We summarized the Reviewer's comments on the submitted manuscript (with track changes) below (in black) and address the specific comments (in blue).

The assimilation was successful when the InSAR snow depth change really captured snowfall events in some cases. However, as can be seen from the results, the InSAR-observed snow depth change is quite noisy under some circumstances. Neglection of wind-blown effect may cause problems because the prior ensembles can only have highly-correlated dSD time series, caused solely by snowfall events.

The reference simulation indicates that the HRRR forcing used for the study underestimates the snowfall in addition to model uncertainty associated with wind redistribution of snow which is not accounted explicitly accounted at model resolution as there is snowfall advection representation in the model. The assimilation of Lidar and InSAR retrievals generally improves the simulated snow depth change in terms of spatial pattern and its distribution as discussed in the manuscript, capturing the variability that is averaged out in the HRRR snowfall. That is, the data assimilation captures the variability between the 3 km HRRR resolution and the 90 m resolution of the model. Note that the InSAR retrievals over the model domain also have spatial gaps associated with missing retrievals and impacts assimilation up to certain extent besides uncertainty associated with the retrieval.

Snow depth change is a function of meteorological forcing and snowpack evolution, which is impacted by physical process at multiple scales. The InSAR retrievals at native resolution can capture the finer scale scouring and drifting of snow as presented, which is much more filtered at the model resolution (90 m) after assimilation. Here, data assimilation compensates for the model errors (e.g. processes not well represented in the model) and forcing errors at the model scale. If any scale dependent processes are not well represented in the model or meteorological forcing has errors, the model error can again grow between the assimilation cycle, but data assimilation can correct the model for these errors.

Further, scaling analysis of SAR backscatter and Lidar snow depth estimates in mountainous regions including Grand Mesa (Mott et al. 2011; Manickam and Barros, 2020; Mendoza et al. 2020) shows that minimum variance is reached at scales 100-250 m with clear scaling breaks tied to very high variance at very small scales and topography and land-cover at larger scales. The spatial resolution of this study is around the scale of minimum variance.

We have added the following text in the revised manuscript:

Ln 332: "Further, scaling analysis of SAR backscatter and Lidar snow depth estimates in mountainous regions including Grand Mesa (Mott et al. 2011; Manickam and Barros, 2020; Mendoza et al. 2020) shows that minimum variance is reached at scales 100-250 m with clear scaling breaks tied to very high variance at very small scales and topography and land-cover at larger scales. The spatial resolution of this study is around the scale of minimum variance."

Detailed Comments

Ln 82: and forest over snow

Added.

Ln 120: The role of Lidar in the InSAR assimilation is not clearly stated.

We have added the following sentence for clarification.

Ln 113: "While the InSAR retrievals only provide a change in snow depth, data assimilation requires total snow depth. Therefore, we use the airborne lidar measurements of snow depth to reference the InSAR retrievals and obtain the total snow depth."

Ln 151: Is there an image for the flight tracks?

Yes, they are available from https://uavsar.jpl.nasa.gov/cgi-bin/data.pl. We have added the following sentence in the revised manuscript.

Ln 144: "The flight maps are available from https://uavsar.jpl.nasa.gov/cgi-bin/data.pl."

Ln 312: How to understand this sentence? Do you mean the redistribution of total snow depth to thicknesses of different snow layers? Please clarify.

Yes, the increment from the assimilation of the total snow depth is redistributed to different snow layers. More detailed description of the repartitioning algorithm is available from Shrestha and Barros (2025).

Ln 343: Is 100 m sufficient to fill the gaps between different flight tracks?

The objective is not to fill the gaps in the remote sensing data. We are using the localization setup such that the observations only impact model grid points where they are located. This is to reduce the impact of assimilation to the surrounding grids with different landcover characteristics, and therefore different retrieval uncertainty such as in the case of forested and non-forested grid points. Thus, the cutoff radius was set at approximately 100 m (close to the model resolution).

Ln 365: In line 257, you mentioned that the UAVSAR resolution was 5 m? Why will it be degrated to 50-m resolution here？Please clarify.

We need total snow depth as observation for data assimilation, so we used the ASO Lidar snow depth retrieval at 50 m resolution as a reference and add the snow depth changes from the InSAR retrieval aggregated to the same resolution (50 m) and obtain the total snow depth for assimilation. We have modified the text for clarification as follows:

Ln 350: "In this study, we use the ASO Lidar snow depth data at 50 m resolution (Feb 1) as a reference. We aggregate the InSAR retrievals to coarser resolution (50 m) to match with the resolution of the reference ASO Lidar snow depth retrieval. Then, we combine the reference snow depth with aggregated InSAR retrievals of snow depth change I1 (Feb 1-12) , I2 (Feb 1-19) and I3 (Feb 1-26) to obtain the absolute snow depth pattern over the GM domain on Feb 12, 19 and 26 respectively."

Ln 396: It could be interesting to see the snow density variation time series.

The time series of snow density variation is not available from the ASO Lidar observations or at the snow pits, so we can only compare the distribution for the selected days.

Ln 468: Are there any ground in-situ measurements to be compared?

We show the InSAR comparison with available ground in-situ measurements for all retrievals in Fig. 6 (snow pole) and 7 (pit). RMSE of the lidar measurements over snow pole site used in the study was also around 7-8 cm for the available two dates (Feb 1 and Feb 12) exhibiting good accuracy. Over forested regions, there are disagreements in the spatial patterns between the lidar and the InSAR estimates of snow depth change (Feb1-12) with possible uncertainty in both data sets. More data is required for spatial comparison in forested environments to better understand the differences between lidar and InSAR retrievals. We acknowledge this in the discussion and conclusion sections.

Ln 640: However, it will cause errors if the process model does not consider wind blown effect.

Snow depth change is a function of meteorological forcing and snowpack evolution, which is impacted by physical process at multiple scales. Here, data assimilation compensates for the model errors (e.g. processes not well represented in the model) at the model scale. If any scale dependent processes are not well represented in the model or the meteorological forcing has errors, the model error can again grow between the assimilation cycles, and data assimilation can be used to identify these errors and correct the model for these errors. Since we use HRRR forcing (3 km resolution) for the 90 m resolution run, the assimilation of InSAR retrievals at similar scale after a snowfall event, allows to capture the spatial variability due to precipitation forcing as well.

We have updated the sentence in the revised manuscript for clarity:

Ln 624: "The assimilation of hyper-resolution retrievals of snow depth is equivalent to a downscaling of precipitation forcing with a bias correction besides additional contribution from physical processes not resolved by the model at the given scale."

Figure 4: Which dates?

It's for Feb 1 and Feb 12 (also mentioned in the legend). We now mention it in the Figure caption for the revised manuscript also.

Figure 8: It is better to use shaped areas to represent the ensemble spread.

The figure has been updated in the revised manuscript.

Figure 9:

1.The X axis of (a)-(i) are not presented.

Added.

2. Why there are abnormal seperation lines in (e) and (h)?

It's due to the coarse atmospheric forcing data resolution (3 km) compared to model grid resolution (90 m).

3. Why are there strongly different pattern changes of dSD from 1st, to 4th rows? Why should we trust the results in 4th row? Do you have in-situ measurements represented as dots to be shown on these maps.

The first row shows the snow depth change based on InSAR retrieval only. We compare the different model runs with this observation. The different pattern changes of snow depth change in DA and DAU run compared to the OL run are due to the assimilation of observations – DA (ASO

Lidar retrieval on Feb 1) and DAU (ASO Lidar retrieval on Feb 1 and referenced InSAR retrievals on Feb 12,19 and 26). In DAU (row 4), we additionally assimilate the InSAR retrievals, which brings the modelled snow depth change closer to the observation (InSAR retrieval) – also see the distribution of snow depth change (row 5). Here, we want to emphasize the spatial patterns and distribution of snow depth change, and we show the comparison with the in-situ measurements available in Figs. 6 and 7.

References

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