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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Modelling runoff from a Himalayan debris-covered glacier" *by* K. Fujita and A. Sakai

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In this manuscript the authors modelled the runoff from a Himalayan debris-covered glacier. The hydrological model classified the catchments into four land covers, the debris-covered glacier, the debris-free glacier, ice free terrain and lake. For debris-covered and debris-free glacier melting, the authors used energy balance method to calculate the runoff. The uncertainties of thermal resistance albedo and runoff simulation are also considered by standard deviation method. And the sensitivity analysis also provided some useful information to understand the glacial catchment hydrological processes, especially under climate change. The field work on Himalaya is extremely tough, so hereby I pay my respect to the glacier hydrologists. The simulated results

are convincing and the paper is well written. I have also learned a lot while reading this manuscript. This work surely deserves a publication. I would like to give it as minor revisions. But before publishing, part of the text should be polished/clarified first.

1) The figures of model structure (Figure S1) and distribution of thermal resistance (Figure S4,S5) are shown in supplementary. Why do not you show it in the main manuscript? They are important information I think.

2) P42, L25-26: "The impact of air temperature on inter-annual variability is 23 times greater than that of precipitation." The authors used the standard deviations of air temperature (0.47oC) and precipitation (97mm) to estimate the sensitivity of runoff with the change of temperature and precipitation. For sure, the sensitivity analysis is a useful method to test the influence of climate change on glacier runoff. And I can understand that the authors would like to illustrate the change of temperature has more influence on the runoff than precipitation. However, I think the conclusion could be dangerous: 'It is clear that variability of the total runoff caused by air temperature variability is 23 times greater than that caused by precipitation variability' (P61, L26-28). Firstly, using the standard deviations of temperature and precipitation to do the sensitivity is controversial. Secondly, please be noticed that glaciers also dynamically response to climate change, such as changing the area, the length or depth of ice to adopt to the ice thinning in glacier ablation and accumulation zone. You should mention your assumption somewhere that this sensitivity analysis is based on the present steady condition of glacier, without considering the glacier dynamic. Thirdly, this is only a simulation in this study site which you should mention it, to avoid of generalizing this conclusion.

3) For the structure of Section 2, I recommend the authors to change it a little bit. In order to make it much clearer and easy to read, firstly you can describe the study site and your delineation methods, and then your forcing data of your model, after that you can describe your model structure. For model structure, firstly you can describe the snow melt model combined with albedo calculation, because the snow melt simulation is included in three landscape classes, the debris-covered, the debris-free and ice-free

terrain. Secondly, describe the debris-free and debris-covered glacier melt simulation. You'd better concentrate on the influence of debris on glacier melt, the thermal resistance value in your model. In the end, the simple bucket model for ice-free terrain. Please emphasize the difference between debris-covered and debris-free glaciers runoff simulation.

4) Interestingly, in Fig. 5, I found that the model overestimated the runoff at the beginning of melting season and then underestimated the runoff, especially in 1994 and 1995. To my knowledge the neglecting of the storage effect of snow pack could cause this overestimation of runoff at the beginning of melting season(Gao et al., 2012). In other words, melt water and rainfall is retained within the snowpack until it exceeds a certain fraction(Seibert, 1997). I think at least the authors should explain the reason of this discrepancy.

5) Please make a table of the parameters in the model and their values in this study.

6) The conclusions are a little bit long. I suggest the authors to shorten the conclusions and make a list of the main conclusions. The details could be moved to the discussion part.

Minor comments:

P57, L26 and the whole manuscript: What is 'runoff height'? Did you mean the 'runoff depth'? (Gao et al., 2013)

P.48, L21: If the simulation in this study is in water depth, you do not need to mention the water equivalent (w.e.) for the whole manuscript.

P42, L10: change "establish" into "established". Furthermore, please be conscious of the choice of verb tense in the whole manuscript, such as 'evaluate and discuss' in P44, L26-27.

P42, L8: change "scales" into "scale". Please be conscious whether the noun is countable or uncountable in the whole manuscript, such as 'calculations' in P43, L18, 'mea-

surements' in P44, L15 .,et al.

P42, L12: change "validated" to 'tested' or 'applied'.

P42, L9: rephrase "because. . .", and make this sentence clear. What kind of characteristics of debris is hard to measure? And the necessity of runoff model.

P43, L2: what did you mean by '. . .the delivery of water resources to. . .'?

P43, L6: did you mean '. . . depends partly on'. And please give a reference to this sentence.

P43, L9 and the whole manuscript: what did 'comparable' mean?

P43, L19: remove 'systems'. Change 'in' to 'of'.

P45, L5: remove '(the word "Tsho" means. . .)'

P46, L5: from Eq. 5, we can find that we can get the Gd without the thermal resistance. Is this correct? Can you explain how you got Equation 5 from Equation 4?

P48, L25: why the condensation is included, but the evaporation or sublimation is excluded?

P49, L11: change the function into Qs=. . .

P49, L13: change the function into Qg=. . .

P51, L7: change the function into Dt=. . .

P55, L25: change 'gradient of' to 'corrected'

P56, L3-5: Why did you put the results in the supplementary? This is part of your main results, which is important I think.

P57, L3-5: Did you mean 'We calculated both the root mean squared error (DRMS) and the Nash-Sutcliffe efficiency of simulation'?

P57, L5-7: change into ‘We found that the best estimation is obtained. . .’.

P57, L12-16: Rephrase this sentence.

P57, L20: change the sentence into ‘We further calculate the average value of each components in long term to understand. . .’

P57, L21: change ‘. . .runoffs for. . .’ to ‘runoff in’

P57, L22: are you sure ‘seasonal cycles’ is a proper term? And change ‘annual means’ to ‘annual average’

P57, L27: Remove ‘defined as area-averaged runoff’

P58, L1-3: Rephrase this sentence.

P58, L3-4: Why the similar runoff depth from debris-free glacier and ice-free terrain illustrates the debris free is in a steady state? Explain this point of view.

P58, L9: change ‘. . .the present. . .’ to ‘this’

P58, L10: remove ‘the’ before ‘calibration’

P58, L18: What did you mean by ‘resulting runoff’?

P59, L1: what did you mean by ‘control calculation’?

P59, L14: What did you mean by ‘comparable’?

Section 4.2: this section is the intriguing for me and well written. The simulation showed that the thin and dark debris increased the runoff, compared with debris-free debris covered glaciers. I suggest the authors further explain the reason of your finding to some extent, such as thermal resistance and albedo et al.

P60, L1: Is lake a topographic feature? Please make sure all the scientific terms are properly used.

P60, L2: What did you mean by ‘lake dimensions’? Did you mean ‘lake storage’?

P60, L12-16: Consider to move these sentences to the introduction.

P60, L17-18: I totally agree.

P60, L19: Please clarify what the projection is. The runoff or the glacier or others?

P62, L25: What did you mean by ‘integrated runoff model’?

P63, L20: What did you mean by ‘comparable’? Did you mean similar or different or something else?

P64, L15: maybe change ‘perturbation’ to ‘variability’

P64, L24: ‘. . . on a larger scale. . .’ could be better.

References

Gao, H., He, X., Ye, B., and Pu, J.: Modeling the runoff and glacier mass balance in a small watershed on the central tibetan plateau, china, from 1955 to 2008, Hydrological Processes, 26, 1593-1603, 10.1002/hyp.8256, 2012.

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