The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-167-RC2, 2019

The Cryosphere Discussions
Open Access
EGU

Interactive comment on "Effect of snow microstructure variability on Ku-band radar snow water equivalent retrievals" *by* Nick Rutter et al.

Anonymous Referee #2

Received and published: 30 August 2019

Review of "Effect of snow microstructure variability on Ku-band radar snow water equivalent retrievals" by N Rutter et al.

The authors present a really nice study of the effects of horizontal spatial variability of snow microstructure on retrieval errors. The study is in two parts: first a detailed description of snowpack properties measured in Trail Valley Creek, and second a synthetic retrieval experiment, where synthetic radar observations are generated using a radiative transfer model forced by realistic snow stratigraphy, and then those synthetic observations are processed with a retrieval algorithm. They show that SSA needs to be known quite precisely a priori in order to hit the target accuracy requirement.

The first part is wonderful: it shows in depth the spatial variability of observed properties, and occupies nearly all of the figures and tables. The second part I found hard to

Printer-friendly version

Discussion paper

understand, so am asking for clarifications. To the extent I understand it, I think it is a critical contribution to this field!

In such studies, the details of the synthetic experiment design can make a lot of difference. After multiple re-reads, I had some trouble piecing together what exactly was done. All of my minor comments below are requests for clarification.

My understanding is that this study performs a set of idealized depth retrieval experiments in order to isolate the impact of a singe phenomenon (spatial variability of SSA in a single layer) on retrieval accuracy. It assumes (in my understanding) 1) perfect radar observations; 2) perfect knowledge of snow density; 3) perfect knowledge of background (i.e. soil and other substrate properties) 4) perfect ability to transform SSA into exponential autocorrelation length, and 5) perfect knowledge of SSA in two of the three layers in the snowpack. My understanding is that only depth is estimated by the retrieval, then transformed to SWE; SSA is assumed to be given. The study then systematically varies a spatially homogenous SSA value provided as a constant to the retrieval, and estimates depth, transforms to SWE, in order to compute the error metrics shown in Figure 10.

Anyway please clarify these minor points! I look forward to reading a revised version.

Minor Comments 1. Page 5, line 11. Please clarify somewhere that density is assumed to be known, i.e. it is not being estimated by the retrieval algorithm, and you are giving the radar simulations for the "retrieval scene" the true density. 2. Page 5, line 11. Please clarify somewhere that SSA is treated as a specified input in the retrieval, if that is the case. I'm assuming that it is treated as "fixed" in the retrieval, in other words, you systematically specify a range of values, but the retrieval algorithm is not actually trying to estimate it. I'm also assuming that for each "layer" experiment, SSA in one layer is treated as spatially variable in the truth (using eqn 1), and is varied systematically in the retrieval scene (as shown in Figure 10), but that the other two layers are not only treated as spatially homogenous in the truth, but are also the "retrieval" simulations are

given the true value of SSA. Please clarify this! I've read through a number of times but cannot find that information. 3. Page 5, line 13-14. "Up to three layers were assumed within the snowpack". Can you reword this? I found it really confusing. 4. Page 5, line 16. "Horizontally homogenous snow was assumed for the retrieval". Please just clarify more explicitly here that you consider horizontal spatial variability in the truth, but horizontal spatial homogeneity in the retrieval. 5. Page 5, line 20-21. Please say why you chose 5 intervals? Readers may assume this maps to "landforms" described in page 4, lines 27-29. I assume 5 is more or less arbitrary, or minimum needed to capture spatial observed distributions, which is fine, but please clarify. Also, this is a great chance to explicitly say that the set of 5 simulations represent spatial variability in that the frequency and weights represent the proportion of a scene that might take each SSA value. 6. Page 5, line 21. "across the observed range". This is referring to the in situ datasets of SSA, correct? But readers could easily get confused as this is how you are computing the synthetic radar observation. Please clarify the language? 7. Page 5, line 30-32. I read this section a number of times before I understood that there were a series of retrieval experiments performed, in which the SSA in one of the three snowpack layers was allowed to be spatially variable in the truth. You might say that Figure 3 represents an example of the windslab layer being spatially variable in the truth, and that a-e represent the five histogram classes. 8. Page 5, line 30-31. I don't understand what this means. Please clarify exactly how the retrieval is performed. Is it essentially an iterative, Newton-Raphson type approach, that requires a first guess? And please clarify what "first guess" on line 31 means in this context. This sentence makes me think that for identical experiment parameters (i.e. for the same layer to be studied and same depth) you repeatedly changed the arbitrary first guess to the iterative algorithm, to see whether it is more or less independent from the first guess. I don't think this is what was done, however, based on the rest of the paper, so please clarify! 9. Page 6, line 8. "A perfect retrieval was assumed possible (negligible noise)". This may be confusing for readers, since the paper is based on diagnosing imperfect retrievals, and because there are many sources of noise. Do you just mean that you

assume perfect measurement of radar backscatter is possible, and thus you do not perturb the synthetic observations with white noise? 10. Page 6, line 14. Writing "CF(SWE)" implies that the cost function has one independent variable: snow water equivalent. At a mechanistic level, I don't think that squares with the paper. It seems to me that there are two inputs that are varied in the cost function in this study: depth, and SSA. I'm assuming that density is treated as known. 11. Page 6 line 16 "the estimated microstructure is a function of the SSA". So, a specified SSA value is passed to a function f(SSA), and then that is used to estimate exponential autocorrelation length? If that's correct, please state it. However, to keep this simple, I think you could note somewhere exactly how SSA is transformed to correlation length, and then when you write the cost function just have the input be SSA. 12. Page 8, line 30. "Notable differences ... in different layers". Can you be more specific than "different layers"? I assume you're referring to the three layers assumed in the snowpack: depth hoar, wind slab, and surface snow. 13. I don't understand the equation in Table 1. If you plug in a depth of anything greater than $\sim$0.7 cm, you get a negative number and the surface snow percentage comes out as zero. Is depth intended to be in meters there? Additionally, can I recommend laying out the equation in the paper, and referencing it in the table? It's a little confusing with the way it's formatted in the table.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-167, 2019.

Printer-friendly version

Discussion paper