Authors response to CC-1

The reviewer's comments are in Cambria font.

> The authors' responses are in blue Calibri font and are indented

It is interesting work on fractional snow cover estimation using multisource remote sensing data, including Landsat, MODIS, and VIIRS. Authors evaluate various algorithm and fractional snow cover products.

I have some comments for this excellent work:

1): Line 39-40: Please add a reference that can demonstrate the statement of "… the fraction of precipitation that falls as rain, rather than as snow …"

> Two references have been added to further support this statement.
> https://doi.org/10.1029/2011GL046976
> https://doi.org/10.1029/2007JD008397

2): Line 110: "but these approaches are not available for the dates or areas considered in this analysis". I don't understand this sentence's meaning, can you give more explanations why these two methods (MODiMlab and SnowFrac) were not used in this study.

> Neither of these methods are in production and to the best of our knowledge they were never run for the study area for the dates of the airborne lidar validation datasets. The goal of this study was to assess currently available operational snow cover mapping algorithms and state of the art spectral unmixing methods. These two legacy methods were included in the introduction to give a greater context to the history of snow mapping products and past validation efforts.

3): Lines 841-843: Changed "Bair, E. H., Stillinger, T., and Dozier, J.: Snow Property Inversion From Remote Sensing (SPIReS): A Generalized Multispectral Unmixing Approach With Examples From MODIS and Landsat 8 OLI, Ieee T Geosci Remote, 59, 7270-7284, 10.1109/Tgrs.2020.3040328, 2021a" to "Bair, E. H., Stillinger, T., Dozier, J., Snow Property Inversion from Remote Sensing (SPIReS): A generalized multispectral unmixing approach with examples from MODIS and Landsat 8 OLI, IEEE Trans. Geosci Remote Sens, 59, 7270-7284, 10.1109/TGRS.2020.3040328, 2021a"

> Thank you we have updated reference to correct format in final publication.

4): Lines 847-848: Please modify the citation stye of "Bair, E. H., Stillinger, T., Rittger, K., and Skiles, S. M.: COVID-19 Lockdowns Show Reduced Pollution on Snow and Ice in the Indus River Basin., P Natl Acad Sci USA, 118, 2021b."

> Thank you we have updated reference to correct format in final publication.

5): Line 150: What's your meaning of "fSCA can depend on the snow climate" ? Please give more explanations. Do you would like say that the fSCA depend on snow depth, density, and grain size?

> This statement is aligned with the two papers cited in the sentence (Liston, 2004, Clark et al, 2011). We are providing reasoning from the broader community on why it is important to understand how snow cover mapping performs in various snow climates. Snow cover evolution

and the spatial patterns of snow cover are partially driven by the unique energy and moisture fluxes that occur in various snow climates. This is a reason that drove us to validate fSCA by snow climate in this paper. (See Figure 3, Figure 6, and Section 6.2)

6): Line 317: Please explain the selection of a threshold of 0.01 for converting fSCA to binary snow. Why not 0.1, or 0.2, 0.3?

Line 319 in the original submission gives the explanation for the threshold choice. This threshold was not an fSCA threshold, but instead a data cleaning step during spatial coarsening. A threshold of 1% (0.01) was chosen to remove artifacts from upscaling the 3m snow depths to the final validation resolution. Depending on the geospatial location of a 3m snow depth measurement relative to the final validation resolution pixel, incredibly small snow fractions are possible as only a small portion of a single 3m snow depth pixel might overlap the final validation pixel. (ASO fSCA<<<0.01) . The very low threshold of 1% fSCA, below the detection limit for snow cover from these sensors, was chosen to eliminate these values from the validation dataset.

Section 4.3.1 Upscaling

7) What's the difference of the validation experiment between that was in the data original scales (463 m, or 373m, or 30 m) and that was in the upscaling scales?

We did not perform any validation at the original data scales due to uncertainty in the geolocation of individual multispectral satellite pixels. Prior validation studies cited in our paper have taken this same upscaling approach to validation to ensure that there is overlap between the validation data and satellite observations.

8) Fig. 5: When the canopy cover is over 0.5, these six products have lower RMSEs (Fig. 5a), however, f test are decreasing so fast (Fig. 5g). Why? It is so abnormal. Compared to Fig. 4, low f-test is corresponding to higher RMSE.

In addition, there is higher RMSE for VNP10A1F data at view zenith angle > 50 ° conditions (Fig. 5b), however, its f-test is so high, closing to 1 (Fig. 5h). Please confirm your data.

Thank you for pointing this out. This is an interested case of trying to validate with a small sample size. The F stat is a measure of detection of pixels with snow cover (a Binary detection measure). At high canopy cover, none of the products are great at detection of snow covered pixels, with VNP10A1F showing the worst performance.

Bias and RMSE calculations do not account for false negatives. There are numerous false negatives at high canopy cover values, as seen in the low F stat values. The RMSE and bias are only calculated from the set of true positive detections of snow cover.

Our probability of detecting a snow covered pixel is low for high canopy covered areas, but when we do detect snow, we do a good job of estimating the snow cover for that pixel.

The low RMSE and bias have to do with the combination of low sample size and the aggressive canopy cover adjustments for high canopy cover pixels, that tend to guess snow fraction correctly. The paragraph that starts at line 475 in the initial submission details the very low sample size at these higher canopy cover fractions. The reader is caveated to understand these

sample sizes for the highest canopy cover fractions. For the Landsat data, there was a larger sample size at the high canopy cover fractions as so the sample size enables a better estimate of RMSE and bias.

9) Figs. 4 and 5: The label “snow cover” in these two images are so confusing. I suggest that you modified it to another label word.

Additional clarification has been added to the figure caption.