

Comments on “Summer snowfall on the Greenland Ice Sheet: a study with the updated regional climate model RACMO2.3”, by B. Noël et al., submitted to *The Cryosphere*

Graham Cogley, April 2015

General Comments

This paper evaluates the impact on simulated summertime snowfall in Greenland of a significant upgrade of the physics package of the regional climate model RACMO. The main adjustment has the effect of increasing the proportion of precipitation that falls as snow. Particular attention is paid to snowfalls in the narrow ablation zone, which is hard to resolve even at the 11-km horizontal resolution of RACMO. Here snowfalls retard melting by increasing the albedo, especially over exposed ice. The before-upgrade and after-upgrade mass losses are compared with observations along the well-studied K Transect in southwest Greenland. The upgrade reduces appreciably, but does not eliminate, biases in the simulated surface energy and mass balances.

Most of my comments below are actually requests for the removal of ambiguity. The paper is a generally sound report on improvements in one of the leading regional climate models involved in the continuing quest for more accurate simulation of climatic forcing of the ice sheets. I recommend that it be accepted subject to consideration of the substantive and stylistic points raised below.

Substantive Comments

P1178

L6 What does the adjectival “upper air” mean here? And from what direction do the temperatures “reach” the freezing point? (I.e. say either “rise to” or “fall to”.)

P1179

L10-14 “once snow melts” is rather misleading. The rate of metamorphism increases progressively as the temperature rises towards the freezing point. Presumably the rate of grain growth then remains high (until an episode of refreezing complicates the situation), but the appearance of liquid water is an immediate complication as far as the albedo is concerned. These sentences should be clarified – perhaps by shortening, because it is not clear that this discussion is essential for the purposes of the paper.

P1181

L24 What is an “auto-conversion coefficient”? It may be accepted jargon among regional-scale climate modellers, but is unintelligible to me. (What is being converted into what? And why is the prefix “auto” needed?)

P1182

L5 Should this begin with “In the polar version of RACMO2.3, ...”?

P1184

L13-16 This is confusing and needs rethinking. I think it means “causes moisture-bearing depressions to propagate eastwards towards south Greenland”. But in that case why don’t they produce a topographic precipitation maximum in *southwest* Greenland? Comma after the first “Greenland” in any case.

L26-28

This enhanced northwesterly advection of drier air needs to be reconciled with the eastward advection of *moister* air at L13-16. It seems that you are summarizing average patterns, but forgetting that at any point the wind does not blow in two directions at once. The same problem seems to arise at L27-28, where it may be that “reinforced ... weakened” should be “more frequent ... less frequent”.

P1185

L11 “enhanced” should be “improved” and “conversion” should (probably) be “transition”. Presumably the transition is from rain at the surface in warmer weather to snow in colder weather. But if the simulated phenomenon is the melting of snow flakes as they fall through the air column then the sentence needs to be expanded.

P1186

- L10-15 There is no sign convention for components of the energy balance. The reader “just has to know” what you are talking about. Tables 1 to 3 suggest that the convention is “all fluxes positive except for latent heat”, which is absurd; for example the observed Table-1 melt according to the equation is 737.2, not 42.8. Make all fluxes positive towards the surface, or positive upward or downward, but do not oblige the reader to work out which of your plus signs should actually be minus signs. The “ground” heat flux is oddly named and could perhaps be called the “subsurface heat flux”. But why, having been introduced here, is it not mentioned again? You could say, for example, that its annual averages do not exceed $X \text{ W m}^{-2}$ in magnitude.
- L19 “2010-2012 (S10)”: the AWS began operating in 2011 according to P1183 L10. Clarify.
- P1188
L2-8 Some clarification is needed here of what “prescribed” (L3) and “restricted to” (L8) mean. I think this would be achieved by moving “No ice albedo ... (Fig. 5f)” to L3, and continuing with “, and so RACMO2 prescribes the albedo as 0.55. In recent summers, ...”. The “In fact, both ...” sentence could be deleted because it is out of place and unhelpful.
- P1191
L14-15 Unclear. Should this be “because in inward-propagating air masses this change delays cloud formation to higher elevations further inland”?

Stylistic Comments

- P1178
L9 “snowfalls”
- L10 “have the potential to” is a verbose way of saying “can”. Delete the unnecessary “locally”.
- L19 Do not hyphenate the names of decades (such as “the 1990s”).
- L22-22 Commas needed at either end of the “and solid ice ... Rignot et al, 2011)” clause.
- P1179
L15 “have the potential to” again, but here it needs to be deleted altogether.
- P1180
L1 Change “the use of an explicit” to “an explicit model of”.
- L20 Capitalize “Research”.
- P1181
L6 There is no need to capitalize terms simply because you are about to turn them into acronyms ...
- L7 ... and in fact this acronym is not used again so it is unnecessary.
- L10-11 Do not capitalize “independent column approximation”. And again, do not bother to define an acronym you are not going to use. There are too many acronyms in the paper already.
- L12-13 “between ... and” or “of ... with”.
- P1182
L12 “RACMO2.1”.
- L22 “0.30”, and use equal numbers of decimal digits in similar contexts below.
- L26 Yet another unused acronym. This is the second definition of this one. Delete both it and the one on P1180.
- P1183
L22 “gradient”.
- L23 Delete “of”.
- L25-26 “decreased/increased SMB in the west/east” is easy for the writer and hard for the reader. Say “decreased SMB in the west and increased SMB in the east”.
- P1184
L11 “from southwest to northeast”.
- L17 “Relative to RACMO2.1, RACMO2.3 is 0.1 to 0.3 °C cooler in ...”.
- L23 “precipitation in”.

L24-25	“in the northwest, on the lee side of” (or “in the lee of”).
L26	Delete the meaningless “overall”.
L28	“subsequently” should be “consequently”.
P1185	
L18-19	Again, easy to write but much harder to read. Say “The reduced summer snowfall in the centre and southeast and the increase in the southeast are not compensated by opposite and equivalent rainfall changes;”.
L28	“significantly exceeds in magnitude”.
P1186	
L9	“where there are significant differences in SMB between the two model versions”.
L10-15	<i>M</i> is not defined (it cannot be the SEB.) “radiation” (or “radiation fluxes”) in three places.
L22	“show”.
L1187	
L13	Delete “values”.
L25	Insert “simulated” before “summer snowfall”.
L1188	
L13-14	“too large. However,”.
L20	I am not sure what “a partial recovery” means. Perhaps “longer persistence”?
P1189	
L15	I am not sure what “determined” means here. “selected”?
L26	Change “Solving” to “Correcting”.
P1190	
L2	“in combination with”. Comma needed after “ LW_d ”.
L12	“least-squares”.
P1191	
L16-17	“Another change that is simpler to implement is improvement of the background ...”.
Table 1	“mean annual”, not “monthly mean”. Presumably you have averaged the 12 monthly means and then the nine annual means. In L5 of the header, say “between RACMO2 and S5 observations” (as at L3).
Tables 2,3	“annual mean”, not “monthly mean”.
Table 4	“annual mean cumulated” is not correct; you mean “mean annual”. The fact that it is “cumulated” over the year is irrelevant. Save space by deleting the S5-S10 unit column and putting the units after “SMB” in the header.
Figures 2,3	“mean annual”, not “annual mean cumulated” (in four places in all).
Figure 4	“cumulated” is unnecessary.
Figure 5	Delete “Absolute value of” and “, respectively”.
Figure 6	Change “combined with absolute” to “, and”.
Figure 7	Perhaps the lines for Stake data and RACMO2.3 could be made thicker, so as to distinguish them from the single-stake lines.
Figure 8	Add the stake identifiers along the top axis of the graph to make it easier to interpret the caption.