Response letter for to first review round of:

Using Sentinel-1 wet snow maps to inform fully-distributed physically-based snowpack models

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In the following, comments from the reviewer appear in black. The authors' answer is in blue, with planned changes in italics.

Reviewer #2

I reviewed with interest the manuscript by Cluzet and colleagues on using S1 wet snow maps in snow model evaluation. Authors provided a novel contribution on the long-standing topic of using wet snow maps in snow modeling, by evaluating an operational snow model in Switzerland with several years of wet snow from S1 and fractional snow cover from S2. Results show a general good agreement, with a North vs. South bias that was improved by adjusting fresh snow albedo.

Overall, the research is novel, relevant, and timely. Particularly the intuition of a wet snow line is interesting and will likely be used in several future papers. Thus I am in favor of publication, after a minor revision.

Thank you for your positive feedback on our study and your valuable comments for improving the manuscript. Below, we have provided our responses to your comments and outlined the changes we plan to implement to enhance the paper.

Like R1, I was also a bit puzzled by the choice of adjusting fresh snow albedo as the main approach to correct the mismatch between model simulations and observations of wet snow. On the one hand, I understand that this variable is related to snowmelt onset and thus is one of the variables involved in this mismatch. On the other hand, in my understanding fresh snow albedo has a clear impact only when snow is fresh, while parameters related to the seasonal evolution of albedo seem more important to me here. Also the procedure that led to this adjustment is not clearly outlined and should be better discussed.

The fresh snow albedo affects the surface albedo not only after snowfall, but throughout the entire season. Therefore, it is more effective to adjust the start value (effective from the beginning) rather than the albedo decay functions (which only become effective after some time). The procedure that led us to this adjustment is now clearly explained in the response letter to review #1 (see above), and we performed significant changes to reflect that in Sec. 2.3 and in the discussion Sec. 4.2.

Another potential opportunity for improvement here is that the whole of the discussion around the wet snow data is performed in terms of wet snow line, rather than pixelwise values. Authors are clear on why they are doing so, and I generally agree. I still believe that computing confusion matrices for aspect or elevation classes would provide additional insights around model performance.

This is an interesting suggestion; however, computing confusion matrices may be misleading because the problem is slightly ill-posed. Intrinsically, the “wet snow” class is conditioned by the presence of snow. Computing a confusion matrix for wet snow would result in evaluating both “snow presence” and “wet snow” at once, with an unknown relative weight. Fig. 4 shows well that that Sentinel-1 wet snow retrieval relies on an auxiliary snow mask (see added elements in Section 2.2) to put pixels below 40% SCF in the “no snow our dry snow or patchy snow” whose accuracy is questionable at low elevations. In fig. 4, 6a and 7a, below 2000m, a significant number of pixels are classified by AlpSnow WSM as “no snow our dry snow or patchy snow” while the model still has snow. Arguably, we could filter the model with its own snow cover fraction, to reduce this mismatch, but we would nevertheless end-up evaluating this model component too, instead of just evaluating the wet snow part.

Some more minor comments:

- Line 26: maybe also mention lateral flow as a way for snowmelt to move away from the snowpack without exiting from the bottom of the local snow cover

We believe that this comment applied to paragraph 36-44, which was edited accordingly.

- Line 99: maybe better define what these hydrologic units are and how they were delineated?

The corresponding sentence was changed into:

We focus our analysis on 16 subcatchments with relatively homogeneous snow conditions (“MEZ”, as defined by the Swiss federal office of environment), which cover the alpine area of the domain.

- Line 141: remove one “and”

Fixed

- Line 158: maybe spend some more words on this FSC = f(SWE, HS) relation here, given that it is quite important for this paper?

We agree and added further information including a reference to Helbig et al (2021) for full information:

A subgrid parametrization is used to derive pixel-level snow cover fraction from seasonal values of SWE and HS (Helbig et al., 2021). This model component accounts for the impact of subpixel terrain roughness and slope variability on snow depth distribution at the peak of accumulation. For instance, smooth and flat pixels usually exhibit homogeneous subpixel SWE distribution, leading to a more rapid reduction in snow cover as SWE decreases Fresh snow events are assumed to produce abrupt yet transient increases in snow *cover fraction. Accounting for this is essential for comparing model outputs with satellite retrievals of snow cover fraction at this scale.*

- Section 3: I would recommend including more quantitative metrics here in place of wording like "excellent", "higher elevations", etc.

"Excellent" is used in l. 204 to qualify the comparison between flat-field snow depth observations and simulations since the curves are often barely distinguishable. Detailed performance statistics are available in Oberrauch et al (in press), Winstral et al., (2019) and Mott et al., (2023). We added a reference to these papers here:

Overall, the match is excellent, in particular during the accumulation period, which is consistent with the fact that these observations were assimilated for correcting errors in the snowfall input (see Sec. 2.3) For a detailed evaluation of FSMoshd against station data, readers are referred to Winstral et al., 2019, Mott et al. 2023 and Oberrauch et al. (in press).

"higher elevations" is used l.217 to qualify the difference between modelled and observed wet snow maps. The purpose of this paragraph is precisely to say that only qualitative information can be derived from map comparisons, stressing the need for the aggregation which follows, and gives quantitative numbers (e.g., l. 229). Nevertheless, to be more specific, we edited the instance l. 217:

In the south-facing slopes, the observations indicate wet snow conditions several hundred meters higher than the model simulation.

References:

1.
Helbig, N. *et al.* A seasonal algorithm of the snow-covered area fraction for mountainous terrain. *The Cryosphere* **15**, 4607–4624 (2021).
Oberrauch, M. et al. Improving fully distributed snowpack simulations by mapping perturbations of meteorological forcings inferred from particle filter assimilation of snow monitoring data, *Water Resources Research*, (in press)