

Interactive comment on “Climate change and mountain water resources: overview and recommendations for research, management and politics” by D. Viviroli et al.

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We thank reviewer #3 for the comprehensive and careful review and for the many valuable thoughts it contains.

In response to the main criticisms of our manuscript we recognise that there is need for stating more precisely what we attempt and what not. We will clarify that we wish to highlight important research topics and point at issues in management and policy which seem important from our point of view. It seems that this was obvious to the two other reviewers but may not be so clear to any reader. Hence, we will pursue the

proposed way of focusing more explicitly on issues from the perspective of research in our revised paper and stress what our background is.

We have probably also not said very clearly which aspects of the regional papers we will summarise in the overview and why, and what issues of the overarching topic ‘climate change and mountain water resources’ we are omitting intentionally to reduce the scope of our summary paper to a manageable level. This will be clarified as well.

As to the question of scales involved, we wish to stress that we do not have the ambition to provide insights into local-scale problems. This reviewer’s expectation of a fully comprehensive assessment is neither feasible nor attainable, not even for a single regional case-study. Such a manuscript would be book length, and the notion that we have all of this information available to begin with is false. Just to give one example, groundwater is an important issue globally. The current state of groundwater resources, however, is essentially unknown for most regions, not to mention its state regarding the global scale and global climate change impacts. To do what the reviewer asks for even for a single region, addressing all relevant local-scale perspectives would be a decade’s work, and many holes would remain. Addressing everything is therefore simply impossible, and the reviewer’s call for us to take this on is not reasonable. We feel reassured by the positive comments of reviewers #1 and #2 that the overview we attempt has its value, provided that we define its scope more explicitly.

It should also be noted that many of the specific issues are substantially addressed in the Special Issue contribution by Hamlet (2010) on the Pacific Northwest, in particular the collision between projected climate change impacts to multiple sectors affected by water, water resources planning and management, and water policy. These issues are extraordinarily complex, and there is probably no one in the Pacific Northwest who has the answers this reviewer expects us to provide for the globe.

To summarise, we will clarify the scope of our contribution in compliance with reviewer #3’s comments and will be happy to incorporate the valuable suggestions as far as they

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are applicable in the context of our article.

We will address the detailed manuscript comments in a supplement to this reply upon submitting a revised version of our manuscript. Below, we would like to comment on some issues raised in reviewer #3's generic comments (pages 1–3 / lines 1–125):

– Lack in transparency of methods and data used and their origin from mountain regions: This will be improved by providing the underlying data as supplementary material (see also comments by Reviewer #1 and our reply)

– We beg to differ with the notion that ‘the core of the paper is a regurgitation of Viviroli's global scale hydrological research’. The global scale research mentioned is used to place the case-study regions in a context and not in the least the core of the paper. This will be clarified in line with the issue of which scales we focus on and which not.

– Logical coherence in discussion of water supply and water demand: Our premise in Chapter 3 is that mountains mainly act as supply regions and lowlands host the lion's share of water demand. Exceptions apply, of course, but we believe that this simplification is defensible for an overview of the topic.

– Water resource problems cannot be solved by global-scale modelling: We agree, and we do not claim so in our paper. As stated at the beginning of this response, we recognise that there is need to stress that the global-scale discussions serve to place our study regions in a context. We will also stress the importance of regional modelling approaches and monitoring as well as the importance of predictions in ungauged basins (PUB initiative).

– Authors: 1) No key experts in the water management and politics field in mountain regions: Karl Schwaiger heads the international water management department at the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, and Bruno Schädler has dealt with various aspects of water management and policy for almost thirty years at the Swiss Federal Office for the Environment. 2) Narrow

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distribution and no representative from South America: This is not correct. Some of the co-authors have extensive field experience in other mountain regions and maintain active contacts to regional research and management institutions (Buytaert and Vuille: South America; Archer and Fowler: Pakistan). 3) No apparent contributions by Greenwood, Woods, Schwaiger and Schaedler, no citations to their work: Can an author's contribution be assessed by looking for references to his papers? We do not think so. The four co-authors mentioned have made substantial contributions to the paper and edited the manuscript.

– No explanation for the choice of single detailed example for Switzerland: Switzerland was chosen to prove a point: Even one of the densest meteorological observing systems over complex topography world-wide (Schmidli et al., 2001; Weingartner and Pearson, 2001), lacks representativity for high altitudes. We will clarify this.

– Most sub-sections are not relevant to the title since they do not treat mountain-specific issues: This is not correct. The most prominent examples are precipitation which is discussed with emphasis on downscaling in mountain regions, Snow Water Equivalent which is primarily an issue of mountain regions in our context, enhanced warming which is a mountain issue by definition and monitoring networks which are discussed in relation to altitude. As we mention in our conclusions, some of the problems mentioned are indeed universal to water resources management under climate change but amplified in mountain regions. From the two other reviews we deduce that the issues treated are relevant, and we will try to clarify the reference to mountain-specific issues where necessary.

– Upstream-downstream logic in hydrological issues and water management approaches: The highland-lowland perspective suggested was used for water resources where it seems indeed appropriate. It is however not meaningful for other aspects mentioned in the previous point.

References:

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Schmidli, J., Frei, C., and Schär, C.: Reconstruction of Mesoscale Precipitation Fields from Sparse Observations in Complex Terrain, *Journal of Climate*, 14, 3289-3306, 2001.

Weingartner, R., and Pearson, C.P.: A comparison of the hydrology of the Swiss Alps and the Southern Alps of New Zealand, *Mountain Research and Development*, 21, 370-381, 2001.

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