November 14, 2024

Evaluation of high resolution snowpack simulations from global datasets and comparison with Sentinel-1 snow depth retrievals in the Sierra Nevada, USA
By: L. Sourp et al.

General Comments

In this paper, the authors create a modeling pipeline which leverages global-scale meteorological analyses (ERA5 and ERA5-Land) to force SnowModel and produce 100 m SWE estimates in the Tuolumne River Basin for a seven year study period. They then compare the modeled results to ASO lidar SWE/snow depth and S1-derived snow depths, showing surprisingly performance even with the coarse scale forcing data. The results presented here are novel/robust and provide a baseline to extend this modeling technique to other data sparse regions around the globe, which could provide marked enhancements to SWE/water resource forecasting.

The manuscript is clearly written and the comments from the previous reviewers have all been properly addressed and integrated into the text. I find the discussion of the results well throughout and the figures well presented. The comments provided below are mostly minor, the most important being the adding of numerical error statics to the paragraph between L233–245. Once these are addressed this article is suitable for publication and will be a solid edition to TC. Congrats on a very nice study!

-Jack Tarricone

Specific Comments

L32: How does Pléiades retrieve snow depth? I know, but a bit more information on stereo photogrammetry would be good for a broader audience. Same thing for ICESat-2.

L33: Add a bit of info on co/cross pol S1 retrieval algorithm

L70: “worldwide” is a bit confusing, as it reads on first pass this SWE data is worldwide. Maybe "Globally publicly available from this basin” ?

L113: I like the discussion of the density uncertainty here, but would add a reference to Raleigh & Small (2017) and rework for a more robust statement.

L149–153: I recommend creating a table in the appendix with all model parameters mentioned in this text so future work attempting to replicate your work knows exactly what you did. While I see they're buried in the Github page, I'm not sure exactly where to find them.

L196–202: A bit confused on how you're referencing "interquartiles" here. Also the text states, "...for the wet year 2017, they peak respectively at 0.64 and 0.82 m." Yet, when I look at the boxplots it seems 06-04 has the max value, which barely extends below –0.5.

Please check this paragraph for clarity and correct numbers.

L214: Note TC date formatting requirements (https://www.the-cryosphere.net/submission.html): "1 April 2016", I won't ask you to do this but will likely need to be updated in the copy editing stage!

L225: Why is the resampling procedure set up this way? It seems like you're losing valuable information if you're throwing away a whole 1 km pixel if 1 of 400 50 m pixels is missing. Not saying it's incorrect but some justification of why this is the proper method should then be added in Section 2.2.3 then.

L233–245: Add values to bias, SD, R^2, and RMSE when referenced, this will likely require some tweaking of the language as well. You've performed solid analysis that is not being communicated clearly in this paragraph!

L237: Remove "seems to be" – no need for subjective language when you've conducted numerical analysis. Use the error metrics you calculated and state the performance of each dataset!

L240: How do we know S1 it underestimates? State specific metrics used to support this sentence.

Figure 7: Provide number of values in each scatter plot (n = xx). I only say this because you said there are different numbers in each, so the reader should know how much that varies.

L273: I would add a figure in the appendix of this analysis, as you're referencing something you did but provide no data/figure to back it up.

L300: I would add some context to the Shao et al. RMSE of 0.04 m for ERA5-Land. What are some of the uncertainties associated with validating a 9 km pixel against point-based in situ observations? Would these be magnified in complex mountain terrain?

L309: Not sure I totally agree here, “seems to represent quite well” yet R^2 0.25–0.53. Maybe “agrees moderately”?

L319: Recent work has shown S1 struggles in shallow snow (<1.5 m), as there is almost no physical co/cross pol backscattering signal detectable (Broxton et al., 2024; Hoppinen et al., 2024). The technique has been shown to work well in the Alps and moderately well here as they both have deeper snowpacks. I would caution against recommending it for operational use as (1) Many snowpacks are not deep and therefore not well suited, (2) No one has been able to produce the Lievens method to anywhere near the quality of the closed-source code he has. This supports that your modeling pipeline is superior!

Technical Comments:

Fig 1: Change color scale to 0.

L97: Replace ‘(see below)’ with the specific section you’re referencing.

L100: Add link to C-SNOW website here.

L113: What does “w.e.” mean here and throughout the manuscript? Excuse my ignorance if this is a common phrase.

L132: DEM already defined.

L199: Noting “w.e.” again. Found a few examples of what it could but still unsure.

L210: State two dates.

Figure 5: Added (left) and (right) in caption after corresponding dates.

L212: Remove double period.

L263: “most probably” -> likely

L308: “modelisation of snow density” -> modeled snow density

L341: “global datasets only” -> global publicly available atmospheric reanalysis datasets only

L349: “near real time” -> near-real-time

Bibliography:

Broxton, P., Ehsani, M. R., & Behrangi, A. (2024). Improving Mountain Snowpack Estimation Using Machine Learning With Sentinel-1, the Airborne Snow Observatory, and University of Arizona Snowpack Data. *Earth and Space Science*, *11*(3), e2023EA002964. https://doi.org/10.1029/2023EA002964

Hoppinen, Z., Palomaki, R. T., Brencher, G., Dunmire, D., Gagliano, E., Marziliano, A., et al. (2024). Evaluating Snow Depth Retrievals from Sentinel-1 Volume Scattering over NASA SnowEx Sites. *EGUsphere*, 1–35. https://doi.org/10.5194/egusphere-2024-1018

(^ published article should be coming out soon so be on the lookout for that)

Raleigh, M. S., & Small, E. E. (2017). Snowpack density modeling is the primary source of uncertainty when mapping basin-wide SWE with lidar: Uncertainties in SWE Mapping With Lidar. *Geophysical Research Letters*, *44*(8), 3700–3709. https://doi.org/10.1002/2016GL071999