

The Cryosphere Discuss., referee comment RC1  
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## **Comment on tc-2021-167**

Anonymous Referee #1

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Referee comment on "Brief communication: A framework to classify glaciers for water resource evaluation and management in the Southern Andes" by Nicole Schaffer and Shelley MacDonell, The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-167-RC1>, 2021

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## **Review of "Brief communication: A framework to classify glaciers for water resource evaluation and management in the Southern Andes" by Shaffer & MacDonnell**

### SUMMARY

This brief communication proposes a new classification of the glacier landforms present in the Andes. The classification focuses on the sensitivity of the landforms to climate change and their hydrological impacts rather than purely on their geomorphological traits. The proposed classification is suggested to contribute to the discussion on the development of glacier protection legislation in both Chile and Argentina, which up to now have been relatively unsuccessful.

### GENERAL COMMENTS

In general, the manuscript is well written and the message the authors intend to convey is clear. However, I have to say I am slightly confused about the intention of this communication. On the one hand, I do see the benefit of publishing this work in The Cryosphere, as this discussion may also exist in other parts of the world and a consensus

in identifying glacier sensitivity from a policy standpoint could be beneficial. To serve this purpose, I do think the manuscript in its present form is (too) much focused on the Andean case. On the other hand, I wonder whether (the message of) this manuscript wouldn't be a better fit for a journal or other medium that allows direct targeting of the intended audience, i.e. policy makers, nature conservatists and water resource managers in the respective countries. I am not saying I do not see the benefit for TC and a "general" audience, but a more general focus would better support that.

I am also wondering how relevant it really is to identify the different landform types from a legislation perspective. Apparently, the political discourse has not yet been fruitful with respect to the GPL, even when just considering them as a single entity. Wouldn't introducing a system of sensitivities complicate things even further? In my opinion, the current manuscript does not express clearly enough how the introduction of the proposed classification would benefit the discourse around glacier protection, how it would benefit drafting related legislation, and how water resource management will be improved as a result.

I agree that the (quite minor) redefinition in classes defined by the authors with respect to traditional geomorphological categories of clean-ice, debris-covered and rock glaciers could improve assessment in terms of sensitivity and hydrological impacts up to a certain extent. However, in essence, the classification is still just based on a simple interpretation of the surface morphology, which is an oversimplification. This results in the straightforward and broad classes "sensitive" vs "insensitive", which may be too much of a black and white approach to be really useful in practice. High heterogeneity and variability exist among glaciers in their sensitivity and hydrological response, and this is for a considerable part irrespective of glacier surface type. It may be due to other geomorphological specifics of a glacier that are not considered in the proposed classification (e.g. slope, elevation, bed lithology, aspect etc.), but also due to differences in local climate, local anthropogenic disturbances, and possible feedbacks therein. Could some of these components be included somehow? Wouldn't an (even simple) modelling approach allow for a more informative estimation of the actual sensitivity of the glaciers? I would suggest the authors to at least elaborate on the limitations of such a simple classification and place it into a context of other, more developed approaches such as regional and/or individual glacier modelling. "Advanced" approaches would also be better to identify potential tipping points and transient effects, which could be very important arguments in policymaker discussions and conveying the urgency of expected changes in hydrology.

I do not really understand the difference between landform and glacier used in the manuscript. A glacier seems to me as single entity, especially since it is hydrologically connected, but here it is suggested that a glacier is actually a landform that can consist of multiple glacier types. I would suggest using a better description of and distinction between these terms. Also, taking the most sensitive part from a geomorphological perspective in a "hydrologically-connected" case to represent the sensitivity of the entire glacier/landform is not necessarily valid. The system should rather be classified as a whole. This goes back to my previous point: will this simple classification adequately represent sensitivity of the existing wide range of glaciers and glacier systems? For all glaciers, but particularly for a multi-type ones, sensitivity very much depends on the type of external forcing that causes a potential disturbance. If, for instance, the lower part of a glacier system is heavily debris-covered, it could be relatively insensitive to climate

warming due to the insulation the debris provides in the ablation zone, but could be highly sensitive to processes that affect accumulation zone albedo such as the snowfall frequency or black carbon deposits.

#### SPECIFIC COMMENTS

L159-166. This is a good point, but it further reveals the complications with the sensitivity classification. I agree that a protection plan should evolve over time, but it should ideally already account for these temporal processes and effects from the get go. Is there any way temporal evolution could be included in the sensitivity classification approach? How would this affect the discourse and development of GPL?

L261-263. I am not sure why it is necessary or even desirable that non-experts can determine the sensitivity of a glacier. A well-developed database of glacier sensitivities created by experts using thorough analysis will deliver a much more insightful indication of the sensitivity of glaciers in a region or catchment and will serve policymakers better.