

The Cryosphere Discuss., referee comment RC2  
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## Comment on tc-2022-159

Anonymous Referee #2

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Referee comment on "Landsat, MODIS, and VIIRS snow cover mapping algorithm performance as validated by airborne lidar datasets" by Timbo Stillinger et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-159-RC2>, 2022

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### General comment

Overall this is a well-constructed paper that offers a new development in the assessment of fSCA products delivered by several spaceborne sensors (MODIS, VIIRS, Landsat) against snow cover as determined from lidar-derived snow depth maps provided by the Airborne Snow Observatory (ASO).

I found the discussion particularly well laid out and containing many useful points that will serve the community well, particularly as we consider more MODIS – VIIRS data continuity for snow cover mapping.

I recommend publication once the specific comments below have been addressed. I have also noted technical/editorial points below that should be addressed.

### Specific comments

The authors frequently refer to MODIS as having 463 m resolution, which is a fair point to make, but I think this should be better supported by relevant references/explanation to ensure that readers understand the reason for the distinction. This is particularly the case when most documentation (including that cited by the authors) refers to 500 m resolution, and where most readers would be interacting primarily with MODIS products that are resampled to a 500 m grid.

A central challenge to this approach is the conversion of snow depth (in this case from the ASO maps) to snow cover, in order to compare against fSCA products. Here, the authors used an 8 cm threshold to convert snow depth to snow cover in the ASO data, based on reported MAE of 8 cm for ASO snow depth products (Painter et al., 2016). I found the justification for this somewhat lacking, noting that Painter et al. state that (as of 2016), ASO data had not been subject to a full accuracy assessment in forested areas and steep terrain, and the 8 cm MAE is determined with respect to manual snow depth

measurements – a comparison which can itself be problematic. Given the role of the ASO snow depth products as the reference dataset underpinning the analysis presented in this manuscript, I think there is scope for a more robust approach to converting ASO snow depth to snow cover. This could include, for example, analysing residuals in ASO products for snow-free areas, and comparing ASO snow depth maps with optical imagery acquired contemporaneously (if/when available). It would be interesting to consider more fully the quality of ASO snow depth maps in steeper terrain where, for example, even relatively small co-registration errors may result in large errors (both positive and negative) in snow depth estimation. Furthermore, discarding snow depths <8 cm seems a bit blunt given that depths of much less than that can certainly contribute to a snow signal detectable by the fSCA mapping techniques employed in this paper. I was hoping that these issues may have been considered in the discussion (e.g. sec. 4.6).

### **Technical/editorial comments**

Line 27: "...spectral mixture..." should be spectral unmixing?

Line 42: "...billions of people." This reads a little imprecisely/colloquially, and repetitive with respect to Line 2.

Line 61: "At a 463 m spatial resolution..." some further explanation/reference here would be useful, as many readers would expect to see 500 m here, as widely documented, and most users are typically interacting with data resampled to a 500 m grid. It is also worth noting that it is possible to map snow from MODIS at finer (e.g., 250 m) resolution.

Figure 1 (caption): "Pixels are 463 m." This statement is a little ambiguous, perhaps make explicit reference to the spatial resolution?

Line 110: "MODiMlab" should be MODImLab?

Figure 3: I think this figure would benefit from some additional context, especially for readers outside of North America. Perhaps major basin outlines and/or elevation contours (at an appropriate interval for scale), for example, could be added?

Table 2: Reference Hall et al., (2019) missing from reference list? Presumably the document referred to is: MODIS Snow Products Collection 6.1 User Guide? Which would be Riggs et al. (2019). In any case, only refers to the spatial resolution being 500 m.

Line 207: "... (see Fig. 4)." Should be figure 2?

Line 304: what changes beyond the basin boundaries to make data unreliable?

Line 308 – 314: I'm not sure that the case is well made here for the 8 cm threshold – see previous comment.

Line 314 – 315: How was the resolution coarsened? The choice of technique will impact results, so please be specific.

Line 324 – 328: Mirroring my earlier comment, given the importance of ASO data to the rest of your analysis, I think you could go further in evaluating its quality and considering limitations here.

Line 384: It could be useful for readers to indicate the range of typical values you see here for F statistic?

Line 469: "All snow cover fractions..." is all the right word here? Implies all possible outcomes occurred/observed, perhaps indicate the range of observed fSCA?

Line 484: "...constricted..." would constrained or restricted be better here?

Figure 4: x axes should be labelled on plots.

Line 545: Collection of ASO data suggests good viewing conditions, but is there no possibility of cloud impacts – seems like a question worth asking if maritime regions see highest RMSE?

Line 548: "...slightly edging out..." perhaps outperforming would be better phrasing here?

Line 732 – 734: Is it realistic that there might be no issues with the reference data contributing here?

## **References**

- Painter, T.H., Berisford, D.F., Boardman, J.W., Bormann, K.J., Deems, J.S., Gehrke, F., Hedrick, A., Joyce, M., Laidlaw, R., Marks, D. and Mattmann, C., 2016. The Airborne Snow Observatory: Fusion of scanning lidar, imaging spectrometer, and physically-based modeling for mapping snow water equivalent and snow albedo. *Remote Sensing of Environment*, 184, pp.139-152.
- Riggs, G.A., Hall, D.K. and Román, M.O., 2015. MODIS snow products collection 6 user guide. National Snow and Ice Data Center: Boulder, CO, USA, 66.