Responses to Peer Reviewers

Reviewer #1

General comments:

The impacts of climate variability and human activities on hydrological process are heavily studied recently. In this article, such impacts on green water and blue water are assessed separately, which is claimed as the novel contribution for the community. However, according to the famous mean annual water balance equation (P=E+R, where E is green water and R is blue water), the methodology for the evaluation on both E and R is not necessarily different from that for streamflow (R) only, since the green water E is just a residual term (E=P-R).

Authors' response:

The process of E is more complex than just a residual term. In particular, when land use is changed, this will first influence E, and then R (which then is the 'residual'). However, in our study area and research, the situation is more complex than P=E+R. We include three types for blue water (not only runoff): surface runoff, lateral flow and groundwater recharge; and two parts for green water: evaporation and transpiration (simulated individually by SWAT, not simply treated as a residual). Soil moisture changes (ΔS) are also considered, as they are not equal to 0 in the short time periods. P=E+R is easy to use at a river basin level, but it does not reveal the spatial variation within the Heihe river basin, which we are interested in. We hope this argument is convincing, without the need to modify the manuscript in that regard.

The novel contribution of this paper is green-blue water transformation due to human activities and climate variability, which is the reason why we require estimates of both blue water and green water. Therefore, we will change the title to "Green-blue water transformation due to human activities and climate variability: a case study of the Heihe River Basin in Northwest China". In recent years, most water flow transformation studies focus on precipitation and local precipitation exchange (Smith et al, 2003), precipitation and evaporation exchange (Joachim et al, 1999; Xu et al., 2013) and surface water and groundwater exchange (Marios et al., 2000). However, green and blue water flows transformation remains a rarely studied topic, and it still needs further study.

Further, the methodology used in this article is definitely similar to other stream flow attribution studies (i.e., fixing-changing method as called by Li et al., 2012). There exist a lot of other methods which could generally be classified into elasticity method and decomposition method.

Authors' response:

True, a lot of methods have been used to analyze impacts of human activities and climate change on hydrological variation. Li et al. (2012) used the fixing-changing method to quantify the impacts of climate variability and plantation expansion/reduction on streamflow. Yang et al. (2008) used the SWAT model and uncertainty analysis to support decisions about alternative management strategies, e.g., the land use change, climate change, water allocation, and pollution control. There are also many other methods for the impacts of climate and socio-economic analysis to hydrological processes (Reinhard et al., 2004). We will mention such alternative methodological approaches in our revised paper, but this should not distract us from doing scenario analysis based on the well-established SWAT model. Many studies emphasize climate change impacts on water resources in the future by establishing future scenarios (Xu et al., 2003; Wei et al., 2009), but few focus on the past. With a "past" scenario analysis, we separate the contributions of different factors to the green-blue water transformation.

Also, the topic of socio-hydrological research focuses on the interaction of social and hydrological processes. The aim of the article does not fit well with the special issue.

Authors' response:

As stated in the background information of the Special Issue, hydrology as an earth science often looks at the land surface as a pristine system, unaffected by humans. Humans are seen as an integral component of the system, yet these studies tend to be applied and narrowly focused on addressing a specific water problem. One important objective of the Special Issue is to address understanding and case studies of coupled natural-human hydrology to understand the coupled natural-human system.

In our paper, we not only analyze the spatial and temporal distribution of the green and blue water flows under natural climate variations without considering human activities, but also build scenarios to simulate green-blue water transformation by explicitly considering different human activities, e.g. land use and irrigation. Our paper provides a case study to understand how humans have changed to hydrology of a specific study region relative to effects of climatic variation, for a previously unstudied topic (green-blue water transformation). Hence, we argue that the topic is exactly within the scope of the Special Issue, even if we were not able to investigate mutual two-way feedbacks between humans and water systems, which would indeed require a different concept and different research questions.

Specific comments: It is better for the readers to understand if the unit of green water and blue water change could be converted from water amount to the water depth (i.e.,mm) averaging over the corresponding land area.

Authors' response:

Agree! We will make the revision in a new version; we have added Table 2 (see Page 5 in this Response Letter), which shows the green and blue water flow change with a unit of mm.

Reference

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Smith,R., Jiang,Q., Ma,T., et al.: Orographic precipitation and air mass transformation: An Alpine example, Q. J. R. Meteorol. Soc., 129, 433-454, 2003, doi: 10.1256/qj.01.212.

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Table 2 Variability of green/blue water flows among difference scenarios (Units: mm)

Sub-basins number	GB (S_B-S_A)	GB (S_C-S_B)	GB (S_D-S_C)	GB (S_D-S_A)	B (S_B-S_A)	B (S_C-S_B)	B (S_D-S_C)	B (S_D-S_A)	G (S_B-S_A)	G (S_C-S_B)	G (S_D-S_C)	G (S_D-S_A)
1	4	-1	0	3	0	1	0	1	3	-2	0	1
2	6	0	0	6	0	0	0	0	6	0	0	6
3	4	-1	0	3	0	1	0	1	3	-2	0	1
4	7	0	0	7	3	-3	-2	-2	5	2	3	10
5	6	0	0	6	0	1	1	2	6	-1	0	5
6	5	0	0	5	0	-1	0	-1	5	1	-1	5
7	5	0	0	5	0	-1	0	-1	5	1	-1	5
8	7	0	0	7	3	-3	-2	-2	4	3	3	10
9	6	0	0	6	2	0	1	3	3	0	-1	2
10	2	0	0	2	0	0	0	0	2	0	0	2
11	-10	1	0	-9	-5	2	0	-3	-6	0	0	-6
12	-10	0	0	-10	-4	1	-4	-7	-7	0	0	-7
13	-10	2	0	-8	-7	2	0	-5	-2	-1	0	-3
14	-10	1	0	-9	-8	5	-1	-4	-2	-4	6	0
15	-7	0	0	-7	-7	1	-8	-14	0	3	4	7
16	-7	0	0	-7	-8	0	0	-8	1	0	0	1
17	4	1	0	5	2	3	0	5	2	-2	0	0
18	1	0	0	1	0	9	-1	8	2	-9	4	-3
19	-10	1	0	-9	-8	2	-5	-11	-2	-2	10	6
20	1	0	0	1	0	9	-1	8	1	-9	4	-4
21	1	0	0	1	-2	1	0	-1	2	0	0	2
22	-1	0	0	-1	-2	0	0	-2	1	0	0	1
23	-1	0	0	-1	-4	1	0	-3	4	-2	0	2
24	-16	0	0	-16	-19	-5	-6	-30	2	6	7	15
25	-10	1	0	-9	-4	2	0	-2	-6	-1	0	-7
26	0	-1	-2	-3	-9	-9	-4	-22	8	9	8	25
27	20	1	0	21	2	11	0	13	18	-10	0	8
28	-3	0	0	-3	-3	10	-2	5	0	-10	4	-6
29	-11	0	0	-11	-2	6	-9	-5	-9	-6	7	-8
30	41	0	0	41	14	20	0	34	27	-21	0	6
31	1	0	0	1	0	0	0	0	1	0	0	1
32	51	0	0	51	29	-7	-13	9	21	8	9	38

Note: GB is total green and blue water flows; B is blue water flow; G is green water flow; S_A is scenario A; S_B is scenario B; S_C is scenario C; S_D is scenario D. S_j-S_i is difference between scenario j and i.