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Geoscientific Instrumentation Methods and Data Systems Discussions
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Interactive comment on "A low-cost acoustic permeameter" *by* S. A. Drake et al.

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A. General Comments

This paper provides techniques for measuring snow permeability using acoustics and is important since it provides an up-to-date description of how impedance tubes can be utilized for this purpose. Moreover, the techniques given in the paper provide a reference implementation that can be used as a starting point for other acoustic experiments. I highly recommend this paper to be published after some clarifications are made.

The apparatus figures (Figure 1 and Figure 2) at the end of the paper should be supplemented by photographs of actual devices in the lab and in the field. Addition of this

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visual information would greatly improve the exposition of your research.

To me, it is not clear how the apparatus was deployed. Please provide a field location and time of deployment (i.e. winter or late winter). If the snowpack was layered, did the layered snowpack influence the volume-averaged measurement of permeability? Did reflections occur due to changes in acoustic impedance between snowpack layers? What was the maximum snow depth for which the device was tested? What were ambient temperature conditions at the time of measurement? Did reflections from the ground at the bottom of the snowpack influence experimental results? I am assuming that your apparatus worked well at lower ambient temperatures. Are the effects of wind on the measurement technique known? These effects are briefly stated in the caption of Figure 3, but should be discussed (i.e. a few sentences or a section) in the text. What about the effects of snow liquid water content? The presence of water in the snowpack will modify the measured permeability. Is an effective permeability being measured? I would assume that the method described in your paper works well for snow with small amounts of liquid water content.

Can you comment on impedance discontinuities related to sound waves at tube boundaries? Was the tube pressed into the snow or suspended above the surface of the snowpack? An air gap at the open end of the tube will create a discontinuity and sound pressure wave reflections should occur at this location. Are the reflections of small magnitude? If the air gap is closed by pressing the tube into the snowpack, this creates a porous media boundary condition at the end of the tube. How many tests were used to validate and calibrate the system? This is not clear from the figures in the paper and should be stated somewhere in the text.

B. Specific Comments

Page 2: Lines 2-3: To give the reader some context, you may wish to provide the equation for Darcy's Law in this section of the paper and briefly state how higher-magnitude values of permeability will increase air exchange with the snowpack. I feel that this would be helpful for exposition, particularly for readers who are unfamiliar with the concept of applying Darcy's Law to porous media such as snow. This can be referenced later in the paper as what is now Equation 1.

Lines 16, 23, 27: The deployment of the acoustic permeameter in the field is difficult to visualize, despite the nice schematic diagram given as Figure 1. Along with Figure 1 (perhaps as Figure 1b), you could include another figure showing how the acoustic permeameter was situated to provide in-situ measurements. I find it most appealing that the permeameter can be assembled from commonly-available parts.

Line 27: The Heathkit IG-1275 is an older (analog) signal generator that probably works well. For future experiments, perhaps Direct Digital Synthesis (DDS) could be used. Can you comment here (or in another section of the paper) on oscillator drift with respect to component aging (i.e. change in capacitance values over time), temperature, jitter, and frequency accuracy? Can you measure the time-domain jitter and the oscillator phase noise and report these measurements in a quantitative fashion? Such numbers are important since they demonstrate that simple equipment can be used.

Page 3: Line 1: I am assuming that the tube was placed on the snow surface so that the end of the tube opposite from the speaker was in contact with the snow. Could you add a subfigure to Figure 1 showing how the tube was placed in relation to the snowpack? A photograph would be very informative.

Lines 3-4: Did you use phantom power for the microphone? Generally, the use of phantom power increases microphone sensitivity. Even if the microphone is not a high-end reference mic, for future experiments it can be calibrated using a pistonphone or a reference sound source. Calibration in an anechoic chamber would be useful. Can you provide an approximate sensitivity for the microphone? This is easy to provide if the voltage output of the microphone is measured with a source set to a reference frequency (i.e. 1 kHz).

Line 10: The calibration setup is difficult to visualize here. Consider adding a figure or a picture to demonstrate.

Line 15: Rationalize here why the low-frequency approximation works well.

Lines 16-17: Which numerical scheme was used for iterative adjustment?

Line 27: Is this RMS amplitude?

Line 31: Can you clarify what is meant by “initial amplitude”? An equation might be suitable to reference rather than a description in the text.

Page 4 Line 2: Can you list the manufacturer part numbers here (and reference page 12, Table 1 of the paper)? Does the manufacturer provide reference data for foam permeability?

Page 5 Line 6: List low-frequency assumptions either here or above (see Page 3, line 15 comment).

Line 17: What are these empirical calibrations, and how were they derived? Can you provide an equation or a reference? Are these empirical calibrations necessary due to instrumentation error?

Line 24: What is the origin of the white noise? Is this due to the sampling system (i.e. oscillator and ADC) and environmental noise?

Line 26: Why is 50 Hz being used here as a reference frequency?

Line 29: It would be good to include reference to a calibration equation here showing coefficients for the experimental system.

Page 6 Line 6: What is the valid range of frequencies for the low-frequency approximation?

Line 15: Can you include the calibration equation here?

Line 17: Consider specifying the volume of the signal generator with respect to acoustic power of the source. The RMS voltage is also useful to state here, but how does this relate to the Sound Power Level?

Line 26: What about non-linearity in the loudspeaker response? Note that loudspeakers are extremely non-linear transducers. Loudspeaker pre-emphasis techniques and equalization might be useful to use in the future.

Page 8 Lines 7-8: What is the range of snow densities, and how many snow sampling points were used?

Line 22: Is the 5 cm material thickness associated with the same accuracy and precision with respect to measurements made with actual snow?

C. Technical Comments Throughout the paper, please provide SI units for all variables. A list of nomenclature at the end of the paper would be helpful.

Page 4, Line 20: Remove comma between the closing bracket ")" and the Arakawa (2009) reference.

Figures 3, 4, 5, 6: Consider removing dashes "-" between units in the axes labels.

Figure 3: Consider providing a legend in the figure.

Figure 2: Explicitly state that "P ATM" is an atmospheric reference pressure. A reference to Hardy and Albert (1993) could be included in the figure caption.

Please also note the supplement to this comment:
http://www.geosci-instrum-method-data-syst-discuss.net/gi-2016-13/gi-2016-13-RC1-supplement.pdf

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