

# Reviewer Responses Round 3 - Evaluating Snow Depth Retrievals from Sentinel-1 Volume Scattering over NASA SnowEx Sites

September 12, 2024

We thank both reviewers for their thoughtful comments and consideration. Please find our responses detailed below along with the track changes document included.

## Reviewer 3

*My only concern still remains with Fig. 1. I would suggest adding a red arrow showing "backscatter" from the snow-ground interface in VV. As it stands, it seems like there is only specular reflection from the ground, thus no VV signal. VV is still the dominant source of backscattered power measured by the sensor between the two polarizations (compared to VH).*

We realized our returning energy having such a steep angle was confusing and could be interpreted as specular instead of returning energy. We have adjusted the angle to show returning energy directly going to the monostatic configured sensor and showing specular reflection from only the ground interface. Hopefully this is clearer and we appreciate you pointing this out.

*I would also suggest adding a reference to Borah et al. (Preprint) and Zhu et al. (2023), which supports some of the points in the results/discussion sections.*

We have incorporated these great papers/pre-prints into the discussion in the appropriate locations. Thanks for sharing!

## Reviewer 4

*These in situ stations are the ones in your LIDAR regions. I would recommend using the entire snotel stations in the Sentinel-1 frames you processed. I assume there should be tens of snotel stations in them. You don't need to just use the in situ stations in LIDAR data.*

This is a great idea for a future analysis but outside the scope of this analysis since we are primarily focused on a comparison against our high quality SnowEx lidar snow depth datasets. The CR analysis against the snotel stations is primarily to inform the reader's understanding of the relationship between the Sentinel-1 cross ratio values and snow depth through time. We feel that future analysis exploring the tens to hundreds of snotels in the Sentinel-1 scenes would be an excellent contribution and have included this suggestion in our "Future work" section (line 412-413).

*It is showing the mean and 75% but the histograms are not normalized. Like I said, the maximum of blue in 5a should be much bigger than the maximum of orange if they are normalized.*

We do not disagree with this statement; however, we are intentionally choosing to compare the raw data throughout our analysis, not the normalized values.

*Again it is not clear when you are talking about 2-6 days, does it include ascending, descending, S1A, and S1B? If so, it needs to state it here.*

We have updated line 159 from “we downloaded all available S1 images...” to “we downloaded all available (ascending and descending, S1A and S1B) S1 images...”

*Also, I don't think the statement of “most locations” have 2-6 days acquisition is correct. It would be best if you show a heatmap for the study area to show the mean revisit time. If there is no overlap, you will have 6 days including asc des. If you have overlaps it should decrease to 3 days. And the overlap in mid-latitudes are not for most locations.*

We have changed this sentence to 2-12 days to address your concerns. We have also included an additional Appendix C table clarifying all acquisition timings, platforms, orbits, and flight directions we used for each site.

*I don't see explaining about all acquisitions in appendix A*

This information is actually in the main text starting on line 160. We have reworded this section to clarify the technique used in Lievens et al. (2022).

*”Also clarified we used all available images” - The sentences explaining this needs some grammatical edits, very hard to read.*

We apologize for the confusion. We were attempting to state that we had added language clarifying that we used all available Sentinel-1 images that fell within the bounding boxes of our lidar acquisitions including ascending, descending, S1A and S1B. Hopefully the revisions made in response to your comments above help to clarify the text in this section.

*If you are explaining something in the text, it should be clear. I do not understand what you did here. You mentioned in order to resolve incidence angle difference, you are subtracting the mean so they all have the same mean? If so, mean of what? Spatial or temporal mean. What do you average? If I understand this correctly, shifting means will affect the CR from snow. I also read the appendix A. Over there it just explained how you manage the wet snow by looking signals with the same orbit configuration, not subtracting the mean.*

We have rewritten these sections (lines 160 onwards) to clarify how we are handling the varying incidence angles between different orbit geometries. Since we also directly reference the same methods described in Lievens et al. (2022) we hope the combination of the clarified writing, that reference, and our open source code will allow readers to understand our methodology.

*“Added definition of SNR term as we are using it here (lines 250).” - The SNR is used in an incorrect way. I am not sure why we use noise here anyway. If we are talking about signal, we can just say backscattered signal from snow increased or decreased. The new edit makes it even harder to follow.*

We disagree that this is an incorrect usage of SNR and believe that our new wording clearly spells out that noise refers to non-snow (ie non-signal of interest) related backscatter signals. We discuss the relative changes in our signal of interest to our non-signal of interest (noise).