Z.M., Yang, Q.K., Li, R., Jiao, F., 2010. Parsimoniously modelling perennial vegetation suitability and identifyingpriority areas to support China's re-vegetation program in the Loess Plateau:Matching model complexity to data availability. Forest Ecology andManagement 259 (7), 1277–1290.

11185 – L7-L11: same comments as for the abstract

11185 – L22-L25: "While numerous studies : : : to climate change" The study period of this paper, 1961-2010, is also in the past

Response: The sentence has been improved as "While numerous studies have investigated impacts of climate and vegetation on hydrological processes, few have explored impacts of vegetation on hydrological processes from the point of view of the response of vegetation to climate change".

Section 2: The study area should be discussed separately. Baseline figures and numbers for evaporation, runoff, precipitation, potential evaporation, effective rooting depth, etc. should be given.

Response: The study area has been separated in the improved version. Some information about the basin also provided.

Section 2: A detailed tabulated overview of the two scenarios applied would help the reader.

Response: Static and dynamic Z_e scenarios were sued to calculate the E using the BCP model, and then used the slope of different E to assess the influences of climate and vegetation change on E. Some information was added in the improved version.

Section 3.1: The negative trend for potential evaporation came as a surprise to me. Ingeneral, potential evaporation is expected to increase with climate change. It would begood if the authors could indicate which factor, radiation, temperature, humidity, windspeed, is mainly responsible for this unexpected negative trend.

Response: In general, E_p presented slightly decreasing trends with an average slope −0.13 mm a^{-2}, while it presented increasing trends in most part of the basin, especially in the upper and middle regions of the basin. Temporal trends of E_p reflect the combined effects of net radiation, wind speed, relative humidity and air temperature. This study results are consistent with the study results with Liu and McVicar (2012).

11188 – L1: "Ep and P exhibited increasing trends" The sentence before was that theyhad decreasing trends. Something is wrong here.

Response: It is a mistake in this sentence. *"E_p and P exhibited increasing trends"* has been corrected as "E_p/P exhibited increasing trends with an average increase of 0.004 mm a^{-2}".

11188 – L2-L4: The vegetation fractions : : : for calculating Ze." This should be thoroughlyexplained in methods!

Response: The vegetation faction for trees (Fig. 1c) and grass (Fig. 1d) were calculated using the f_{PAR}, which mainly used to outline vegetation type and extent. According to assumption, the vegetation type and extent in our study is fixed, which used to calculate the Z_e. By the static and dynamic scenarios of Z_e, we can obtain the change in partition of P into E and Q. The vegetation faction were presented here as results.

Section 3.1: As said in the general comments, it is a complete black box how Z_e iscalculated.

Response: Generally, under water-limited conditions, the higher the precipitation (or lower E_p/P) the deeper 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. mostly model captures the first in calculating the effective rooting depth. In our study, we also calculated effective rooting depth using the model provided by Guswa (2008), that also mainly reflect the first condition. "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 theeffective rooting depth modelof Guswa (2008), a large water-limited basin (data provided in Fig. 2)".Some materials were added in the improved paper to explain the Z_e calculation.

11189 – L13-L15: "The relative contribution : : : was obtained (Fig. 6b)" Could this forclarity be written down in a formula?

Response:According to your comments, the relative contribution was addressed as followed formula:

$E_c = (S_{sz}/ S_{dy}) \times 100\%$

$E_v = ((S_{dz} - S_{sz})/ S_{dz}) \times 100\%$

where, E_c is relative contribution resulted from climate on E; E_v is relative contribution resulted from vegetation on E; S_{sz} and S_{dz} is the trend ($p < 0.05$) of modeled E under the static Z_e and dynamic scenario, respectively. According to the formula, the relative contribution of climate (Fig. 6a) and vegetation (Fig. 6b) for each grid cell were obtained.

*11192 – L9-L11: "Z_e **Response** to : : : this water-limited region" I do not understandthis sentence. I think something is wrong with its structure and to which hydrologicalprocesses is referred?*

Response: As anticipated, although climate change regulates changes in E and Q, Z_e response to climate change contributed greater to changes in E and Q for this water-limited region.

11187 - "Along with climate : : : topic to date" This is a redundant repetition of theintroduction.

Response: This sentence has been deleted from the revised version.

11191: L2-L4 "In this study : : : and McVicar (2012)" Details for this calculation should be given transparently elsewhere in the paper, before this discussion could makesense.

Response: Here, BCP model with dynamic *n* can reflect the influences of ecohydrological parameter on partitions of P into E and Q. n also were address in the result section as "Modeled time series of *E*using the BCP model with the dynamics *n* (average *n* is 1.81 at basin scale)".

Table 1: What is the left and what is the right part of this table?

Response: The table 1 here been improved, left and right of the table 1 is the summaries for *E* and *Q*sensitivities to changes in ecohydrological variables, respectively.

Figure 1: in (a) I would write "Temporal trend in P" and in (b) "Temporal trend in Ep". Iwould also write in the caption that the Yellow River Basin is shown.

Response: According to your comments, the figure 1 and its caption have been improved.

Figure 1: The information about grass and trees should be in a separate figure, whichshould be discussed in methods. Also, it is not very clear what exactly is done with thatinformation. Moreover, this is a quite simple land-use classification, i.e., not even cropsare included. This choice should be defended in the paper.

Response: The cover fraction of grass and tree were addressed here to outline theextent of the vegetation for the calculation of Z_e, The calculation for Z_e has been moved to method section. the fraction of grass and tree mainly used to calculated Z_e, were deleted from the paper.

Figure 3: The very small differences between the static and dynamic scenario make ithard to judge whether the changes in the Ze parameter even make sense. In the textan NSE of 0.85 for the dynamic scenario is mentioned, but what is the NSE for thestatic scenario?

Response: The changes of Z_e contribute slight influence on the changes of E. The NSE is 0.83 for the static scenarios, which also has been added in the revised manuscripts.

Figure 4: It took me some time to understand this figure. After a while I think I understood that it is not about temporal changes, but about relative differences between the two scenarios. A formula would be helpful.

Response: Figure 4 presented the modeled percent differences in mean annual total *E* (a) and *Q* (b**)** between static Z_e (Z_e for 1961 was fixed throughout the 1961–2010 simulation period) and dynamic Z_e (Z_e was influenced by specific water and energy conditions for each grid cell in accordance with specific climate change conditions).According to your comments, the formula was added in caption for fig. 4. $E_{change} = \left({(E_d - E_s)}/{E_d}\right) \times 100\%$, where, E_{change} is percent differences in mean annual total *E*, E_d and E_s is mean annual total *E* between static Z_e and dynamic Z_e. $Q_{change} = \left({(Q_d - Q_s)}/{Q_d}\right) \times 100\%$, where,

Q_{change} is percent differences in mean annual total Q, Q_d and Q_s is mean annual total E between static Z_e and dynamic Z_e.

Figure 5: In Figs. 1 and 2 the static scenarios are shown in (a) and the dynamic in (b).In this figure the opposite is true. Moreover, the panels are very similar and relativedifferences as in Figure 4 would be easier to interpret.

Response:OK, the figure 5 is improved consistent with fig. 1 and 2. The manuscript also has been improved to consistent with the changes in Figure. Fig. 5 wanted to address the slope of E with static and dynamic Z_e and also that with significant changes in slope. The changes in slope were used to reflect the influence of changes in Z_e on the E. The figure 4 used to reflect the changes of value of E due to changes in Z_e.

Figure 6: If a understand correctly, the assumption is that E is 100% explained by climate when the changes in E for the static scenario are equal to the changes in the dynamic scenario. Some more text could be spend on why some regions are 100% explained by vegetation. Is that perhaps related to very low evaporation values?

Response: In this paper, the contribution of climate on E is regarded as the slope of E with static Z_e scenarios was divided by the slope of E with dynamic Z_e scenarios; while the 100% - contribution of climate on E was regarded as the influences of vegetation on E. In the long term, slopes of E with static and dynamics are consistent with each other, the changes of Z_e are mainly resulted from climate, on the contrary, it’s regarded as the changed in E mainly influenced by the vegetation. In order to explain this trends, the Figure 6 were improved, the extent with significant trends of E with dynamic Z_e scenarios were showed.

Figure 6: Why is there not a figure for runoff as well?

Response:In this paper, E is influenced directly by thechanges of climate and vegetation, and then Q (P-E) was calculated. The slope of E with static and dynamic Z_e used to reflect the influences of climate and vegetation on E.

Technical corrections

11184 - L22: resource -> resources

Response: Corrected.

11185 – L25: was -> is

Response: Corrected.

11191 L3: calculated -> calculate

Response: Corrected.

Figure 3: Ea -> E

Response: Corrected.

For reviewer 2 comments

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 Ze 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 calculated Z_e in the Yellow River Basin.

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

where Z is the rooting depth for different vegetation.

For W≥1, X is calculated as

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

And, for W<1, X is

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

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

$$A = \frac{\gamma_r D_r}{L_r W_{ph} T_p f_s} \tag{4}$$

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 ℃ (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:

$$Z_e = \frac{F_t Z_t + F_g Z_g}{F_t + F_g} \tag{5}$$

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 Ep/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 consider1961 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 resultingof 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 landuse 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 changes 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 Ze (see first comment)? How do you calculate kappa and alpha?Which data are you using for their calculation? How do you calculate the trends? Which data are you using to calculate Ep?

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, Ze 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 theeffective rooting depth modelof 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 theZ_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 rive 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 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 courses, 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 aˆ-2' and not just '-0.96 mm aˆ-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.