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Interactive comment on "The role of glaciers in stream flow from the Nepal Himalaya" *by* D. Alford and R. Armstrong

Anonymous Referee #3

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This study addresses the important problem of contribution of glaciers to the Nepalese rivers. About 80% of the glaciers in the Ganga basin are in the Nepal Himalaya and this study discusses relevant scientific questions. The estimation of glacier contribution is achieved by using glacier hypsometry and ablation gradient and non-glacier contribution is estimated by basin hypsometry and runoff gradient. However, some of the assumptions made in the methodology required to be rephrased and reworked in accordance with the present understanding of the glacial processes.

Authors could improve the build up of the paper by collating existing knowledge base on glaciers role in the streamflow in general and Himalayan region in particular. Authors argument that the "The models developed for this study indicate that neither streamflow timing nor volume of the rivers flowing into the Ganges basin from Nepal will

be affected materially by a continued retreat of the glaciers of the Nepal Himalaya" (page 479, L14-16) is not fully substantiated in the paper. Here, authors consider glaciers as stand alone hydrological unit and overlooked the fact that the glacier recession/advancement is a pointer to the changes occurring to the mountain hydrological system as a whole. It is a well accepted fact that the glacial change in a region could influence the changes occurring to the surrounding environment through the feedback mechanism mainly driven by the albedo feedback (cf. Patterson, 1994). Globally, the main role of glacial contribution to the streamflow is limited to reduce the inter-annual runoff variations at certain percentage glacierization of the catchment. For Swiss Alps, least inter-annual variation occur at 30-60% glacierization (Rothlisberger and Lang, 1987; Chen and Ohmura, 1990; cf. Casassa et al., 2009) and 10% for the North Cascades (Meier and Roots, 1982). So, while looking at the role of glaciers in the streamflow from Nepal Himalaya, under a very different climatological set up dominated by the SW monsoon, one would expect authors to focus on the extent of this "compensation effect". In fact authors make this important statement in Page 480, L 1-3 & L 7-10 that " the role of glaciers in the hydrology of the Nepal Himalaya is very much dependent upon the scale at which this role is assessed , as well as upon the location in the river basin for which the assessment is undertaken" and " The probable impact would become progressively greater as one moved upstream in a basin, decreasing the distance to the glacier terminus". But no assessment of this important role of glaciers are provided while these rivers are flowing through Nepal, instead provided the basin outlet assessment of glacier contributions.

Page 471, L8-10: Most of the peer reviewed research on Himalayan cryospheric system suggested that the contribution of Snow and glaciers together is significant in its principal tributaries. (Singh et al 1997, Singh and Jain,2002; Kumar et al.,2007). On the other hand non-peer reviewed, grey literature like WWF(2005) emphasized the role of glacier melting in the river flow as mentioned by the authors (P471- L10). So the emergence of a dominant view point on role of glacier melting and its impact on streamflow today is being facilitated by diverse sources. Most recently a discussion

paper by Mr. V.K Raina (2009), again a non-peer reviewed work, has had impacted the debate on climate change and Himalayan glaciers. Hence, it is very important to mention the source of existing points of view presented in the paper, so that readers could judge and rate the authenticity/credibility of these statements.

Page 476, L 3- 14: A proper description of the study area with locations of nine hydrometric stations and sub –catchments marked on the Fig-3 may be appropriate. Altitude of the nine hydrometric sites and information on percentage of glacier cover in each of these sub-catchments in Table -1, will be informative. Discussion on the climate of the region with emphasis on the pivotal role of monsoon in the glacial processes as well as river flow may be very useful to contextualize the present study. One would be interested to know the period of streamflow record used in the study?

Page 476 ,L 16 “Orographic gradients are shown in Fig.3” Change to Fig.4

Page 477 L 12-20 : There are three important issues regarding the glacier melt model,which needs to be addressed by the authors:

1. Equating Equilibrium Line Altitude (ELA) with 0o C isotherm goes against established definition of Equilibrium Line Altitude (ELA) in mass balance parlance. 0o C isotherm imply ‘no melt’, while ELA signify $\Delta S = 0$.

2. “Little or no melt was possible at any time above the ELA” is not a realistic assumption. For medium sized glaciers, Accumulation Area Ratio (AAR) corresponding to the zero mass balance range between 0.58 to 0.73 (Dobhal et al.,2008). This problem may be resolved by dropping the first assumption (ELA = 0o C isotherm) and using a melt gradient in place of ablation gradient. Theoretically, the assumption of little or no melt is possible above the 0o C isotherm is well appreciated. This assumption will force overestimation of glacier melt from the ablation zone to match the glacier discharge.

3. Assumption of equilibrium condition needs to be revisited as Nepal glaciers are under the recessional regime experiencing negative mass balance (Ageta et al., 2001,

Fujita et al.,2001) and this will lead to underestimation of glacier contribution in a recessional regime.

Page 479 L 2-3 “ The snow and ice lost by the ablation zones of the glaciers may become runoff. . .. .” . Such statements, suggesting only ablation zone of the glaciers is contributing to the glacier discharge may be avoided.

Page 479 L14-16 “The models developed for this study indicate that neither streamflow timing nor volume of the rivers flowing into the Ganges basin from Nepal will be affected materially by a continued retreat of the glaciers of the Nepal Himalaya” –No analyses of flow timing is presented in the paper.

Page 481, L8-11: Fully agree with authors view regarding the IPCC, 2007 statement in WG-II Chapter -10 (Asia) on the future status of the Indus, Ganga and Brahmaputra rivers. Primarily because the statement “The current trends of glacial melts suggests that the Ganga, Indus, Brahmaputra and other rivers that criss-cross the northern Indian plain could likely become seasonal rivers in the near future as a consequence of climate change and could likely affect the economies in the region” (IPCC,2007) itself is not sourced from any credible research work published in a peer reviewed journal. Please note that no reference is attached to this very important statement in the IPCC, 2007 report and how IPCC arrived at this important conclusion in not known. Hence the author’s view that such sweeping generalizations should not be made without proper studies on the role of glaciers in each of the major river basins is fully justified. The statement in the paper required proper referencing of the IPCC, 2007 , Chapter 10 statement, as each chapter of the IPCC report have different citations.

Table -1 Please add station altitude and percentage glacier cover of individual basins

Table-2 Shift Marsyangdi- 439 from column -1 to column-2

Comments of the other reviewers and the reply of the authors were already posted when compiling this review.

References

Ageta , Y ., Naito,N., Nakawo,M., Fujita,K., Shankar, K., Pokhrel,A.P. and Wangda,D. 2001. Study project on the recent rapid shrinkage of summer- accumulation type glaciers in the Himalayas,1997-1999, Bull.Glaciol. Res.,18,45-49

Casassa,G., Lopez,P., Pouyaud,B. and Escobar,F. 2009. Detection of changes in glacial run-off in alpine basins: examples from North America, the Alps, central Asia and the Andes, Hydrological Processes,23 31-41.

Chen, J. & Ohmura, A. 1990. Estimation of Alpine glacier water resources and their change since the 1870s, IAHS Publ., 193, 127-135.

Fujita, K., Kadota,T., Rana,B., Kayastha,R.B. and Ageta,Y. 2001. Shrinkage of Glacier AX010 in Shorong region, Nepal Himalayas in the 1990s, Bull.Glaciol. Res.,18,51-54.

IPCC, Cruz,R.V.,H. Harasawa, M. Lal, S.Wu, Y. Anokhin, B. Punsalmaa, Y.Honda, M. Jafari, C. Li and N.Huu Ninh. : Asia, in: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by: Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden P. J., and Hanson, C. E., Cambridge University Press, Cambridge, UK, 79-131, 2007.

Kumar, V., Singh, P., and Singh, V.: Snow and glacier melt contribution in the Beas River at Pandoh Dam, Himachal Pradesh, India Hydrolog. Sci. J., 52(2), 376-388., 2007. Meier, M.F and Roots,E.F. 1982. Glaciers as a water resource, Nature and Resource,18 (3),7-14

Paterson, W.S.B. 1994. The Physics Glaciers, Pergamum press

Rothlisberger,H and Lang, H.,1987. Glacial Hydrology: In Glacio-fluvial sediment transfer An Alpine perspective, edited by .A.M Gurnell and M.J ClarkJohn Wiley & Sons, 207-284.

Singh, P. and Jain, S. K.: Snow and glacier melt in the Satluj River at Bakhra Dam in the Western Himalayan region. Hydrolog. Sci. J., 47, 93-106, 2002.

Singh, P., Jain, S. K. and Kumar, N.: Estimation of snow and glacier contribution to the Chenab River, Western Himalaya, Mt. Res. Dev., 17 (1), 49-55, 1997.

Raina, V.K .2009. Himalayan Glaciers A state-of-Art review of glacial studies, Glacial retreat and climate change,Ministry of Environment and Forest, Govt. of India. 56 pp.

WWF, 2005, An Overview of Glaciers, Glacier Retreat and subsequent Impacts in Nepal, India and China, WWF Nepal Program, Kathmandu, Nepal, 70 pp.

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