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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Analyzing streamflow changes: irrigation-enhanced interaction between aquifer and streamflow in the Republican River Basin" *by* R. Zeng and X. Cai

Anonymous Referee #1

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The authors applied SWAT model to simulate streamflow of the Frenchman Creek in the Republican River Basin shared by Nebraska, Kansas, and Colorado. They simulated the variations of streamflow components (baseflow, subsurface flow from the unsaturated zone, and surface runoff) in a 45 year period under non-irrigation and irrigation scenarios. The simulation results suggest that groundwater pumping for irrigation reduced the total streamflow by about 50% during the 45 year period, mainly by the reduction of baseflow component. Groundwater irrigation, however, increased the soil moisture and thus increased the subsurface flow (in the unsaturated zone) to the stream. The novel part of this research, as stated in the manuscript, is the modification

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to SWAT by linking the baseflow component to aquifer storage (by adding groundwater pumping in the water balance equation) as shown in equations 2 and 3. However, because the authors did not present the basic hydrogeological information of the study area and the calibration procedures of the SWAT model, and they did not cross-check whether their modeling parameters represent the real hydrological conditions of the study area, I am not able to evaluate the reliability of the modeling results. I think that the manuscript needs a major revision before it can be considered for possible publication. I suggest that the authors analyze their modeling results by cross-checking the real hydrological and hydrogeological conditions of the study area.

My comments include: 1. Equation 3 is problematic. In a groundwater irrigation watershed such as the Frenchman Creek Basin, long-term groundwater pumping led to the decline of the water table and created a regional cone of depression. Thus, groundwater from the adjacent areas will likely move into this aquifer-depleted watershed. This lateral flow contributed water to this basin. Thus, Equation 3 should add a term for the lateral flow component. Otherwise, the modeling result will very likely over-estimate the aquifer storage depletion (see the results in Figure 9).

2. The authors did not provide any geological and hydrogeological information about the study area. Does the aquifer have a shallow and deep layer that exchange water? If the shallow aquifer leaks water to the deep aquifer, will it affect the calculation of baseflow?

3. Does alpha in eq. 1 and eq. 2 have the same definition? Please explain.

4. Provide details on the model data, parameters and calibration procedures in the manuscript. Most readers do not have access to the master theses of the first author. Without knowing these details, readers are not able to know how well your model has been calibrated.

5. Perform baseflow analysis using a baseflow separation method and cross-check this baseflow with the baseflow produced using your SWAT model.

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6. In Figure 6, your analysis of the irrigation case indicated that the baseflow accounts for about 70 to 80% in the total streamflow from 1980 to 1994. This seems to be an extremely high ratio of baseflow. The groundwater level in Chase County declined significantly in the past 30 years. According to the 2012 groundwater level map of Nebraska, the water level on the north and south sides of the Frenchman Creek above the Enders Reservoir declined more than 10 m, and in some areas, the decline exceeds 20 m. This major decline of the water table may have significantly reduced the amount of the baseflow or may have induced a losing condition for some segments. If it is a losing stream, the streamflow may not have such a high percentage of baseflow.

7. The authors need to update their references. Some researchers have used SWAT to calculate baseflow. I suggest that some of these studies should be cited. Additionally, groundwater modeling, streamflow trend analysis, and hydrogeological studies have been conducted in the Republican River valley in the past several decades. Some of these studies are relevant to the authors' study.

8. The quality of Figure 3 needs to be improved.

9. I have difficulty to understand the results presented in Figure 9. As shown in this figure, the accumulative aquifer storage change from 1968 to 1994 was approximately 5500 mm (or 55 m). Does this mean that the average decline of the water table in the Frenchman Creek Basin was 55 m? However, the actual decline level of the water table in the Frenchman Creek Basin was much smaller than that value (see my comment 6). Judging from Figure 9, the average aquifer storage depletion had been about 10 m in 1975. This level of decline may have resulted in disconnection of the stream from the aquifer. A disconnected river will unlikely receive baseflow from the aquifer.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 7783, 2013.