Responses to Peer Reviewers

Reviewer #4

The SWAT model was used to assess the impacts of human activities and climatic variability on green and blue water flows in the Heihe River basin. Although the main content and the title talk about climatic variability, the introduction section generally focuses on global climate change. Without careful attribution study, the climatic variability is hardly related to climate change. The introduction must be rewritten to fit the title and content.

Authors' response:

We thank reviewer's suggestion. We will re-write introduction to fit the title and content.

The experiment design seems problematic. The difference of climate condition between two 3-year periods (i.e. 2004-2006 and 1984-1986) was referred as climate variability. As a 3-year period is rather short, it is possible some year happens to be wet or dry. The difference is neither a reasonable index of climate variability nor the change of climate variability in the period of 1986-2005. The climate variability and its temporal scale must be defined in the manuscript. Overall, the climate or hydrology variability (inter-annual or inter-3-year) is very large and it is not surprising that the variability could be much larger than the impact of human activities.

Authors' response:

Climate variability refers to short-term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with dry or wet events (SEACI, 2005; http://www.seaci.org/). The study period is a difficult decision. If we use a long period average, i.e. 1980-1990, actual climate variations may be hidden by the average treatment. But if we only use one single year (e.g. 1986 and 2005), sharp variations are likely to happen, e.g. in wet or dry years. Therefore, we choose the 3-year average as one solution. Based on our previous analysis, the two periods (1984-1986 and 2004-2006) do not belong to typical dry or wet years (Zang and Liu, 2013). We will add this information in revised manuscript.

The proportion of human activities impact to long-term change is of great interest, but the comparison between human activities impact and dry-wet difference is less meaningful.

Authors' response:

We thank reviewer's suggestion; we will reconsider how to analyze the contribute of climate variability and change to the water flow changes. We will emphasize more on the proportion of human activities impact to long-term change.

The authors quote the definition of blue water from Falkenmark (1995). Water in river, lakes, aquifers and wetlands are defined as blue water. They have also mentioned that water in aquifers (groundwater) provides over 90% in the downstream regions and human activities have changed distribution of lakes. However, the authors did not provide the information how they revised the SWAT model to handle the influences of human activities on groundwater and lakes. As the information is the key to understand the model results, it must be clarified in the method section.

Authors' response:

Water in aquifers (groundwater) provides over 90% for cropland irrigation in the downstream; hence, irrigation will influence groundwater in downstream. We have set the groundwater parameters in the SWAT model, such as the initial depth of water in the shallow aquifer, the initial depth of water in the deep aquifer, the recession constant of the slow shallow aquifer, the coefficient that separate the seepage from slow shallow aquifer into seepage to the deep aquifer and the recharge of the slow shallow aquifer. The parameter values were obtained from Zhou et al. (2009) and Zhang et al. (2004). Other parameters about groundwater (ALPHA_BF, GW_DELAY, GWQMN and GW_REVAP) have been calibrated in previous research (Zang et al., 2012). We set lakes and groundwater as the water sources based on topography. The groundwater parameter values were all defined at a sub-basin level. Because of the lack of more detailed information, we considered no spatial heterogeneity of the groundwater parameters within a sub-basin level. We will add this information in the revised paper. Influences of human activities to lakes are mainly reflected by land use change and by irrigation water withdrawal from lakes.

One unsupported result is that land use change (mainly urbanization) would cause more blue water flow. This result fully relies on the model. However, the model is not validated by any observations. Urban area is also a possible water consumption area (e.g. domestic water use, green infrastructure). How the urban land cover was treated and validated in the modified SWAT simulations?

Authors' response:

We have taken the reviewer's advice, and provided additional validation of the model results by comparing them with observations for the Zhengyi Canyon in midstream, where high intensive human activities occur. The validation results are satisfying as shown in Fig. 3 (see Page 4 in this Response Letter), which will be added to the revised manuscript. We agree that urban area is also a possible water consumption area. The urban area is mainly located in the midstream region, and the validation for the Zhengyi Canon could help increase the reliability of the model for the hydrological simulation in urban area.

Reference:

Zhou, J., Li, X., Wang, G. X., and Zhao, J.: The spatial-temporal variation analysis of groundwater and response to land use change in the middle reaches of the Heihe river basin, Journal of Natural Resources, 24,3, 498-506, 2009.

Zhang, G. H., Liu, S. Y., Zhang, C. Y. et al.: Evolution of groundwater circulation in the Heihe river drainage area, Geology in China, 31, 3, 289-296, 2004.

Wang, L. C.: The town development process history and driving mechanism of Heihe river basin, PhD thesis of cold and arid regions environment and engineering research institute, CAS, 2007.

Zang, C. F., and Liu, J. G.: Spatial and temporal pattern difference of blue-green water flows in typical reference years in the Heihe River Basin， northwestern China, Journal of Beijing Forestry University, 35, 3, 1-10, 2013.

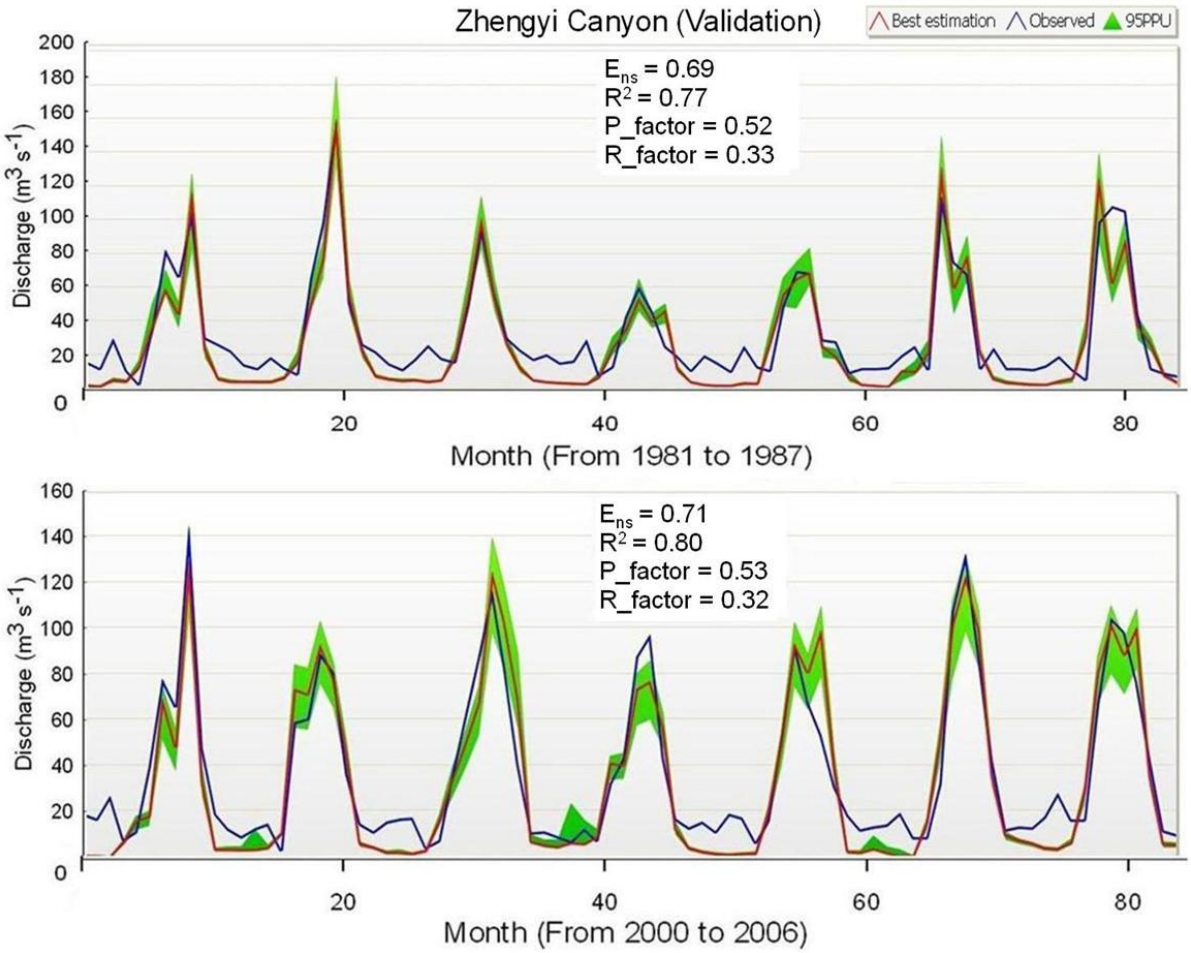

Fig. 3. The validation of the SWAT model at Zhengyi Canyon