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The Cryosphere Discussions

Interactive comment on "Refreezing on the Greenland ice sheet: a comparison of parameterizations" *by* C. H. Reijmer et al.

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This work deals with a topical problem, namely the retention of water, originating from snow en ice melt or rain, in the near surface layer of the Greenland ice sheet. It is clear and well structured and invites to read to the end. The good introduction is promising but some experiences and conclusions are a bit disappointing because a large part of this work is descriptive without reaching a clear goal.

Until now, it was clear that different retention parameterizations produce large local divergences, while global values only reveal moderate differences. The scientific value of this work could be, in the absence of enough observations, to produce a more comprehensive retention model, built in a Regional Atmospheric Climate Model with an Energy Balance Melt Model, serving as reference for simpler parameterizations and opening

the way to develop new parameterizations of a higher level, capable to reproduce a good local approximation of the retention in spite of a reduced number of parameters. Such models should be utile for instance to be coupled with Positive Degree Day (PDD) melt models. In fact, my questions are more addressed to the reference model than to the parameterizations.

I tried to detect how the coupled snow model works. I had to go from one reference to the other (Ettema et al., 2009; Bougamon et al., 2005; Greuell and Konzelmann, 1994; Zuo and Oerlemans, 1996;. . .). It should be easier for the reader to resume and clarify the key retention mechanisms of the coupled snow model in this paper and to direct the discussion about different parameterizations in this context. About the references, there is something I don't understand. I read in "3.1The coupled snow model" of this work at line 20: "No slush layer forms, the remaining liquid water runs off without delay" Why? The models of Bougamon and Greuell produce a slush that can later on refreeze as superimposed ice. If I understand correctly, refreezing is only possible for the water percolating through the snow or firn, but if it reaches an impermeable layer no refreezing occurs? Nevertheless, for some regions, for instance in the neighbourhood of the run-off line at Central West Greenland, the reference retention is higher than all of the parameterization ones (see Fig. 7). What is it that I don't see?

The discussion about Pmax (4.2.7 Pmax) reveals other surprising facts. As pmax = 0.6 corresponds less or more to the maximal value of possible retention (theoretically and observed) we may expect that the total amount of retention should be overestimated by Re1991. Surprisingly not, as the pmax has been tuned to 0.65. This suggests that the reference retention could be overestimated. It is also remarkable that the ice sheet average of Er/C reaches the high value of 0.28. Unless the "result of multiple cycles of melt and refreezing of the same snow/ice" (page 2742, line 1) plays a dominant role and exceeds the loss of retention caused by omitting formation of superimposed ice. If this is true, it should be interesting to investigate this new scientific issue.

Finally there is need for simple adjusting of some maps and correction of some words.

-Figures 1 and 7 are very important but too small for a good analysis.

-The different scales of figure 1 make it hardly possible to compare the maps. It would be more appropriate to show a map of available water (melt and rain).

-Figures 13: The Pmax fraction is a relative retention potential, while Er/C is the relative effective retention. Don' t use Pmax here. Of course you could speak about the tuned Pmax (= 0.65) producing the same area averaged effective retention (=0.28).

-Page 2735 line 26. I should replace "the difference goes to zero" by "the difference is zero, by definition". If the rain is accounted for, where the water is the limited factor, you have Er = min(Pr,Wr) = Wr = Melt+Rain = Wr_ref = Er_ref . Is it not possible to reserve the yellow colour in Fig. 7 for the zero value alone?

Interactive comment on The Cryosphere Discuss., 5, 2723, 2011.