

General comments

This paper documents several developments implemented to the ORCHIDEE land surface model for use over the Greenland and Antarctic ice sheets. These include (1) a new snowpack initialization routine, (2) a wind-based surface snow density parameterization, and (3) a recalibrated dry-snow densification scheme. Positive impact of these developments on the simulation of surface snow density and vertical density and temperature profiles is demonstrated, but some weaknesses are still noted in representing the Greenland ablation zones.

Overall, this is a comprehensive paper that could fit either in The Cryosphere or Geoscientific Model Development. The paper has gone through one review/revision round, and accordingly, it is already overall in a good shape. I don't have very much to add to the comments on the substance of the paper made by the reviewers of the original manuscript. I do have, however, a significant number of minor comments targeted mainly at increasing the clarity of the paper, polishing its language, and correcting a few typos and other minor errors.

Minor comments

1. line 229: "several years" sounds like an understatement. Decades or even centuries?
2. lines 258–260: Avoid giving percent differences for temperature. They are very different depending on whether temperature is expressed in Celsius or Kelvin.
3. lines 284–285: "The new parameterization is applied to the modeled fresh snow density ...". This is an important point, and it should be perhaps be made even more explicit. If I interpret this correctly, the equation for surface density (Eq. 7) (and Eq. 1 for OR OLD), is only applied at time steps when snowfall adds new snow on top of the existing snowpack, and then the surface density remains constant until the next snowfall event? Rather than computing the surface snow density based on instantaneous wind speed (and temperature for OR OLD) for all time steps (also those without snowfall), which would result in fast and unphysical variations in density.
4. lines 293–295: The use of words "heterogeneous" and "this heterogeneity" in these sentences gives the impression that the wind-speed dependent density parameterization is motivated by the density variations in Greenland, which is

misleading. Please reformulate the wording.

5. line 305: As a follow-up comment, it would be honest to note explicitly that for Greenland, Eq. (7) doesn't capture much of the surface density variations, but rather acts as a bias correction that avoids the strong negative bias resulting from Eq. (1).

6. lines 343 and 392. You should refer to Section 4.1 rather than Section 4.

7. line 389: also mention Eq. (4).

8. line 461: 11.9 kg m^{-3} should be 45.2 kg m^{-3}

9. Fig. 6: Colour should be used for making the figures clearer rather than for artistic purposes. There is no need to use different colours for the different models, because they are cleanly separated into different figure panels. However, using different colors for Greenland/Antarctica/refreezing /no-refreezing would improve the clarity.

10. Fig. 6: As a very minor point, some of the numerical values given in the legends differ marginally from Table 6 (BIAS is panel (b) and RMSE in panel (d)).

11. line 528: add "albedo" before "parameters" to increase the clarity. When reaching this point in the manuscript, at least this reviewer could not remember what Rauolt et al. (2023) was about.

12. line 535: It would be clearer to say "...while ORCHIDEE values are lower by 2 to 3 m yr^{-1} ".

13. line 540: "(May–June 2012, see supplementary material)". So far I can see, there are no figures in the Supplementary material showing May–June 2012.

14. lines 549–551: Since you are discussing a short-term event (12 days), it might be better to use units of $\text{kg m}^{-2}\text{d}^{-1}$ instead of m yr^{-1} .

15. Caption of Fig. 10: Mention the use of the OPT12L albedo parameters, and that panels (d)–(g) are for year 2012.

16. line 572: Fig. 11b should be Fig. 11d? Also, replace "following profiles" with "profiles 2–5".

17. lines 634–635: Noting explicitly that $\gamma = \gamma(\ln(\overline{A}))$ would help the reader to

understand why the logarithm of accumulation rate is needed (on line 642).

18. line 635: Eq. (1) should be Eq. (5). Also, giving the numerical values $C_0 = 0.03$ and $C_1 = 0.07$ would help, as the symbols C_0 and C_1 are not used after Eq. (5).

19. lines 643–644: For completeness, also mention the parameterization of snow-pack thickness in the list.

20. lines 648–649: mention also the use of a lower lapse rate ($6.5^\circ\text{C km}^{-1}$) in the lowest 500 m.

21. Caption of Table A1: explain the meaning of MBE (Obs), MBE (MAR), RMSE (Obs) and RMSE (MAR).

22. Table A4: There are two rows for $z_{\text{snow_max}}$.

23. Supplementary material, Eq. (S1): Something wrong; the units of the two terms on the right hand side don't match.

24. Supplementary material, Eqs. (S5) and (S6): What does T_{soil} mean in the context of the present study?

25. Supplementary material, Eqs. (S8) and (S9). What are the units of T_s ? The numerical values suggest that they might be K for (S8) and $^\circ\text{C}$ for (S9), but this should be noted explicitly.

Language corrections and typos

1. line 177: remove the comma after η .

2. line 193: it should be "in terms".

3. Caption of Fig. 4, third line: space missing after "dots."

4. line 412: "correlation between both". Remove "both".

5. line 445: add "the" before "IMAU-Firn densification model".

6. Caption of Fig. 6: replace "developped" with "developed".

7. Caption of Fig. 8, first and third line: the word "difference" should be used instead of "anomaly".

8. lines 527–530: Add "Because," before "As presented ...", to make this sentence grammatically correct. (Why? "As" refers to only "presented in Section 2.4", not to the last part of the long sentence).
9. lines 654–655: It should be "dependency ... on latitude".
10. line 701: it should be "affected"
11. Caption of Fig. A1: replace "in function" with "as a function of".
12. Figure A.3: I would use "precipitation-weighted air temperature" and "precipitation-weighted wind speed".
13. Caption of Figures S1, S2 and S4: It should be "Dark lines represent".
14. Caption of Figures S3 and S5: "numeroted" should be "numeration" or "enumerated".