

Interactive comment on “Sustainability of water resources management in the Indus Basin under changing climatic and socio economic conditions” by D. R. Archer et al.

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The authors thank Etienne Berthier for his very interesting and constructive comments. 1. Berthier's main concern is with the questionable implication that advance or retreat of glaciers or the occurrence of surging is a guide to the trend in mass balance of the glaciers. The information on mass balance in the Karakoram is indeed weak but not lacking entirely. Our comments are mainly based on personal communication and websites of Ken Hewitt who has spent some forty years surveying the glaciers there. Unfortunately, his information on mass balance is contained in 'grey' website literature and could therefore not be quoted directly. We have tried

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to reflect the substance of his statements in these websites but referring only to his published papers. For example in his web report in <http://www.chinadialogue.cn/> Understanding glacier changes, February 01, 2010. 'Reports of "disappearing glaciers" have come from many parts of High Asia. However, this is not the case in the upper Indus and upper Yarkand River basins. Here, the glaciers have been holding their own for several decades and recently, in the Karakoram Himalaya, many have started thickening and advancing, and, While there was a roughly 10% reduction of the Karakoram ice cover in the first 60 years of the twentieth century, no significant reduction has occurred in recent decades and, as noted, many glaciers are undergoing advances. In another website on Glaciers and climate change in the Karakoram Himalaya: developments affecting water resources and environmental hazards (www.wilsoncenter.org/events/docs/Hewitt_presentation.pdf), he states: I) there has been no massive or even net reduction in the ice cover in the last three decades ii) many glaciers have been retreating or thinned but, since 1995 I found more than 35 glaciers advancing, mid-glacier thickening in a dozen others, and a sudden increase in glacier surges. This website also includes a map showing thickening and surging glaciers. We will amend the section to make clear that ice advance does not necessarily reflect mass balance change but retain the general tenor of the section in the light of Hewitt's comments. 2. The reference to Greenwood et al was a 'holding' reference with the intention of replacing it with more relevant papers from other world mountains in the same HESS special issue. If necessary we will replace with a reference to Cogley (2009) or similar. 2 (2) We appreciate the update on recent literature on glaciers in the Central Himalaya and will modify the section in the light of your information. We accept that the Hasnain reference is 'grey' literature but was quoted simply for the reason that Hasnain has often been cited with respect to rapid glacier decline in the Central Himalaya. 3. We were aware of the Masuo and Heki paper using GRACE gravimetric data but are not yet convinced that issues of applying such data in the highly varied environment of the Upper Indus have been resolved. 4. We accept that in Fig. 1. The Indus Basin the "Glacier and Permanent snow area" is highly generalised and does not

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represent in detail all the glaciated areas of the UIB. It was intended merely to show the configuration of the Indus and its tributaries and the broad relationship between the upland headwaters and the plains of Punjab and Sindh. We do not think that, given the focus of sustainability of water resources in Pakistan that there is added value in greater map precision in glaciated areas. However, we will respond if requested in the formal peer review process. We thank you again for your comment which is of considerable help in updating our understanding of glacier changes in the HKH.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 1883, 2010.

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