Quantifying streamflow and active groundwater storage in response to climate warming in an alpine catchment on the Tibetan Plateau

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Received and published on December 10, 2018

This paper quantifies streamflow and groundwater changes due to climate change in an alpine region with a large glacier. This type of work is very important and is likely applicable to other mountainous areas (e.g. the Rocky Mountains in North America and the Andes in South America). Overall the methods of this paper are relatively easy to understand. There is a good use of appropriate references throughout the paper including relevant papers at nearby study sites on the Tibetan Plateau. I think the paper is worthy of being published, however there are some issues with grammar and sections where the paper could stand to be reworded to increase readability and be more concise. The paper is also lacking in regards to the site description, explanation of methods, and analysis. For more details, see the comments and questions below.

Comments/Questions

1. I would capitalize catchment and station if it has a name before it, i.e. Yangbajain Catchment.
2. Does “the wide and flat valley” have a name. As long as there are no other valleys mentioned, I think after you first introduce and describe the valley as wide and flat for the rest of the paper you could just refer to it as the valley.
3. Throughout the paper sometimes it is referred to as baseflow recession processes and other times it is baseflow recession process. Is there more than one process? What are the process(es) and is the word process even necessary?
4. Since you can separate out baseflow from quickflow using equation 6 and 7, why did you only analyze the base flow recession curves during the fall and early winter and not the entire year. If this is because of the lack of ET or precipitation, then why is there no ET in fall/winter. Is all of the vegetation dead in fall, and what is the vegetation in the area?
5. How valid is equation 9 considering that some of the groundwater will go into deeper aquifers, or could potentially come up from deeper aquifers? Are there any areas in the catchment where there is a gradient such that are losing reaches of the stream? Might want to clarify what exactly is meant by active layer storage.
6. You have a fair description of the valley on the east side of the catchment but no real mention of other prominent features in the catchment. I know this is not a geology paper but if you are going to discuss ground water storage, you should probably give a basic description of the aquifers and rock/soil types throughout the catchment and not just in the valley. I noticed that Figure 3 mentions fractured bedrock but this seems to be the only mention of bedrock in the entire paper. Also it would probably be a good idea to mention what physically separates this catchment (no flow boundaries); i.e., mountains, rivers, etc.; and make sure it is clearly stated in this introduction why you chose this particular catchment.
7. Make sure that is clear from the abstract not only what you are doing, but how is it different than other studies. Also you might want to include as part of the last sentence what should be a major point in this paper; What impact this has on the population and overall environment of the region? You brought this up in the introduction by talking about water supply but you might consider moving this to the abstract.

8. Might want to include some form of outline in your introduction. The introduction is rather long, and it is probably worth another look to make sure that it is as concise and organized as possible.
9. How much water does the thawing of frozen ground/ permafrost add to the system? Is there a way to quantify this and would it need to be considered in dS/dt?
10. It would be a good idea in a future study to include a water budget that includes ET and precipitation.
11. Is there any snow in the catchment, and does it have any impact on streamflow or is all the meltwater just from the glacier in summer?
12. It would be good idea in the future to perform a groundwater tracer study if possible.

Detailed Comments

1. Page 2, line 20 should either be written as an alpine glacier, or alpine glaciers depending on if there are more than one glacier present in the area.
2. Page 2, lines 28-29 "takes responsibilities to" sounds awkward. I would suggest writing something like climate warming plays a key role in increasing streamflow, or climate warming is partially responsible for increasing streamflow.
3. Page 2, lines 30-31 might read better as, which has led to a loss of over 25% of the total glacier volume.
4. Page 2, lines 29-33 it seems that both glacier melt and baseflow are given as the main reason for the increase in streamflow, since the lines use the words "increased streamflow is mainly" and "dominant factor for the increase." It might be best to clarify if the baseflow is from meltwater or if the meltwater only increases streamflow at a certain time of year.
5. Page 2, line 35 $mm^{0.79}d^{-0.21}$/10a seem like rather odd units. Where do they come from?
6. Page 3, line 38 might read easier as, which lead to the enlargement of the storage capacity that can accommodate summer rainfall …, which is slowly released into streams in subsequent seasons.
7. Page 3, line 44 the phrase "way of glacial retreat" would sound better as impact of glacial retreat.
8. Page 3, line 51 might read better as, dry periods, giving it a pivotal role….
9. Page 3, lines 51-56 how is the current glacier retreat different than the melt that help sustained the area during dry periods? Were there any particular dry periods that line 51 is refereeing to?
10. Page 4, line 59 should read, a glacier is known as a "solid reservoir." Not sure if the term solid reservoir actually needs the quotation marks.
11. Page 5, line 88 should put the words of the in front of "areal extent".
12. Page 5, lines 87-91. Sentence order might be better if the portion from the word using to the end of the sentence was moved to just after the word found. It would go something like Evans et al. (2015) found using … on the northern TP that an increase in mean ….
13. Page 5, line 93 capitalize the word basin.
14. Page 5, line 96 do not need the word the before Artic.
15. Pages 5-6, line 97-100 might read better if the phrase "based on numerical simulations" was moved to between suggested and that. The sentence would read … suggested based on numerical simulations that ….

16. Page 6, line 100 I would change “The slowdown” to A slowdown.
17. Page 6, line 104 remove the ly from qualitatively.
18. Page 6, line 110 should add the word a before the word warming.
19. Page 6, line 112 and line 116 insert the before the word catchment.
20. Page 6, lines 113-119 would switch the order of be and theoretically to read … can theoretically be used …. Also, this is a rather long sentence that could be broken up.
21. Page 7, line 121 should either read the non-linearity of the … or a non-linear storage ….
22. Page 7, line 123 this is not really important for the objectives of this paper but I am curious what the authors would consider to be the complex structure or properties of aquifers in the study area that necessitate a non-linear relationship. Is it simply the presence or areas of frozen ground?
23. Page 7, line 126 might want to add the word base in front of flow.
24. Page 7, line 127-128 I would add an apostrophe ‘s after Kirchner.
25. Page 7, lines 134-135 I would write this as to assess the glacier variations due to climate warming.
26. Page 7, lines 137-138 should change in climate warming to in a warming climate. Would also change “the water volume changes in the partitioning” to the changes in the partitioning of water volume.
27. Page 8, line 141 should probably number the last objective to stay consistent.
28. Page 8, line 146 should change highly to significant.
29. Page 8, lines 148-152 I would change “the wide and flat valley” to a wide and flat valley. If I understand it correctly the entire valley is in a fault, so my question would be how large is this fault? I would also be interested to know the type and level of activity of the fault, and what effect this has on groundwater flow. I do not think that you need to say that there is flat terrain, since you already called it a wide and flat valley. Also you say thicker aquifers meaning thicker in comparison to what exactly. Finally, I would change the sentence to read the great thickness of Quaternary loose sediment.
30. Page 8, lines 152-153 I would change the sentence to read Glaciers cover (or A glacier covers if it is only one glacier) about 11% of the catchment, making it the most ….
31. Page 8, lines 154-155 I would move the phrase “according to the First Chinese Glacier Inventory” to the beginning of the sentence and change the rest to read with a majority of glaciers found ….
32. Page 8, line 157 I would change ranges to last.
33. Page 8, line 160 where do the estimates for the area of frozen ground and permafrost come from? Is it from the same map mentioned in the previous line?
34. Page 9, line 163 I would remove the words “The climate in” and just have the sentence start at the second the, and insert the word a in front of semi-arid.
35. Page 9, lines 167-171. I would consider combining the two sentences in these lines to read something like The catchment has a summer (June-August) monsoon with 73% of the yearly precipitation, while the rest of the year is dry with only 1% of the yearly precipitation occurring in winter (December-February).
36. Page 9, line 172 Where is the number for annual runoff depth coming from. Is it supposed to say runoff depth or streamflow?

37. Page 9, lines 173-178. I would reorganize this paragraph a little to say everything about summer, i.e., where the recharge in summer comes from, and the amount of streamflow first then discuss winter.
38. Page 10, line 183 I would change neighbor to adjacent.
39. Page 10, lines 189-190 I would write the units as ˚C/100m or ˚C per 100m. Also, I would change "with elevation" to for elevations.
40. Page 10, lines 198-200 I would move the phrase which…trends to between the words test and is at the beginning of the sentence. The sentence would then read (MK) test, which is robust against outliers… is applied to detect ….
41. Page 12, line 224 take the s off algorithms.
42. Page 12, line 225 using the term first filter equation implies that there is another filter equation, but this is the only one given in the paper. Did you mean to say that equation six is the first filter and that equation seven is the second filter equation?
43. Page 12, line 230-231 I would describe α before b_t, since it is used in equation six and b_t only appears in equation seven. There should also be a semicolon not a period in front of α.
44. Page 12, lines 239-241 I would put the variables in the order that they appear in the equation. Although it is acceptable to start a sentence with the word and I do not think it is necessary for this sentence. I would just start the sentence with the letter K.
45. Page 13, lines 256-258 if it takes three days for the signal from a rain storm to peter out why remove only the first two? Also, if you are making use of a filter to separate baseflow then why bother to remove any days?
46. Pages 13-14, lines 262-265 where does the value for Δy_{crit} come from? I do not think the word meanwhile is needed in this sentence. I am assuming that the process that starts on line 263 is the next step in the overall baseflow process and not something that is done because of $\Delta y_{crit,}$ so what if anything is done if the value for Δy_{crit} is reached. Also there may be a word missing, such as regression, after the word squares.
47. Page 14, line 266 I would change "the fixed" to a fixed. How realistic is it to have b fixed as a constant, is there any precedence for having a fixed value for b? What would the effect be if b was not fixed? Is there be any reason you would fix b instead of a?
48. Section headings for 3.1 and 3.2 the headings only mention streamflow but both sections discuss climate trends. I think you should reconsider the names of these sections. The names could simply just be Annual Variations and Seasonal Variations.
49. Page 14, line 278 add the word a in front of non-significant.
50. Page 14, line 279 I would change the wording to, The similarity in the trends of annual streamflow…. The wording as written is confusing and makes it seem that there was a trend found by plotting temperature vs. streamflow instead of the idea that they both have their own increasing trend with time.
51. Page 14, lines 282-283. I would rewrite this sentence to read, The significant rise in air temperature has caused a continuous retreat of the glaciers in the catchment. The current wording does not seem to be grammatically correct.
52. Page 14, line 283 I would remove the word twice and the (I &II volumes) and just write the word Inventory as plural.
53. Page 15, line 284 I do not think that you need to give the dates of the glacier inventories again, since they are already in the methods section.

54. Page 15, line 285 you might want to add the word respectively before the word over to be consistent with the rest of the paper.
55. Section 3.1, paragraphs 1-2 I would combine these paragraphs. This could be done by combining the last sentence of the first paragraph with the sentence that goes from line 285 to 288. I think that the current first sentence of paragraph two could be eliminated. Starting at the end of line 280 perhaps state something to the effect: may act as a primary factor for accelerated glacial retreat leading to increasing streamflow. Then put the numbers for the decrease in glacier size. Then end the paragraph with the Prasch results. Make sure it is clear what sets your findings in this section apart from the Prasch results.
56. Page 15, line 290 remove the word remain and add the word a in front of significant.
57. Page 15, line 293-294 put the word the in front of annual mean streamflow. Might want to reword the start of the sentence as According to the baseflow separation method described above …. I would change this to being the second sentence in the paragraph.
58. Page 15, line 296 put the word the in front of the word two. I would remove the phrase the result shows that because I think that it is obvious that the rest of sentence comes from the results. Could also change it to the MK test shows that ….
59. Page 15, line 298 change the word this to the.
60. Page 15, line 302 add a comma in front of which. I feel like the first part of the sentence before the word which has already been covered by the previous paragraphs.
61. Page 16, lines 306-307 You say that intra-annual variation is obvious from the hydrograph in Figure 2. The first problem that I have with this is that Figure 2 is not really what I would call a hydrograph, since a hydrograph is typically a line graph of discharge at a location vs. time. Second in a quantitative study such as this I would avoid stating that anything is obvious without applying a statistical test like a coefficient of variation.
62. Page 16, lines 307-308. I am not sure where you are going with this sentence, and I am not sure if this sentence is even needed. It seems more like the rest of the paragraph is about how streamflow components change based on the season not how they change with magnitude of streamflow.
63. Page 16, lines 308 this sentence is worded strangely. I have never heard it called a variation trend. What exactly is a streamflow regime?
64. Page 16, line 310 not sure the word however is even necessary.
65. Page 16, lines 308-316. Seems like it is getting repetitive and I think this whole section needs to be redone. For example, it says that quick flow shows no trend for all seasons then it says that "streamflow and its two components" have no trend in summer. All seasons would by definition include summer. Another example is saying that baseflow and streamflow have a trend at the 5% level in autumn, winter, and spring; and then going on to state "streamflow increases at the 5% level in autumn" just one sentence later. Maybe try saying all the trends for streamflow in one sentence, then break it into trends for baseflow and quickflow in the next two sentences.
66. Page 16, lines 320-321 it has already been stated in the paper that monsoon rainfall is 73% of total precipitation, this does not have to be restated here.
67. Page 16, line 322 instead of just saying that the glacier meltwater is considerable is it at all possible to quantify this.
68. Page 16, line 323 Is it possible to estimate using a water budget how much of the monsoon rain actually makes it all the way to the stream and how much goes to ET or groundwater?

69. Page 16, line 324 remove the word the from the end of the line.
70. Page 16, line 325 make the word valley plural.
71. Page 17, line 326 change are to is.
72. Page 17, line 333 change selected to selection.
73. Page 17, line 339-340 would change" by all decades of the" to decadely for the, or change the phrase to read by the decade for the 1980's…. I would also perhaps change year-to-year to yearly.
74. Page 17, line 342 I would change it to read K and m for each year or decade….
75. Page 17, line 344 Put the word a in front of recession period.
76. Page 17, line 345-346. If you made change #74 then this last sentence could be eliminated completely, since it does not add anything.
77. Page 18, line 348-349 would change "for each decade of the" to just simply the word the.
78. Page 18, line 351 would change it to the word this.
79. Page 18, lines 356-358. Make sure what you are saying here matches the graph. It seems to me that there were significant increases and decreases in the 1980s, there is a rather large decrease at the beginning of the 1990's not just a slight variation, and it appears that the 2000's have a large increase followed by a decrease before basically leveling off until around 2007 before dropping again.
80. Page 18, lines 358-360 I would combine these two sentences. To something like but its overall increasing trend of 7.7 ($mm^{0.79}d^{-.21}$)/10a at a significance level of 5% is similar…. I would maybe include somewhere in the paragraph what the decadal trend is numerically rather than just saying it is similar to the yearly trend.
81. Page 18, line 367 change it to this.
82. Page 19, line 372-375 is not really worded in the most concise manner possible. Might change to Our hypothesis is that increased groundwater storage in autumn and early winter is associated with frozen ground degradation due to rising temperatures during this period.
83. Page 19, line 375-376 would change word order to read paths in a glacier fed catchment, which is under-lain by frozen ground.
84. Page 19, line 380-382 perhaps change "to percolate" to the phrase that can percolate. Not sure if the part after the last and in the sentence make sense or is needed. Should not have the word and twice in a list of changes if that is what this is.
85. Page 19, line 383 change earlier to early.
86. Page 19, line 385 change increase to increased.
87. Page 19, last paragraph should include numbers to quantify frozen ground degradation, and if at all possible maybe the thickness of the various layers of aquifers and frozen ground/permafrost.
88. Page 20, lines 392-393 change "larger glacierization and large-scale frozen ground" to something like a large glacier and widespread frozen ground coverage.
89. Page 20 line 397-398 I am assuming by "analyzed the seasonal variations…" you mean the last paragraph of 3.3. If that is the case, I would not really consider this an analysis, but would rather call it a discussion and change the word analyzed to discussed. Figures are referenced but there was really nothing done in the line of statistically quantifying anything like how much frozen ground amount changes seasonally or yearly. Also, it says the "phrase streamflow and its components but the entire last section of the paper only mentions baseflow not flash flow or total streamflow.

90. Page 20, line 402 put a comma in front of which.
91. Page 20, line 408 states baseflow recession slows down in winter and spring but the study only measured this for fall and the very beginning of winter.
92. Page 21, line 410 add the word a in front of the word warming.

Figure based comments

1. Figure 1 make sure that you use the highest resolution figure possible, so that the legends remain readable. Since the figure is on a page by itself you might want to reduce white space by making the figure take up as much room as possible.
2. Figures 2, 4, and 7 is this really runoff depth or is it streamflow. On page 7, line 75 it mentions streamflow not runoff depth when it references figure 2. Same thing on page 14, lines 274-276 for figure 4a; and on page 16, lines 309-310 and 316 for figure 7. To me runoff depth implies overland flow, which can be highly variable over a catchment and is hard to measure as a depth.
3. Figure 2 I would split this into a 2a and 2b with 2b just having temperature. Alternatively, the two axis on the right hand side could be combined, since the numbers are almost the same for both.
4. Figure 3, I would change the color of either the surface flow paths or the ground water flow paths because it is hard to tell that there a darker blue when groundwater covers them up. Not sure if surface water flow path arrow is even necessary.
5. Figure 7 might want to change one of the lines in figure to a different color, since color is allowed in this journal. The lines in figure 7d in particular are close together and it is hard to differentiate the two since they are both black.