Comments from H. Gao

I should congratulate the authors of this paper. It is a smart idea to use hydrological model to test the influence of human activities and climate variability on green and blue water, and separate them apart. The conclusions could be useful for decision-makers and guide the watershed management. It must be a well-cited paper.

Authors' response:

Thanks!

There is one point I cannot fully understand. Firstly, I totally agree with the conclusion that "The total water flows have increased in the past 20 yr in the Heihe river basin, mainly as a result of increasing precipitation". However, from Table1, I found that the impact of land use change on the variability of blue water flow is even larger than the impact of climate variability (Table 1).

Authors' response:

The impact of land use change on the variability of blue water flow is indeed even larger than the impact of climate variability. We will remove the statement on precipitation and give a more appropriate interpretation of the land use influence.

Comments from H. Gao

The authors explained the increase of blue water by urbanization (page 9487, line 18), which reduced the infiltration and increased the surface runoff. From Table 2, I noticed that the urban area is even less than 1% of the total Heihe River Basin, which is hard to have such great influence. On the other hand, the industrial and domestic water usage could consume more water than other land uses, which has a negative impact on the increase of blue water. Could you please further explain this result?

Authors' response:

This is a very important question. Urban area is not large in the basin, but it is very decisive for blue water flow generation. Furthermore, because the resolution of land use data is 1 km^2, we may miss smaller village, small town and mining areas. To make the simulations more accurately for the revised paper, we will identify towns and villages in the SWAT model based on sub-basin level (i.e. three classes of residential or town areas; high, middle and low intensive). Only the intensively populated areas were referred to in Figure 4 of our paper (Wang et al., 2007). Furthermore, the urban distribution has significant spatial difference (Fig.

A3), and the green and blue water flow variation also have significant spatial difference (Table 2). The green and blue water flow changes were occurring in the midstream of the Heihe river basin, where most of the cities and human activities of the river basin are located (Fig. A3), and most of the irrigation expansion also occurred there. Besides urbanization, irrigation expansion also contributed to the simulated green and blue water flow changes. The total discharge of the Heihe river basin is 3.3 billion m^3 (Li et al., 2009), and the land use changes in the midstream area have changed by nearly 6% the blue water flow in the entire river basin. There are also other types of land cover changes, but they did not influence the green and blue water flow significantly.

It is true the industrial and domestic water usage could consume more water than other land uses, which has a negative impact on the increase of blue water. However, in terms of water consumption, the industrial and domestic sectors use minor amount of water in comparison of agriculture. In this study, we do not consider the water consumption from both the sectors, and we will mention this shortcoming.

And does the implement of water redistribution policy in the midstream of Heihe also have an impact on increase of the blue water?

Authors' response:

This is also a very important topic. While a water reallocation within the basin does not increase or decrease the total water quantities of a watershed, it can indeed change the proportion of the green and blue water flows. The implementation of water redistribution policy in Heihe river basin is very important for water resources and ecosystem sustainability, but it is difficult to simulate policy changes and their very contributions to flows by the SWAT model used here. We will mention these policies, but will have to identify their quantitative neglect as a shortcoming of the paper.

Reference:

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.

Li, Z.: Runoff simulation in the upper reaches of Heihe River Basin and uncertainty anakysis in hydrological modeling, Degree of Doctor of Engineering of Beijing Normal University , 5-21, 2009.

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.

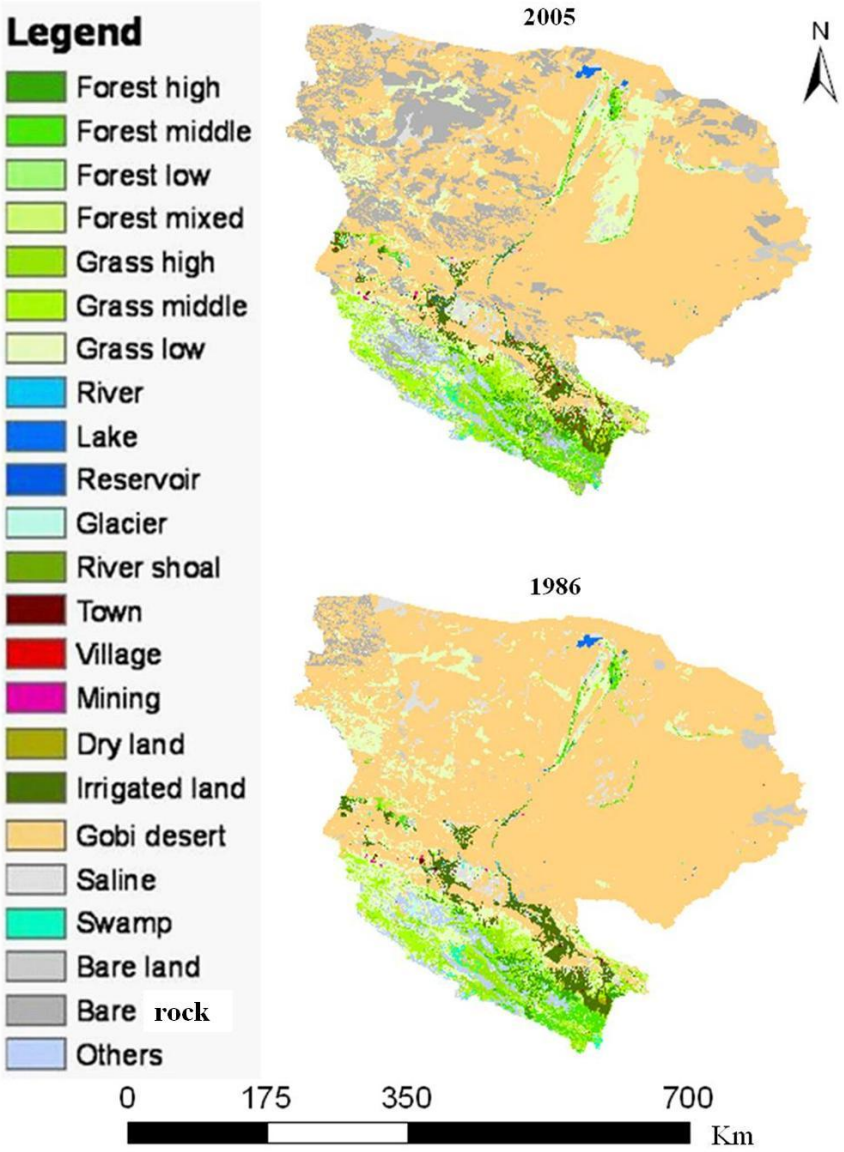

Fig. A3. Land use map in the Heihe river basin in 1986 and 2005