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Interactive comment on "Development of physically based liquid water schemes for Greenland firn-densification models" *by* Vincent Verjans et al.

Anonymous Referee #3

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In this paper, authors simulated liquid water infiltration and densification of firn using several model schemes. They were performed for four field sites in Greenland. Validation using the field observation data was also performed. In my opinion, this study provides scientific valuable results. I have several suggestions to provide better information.

1) Measured temperature was used for the validation of models. Simulated runoff was also discussed. However, figures for these results were not shown. Lack of figures sometimes makes difficult to understand in detail. In TC, authors can use a supplement file to show figures relatively less important. Therefore, figures of them should

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Discussion paper

be added using a supplement to support the discussion in the main text (see minor comment P13 L22-28, P14 L14-15).

2) The simulation in this paper was performed for four fields. Tables were provided for results in each field showing total or averaged simulated values. I would like to suggest that the author provide a table which shows the comprehensive result to see the difference between fields about simulation results (see minor comment in P19L5 and P22L26). This is not prerequisite for acceptance, but it will help to understand the overall result.

3) Although the main target of this study was the validation of liquid water infiltration model, density and temperature data were used instead of liquid water content for validation. It leads to the limitation of the validation itself. Discussion about the limitation because of this is also necessary.

4) This simulation study can provide several suggestions for a laboratory experiment and field observation required to improve the model. Although limitations are written in conclusion, detailed discussion about limitation and suggestion of new experiment and observation (e.g. liquid water infiltration experiment into firn or observation of liquid water.) will be informative for future research.

Minor comments

P8 L26-27 In this sentence and Eq. (17), the saturated water content was estimated as i/w (0.917?) of pore space. It seems to be used for convenience in calculation. Yamaguchi et al. (2010) obtained the saturated water content was about 90% of pore space in their gravity drainage column experiment. Although they are coincidence, this paper had better be referred to show that the assumption in Eq. (17) is consistent.

P13 L22-28 Figures for simulated runoff had better to be shown in a supplement.

P14 L14-15 Comparison between observation and simulation of temperature also needs a figure in a supplement.

P17 L18-30 In terms of average value, DPM had a good agreement. However, the simulated result of DPM was a constant value for vertical and maximum density was underestimated. In my opinion, the depiction “good agreement” feels not suitable (depiction “average density is reasonable” may be OK). The state of this result had better be that present liquid water infiltration scheme has limitation and requires future improvement.

P19L5 Here, densification model had a larger effect than water infiltration model. Is this trend only this place or common for all four places? Comprehensive table comparing between fields about this will help to check this question. (This is suggested in major comments.)

P20 L27 L31 Fig8f? Recheck the figure number.

P22 L7-9 Is it mean that the simulation using BK and R1M were performed by CROCUS whereas DPM was performed by SNOWPACK? If so, the difference in results receives the effect of the difference of numerical snowpack model. Did authors check the difference of them performing a simulation with the same water infiltration scheme? SNOWPACK has Bucket and RE scheme comparable with BK and R1M, respectively.

P22 L26 This results seems that the DPM is not suitable for this place (actually, improvement is necessary for preferential flow scheme). As discussed in P17 L4-8, BK and R1M reproduce surface ponding and refreeze. If a suitable model is different depending on the field, the most suitable scheme had better be shown for each field. Comprehensive table suggested in a major comment is useful to show a comparison between fields.

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