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The Cryosphere Discussions

Interactive comment on "Combined diurnal variations of discharge and hydrochemistry of the Isunnguata Sermia outlet of the Greenland Ice Sheet give in sight on sub glacial conditions" *by* J. Graly et al.

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Please see our line by line reply below. The original review is marked with the "«" ad "»" symbols.

«This paper provides a relatively high-resolution record of hydrochemistry measurements obtained just in front of the subglacial outlet of a western Greenland glacier over 6 days in July 2013. The record is primarily compared with discharge as assessed with time-lapse photography. The authors use these data to infer properties of the subglacial drainage system upstream from the terminus, and suggest that the lack of an

inverse relationship between discharge and solute concentrations could be indicative of subglacial water accessing a linked-cavity system during peak discharge and being effective at drawing solutes from these cavities during the falling limb. The paper presents a useful new dataset on subglacial hydrochemistry which was clearly hard won, albeit covers rather a short period (6 days, albeit with 3 hour increments). The use of time-lapse photography to obtain a measure of relative discharge is a neat concept for overcoming the difficulties of measuring stage in such an active environment. So I think that ultimately the authors present some good material here.»

We thank Dr. Bingham for his interest in our data set.

«However, in its current form, I did not find the discussion of the data especially insightful or even especially novel. In essence, I feel the authors have to rewrite the discussion for the paper significantly to make a convincing case that the paper is presenting a novel advance. At the moment, because the paper is based on rather limited data, I think that approach has to involve providing a far more comprehensive grounding of the ideas proposed here against what has, or they might argue has not, been interpreted from elsewhere. My comments below concern the Discussion section (though some wider referencing and context would also benefit the introduction). I also made some minor comments throughout the paper (not including the Discussion/Conclusions) in the attached supplement.»

We have revised the introduction and discussion to better reference the wide range of contexts in which hysteresis between solute flux and discharge is observed, including non-glacial settings. Whereas gradual increases solute flux during waxing flow may been observed in a wide range of contexts, we feel that the observed spikes during waning flow are in fact novel. The only previous study that (to our knowledge) has reported such behavior in a glacial context is the Anderson and others paper cited in the introduction. And in that study, the phenomenon occurred on a multi-day timescale, whereas it occurred on an hourly scale here.

«Discussion Given the precariousness of the discharge results (I do have sympathy; I know all about the challenges of getting these data), I'd recommend the discussion explicitly focuses on the hydrochemistry variations, albeit using some of the qualitative discharge observations as context (i.e. I suggest excising Section 5.1). I then think you should partition the discussion into subsections which might broadly be described as (i) synthesise the main finding here, i.e. midsummer lag observed between hydrochemistry and discharge; and propose the conceptual model that water accesses distributed system on falling limb; (ii) compare this model comprehensively with findings/suggested interpretations of subglacial hydrological behaviour from other glacial systems where hydrology and/or hydrochemistry of meltwater have been observed.»

We have rewritten the first paragraph of section 5.2 to discuss differences and similarities with other hydrological systems. We felt it was necessary to keep section 5.1 mostly because the Smith and others paper argued against any diurnal changes in discharge at Isunnguata Sermia, and our study refutes that.

«I think the single biggest failing of the paper right now is that it doesn't adequately reference many other relevant studies, and therefore much of the context for justifying the discussion here is missing. For example, I'd say it should be well known from a number of studies of the hydrology of Greenland's outlets (e.g. from the Edinburgh and Bristol groups), and even large polythermal glaciers (Skidmore and Sharp, 1999, Annals of Glaciology) that the larger the catchment, the less likely one is to observe an "alpine-style" inverse relationship between solute concentration and discharge. Similarly, the above groups, and others, have acquired datasets that evince significant subglacial drainage system evolution as the melt season progresses many km upstream of outlet portals (e.g. Bartholomew et al., 2010, Nature Geoscience; 2011, EPSL) – and you'll see in Bingham et al. (2006; Earth Surface Proc. Landforms) evidence that by late July an Arctic subglacial system at similar latitude to your study area can be channelized, but discharge still accesses the distributed (your "linked-cavity") system at times of exceptional melt inputs. If you're going to entitle the paper "gives insight into subglacial

conditions" then I think the insight only comes by making a much more comprehensive comparison with other relevant studies.»

We now include the papers you suggest in our discussion section.

«Finally, since one of the setups of the paper is to assess whether solute/discharge follows a positive/inverse/complex relationship, a comprehensive background for this (albeit pre most Greenland hydrology studies) is given by G.H. Brown (2002) Glacier meltwater hydrochemistry, Applied Geochemistry, 17, 855-883.»

The Brown paper is now cited in the introduction.

«Please also note the supplement to this comment: http://www.the-cryosphere-discuss.net/tc-2016-137/tc-2016-137-RC2-supplement.pdf Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-137»

Most of the annotations on the PDF have be implemented as requested.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-137, 2016.