

REVIEWER 1

Review comments below are reproduced in blue and responses are in black.

General comments

This study explores whether assimilation of remotely sensed snow depth observations available for forest clearings improve snowpack simulations below forest canopies where these measurements are missing. The authors performed six different data assimilation experiments using various configurations that affect prior correlations, and thereby the ability of the data assimilation schemes to propagate information from observed (open) to unobserved (forested areas) locations. The results show that four out of the six experiments improved the simulations in forested areas compared to the reference simulation. In the discussion, the authors provide an informative judgment of the results and specify future research possibilities for improving their methods further. Overall, the research presented in this study is highly relevant, as snow in forests can be important for a large range of scientific (e.g., ecological studies) and practical (e.g., water resources management) applications. The methods presented here are at the forefront of snow data assimilation research and demonstrate promising results. The study is well-written and provides valuable insights, and is therefore an excellent study that only requires a few minor adjustments before eventual publication in my opinion.

We sincerely thank the reviewer for their positive and encouraging feedback on our work. We are glad that the study's relevance and methodological contributions were clearly conveyed, and we appreciate the recognition of its potential applications.

We believe these improvements will further strengthen the clarity and impact of the manuscript. Below we provide a point-by-point response to each of the comments.

Specific comments

L 71-83: I think this paragraph can be shortened and should focus on why snowpack monitoring in forests, in particular below forest canopies, is challenging.

We will remove most of this paragraph and merge the relevant parts with the following one, which discusses the challenges of remote sensing in forests.

L 84-134: I recommend to shorten these two paragraphs too since the introduction is rather verbose. Just state the main problems concisely with references to the extensive literature, such as on challenges with forcing data as one example.

These two paragraphs will be simplified, removing details that are not relevant to the work.

L 42-201: Overall, I find the introduction a bit long and verbose. Please shorten where possible.

Several paragraphs will be shortened, simplifying the text where possible without changing the main message.

L 209-214: I don't understand this sentence. Please clarify.

We will simplify this as follows: "From all the available areas, we have manually selected a domain of ~2x2 km that maximizes canopy heterogeneity and the observed snowpack data that are incomplete due to dense canopy cover"

L 251-253: Please provide a scientific valid justification why this model was selected. Technical simplicity is not enough in my opinion. Why is the model appropriate for the experiments performed in this study? Which previous studies supports the choice of this model for the particular region, snow conditions and canopy properties?

The methods presented here are independent of the model and forcing used (as stated in Discussion). The 'better' the model and forcing (and observations), the easier the data assimilation will be. Each application will require the use of a different model. In any case, FSM2 is a widely known model, with a multitude of scientific and operational applications as outlined in Essery et al. (2025), which maintains a very good compromise between accuracy and computational cost. We will clarify this with the following sentence:

"In any case, the methods presented here are independent of the numerical model and forcing used, so they are transferable to different snow data assimilation initiatives."

L 504-506 and Table 1: I assume this table is for the snow depths of the canopy-covered cells? This is what L 231-233 states. Nevertheless, please specify this in the table caption and the text to avoid misunderstanding, or start the result section with repeating the information on L 231-233.

The referee is correct, we will clarify this in the caption as follows:

"Table 1: Validation metrics comparing the under canopy (withheld) and forest gaps (assimilated) observations"

L 602-606: Please add some more text here to guide the reader what the figure shows. It seems that low precipitation multipliers are associated with negative temperature adjustments, for instance. Is there an elevation trend in the values for precipitation multipliers and temperature additions?

This figure should be interpreted with caution. We are assimilating a single spatially incomplete observation, the amount of information available is limited. This correlation between precipitation and temperature is probably subject to equifinality. It is possible, and very interesting, to use data assimilation to identify weaknesses in numerical models by identifying irrelevant, highly sensitive or uncertain parameters. However, this would require a very different experimental design, with much more informative observations. Furthermore, this must be analysed jointly with the uncertainty of each inferred parameter, not just its posterior mean as shown here. We believe that this exceeds the scope of this work, and we will add the following sentence to clarify this:

"Figure 6 should be interpreted with caution. It is designed to provide a rough estimate of the posterior parameter values. However, drawing conclusions beyond that is risky, since there is likely to be equifinality in the parameter posteriors of the simulations, something

that is merely suggested by the obvious correlation between the posterior mean parameters.”

L 623-636: It would be interesting to know how much time was spent running the model and how much time was needed for the DA algorithm separately. If I understand correctly, you run 100 ensembles with 40401 cells, and repeat this simulation 4 times in the iterative framework. Correct?

In this experiment, we generated ensembles consisting of 100 members (FSM2 realisations) for the 40,401 cells and repeated the process in four iterations. In any ensemble data assimilation algorithm, the greatest computational cost is due to the numerical model itself (or associated operations such as I/O). The analysis itself has a negligible cost, except in extreme cases where thousands of observations are assimilated (here we only assimilate a few for each cell) and therefore the cost of the domain localized linear algebra operations may be no longer negligible.

L 669-747: Maybe split these two long paragraphs into shorter ones.

We will separate these two paragraphs into simpler paragraphs.

L 788-792: Please simplify this sentence since it is hard to read and understand.

We will simplify as follows:

“The differences found in the implementation of the prior covariance function in the Mahalanobis and Euclidean spaces, suggests the importance of future research investing effort in exploring of specific covariance function that better capture the snowpack spatial patterns”

Technical comments

L 137: Capital letter after comma.

L 186-188: “Available” twice. Remove one.

L 209: “snow-off”?

L 275: What is “2m air fields”?

L 288: Missing period.

L 308: I guess “using” is missing.

L 364: On period too much.

L 475: Abbreviation PCA has not been introduced.

Thanks for spotting these typos, they will all be corrected.