The Cryosphere Discuss., 9, C1471–C1474, 2015
www.the-cryosphere-discuss.net/9/C1471/2015/

The Cryosphere
Discussions
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Interactive comment on "Intercomparison of snow density measurements: bias, precision and spatial resolution" *by* M. Proksch et al.

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Received and published: 24 August 2015

General Comments

Snow density is a fundamental and commonly measured snow parameter to which little attention has been paid to measurement accuracy. This paper quantifies spread and uncertainty in snow density profiles using a very carefully collected set of measurements in both laboratory and natural environments. Micro CT measurements provide the means to compare traditional gravimetric sampling with a state of the art technique. The results are clearly presented, and provide clear baseline information to guide the acquisition and interpretation of density measurements. I have some relatively minor comments which will hopefully improve the final version of the manuscript (note page numbers refer to the 'print-friendly' pdf version:

1. In no way do I disagree with the statement on page 3585 that "for a wide range of applications, users need the higher resolution and efficiency of technologically more sophisticated measurement methods." But there are also many applications for which detailed SMP or CT derived density profiles provide far too much vertical resolution (i.e. microwave remote sensing applications where 1 or 2 layer snow models are used in operational retrievals). So anothe contribution of this paper is in showing how the high resolution measurements, simplified to coarser vertical resolution, compare to traditional gravimetric profiles. I think it's worth adding a statement that the value in these comparisons is not just to understand what vertical resolution is lost with traditional sampling, but to quantify how sub mm scale profiles aggregate back to coarser vertical resolutions.

2. Section 2.2.2. The wedge cutter has 10x the volume of the box and cylinder cutters. While this influences the vertical resolution, it may also play a role in the measurement error and uncertainty. There are wedges (and boxes and cylinders) available with different volumes. Can any comment be made on the sensitivity of the results to cutter volume?

3. This is more of a lament than a comment, but it's very disappointing that the SMP measurements are not usable. The CT was essentially used as reference, but no estimate of uncertainty is provided in section 2.3. The SMP measurements would have no doubt helped in this regard, but can information be added on the potential error in the CT derived density?

4. Section 2.2.3 and Section 5.2.2: It's clear the presence of ice crusts have a significant impact on the density uncertainty. How confident are you in the technique of ". . .weighing a carefully extracted ice layer sample with a known volume". How was the known volume determined? Is this method sensitive to a minimum volume or mass? What precision of mass measurement is required? It seems like a better field method for the determination of ice crust density is required.

5. Section 3.1: Based on figure 2, there was a large density range in the lab measurements, and hence the characteristics of the 13 snow blocks. Some additional details would be helpful. What were the characteristic grain types/hardness?

6. Page 3591 lines 10-15. The thresholds between density over- and underestimation are stated to be for "box cutter, wedge cutter, and densities by layer" which I believe is referencing Figure 4. The caption to figure 4 shows box, wedge, and cylinder. Please clarify.

7. This is very subtle, but when the measurements are evaluated at the resolution of the cutters (Figure 4) the changing bias with density magnitude is apparent for all three cutters (overestimate for low densities; underestimation for high densities). When the measurement are evaluated at the resolution of the traditional layers (Figure 5) the wedge sample bias with density magnitude is consistent with Figure 4, but the box and cylinder switch to slight underestimation at lower densities and overestimation at higher densities (opposite to Fig 4). Any simple explanation as to why? There seems to be one clear box cutter outlier in Figure 4. Was this one measurement looked at carefully?

8. Figure 6: It would be interesting to see full profiles at the same resolution of all sampling techniques (Fig 3 shows all 4 profiles but at their native vertical resolutions). Perhaps this could be added to Figure 6 for the 3 and/or 10 cm resolution CT panels?

9. Figure 7: Nice figure!

10. Despite the issues shown in Figure 8, overall, I would say these results are quite encouraging with respect to the traditional field measurement of snow density, if careful samples are extracted by experienced users. This is particularly true for applications that do not require high vertical resolution, but for which 10 cm density profiles provide more than enough information (i.e. microwave snow modeling), and mean values for 1 or 2 layers are all that is required. Some brief comments in Section 6 with respect to applications that do not require high vertical resolution measurements (i.e. remote sensing; hydrology) would be helpful.

Editorial Comments

Abstract: consider rephrasing to "...In the field, the density cutters tend to overestimate (1 to 6%) densities below and underestimate (1 to6 %) densities above a cutter-type dependent threshold that fell between 296 to 350 kgm$-$3, respectively."

Page 3583 line 23: change to "...although there was a tendency for inexperienced users to overestimate the density of light snow and depth hoar by 6 and 4 %, respectively."

Page 3583 line 26: Within the cutter types? I think you mean between.

Page 3584 line 23. This is the first mention of the Microsnow 2014 workshop in the body of the paper. Some additional background on the workshop/experiment would be nice here.

Section 2.2.2: information is provided for the commercial availability of the box and wedge cutters but not the cylinders. Can this be added?

Page 3587 line 3: this may be obvious, but I suggest clarifying that the 55 cm cylinder was inserted vertically.

Page 3596 line 6: change 'measurements' to 'measurement'

Page 3596 line 14: change 'looses' to 'loses'

Page 3596 line 17: change 'loosing' to 'losing'

Interactive comment on The Cryosphere Discuss., 9, 3581, 2015.