

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2020-357

Anonymous Referee #1

Referee comment on "A local model of snow-firn dynamics and application to Colle Gnifetti site" by Fabiola Banfi and Carlo De Michele, The Cryosphere Discuss.,
<https://doi.org/10.5194/tc-2020-357-RC1>, 2021

Integrated model of glaciers, hydrology, and dynamics is important as described at the beginning of the abstract and Introduction. The model of this study has calculated the density of snow and firn in one dimension to use as a part of the chain of integrated model. In this case, the discussion of strengths of the model with scientific impact and a solid validation are necessary for focused part of the model. In this paper, the model produces several outputs, and the snow and firn density was used for validation of the model by comparison with actual measurements. Equations (2) and (3) describe the density calculation scheme in detail. So the main target seems to be snow and firn density. In my opinion, the verification of firn density in this study is insufficient to confirm the ability of the firn densification model.

I think it would be better to use the ice core data in Table 2 more effectively and discuss the reproducibility of density more thoroughly. Comparison of firn density profile like Fig. 5 is important. But simulated firn density was underestimated and the discussion for it was lacking. Also, comparison of Fig. 11 was averaged density for entire snow and firn. It is not suitable for validation of firn densification models. This study also calculates snow transport amount, but this simulation was not compared with observed data. So, reproducibility of snow and firn density is most important for the contents of this paper, and I wrote comments about the density mainly.

minor comment

L125 How much does the range of density of ρ_F estimated in these simulations? If it is treated as an impermeable layer, it means that water cannot flow through the voids, and the density must be quite large. If the density is about 450 as shown in Fig. 11, it should not be impermeable. Please show the range of ρ_F in the simulation.

L157-159 165-169 Is it sufficient for adjustment for firn densification model? According to figure 5, densities in the deep layer seems to be small in the simulation. So additional adjustment for snow-firn densification models may be necessary. In the text of this paper, it seems that the model is optimized for lower temperatures than field in this study. I think it may lead to a possibility of underestimation of densification.

L220 If the ice core introduced in table 2 includes a density profile, it is an important validation data for this paper. So it should be used more for validation. Despite γ' was shown for the first time, the explanation of γ' comes in at L278, which is a later sentence than here.

L270 Since Japanese snow has speciality compared to European snow due to warm and heavy snow areas, parameters optimized in Japan may not be suitable to apply the field of Italian Alps? Is there any other parameter optimized for Italy or other European regions?

L276 is the NSE used here Nash and Sutcliffe (1970)? If so, NSE is commonly used for the validation of the runoff amount, but I am not sure whether it is suitable for validation of snow depth or not. Do you have any reason to use NSE rather than RMSE or MBE? What is the advantage of using NSE for modeled snow depth?

L295-297 It is important to compare density profiles such as Fig.5 to validate firn densification models. In this comparison, simulated snow density is underestimated when the firn density is larger than 600kg/m³. So I guess the compressive viscosity is overestimated. Is it common the present firn densification model underestimates snow density in other studies? I think that the more detailed discussion is necessary for this comparison.

L311-316 The range of firn density is usually 400-830 kg/m³. And 400 is especially small, it is almost the same as snow. So, the range of 350-450 in Figure 11 is a particularly small value. It is due to be estimated by average for snow and firn layers. Although this comparison appears to be in agreement, using the averaged density value of new snow and old firn is not suitable to validate the firn densification model. Is there any idea to separate the model output for firn layers accumulated in each year? Direct density comparison of dense firn is necessary for validation of firn densification model.