Review of Spatially distributed snow depth, bulk density, and snow water equivalent from ground-based and airborne sensor integration at Grand Mesa, Colorado, USA

Meehan et al., The Cryosphere Discussion

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The authors improved significantly the article by reorganizing and reducing the main body of the text. The work gained in clarity and the main results are better highlighted. The article remains rich in methods and some analysis are still a bit hard to follow but overall, I only suggest to take into account the following minor comments. For futur works, representation of the various estimations of SWE, snow depth and density could be clearly represented with bar plots and whiskers for uncertainty.

Minor comments

L13 for spaceborne remote sensing => « with remote sensing methods », the article has little to see with spaceborn methods.

L28 Maybe add a more general sentence about climate change impact on snowpack at global scale before zooming on the western US ?

L43 « light detection and ranging (LiDAR; e.g., Deschamps-Berger et al., 2023; Hu et al., 2021) aboard ICESat-2 (Abdalati et al., 2010). ». I suggest to also cite Treichler et al. (2017) with ICESat and Besso et al. (2024) with ICESat-2. Abdalati et al. (2010) is a bit outdated, it was published 8 years before the launch of ICESat-2. I do not think it is necessary to cite an article for ICESat-2 but in that case, Magruder et al. (2021) could be an option :

« light detection and ranging (LiDAR) with ICESat (Treichler et al., 2017) and ICESat-2 (e.g., Hu et al., 2021 ; Deschamps-Berger et al., 2023; Besso et al., 2024).»

Besso, H., Shean, D., Lundquist, J., Mountain snow depth retrievals from customized processing of ICESat-2 satellite laser altimetry, *Remote Sens. Environ.*, Volume 300, 113843,ISSN 0034-4257,https://doi.org/10.1016/j.rse.2023.113843, 2024.

Magruder, L., Neumann, T., & Kurtz, N. ICESat-2 early mission synopsis and observatory performance. *Earth and Space Science*, 8, e2020EA001555. https://doi.org/10.1029/2020EA001555, 2021.

Treichler, D. and Kääb, A.: Snow depth from ICESat laser altimetry– A test study in southern Norway, *Remote Sens. Environ.*, 191, 389–401, https://doi.org/10.1016/j.rse.2017.01.022, 2017.

L57 « empirical models spatially distribute density in SWE estimates » => « empirical models are used to spatially distribute density in SWE estimates » ?

L65 « Machine learning (ML)... » Is ML different from empirical models ? The same Broxton et al. (2019) citation is used L57. It makes this last sentence a bit confusing.

L65-67 Further, how different is « verification » from « validation » ? Verification sounds vague and makes the whole sentence circular (validation is lacking requiring validation to gain confidence).
L70 « simpler » => « simple » ? or simpler than what ?
L80 « require appropriate constraints » quite vague, please precise.
L90 «Our work leverages **airborne** LiDAR » ?
L95 « highlights interactions between snow [...] on the densification process » interactions on ?
L97 « to assimilate parameterizations » assimilation data is the usual term, what are you refering to here?
L155 Eqn 1. It not clear how CHH−HV would be calculated from this equation. Is it by setting i=1 and i=2, respectively in the first and second sum ?
L160 Eqn 2. Does CHH−HV depend on t ? Add *max(C)*. The max is calculated within the window or all the data ? CHH−HV and C(t) seem interchangably used for coherence (L155, L158) and normalized coherence (L160). Please clarify the notation.
L190 « were resampled to the 1 m resolution » using nearest-neighboor algorithm ? Precise.
L197 « to co-register the LiDAR » from your answer, I understand that you do not shift or translate the LiDAR data but rather associate LiDAR points with snowpits. Could « pair », « identify », « match » be more appropriate than « co-register » ?
L243 : « by retraining on random subsets of data. » not clear at all.
L260 « upscaled » how ? Using what algorithm ?
L262 «the RMSE (11 cm) was used to estimate the random error » RMSE is impacted by systematic errors (i.e. bias), thus it should not be used to estimate the random error.
L302 « Using supervised ML regression**,** » add coma ?
L20 « drives **SWE** spatial patterns » ?
L388-390 « that are on the scale of the 1 m resolution data products. » I am a bit doubtfull of that. The density models were trained on raster variables smoothed at 5 m and 25 m resolution. Thus a 1 m shift is small compared to the actual resolution of the densities and should have little impact. Especially taking into account the little variability of density at this scale (Fig 5.). Following your answer to my previous similar comment : how do you understand the fact that « f*urther perturbations of data alignment led to »* a much smaller error (1 kg m-3) than the error mostly attributed to misalignment (30 kg m-3)?
L403. Maybe comment on the fact that Yildiz et al. (2021) had a smaller study site which limited the lag considered to a maximum of ~50 m ?
L435 « To capture the range of processes (i.e., elevation, slope, aspect, and forest attributes) » these are not processes.
L468 « is...was » unify tenses ?
L483 « a SnowEx pit in two hours » give an estimate of the depth of the pit as it is has a major effect on required time.
L501 « that snow pit observations are independent and unable to resolve spatial patterns < 150 m scale » this a result of the sampling strategy, not of the snow pit approach in itself.

Fig 2. State in the legend that the colorbar is centered on the mean value. Idem in similar figures.

Fig 5. Interesting, more variability in depth and SWE in forest compared to open, but less in density. Could be worth commenting in 3.4 ? Could it result from relative importance of wind transport, canopy interception… ?
Fig. B2. The yellow histogramm is hardly visible. Maybe make it darker ?
Fig S8. Did you filter out negative values ? If so, state it in the methods, if not use a colorscale allowing negative values.