Reply to Charles Fierz comments on "Comparison of manual snow water equivalent measurements: questioning the reference for the true SWE value" by Maxime Beaudoin-Galaise and Sylvain Jutras, The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-354-CC2, 02 Feb 2021

Comments in blue
Answer in black

I agree with the reviewers and the comment by M. Schneebeli that this is a valuable, carefully performed study but also that it mainly supports previous findings. I too cannot find novelty and basically new findings that would warrant title and publication.

In my view the study fails by comparing methods using core samplers with pit methods that are inadequate to determine the water equivalent of snow cover (SWE). Indeed, as mentioned by Anonymous Referee #1, it is of great importance to perform a continuous sampling of the snow cover irrespective of any stratigraphic, subjectively determined layers to obtain SWE. The pit methods presented in the paper are far from complying with this requirement. Even a nice uncertainty and error estimation exercise does not convince me of basically new findings here and, in fact, I am not surprised by the (negative) outcome. On the other side, the comparison of the core snow samplers do support previous findings indeed, thus no novelty there.

I understand from the authors' replies that adjustments to the paper will clarify some open questions, but this will not suffice to overcome the main flaw addressed above.

On behalf of Sylvain Jutras, co-author, and myself I thank you for your interest and your comment on the submitted manuscript. On our side, we are surprised that the snow pit method performed in our study is considered inadequate. Although a continuous density sampling irrespective to stratigraphic layering might be more recommended, we don't believe that our method performed should be judged to be incorrect. To our knowledge, there is no scientific literature stating that the density measurement per snow layer is incorrect.

Also, the density sampling method performed in our study is supported by scientific literature. Here is a list of references (scientific articles and protocols), describing the estimation of the water equivalent of snow cover from a snow pit with density measurement per snow layer:

- Canadian Avalanche Association (CAA): Observation guidelines and recording standards for weather, snowpack and avalanches, Revelstoke, British Columbia, Canada, Canadian Avalanche Association, https://cdn.ymaws.com/www.avalancheassociation.ca/resource/resmgr/standards_docs/OGRS2016web.pdf
- Pomeroy, J. W. and Gray, D. M.: Snowcover accumulation, relocation and management, Bull. Int. Soc. Soil Sci. no, 88, 1995.
- Senese, A., Maugeri, M., Meraldi, E., Verza, G. P., Azzoni, R. S., Compostella, C. and Diolaiuti, G.: Estimating the snow water equivalent on a glacierized high elevation site (Forni Glacier, Italy), The Cryosphere, 12, 1293–1306, https://doi.org/10.5194/tc-12-1293-2018, 2018.
- Sturm, M., Taras, B., Liston, G. E., Derksen, C., Jonas, T. and Lea, J.: Estimating snow water equivalent using snow depth data and climate classes, J. Hydrometeorol., 11, 1380–1394, doi:10.1175/2010JHM1202.1, 2010.

These four references describe a method for estimating the SWE of the snow cover with a snow pit similar to that performed in our study. The references CAA (2016) and Sturm et al (2010) have been added to the line 75 in order to justify the method used in a revised manuscript. It was also specified in subsection 2.3 (line 175; Snow pit measurements) that our snow pit density sampling is referred to existing methods, by referring to the four references mentioned above. The snow pit method used and analysed in our study to determine the SWE therefore corresponds to established protocols.

In addition, it is necessary to consider for the snow layers thicker than the density cutter used, the measurements were made at different depths (and vertically if possible) for the same layer in order to best cover the inter-layer variability. With an average coefficient of variation of 5.54%, we therefore consider this variability to be low. However, we consider that there is a bias related to the SWE estimate for ice layers by the density per layer sampling, as discussed in the section 4.3 (lines 514-527). We believe that a continuous sampling of snow cover for our study area also has limitations due to the large amount of ice layers in the typical snow cover present. In the 91 snow pits made, there was an average of 5 ice layers per snow pit (± 2 ice layers), which represents an average cumulative ice thickness of 15 cm per snow pit (± 10 cm). These ice layers are important elements in the stratigraphy of our typical snow cover. With a low-volume density cutter (250 cm^3), it would have been difficult by a continuous sampling of the snow cover to estimate SWE without introducing an additional bias by measuring through numerous ice layers.

Your comment also demonstrates the importance of properly describing the snow pit method performed and this will be improved in the revised version of the manuscript. There are different sampling strategies and different density cutters, but several articles use the snow pit as the true SWE reference, but without having any reference to support this statement. Some studies cited in our manuscript (ex: Sturm et al, 2010 (DOI: 10.1175/2010JHM1202.1); Choquette et al, 2013; Henkel et al, 2018 (DOI: 10.1109/TGRS.2018.2802494)) used the snow pit as the reference true SWE, but without having a reference to support that it is the most accurate method. We do not want to question the seriousness and the scientific contribution of these studies, but simply that there is a lack in the literature on the validity of the snow pit as a reference method of estimating the water equivalent of snow cover. Our study aims to address part of this questioning with methods carried out regionally, and this is why it brings, in our opinion, a new contribution in snow science.