The Cryosphere Discuss., 5, C1547–C1551, 2011
www.the-cryosphere-discuss.net/5/C1547/2011/

The Cryosphere Discussions

Interactive comment on "A multi-parameter hydrochemical characterization of proglacial runoff, Cordillera Blanca, Peru" *by* P. Burns et al.

Anonymous Referee #2

Received and published: 14 December 2011

Review of Burns et al, TCD, A multi-parameter hydrochemical characterization of proglacial runoff, Cordillera Blanca, Peru

This paper investigates the hydrochemical properties of the waters draining from a glaciated catchment in the Cordillera Blanca, Peru. The paper contains a wealth of detailed hydro-chemical data (pH, conductivity, major cations and anions, nutrients and stable isotopes of water) collected over a three day period during the dry season in July 2009. The data, from a catchment in the Peruvian Andes, comes from an area (continent!) with very little data of this nature collected to date and has the potential to add a valuable new study set to the glaciological literature. The key aim of the paper appears to be the determination of the proportions of runoff from the Quilcayhuanca catchment which are derived from glacial as opposed to groundwater sources. It is

clear that the runoff volume and water quality draining from this type of catchment is crucial to the availability and use of water in relation to downstream water resources. Unfortunately, while the potential significance of such a study is apparent, the paper fails to deliver a clear or convincing analysis of the data or to describe its significance. Furthermore, the paper is very long and needs considerable editing to make the main findings clearer.

Major areas of concern

1) Purpose of the paper? The paper fails to set up effectively the real purpose of the work. For example, after reading the abstract, one is not any wiser as to the significance of the study or why it is being carried out, and this concern perpetuates throughout the manuscript. This lack of clear direction ensures that the reader is continually left wondering why something is being analysed and what it will actually contribute to the individual study and/or wider knowledge. The paper therefore needs to be set up with a much clearer remit. For example, the abstract suggests that "The study objective is to determine the spatial and topographic controls on geochemical and isotopic parameters in the Quilcayhuanca drainage basin" without stating why. The introduction then concludes with the line, "A two end-member mixing model is used to determine relative contributions of groundwater to the Quilcayhuanca basin, and these results are then scaled to the large Cordillera Blanca drainage basin". There are many reasons why determining the differing contributions to catchment runoff (not "groundwater" as stated here) may be of value, but the authors must explain what these are.

2) Lack of rigorous editing. The paper reads like a manuscript which has been submitted prior to thorough editing. As a result, 'everything' appears to be in here whether the paper really needs it or not as demonstrated by the following (and not exhaustive) set of examples: i) The tables. These are far too long and present large amounts of in places irrelevant data. The authors need to decide which of these data are actually important to the discussion and report on them (often in the form of figures) and remove the rest. At the moment, the 8 detailed tables are not adding much. ii) Water sample

analysis. The description of every lab, department, university and machine is overkill. iii) Results and discussion. The reporting here is overly long; the individual paragraphs in the sections on ions, nutrients and isotopes (4.2, 4.3 and 4.4) for example are excessively detailed and don't add much. More succinct summaries of the key points would be far more accessible, especially if the aims of all the analyses were made clearer up front. With respect to the nutrient analysis for example (4.3), if the key aim was to distinguish between the Quil Streams and Groundwater, the one statistically significant relationship could have been discussed and the other insignificant correlations could have been summarised in one line. iv) Study Area. This could be reduced substantially. Once again, if the purpose of the paper was made clearer, the level of detail required here would become more apparent.

3) Significance of results? The paper is based on the collection of just three days of runoff and hydrochemistry data from the Quilcayhuanca Basin (90km2) and these data are then used to upscale the implications to the Rio Santa catchment (12,200km2). While it is important to try and put local data sets in to a wider context, this extrapolation seems unjustified given the temporal and spatial limitations of the data set. A couple of lines on potential implications of upscaling, with obvious limitations, would therefore be more appropriate than a whole section on this (4.6).

4) Glaciological context. The paper would benefit from a better reading of the hydrochemical glacial literature with particular reference to the work of earlier investigators in glacio-hydrochemistry such as Collins and Sharp (e.g. Collins, J. Glac, 1979; Sharp et al, J Glac, 1995), especially regarding mixing models. At the moment, some of the glaciological analysis seems flawed. For example, the glacial literature suggests that conductance in meltwater runoff typically peaks with minimum runoff and vice versa (i.e. an inverse relationship between e.c. and Q) yet this paper seems to report the opposite (Fig. 5) in which case, it merits further discussion. Furthermore, with respect to Fig 4a, the authors observe that specific conductance decreases downstream. However, the explanation that this is because of increasing glacial discharge downstream

(p2492-3), cannot be supported because the glacial discharge is input at the top of the catchment and is thus not contributing to the increasing discharge downstream. Therefore, the changing (decreasing) e.c. and increasing discharge (Q) with decreasing elevation must be the result of additional waters added to the proglacial runoff over and above the glacial contribution.

5) Odd data limitations in relation to wider study aims. If a key aim of the study was to test the proportions of water being derived from different sources, it seems odd that more effort didn't go in to monitoring glacial runoff from the ice margin. The volumes mentioned (page 5) are not large so determination of the discharge from the glacial source waters would give a very good handle on what proportion of the total 1.2 m3s-1 was derived from direct glacial runoff. This would help constrain the mixing model calculations and strengthen lines such as "the surface waters leaving the valley at the lowest site in the drainage basin were calculated to be a mixture of approximately two-thirds surface water (mostly glacier melt) and one-third groundwater".

More specific comments

P2484, lines 21-24. This sentence makes no sense, "Among other effects, climate change and glacier recession threaten to decrease dry season discharge in this regions, representative of many global sites where highland water ecosystems reach downstream demand (Barnett et al., 2005; Weingartner et al., 2007)" and is a typical example of where more thorough editing is required (2 above).

P2485, lines 4-5. "Thus we focus here on how glacier melt fed streams are impacted by water-rock chemistry throughout a proglacial valley" – what is the relevance of this? This is an example of where the purpose of the study needs to be explained more fully (1 above). The subsequent paragraph (lines 6-14) makes some attempt to do so but the style of writing makes it very unclear – it needs to be more succinct.

P2485, lines 18-20. "An understanding of these geological and hydrological controls is beneficial for the utilization of mixing models which can be used to determine relative

contributions from end-members such as precipitation, groundwater, and glacier melt". Again, this actually says very little, in part because of the sentence structure. You need to explain far more clearly why determining the different end members matters and that mixing models are an effective method of achieving this separation (due to the fact that the differing geology and hydrology impart distinct hydro-chemical signatures on the source meltwaters).

P2486, line 25. The 22% loss figure is wrong with respect to the areal extent (which is in fact $\sim$17.4% loss). And if the 22% figure in fact relates to volume loss instead, then this needs to be made clear.

P2490, lines 13-18. This final paragraph is surely part of the results and should be moved.

P2491, lines 23-25. These very acidic waters (mean 3.6), when compared with most glacial environments, are very noteworthy and surely merit further discussion. The very acidic pH has significant implications for water resources and contrasts completely (as noted) with meltwaters from most glaciated catchments. This seems a key finding that needs developing, especially as the pH of the groundwater is high ($\sim$6-7). A plot of changing pH with elevation would be of far more interest than plots 4b-c which are not significant and can be covered in a couple of lines in the text (see 2iii) above).

Figure 3. Not needed.

Figure 4. As noted above, Figs 4b-d don't really add anything and could be removed while the text that relates to them could be substantially reduced.

Interactive comment on The Cryosphere Discuss., 5, 2483, 2011.