Reviewer 1:
"Firstly, I would like to thank the authors for giving careful consideration to my comments and suggestions. The original manuscript has undergone extensive reworking and improvement. The most significant change is the removal of the cross-sensor and cross-site experiments. While these experiments were interesting, I agree with the authors that excluding effects related to the acquisition date is likely to be very challenging. That being said, it would be interesting to conduct future surveys of the study areas with different drones on the same day. In any case, the removal of these experiments has resulted in a much more concise study setup.

On the other hand, the authors have expanded their analysis to include additional lidar measurements. I think this is an interesting addition, particularly as it fits well within the scope of drone-based snow observations. The main conclusion of this new experiment is that lidar and optical approaches produce similar results in cases of relatively thick (and homogeneous) snow cover, but are sensitive to thresholds in cases of thin and patchy snow. I would expect this discrepancy to be mainly caused by uncertainty in the lidar snow depth instrument, as mentioned by the authors, or by mixed optical pixels (i.e. non-continuous snow cover). Could you therefore analyse which areas in the lidar maps (based on different thresholds) disagree with your optical snow cover maps? In Section 4.3, you suggest that a measurement uncertainty of 2 cm may be a reasonable threshold value. Why not use your dataset to determine an optimal threshold value for your lidar? I think this could be an interesting addition to your results.

Response:
We thank the reviewer for the thoughtful comments and for recognizing the improvements and clearer focus of the revised manuscript.

To better contextualize the comparison between the optical and lidar snow cover classifications, we added examples of spatial cross-classification maps between the optical and lidar-derived snow cover products, as suggested. The revised manuscript now reads as:

"*Similar threshold sensitivity occurred on 2021/03/03 and 2021/03/07, when increasing the snow depth threshold from 0 to 10 cm reduced the estimated fSCA by more than 60 percentage points. The optical reference fSCA on these dates was 82% and 72%, respectively, indicating discontinuous snow cover during the melt stage. During these periods, increasing the minimum snow depth threshold systematically reduced the estimated fSCA, producing a pronounced gradient among thresholds. The spatial cross-classification maps for 2021/03/07 (Fig. 12) further showed that these reductions were concentrated along snow transition boundaries, near fragmented snow cover or in localized shallow snow regions. At low thresholds, lidar derived maps identified extensive shallow snow areas that corresponded to optically detected snow cover, whereas high thresholds increasingly classified these regions as snow free. In contrast at the 0 cm threshold, the lidar indicated localized snow presence in areas that appeared snow free in the optical imagery (Fig. 12), which is also reflected in the higher lidar derived fSCA relative to the optical reference shown in Fig. 11. One possible explanation is that small positive elevation residuals associated with residual vegetation, surface roughness, or registration uncertainty were retained within the snow class at near zero depth thresholds. Another is that in these open areas, the 1 m pixels in the snow transition boundaries had a point cloud density that resolved variations within a single pixel. This behavior became more apparent as snow free*

patches expanded during the melt period (Fig. 11, S-15). Although no independent surface characterization was available to verify these features, the spatial distribution of these lidar false positive snow detections suggests that near zero lidar snow depth thresholds may be sensitive to non-snow surface structure, potentially leading to overestimation of lidar derived fSCA."

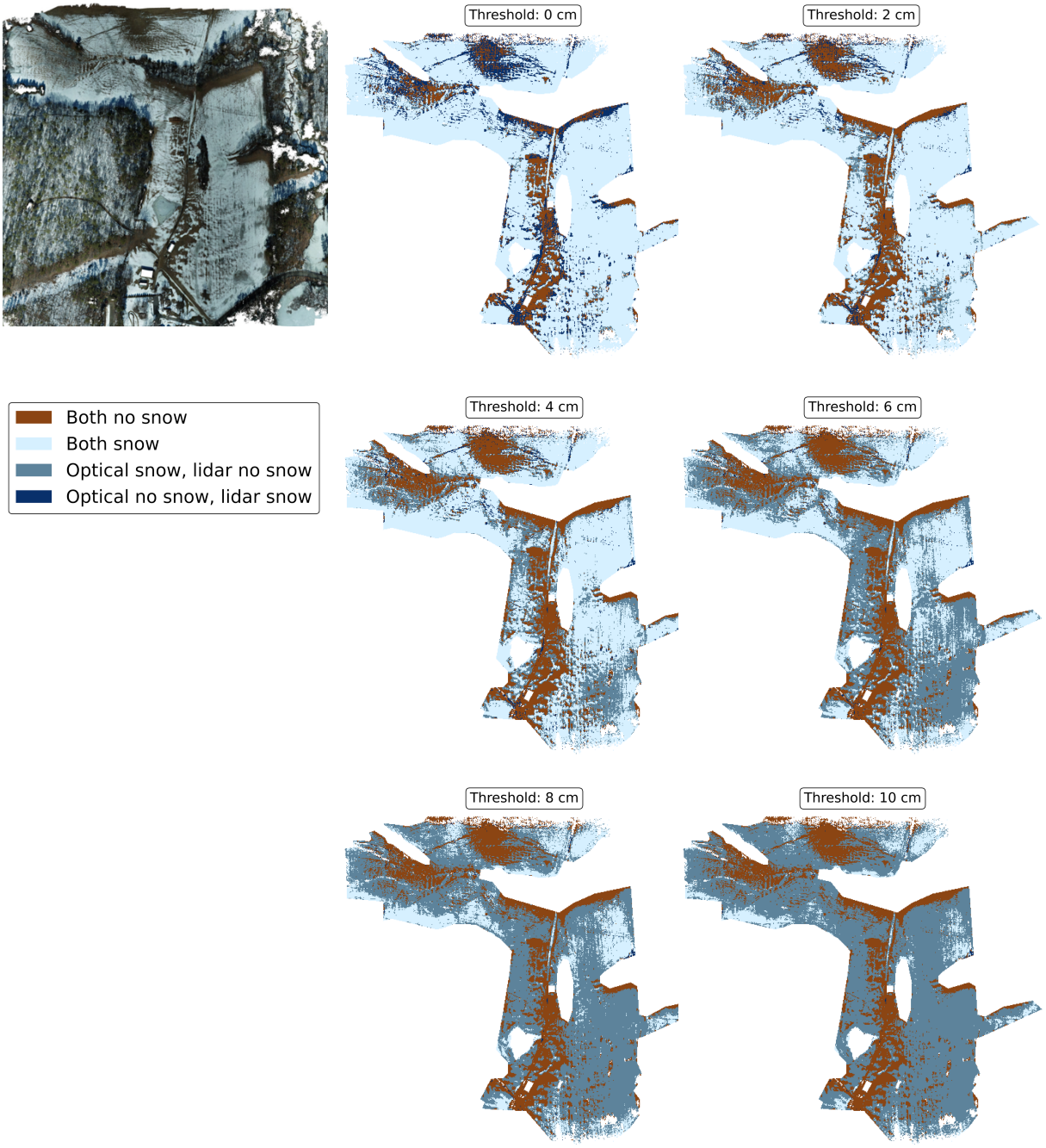


***Figure 12**. Optical and lidar-derived snow cover map comparison for 2021/03/07 under lidar snow-depth thresholds from 0 to 10 cm. Colors indicate pixel-wise comparison classes between*

the two snow cover products. The optical snow cover was aggregated to the 1 m lidar grid using majority voting prior to comparison.

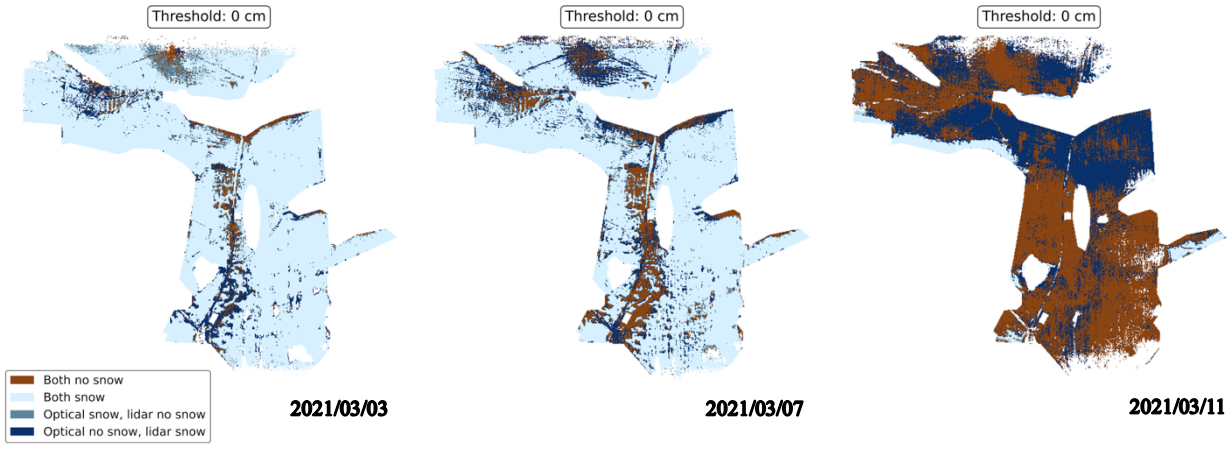


***Figure S-15**. Comparison between optical and lidar-derived snow cover maps during melt phase*

Regarding data availability, the authors have confirmed that they will make the dataset publicly available once it has been approved for publication by their funding agency.

Response:
Data is available upon request. We updated the data availability sections accordingly.

A minor complaint: in the submitted author's response, the final section of my comments (and author responses) is missing. I do not think this was intentional, but rather a formatting issue. As my comments mainly concerned technical corrections, I trust the author has revised them in the new manuscript.

Response:
We apologize for this issue, and if any comments or responses were missing, it was certainly not intentional. We greatly appreciate the reviewer's careful technical comments and would be more than happy to address any overlooked points. To forward the discussion and to ensure that we have included all the comments, below appears a screen shot of the final section of the reviewer's PDF and our response to the last comments regarding lines, 62, 67, 159 and 226 as well as Figures 1 and 5. If there was an additional file or section that we missed, we would appreciate if it could be shared with us so that we can revise the manuscript prior to publication.

Technical Corrections

- Line 62: Here you could add a reference to large-scale snow cover products based on NDSI (e.g. https://essd.copernicus.org/articles/11/493/2019/)
- Line 67: replace „blue-channel thresholding“ with „blue-channel“ reflectance (or similar)
- Line 159: There is no citation of MODIS data.
- Line 226: missing reference „NOAA’s publicly available archive (ADD-REFERENCE)“
- Figure 1: The panel on the bottom right appears to be a Google Earth background. I think there should be a reference to this somewhere.
- Figure 5 and other bar charts: Do not include both red and green bars in the same graph.

Thank you for pointing this out. The word “rapidly” has been removed from the text for clarity.

Line 685-688: How do your results validate “satellite snow cover products, converting satellite NDSI observations of fSCA, and downscaling satellite SCA observations”? Explain this or delete.

Response:
Previous studies have used higher-resolution satellite snow maps (e.g., Landsat-derived snow cover or fSCA) as reference data to validate coarser-resolution snow products and to diagnose mixed-pixel behavior under patchy snow conditions. For example, Salomonson and Appel (2004) used Landsat ETM+ as higher-resolution reference information to derive the relationship between MODIS NDSI and fractional snow cover within 500-m pixels. Similarly, Rittger et al. (2013) evaluated MODIS snow-cover mapping methods using Landsat-based snow maps as reference. Additional work has validated MODIS fractional snow cover retrievals using temporally and spatially coincident Landsat scenes across multiple regions.

UAS-based optical imagery provides centimeter-to-decimeter spatial resolution, substantially finer than publicly available satellite imagery (e.g., Sentinel-2 at ~10 m) and even typical commercial optical imagery (~1–3 m). As a result, UAS snow-covered area (SCA) maps can serve as a more detailed reference dataset for validation and mixed-pixel analyses, particularly in landscapes where snow cover is highly heterogeneous and prone to patchiness. To date, UAS SCA maps have been less commonly used for satellite snow-cover downscaling than higher-resolution satellite products, but examples do exist (Johnston et al., 2025). Instead, several studies have primarily used UAS-derived snow maps to support MODIS-scale (500 m) fractional snow cover (fSCA) estimation by training machine-learning models with UAS observations as reference data (Liang et al., 2017; Liu et al., 2020). Our study offers a guidance on effective approaches to map SCA using UAS observations that potentially can be used for the above-mentioned applications.

We added appropriate references for the mentioned applications.

“*It further offers guidance on effective strategies for producing UAS derived SCA maps that can later be used for a range of purposes such as validation of satellite snow cover products, converting satellite NDSI observations to fSCA, and downscaling satellite SCA observations (Salomonson and Appel, 2004; Rittger et al., 2013; Liang et al., 2017; Johnston et al., 2025).*”

Line 705: Data availability => Drone images and classification masks should be made available to reproduce results. Technical Corrections

Response:
Thank you for the comment. This is an extensive dataset that we would like to make available to the community. We have requested approval from our funding agency (DoD) to make the dataset publicly available. Unfortunately, the release of the dataset must remain pending until this approval is granted

Line 62: Here you could add a reference to large-scale snow cover products based on NDSI (e.g. https://essd.copernicus.org/articles/11/493/2019/)

Response: We added the Gascoin et al. (2019) reference.

Gascoin, S., Grizonnet, M., Bouchet, M., Salgues, G. and Hagolle, O., 2019. Theia Snow collection: High-resolution operational snow cover maps from Sentinel-2 and Landsat-8 data. *Earth System Science Data*, *11*(2), pp.493-514.

Line 67: replace „blue-channel thresholding“ with „blue-channel“ reflectance (or similar)

Response:
The text has been revised as suggested:

“*Promising methods for differentiating between snow and non-snow in UAS RGB imagery include machine learning (ML) classifiers such as maximum likelihood, random forest, support vector machine, k-means clustering (Liang et al., 2017, Belmonte et al., 2021, Johnston et al., 2025; Niedzielski et al., 2018), and thresholding approaches such as static or dynamic thresholding of blue-channel reflectance.*”

Line 159: There is no citation of MODIS data.

Response:
The appropriate reference has been added.

Line 226: missing reference NOAA’s publicly available archive (ADD-REFERENCE)“

Response:
The appropriate reference has been added:

“*Subhourly air temperature and shortwave radiation data was obtained from the USCRN stations located at the study sites, through NOAA’s publicly available archive (NOAA NCEI, 2025) Air temperature (°C) and incoming shortwave radiation (W/m²) from 2020 to 2025 at five-minute temporal resolution were used to calculate the mean and standard deviation during each survey.*”

NOAA National Centers for Environmental Information (NCEI). U.S. Climate Reference Network (USCRN) Data. National Oceanic and Atmospheric Administration. https://www.ncei.noaa.gov/products/land-based-station/us-climate-reference-network; Accessed: April 01, 2025.

Figure 1: The panel on the bottom right appears to be a Google Earth background. I think there should be a reference to this somewhere.

Response:
The appropriate citation has been added:

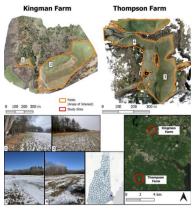


Figure 1. The two study sites, Kingman Farm and Thompson Farm, located at southern New Hampshire (basemap source: Esri, 2024).

Esri, 2024, . World Imagery [Basemap]. ArcGIS Online, https://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer

Figure 5 and other bar charts: Do not include both red and green bars in the same graph.

Response:
The figure is updated with new set of colors

