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Discussions

Interactive comment on "Impacts of beaver dams on hydrologic and temperature regimes in a mountain stream" *by* M. Majerova et al.

Anonymous Referee #1

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The manuscript draft "Impacts of beaver dams on hydrologic and temperature regimes in a mountain stream" describes a rare opportunity to investigate the basic reach scale effects of beaver colonization over a gradient of dam influence. The others opportunistically leverage a fantastic dataset collected by Schmadel et al 2010 before the stream reach was colonized, by collecting data for several more years as beavers built at least 10 dams over a $\sim$ 750 m distance. Overall the topic is interesting, and the text quite well-written. The type of data collected are fairly basic, but as the authors note there is little "quantitative" study of beaver dam impacts to date. Beaver impoundment will have varied pros and cons in regard to stream restoration efforts that will be highly influenced by the morphological attributes of the degraded system and restoration goals (both physical and biological). There is an amazing opportunity to improve degraded

streams, particularly incised channels in the USA western states, by simply allowing beaver to return (not trapping them), and perhaps actively helping them get a foothold. With the USA state of Utah actively including beaver management in their statewide stream management strategy, studies such as this are strongly needed. Although I generally agree with the overall approach taken here, some things should be better quantified and clarified for this data to be more thoroughly interpreted in the context of seasonal variability. It seems 2010, the "beaver impact" end-member presented here, was perhaps unusually dry (Figure 2), and may have led to complicating human hydrological effects such as enhanced irrigation near the study reach. Further, no attempt is seemingly made to normalize stream temperature results to atmospheric temperature patterns of a given year, making conclusions based on inter-annual comparison less certain. Finally, no straight forward process-based explanation of why increased water levels and retention along this reach caused a system-wide transition from "losing" to "gaining" is presented. These issues, along with other concerns are noted below. Major comments: 1. I assume local air and groundwater temperatures were monitored over the course of this experiment? The results presented here should be put in their context. Reduced peak flows are expected after beaver dams, but what was the avg snowpack each year? Precip? There is clearly much less water flowing through the reach in 2010 overall compared to previous years if one integrates under the Q curves (Figure 2); this "environmental" effect will likely impact peak flows, losing/gaining hydraulics, water temp, residence times. Also, this "dryer" year may have resulted in enhanced local field irrigation which is independent of beaver dam impacts. The authors refer to this loosely on pg 850 and elsewhere- and 80% increase in reach Q over two years is likely not driven primarily by a few ponded areas, unless a reasonable process-based explanation can be presented. As the paper stands it is difficult for the reader to parse direct effects of beaver colonization from inter-annual environmental variability and associated human impact (irrigation); this renders the results much less "quantitative" than the authors imply (eg pg 853, L20). 2. The "window of detection" concept well detailed by Payn et al 2009 should be reviewed and commented on in the context of your results. Beaver dams seem to force surface and subsurface flowpaths outside of the main channel which cause strong variability when making closely spaced in-stream evaluations, but may integrate at larger scales (windows) to result in muted changes. The local discharge patterns described at the top of pg 850 could be influenced by a series of "return flows" from upper impounded areas. Similarly, it is noted on pg 854 that the up-gradient "control" reach lost more water each year of the study, while the impounded reach gained more water. Could something about the higher water table, increased capture area be forcing greater return flow from upstream? Is there any way to parse stream water from new GW inputs chemically based on already collected data? Tracer mass-recovery methods should be better defined, and a mass recovery of -103.7% does not make sense conceptually. There is discussion regarding the increase in residence times on Pg 852, but this does not include the residence times of unrecovered mass/water, so these increases in recovered mass residence time likely underestimate true increases in system residence time. 3. Water above beaver dams is likely poorly mixed outside of some zone of preferential flow. Therefore similar placement of the one thermal sensor in each ponded area is crucial if they are going to be reasonably contrasted between ponds. Perhaps I missed this, but was an effort made to do this? Were they within flowing water or more stagnant water? Conclusions are made based on strong observed temp variability which do not make sense from a Lagrangian standpoint. A slug of water is not likely to heat up then cool down in the intricate patterns shown here as it passes through the reach. Strange and inconsistent patterns in data in Figure 10 (only 2 days) could potentially be explained by incomplete mixing of waters in the area of temp data collection. It would help greatly to plot air temp here. 4. Although alluded to in the discussion, the concept of patchiness could be more strongly presented/commented on here (see http://rsfs.royalsocietypublishing.org/content/2/2/150) . Beaver dams likely increase system productivity by creating varied habitats in close physical contact with one another as the author's mention. This increase in "productivity" may be difficult to quantify with simple point temperature and water flux/head measurements, but they

can perhaps be commented on. 5. It is not clear why a 2006 image is used in Figure 1 to show a post-dam world, and the beaver ponding is digitized (?) from some other unknown image. Either both images should be directly presented or the 2010 image should be used for this figure. The text/symbol size in this figure needs to be increased. 6. Consider shifting Figure 10 to supplemental, and including the current Supplemental IR figure as new Figure 10 Figure 4: Can you plot all of these panels together? They are difficult to compare as-is

Minor comments: (next time please use a continuous line numbering system) pg 840 l2- delete "increasing" l15-mean temperature in the outgoing thalweg? Try to be more specific with these important conclusions. state some conclusions here on local GW heads. 841- perhaps mention that beaver dams break up the average stream slope into a series of punctuated head drops. Overall this intro is in great shape. 843 L19- how old are the relic surfaces? 844 L1- The underlying goals of the restoration project should be clearly stated L4-"roughly around 2005?" surely somebody knows the correct timing L12- Beaver dam height measured how? (eg top to base below water?) L19-extrapolaton seems a bit weird here- 13.3 dams/km based on 10 dams over 750 m- as you arbitrarily defined the reach length, and if the upper control section was included this number would fall 845 L15- where were these pressure transducers installed relative to channel morphology? In a side pool? L18- what is this full range of flow conditions? L20- FloMate 2000? L28- are these return flows surface or subsurface? this seems like a "result" 846 L3 include range of injected masses. Na+ also effects conductivity. L11ish- introduce the mass recovery, concurrent gains/losses methods here presented by Payn et al 2009, mass recovery is later determined but it is not stated how this was done L23- where were these temp measurements made? 0.6 m depth? attached to stake in water column? 847 L10- ice build up influenced by dams? This can effect winter SW/GW exchange L17- how is error on parameters a and b determined? Some main details should be stated here so the paper can stand alone without Schmadel et al 2010 L20** are these changes normalized to local air temps somehow?? 849 L5- Make sure to state temp data were collected above the impounded water upstream of dams, not just right above a dam and right below which would make less sense L25- how did snowpack/melt differ between years? 850 L4- include error estimates on these values, the coauthors previous work clearly indicates this should be done 851 L12-14 move to Discussion section L18 “in the end” too casual L20 what about the lateral transect info form Subreach 5? 852 L2 note these patterns show a potential for water flux, not flux itself- you may be comparing pressure from two different flow paths 854 L15 this is quite vague 857 L17-18 you should be able to comment on this here

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 839, 2015.