

Anonymous Referee #2

Received and published: 1 January 2020 The work by Nanni and co-workers represents a significant contribution to our understanding of using glacial seismology to monitor glacial hydrology. This work utilizes seismic data and observations of subglacial discharge acquired over two full melt season. They then use the theory of Gimbert et al. (2016) to investigate of seasonal variations in seismic tremor can be used to make inferences about seasonal to daily variation in the subglacial hydraulic system. I find the significant results of this paper to be:

- 1) Significant advances in documenting methodology for conducting this sort of analysis. For example, robustly combining multiple seismic records to forms continuous measure of seismic tremor, differentiating anthropogenic noise from glacial tremor (figure 3), and presenting quantitative measures of hysteresis (i.e., equations 15-17)
- 2) Demonstrating that seasonal variations exist between seismic power and discharge (Figure 6) which are most likely related to changes in the subglacial hydraulic system and that the relationship between seismic power and discharge varies depending on the season (section 6.2)
- 3) Demonstrating how the theory of Gimbert et al. (2016) can be used to investigate daily to seasonal variations in subglacial dynamics.

We thank reviewer 1 for these general comments and the very useful suggestions below, which we address point by point.

However, occasionally the authors refer to their model derived parameters as observations when in fact they are a model result. For example on line 462, the authors use the phrase “: : channels are observed: : ”, the channels are in fact not observed but “: : channels are inferred to be at equilibrium: : ” based on the theory of Gimbert et al. (2016). Other instances occur at line 551-555. To summarize, I think it is important to remain clear that the derived values of hydraulic radius (R) and pressure gradient (S) are in fact NOT observations but model derived parameters.

We thank reviewer 2 for this useful suggestions, this is a point that we have indeed discussed between the co-authors. We agree with the reviewer that our quantification of R and S using seismic and water discharge measurements involves using a model. Given that the presently used model has not been fully tested under controlled conditions we agree with the reviewer suggestion that we should acknowledge that R and S are not directly observed, but rather inferred from observations. To address this, we have replaced “observed” by “inferred” or “derived” throughout the manuscript.

Other Comments:

Diurnal Variability, Hysteresis, and Phase lags: Figure 7 clearly shows the seasonal variability of the phase lag and hysteresis in Pw and Q. However, I was surprised to see no measure of coefficient of variation (Cv) as is done in figure 9.

The reviewer is concerned here by the fact that we do not investigate the diurnal variability (Cv) of Pw and Q (Fig.7) as done for R, S, and (Fig.9).

In Fig. 9 we investigate the coefficient of variations Cv in order to investigate the potential causes for diurnal changes in R and S. Doing so we evaluate how much R, S and V vary over the day, and focus on Cv to do so. Doing this allows then for instance to quantify changes in channels shape and pressure conditions at the diurnal scale as we do in the Discussion.

In Fig. 7 we focus on the hysteresis and the phase lag as our aim is to investigate the causes of discrepancy between the diurnal evolution of Q and Pw. The different response of Pw to Q could be caused either by a temporal shift in the Pw evolution (time lag) or a different shape of the evolution (hysteresis), to see the influence of these two factors we have compared the two evolution of the parameters. The coefficient of variations gives an information of the amplitude of the diurnal variations, but does not allow to directly compare the Pw response to Q.

We keep this distinction between Fig. 7 and Fig. 9 in our manuscript, but we have clarified this difference as follows:

[When presenting Fig. 7]

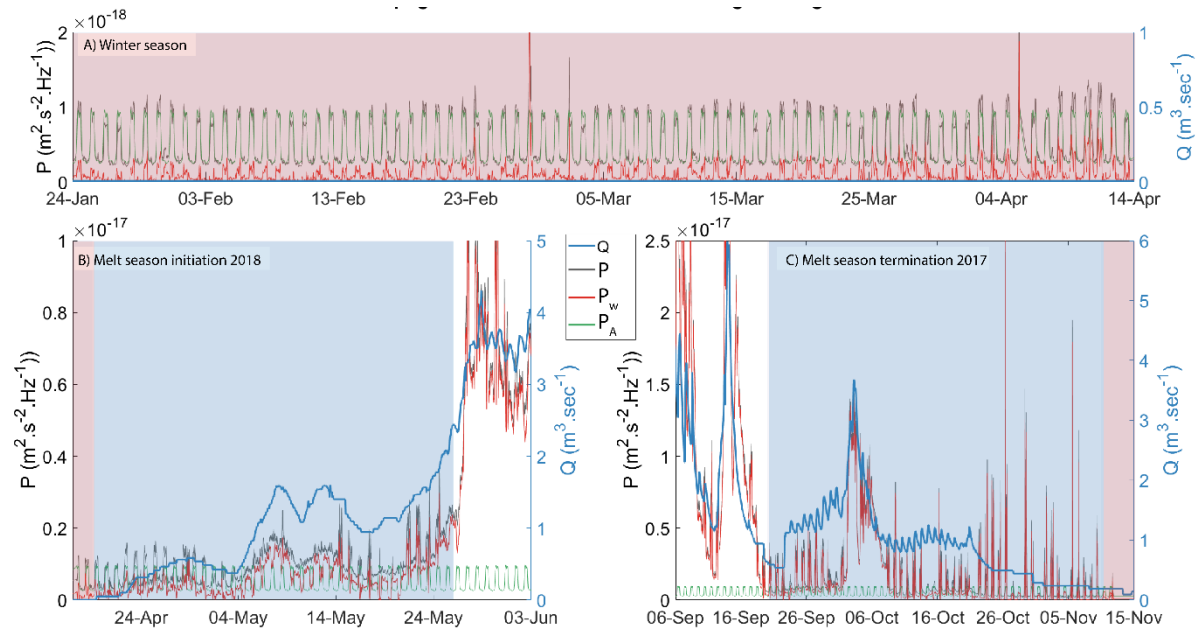
"We focus here on these two indicators as this allows to investigate the diurnal response of Pw to changes in Q and therefore access to changes in the subglacial drainage system."

Figure S3 appears to show that Q often does not display diurnal variability. Is this true or is this just a figure resolution issue? If there are days when there is no diurnal variability in Q, what is the meaning of the phase lag or the hysteresis measurements?

We think that there is here a misunderstanding on the period used to investigate the diurnal variability. We thank the reviewer for pointing out this aspect that needs further clarification. The Figure S3 focuses on the early and late melt season in order to show the influence of the anthropogenic noise. During the early melt season the diurnal variability of Q is very low, that is true, and this might be related to the damping effect of the snow and limited surface melting. We do not study the diurnal variability of Q and Pw during these periods (they are shaded in the figures) because of the anthropogenic diurnal influence and because of the limited diurnal variations in Q. The diurnal variability investigation only starts in late May and ends Mid-September concerning panels b and c. We stress this in lines 315-320.

"To study diurnal changes in Pw without being biased by anthropogenic noise we limit our analysis to the periods [May 15th - September 22th] 2017 and [May 27th - October 28th] 2018 (based on direct observation shown in Fig. S3;"

The reviewer's comment helped us to see that the color code of the shaded area in Fig S3 was not consistent to the one of Fig 5, we therefore made the changes.



Detail Comments: Title: Should include a mention of seismology.

Line 1: should be “: :knowledge of the : :” [Ok, modification taken.](#)

Line 165: remove “days” [Done](#)

Line 173: perhaps “Subglacial water discharge is monitored..” [Ok, suggestion taken.](#)

Line 186 (and elsewhere). I believe that Bar should be replaced with Pa.

[We thank the reviewer for this suggestion, and we changed Bar to Pa to respect SI units.](#)

Line 197:perhaps “borehole type sensors” [Ok, suggestion taken.](#) Line 203: should be “A few data gaps: : :” [Ok, suggestion taken.](#) Line 230: specify as synthetic. [Done](#)

Figure 5: in caption rephrase “Shaded red area” as “Red shaded area” and “Shaded blue area” as “blue shaded area” [Done](#)

Line 285-289: Specific days need to be specified. [Done](#)

Line 298: I would prefer that “in response” should be changed to something like “correlates with”. The phrase in “in response” is an interpretation that already presumes Q is the driver of Pw. [Ok, suggestion taken.](#)

Figure 6 (and line 371): Over what time period is Qref and Pwref defined?

[We think that the reviewer highlighted here and important point that we needed to clarify. Qref and Pwref are defined as the first day of the 2018 melt season. We have omitted to specify this in the original version of the manuscript. This has been added in the main text in the caption of Figure 6 as:](#)

[“Reference values for Pw and Q are taken as the first day of the 2018 melt-season.”](#)

[For line 371 and the reference value of R, S and V we have added:](#)

[Reference values for these three variables are taken as their minimum value of the two years \(i.e. May 10th 2017 for R, May 14th 2018 for S and March 28th 2018 for V \)](#)

Line 371: “We invert for : : :.” [Modification done from “We invert” to “We invert for”](#)

Figure S3: I think that the legend has Pa and Pw switched.

[We thank the reviewer for having identified this. This has been modified in the Figure S3.](#)