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The Cryosphere Discussions

Interactive comment on "Attenuation of Sound in Glacier Ice from 2 kHz to 35 kHz" *by* Alexander Meyer et al.

Anonymous Referee #2

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Review of "Attenuation of Sound in Glacier Ice from 2 kHz to 35 kHz"

This manuscript presents a novel experimental design to measure attenuation in glacier ice in situ. The authors use ultrasonic transducers to collect high-frequency waveforms (chirps, etc.) at varying distances across a glacier. The authors design the survey in such a way that they can characterize the errors in the measurements due to different components of the system (e.g. structural heterogeneity of the glacier ice). The manuscript covers the acquisition system and survey design in detail. A comprehensive error analysis is presented and errors are propagated through to the final estimate of ice attenuation amplitudes. However, I find the conclusions rather lacking, especially the comment regarding the attenuation mechanism as it relates to Rayleigh scattering. I think the authors would do well to reconsider this conclusion and really make an effort

to discuss their reasoning and evidence for this conclusion. I have included my main remarks below, as well as included an annotated PDF so that the authors can improve the English grammar and writing style.

Pg 3 L14 (point 6): The water is necessary to propagate the compression wave. It is also there to keep the hole open I would assume and occurs no matter what because of the drilling method. I do not see the need for this statement. Why not just say water is present in the hole outside of this enumerated list? For instance on page 5 line 5 can be used for this.

Figure 1: It would be great to have a map inset to see what in Italy this is located.

Page 4 L15: What was the surface-air temperature during these experiments?

Paragraph structure (for example the first sentence in Section 2.4): A single sentence is not a paragraph. Please revise these sentences throughout the manuscript.

Why is the electronic noise so strong? Did you use shielded cables? Was the excess cable wrapped in loops?

Pg. 9 L5: Is the crosstalk in the source signal as well? If it is, then how can you remove that cross talk from the amplitudes before you normalize?

Pg 9 L26: What does the following sentence actually mean? It does not make sense to me. "The noise estimate in the noise window matches the noise-level for the signal window reasonably well."

Throughout document: Please use emitter and do not switch between emitter and "sender." This is confusing. You do the same thing with sensor and receiver. Please stick to receiver.

Pg 10 last line: Where is the normalization by N to make this equation represent a mean? Also, the \sigma_i^2 terms cancel, so how is this an error weighted mean?

Equation 1: Why is there not a subscript i (i.e. \sigma_i) on the left-hand side of the

equation? I think there should also be m and n subscripts for this error estimate as well.

In the data processing you do not mean revamping the mean? It is possible that a DC component to the data accumulates over time and that leads to the variation you see in Figure 7, rather than spontaneous changes in the ice? You mention windowing, but not linear or mean detrending. These are common steps in waveform data processing. It would also be interesting to know the air temperature during this time. The drop off in amplitude in Figure 7 at 18h is quite dramatic.

Is the time in plots local time or GMT time? It would be most useful if they were in local time.

Pg 14 L2: The given distances of 10m, 60m, and 90m do not figure 10. Please fix.

Pg 16 L18: Is this variation due to fabric-induced anisotropy? If so, can you please discuss. The term "glacier geomorphology" is not very intuitive as it pertains to sound speed. I do not think readers will understand how geomorphology can cause velocity variations. I am not sure that I understand what you mean here.

You discuss the influence of temperature changes on your measurements, but you do not cite recent and relevant work that studied attenuation as a function of temperature: "Monitoring the temperature-dependent elastic and anelastic properties in isotropic polycrystalline ice using resonant ultrasound spectroscopy", https://www.the-cryosphere.net/10/2821/2016/tc-10-2821-2016.html

Your final comment on Rayleigh scattering in the conclusion section seems unfounded. You reference the Westphal 1965 paper in your introduction, do some experiments, and then say, "look, we found it is not Rayleigh scattering". This is not rigorous, nor is it convincing. You pose no other mechanism and it seems like you would do the community a favor by providing a discussion as to why you think Rayleigh scattering is not the mechanism. Even explaining to the reader what Rayleigh scatter is would be a

useful first step. Are you making this claim simply because your data do not follow an attenuation of frequency to the 4th power?

Please also note the supplement to this comment:
https://www.the-cryosphere-discuss.net/tc-2018-224/tc-2018-224-RC2-supplement.pdf

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