

# Response to the review by Ugo Nanni

We would like to thank Ugo Nanni for taking the time to provide a very thorough review of our manuscript alongside helpful feedback, which will certainly help to improve the quality and clarity of our manuscript. In the following we present our responses to the referee comments and how we will address these in the revision of the manuscript.

The referee comments are presented in ***bold and italic***, our replies follow immediately thereafter.

## Overall comment:

***The study is a methodological contribution that presents a new method to map the topology of supra and en glacial flow and retrieve the water pressure along flow. Such method will benefit to the investigation of glacial hydrology and its influence on ice dynamic. The paper well presents the method. However, the purpose of the work is not clearly articulated and it lacks a wider comparison with other methods (dye tracing, GPR, seismic, satellite observations) that would help to highlight the benefits of this new methods. It also lacks information on what kind of observation are currently needed by the glacial hydrology community and how this new method may contribute to provide such observation.***

We thank the referee for pointing this out and we will, following his suggestions and the ones from the second referee, adjust the manuscript to include a wider comparison with other methods as well as more information on currently needed observations.

***I think that the proposed method is valid and suitable as well as very original and will bring new and useful information about glacial hydrology, at relatively low cost and easy deployment. It is therefore important for such method to be shared with the glaciological community.***

We thank the referee for his positive overall assessment of the method.

***I support the publication of this manuscript on the condition that the authors highlight (1) the advantages and limitations of their method (e.g., water pressure measurements, applicability to other setups, to subglacial environments ...) (2) how their method finds its place in the current methods used to observe and model glacial hydrology and the associated challenges. Such changes might necessitate to revisit the structure of the discussion and conclusion sections as well as to provide some changes on the introduction.***

We will adjust the manuscript to better describe 1) advantages/ limitations of our method and 2) place it better into context of other current methods. For this we will add additional details to introduction, discussion and conclusion section of the manuscript.

*See comments for more details (annotated pdf and comments pdf). My comments are aimed at highlighting where changes could be made to improve the clarity of the manuscript.*

*Please also note the supplement to this comment: <https://tc.copernicus.org/preprints/tc-2021-377/tc-2021-377-RC1-supplement.zip>*

We thank the referee for the detailed comments in the annotated pdf. We have answered these comments directly in the pdf, which is attached.

## Detailed comments:

***TITLE: Topology and pressure distribution reconstruction of an englacial channel***

***“In this paper, you show a few pressure changes because the water is free flowing, so you do not really show your capability to investigate pressure distribution, I would not stress that much on this aspect in the abstract or the title.”***

We disagree. Indeed, the channel is free flowing and the pressure changes within the channel are rather small. The goal of this manuscript is, however, not to go into scientific details of pressure changes within a channel (pressure variation), but to provide a method with which in situ measurements can be spatially referenced. For this it doesn't matter if pressure changes are small or large. Our method could also provide spatial reference to other sensor modalities (e.g., the magnetometer readings from the IMU). Those are, however, not of relevance to the glaciological community (e.g., magnetometer, gyroscope) or are currently not implemented in our drifter (e.g., temperature, conductivity). To avoid the current confusion that we are not talking about the variation of the pressure itself, but it's spatial distribution, we will add the word “spatial” in front of “pressure distribution” in the title and the abstract.

### **ABSTRACT:**

***FP: ‘Water reaching the ice bed influences ice motion and ice dynamical models, therefore requiring a good understanding of glacier hydrology, particularly water pressures and pathways.’***

***Comment: “this is not very clear. I see what you mean, but I suggest rephrasing. Water does not directly influence ice models.”***

Thanks for pointing this out. We will rephrase this.

***FP: ‘However, as in situ observations are sparse and methods for direct observations of water pathways and internal pressures are lacking, our understanding of the aforementioned pathways and pressure remains limited.’***

***Comment: “what do you mean by internal? Specify; “lacking is too strong, for instance borehole measurements can be used to measure pressures”; “What do you mean by aforementioned ? I would suggest rephrasing to me more precise”***

We will rephrase this sentence to clarify it.

***FP: ‘Here, we present a method that allows the reconstruction of planar subsurface water flow paths and spatially reference water pressures.’***

***Comment: “this is not clear what you mean here. I understand that you map pressure, but I would suggest rephrasing.”***

We will rephrase this sentence to clarify it better.

***FP: 'We showcase this method by reconstructing the 2D topology and the water pressure distribution of an englacial channel in Austre Brøggerbreen (Svalbard).'***

***Comment: "the data you show are also obtained on a surface channel and the englacial part you studied is mainly free flowing, I suggest adding this particularity here to do not oversale the study"***

We will add detail about the channel being at atmospheric pressure.

***FP: 'Validation on a supraglacial channel shows an average length error of 3.9 m (5.3%).'***

***Comment: "is it the same channel? You need to precise it, or say that you did the validation on the open part of the channel."***

This sentence relates, as stated, to the "supraglacial channel", not the "englacial channel" and is therefore not the same channel. We will clarify this better.

***FP: 'Our method allows mapping sub- and englacial flow paths and the pressure distribution within, thereby facilitating hydrological model validation. Further, our method also allows the reconstruction of other, previously unexplored, subsurface fluid flow paths.'***

***Comment: "I do not think you proved that the method can be used to map subglacial flow. I suggest to only say "mapping glacial water flow paths""; "Here you just show a few pressure changes because the water is free flowing, so you do not really show your capability to investigate pressure distribution, I would not stress that much on this aspect in the abstract or the title."; "This (hydrological model validation) is not supported in your study, this is speculative on the outcomes of your study"***

We refer to our previous comment in regards to "pressure distribution". We will rephrase "subglacial flow" to "subsurface flow". We will further detail more what we mean in terms of model validation as we indeed had hydrological potential modelling in mind, where the most likely flow path for water is modelled. This could indeed be validated by our method and these models are currently already questioned by maps of englacial (Hansen et al. 2020) and subglacial channels (e.g. Gulley et al. 2012). We will provide additional reference to these papers and specify this sentence.

Hansen et al. 2020: doi:10.1017/jog.2020.1

Gulley et al. 2012: doi: 10.3189/2012JoG11J189

***FP: 'Further, our method also allows the reconstruction of other, previously unexplored, subsurface fluid flow paths.'***

***Comment: “This last sentence is not clear, please detail or remove. What do you mean by previously unexplored ? This is not the first time people map englacial / supra glacial channels.”***

As stated, we refer to “other” “subsurface fluid flow paths”. So, this is not about englacial or supraglacial channels but we were thinking about e.g., pipelines, karst caves, sewage systems and the like where in situ data currently doesn’t exist. We will specify this better.

## **INTRODUCTION:**

***FP: ‘ Water movement through and under glaciers and ice sheets in en- and subglacial drainage systems is an essential factor in the control of ice dynamics (Hubbard and Nienow, 1997; Fountain and Walder, 1998; Irvine-Fynn et al., 2011).’***

***Comment: “do englacial flow really influence ice dynamics ?”; “these referencences mainly concern mountain glaciers and not ice sheets. I suggest adding appropriated references”***

We think these references are appropriate for our case, as we study a small Arctic valley glacier. We will therefore remove the part about “ice sheets” from this sentence instead of adding references for ice sheets, as our method is most likely rather limited for the use at ice sheets due to the current necessity of instrument retrieval.

***FP: ‘Such systems vary in space and time, and their configuration is traditionally inferred using the physical principles (Röthlisberger, 1972) and concepts of hydraulic potential (Shreve, 1972) developed 50 years ago (see review by Flowers (2015)).’***

***Comment: “what do you mean here (‘traditionally inferred’). I suggest adding more precision on how these systems vary in time and space, how they are expected to vary and also how observations confirm or challenge these expectations.”; “I think you need to precise what you mean here by “physical principles”.”; “this is a physical principles. I suggest to add some details to this sentence so the reader can better understand the physic that is required to understand these systems”; “this is not because it was developped 50 years ago that it is necessarily outdated. I do not see the benefit of stressing this, as it already visibile in the dates of references.”***

We will rephrase this part and add additional details.