

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-74

Anonymous Referee #2

Referee comment on "Sentinel-1 snow depth retrieval at sub-kilometer resolution over the European Alps" by Hans Lievens et al., The Cryosphere Discuss.,
<https://doi.org/10.5194/tc-2021-74-RC2>, 2021

The authors present an application of a change-detection algorithm to estimate SWE in the Alps using Sentinel-1 C-band SAR. They explore the effect of spatial resolution on their retrievals. This is an important and timely contribution, and should be of great interest to the community. The paper is well-written so I have very few minor comments. Instead, I'll focus on a really key point which is that I think there is a great chance for readers to misunderstand the maturity level of the algorithm, based on how the paper is presented. This review is five related major comments that unpack this idea.

Major Comments

First, I do not think that the paper adequately reflects the fact that we still do not understand why this method works, even at a basic level. The manuscript instead makes it sound clear that the mechanisms are understood: e.g. in the introduction, page 2, lines 32-page 3, line 2. Taking their points one by one: to their first point (page 2 line 33), no reference was given, and no reason why having lower ground backscatter would change sensitivity to depth; to their second point (page 2, line 33), Chang et al. 2014 do not make this point, that I could see. Readers will assume after reading the introduction that it is obvious why the C-band cross-pol is correlated with snow depth, which is not true. In fact, the authors of this study only introduce the idea that the "physical mechanisms that cause this increase are still uncertain" in the Results & Discussion section (page 10, line 13). Please, bring this critical point into the abstract, introduction and conclusion!

Second, I think it is critical to communicate more clearly throughout that this is an empirical algorithm with calibration parameters that require known SWE data over the domain. The word "empirical" needs to appear in the abstract, in my opinion. Please somehow get this idea into the introduction, abstract, and conclusion.

Third, the authors need to point out that the algorithm only works well if you have accurate SWE data to calibrate against. Indeed, they need to just note explicitly that the accuracy of the approach they are using here is limited to the accuracy of their training data. I think this needs to be presented explicitly in the abstract and conclusions, to avoid reader misunderstanding.

Fourth, the authors should point out that in this study, they are calibrating here against very accurate model results. Here, they are applying the algorithm in this study over a domain where (in my opinion) the most accurate model results are available anywhere in the world. There is no other mountain range, to my knowledge, with the density of observations available in the Alps. Further, globally available model results in mountain ranges are inadequate for most applications, in terms of their spatial resolution and accuracy. See e.g. Mortimer et al. 2020. I think this needs to be mentioned in the conclusions.

Fifth, the authors need to acknowledge explicitly that the first four points mean that you could not use this approach globally, calibrated to models, and achieve the kind of results shown here; this point almost certainly will be lost on readers of the abstract alone. This is a major issue with the manuscript that needs to be addressed in the abstract and conclusions.

I hope the authors do not misinterpret any of these comments: they have done an amazing job uncovering this important new dataset. It has very important possible applications. Reworking the way the paper is presented should help the community get on board with this new dataset as quickly as possible.

Mortimer, C., Mudryk, L., Derksen, C., Luojus, K., Brown, R., Kelly, R., & Tedesco, M. (2020). Evaluation of long-term Northern Hemisphere snow water equivalent products. *The Cryosphere*, 14(5), 1579–1594. <https://doi.org/10.5194/tc-14-1579-2020>