February 1, 2022

Responses to Reviewer 1's' Comments

Global Monitoring of Snow Water Equivalent using High Frequency Radar Remote Sensing
By Leung Tsang, Michael Durand, Chris Derken etal

Reviewer comments are shown in black. Proposed responses are shown in blue.

Reviewer Comment #1

The paper is a very thorough review of the remote sensing methodology for assessing water equivalent in the seasonal snow pack. The primary focus is on technique which utilize X to Ku band radars. There is a detailed discussion of theory concerning scattering from the evolving snow grains, scattering from rough interfaces, the effects of vegetation and complications from snow wetness. In situ and airborne data are used to illustrate generally good agreement between theory and observations.
The paper includes discussion of different retrieval algorithms and their limitations. Suggestions for improving retrievals by augmenting with other data sets (such as passive microwave) as well as incorporation of other radar techniques (such as tomography and InSAR) are included.
The paper concludes with a discussion of two recently proposed satellite missions. Of the two, the Canadian TSSM-Explorer is an early stage of development.

I think this is a useful, stand alone review of current progress in using radar to measure snow water equivalent. The scientific justification and the rational for high resolution radar (as opposed to solely passive microwave techniques from space) are well justified.

We thank the reviewer for their summary and assessment.

One quibble I have is the short statement at the end of section 3.1.1. There, the authors briefly mention the role of layering in the snow pack on backscatter. Given the efforts by several of the authors on the impact of layering, I am surprised that there was not more discussion of a point that could present a problem for thick snow packs and well into the winter season when layering might be expected to develop.

Regarding the role of layering itself, we agree that further work ought to be done on this topic. Indeed, two new studies were published after submission of the manuscript that shed light on this topic: Thompson and Kelly (2021a) and Thompson and Kelly (2021b) present in situ measurements of Ku-band measurements of snow, along with validated forward and inverse modeling, in prairie and tundra environments, respectively. Thompson et al. (2021a) show that for a prairie site, a 2 or 3 layer model parameterization may improve results in some cases, but that a 1 layer parameterization was advantageous in other cases. Thompson et al. (2021b) illustrates the effects of a thick wind slab layer in tundra snow, and how to constrain slab

thickness in a retrieval. We will add discussion of both of these manuscripts to the discussion at the end of section 3.1.1.

More generally, papers of this sort often set up the scientific and engineering arguments for a satellite mission. Because TSSM seems to be moving along, it is not clear to me whether the paper is designed to influence development beyond the completed Phase 0 study. If so, then the point might be emphasized with a discussion of recommended mission and instrument requirements. If not, then the paper losses some of its justification in my opinion.

We agree that papers such as this are often motivated by the need to articulate the rationale for a satellite mission, but we disagree that the current forward progress of TSMM minimizes the need for this paper. First, TSMM is not yet selected for full mission implementation. Second, the paper stands on its own as a summary of the notable progress made in this field (especially over the past decade), and we believe is of great value as a review even aside from the need to motivate a satellite mission. Our rationale is that there is a lot of work on this topic, indicating significant interest across the snow community. Our aim is to provide a summary of that work with significant updating of work since 2010 (last reviewed archival journal paper in H. Rott et al. *Proceedings of IEEE* 2010). Since 2010, there have been significant amount of work in volume and surface scattering modelling, ground and airborne measurements, retrieval algorithms etc. which should thus also be of interest, as no review paper has yet been published. Thus, we believe the paper has adequate justification even aside from the need to motivate TSMM or any other future snow-radar mission concepts.