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Interactive comment on "Impact of updated radiative transfer scheme in RACMO2.3p3 on the surface mass and energy budget of the Greenland ice sheet" *by* Christiaan T. van Dalum et al.

Anonymous Referee #2

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The authors evaluated the effect of a new snow/ice albedo and radiative transfer treatment in RACMO2 model over the Greenland ice sheet by comparing with several different in-situ measurements. They found that the modeled surface mass balance generally agrees with observations and the new snow/ice albedo treatment has a nontrivial impact on the surface mass balance. The paper is generally well-structured and suitable for this journal. Before it can be considered for potential publication, I have a few comments and suggestions for the authors to consider. Particularly, there are several places that still need more clarifications.

Specific comments: 1. Title: I suggest including "snow and ice" before "radiative trans-

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fer scheme" to avoid potential confusion.

2. Abstract (Line 6): "The surface mass balance is in good agreement with observations". Please be more quantitative, e.g., bias within a few percent?

3. Lines 68-71: Does the update of multilayer firn module only includes an increase in the number of layers? How about related physical processes? Any updates on the physics? More clarifications would be good.

4. Lines 73-82: Although the authors mentioned that their recent paper (Van Dalum et al. 2020) provided a detailed description of the new snow albedo module, it would be good and informative to include some key elements of this new snow/ice albedo module. For example, as partially mentioned in the introduction, snow grain properties (size, shape), snow impurities, and snow layer structures are critical to snow albedo calculation. How does the new albedo module deal with these elements? Also, more descriptions of the bare ice albedo parameterization are needed. How does the module handle ice underlying snow layers, e.g. assuming a fixed ice albedo or explicitly resolve radiative transfer within ice layers below snow? Besides, what snow and ice processes have been included in this coupled RACMO2 model, e.g., sublimation, redistribution, snow grain growth, refreezing, etc?

5. Lines 89-97: How does the model deal with the Gs (subsurface conductive heat flux) at the ice surface below snow layers? Or did the authors only consider Gs at the soil/ground surface below both snow and ice layers? Does the runoff only include water coming out of snowpack above the underlying ice? Is there lateral water flow between neighboring grids in the model? A more straightforward question would be whether the model deals with the permanent ice glaciers under snow layers? If so, how?

6. Section 2.3: The authors calculated internal energy absorption at non-FR time steps by using a simplified Beer's law (i.e., exponential decay) equation. Would this cause any discontinuity of the absorption profiles between non-FR and FR time steps since the TARTES is used for FR time steps?

7. Section 2.5: What are the observational uncertainties of these in-situ measurements?

8. Section 3.2: This part is very interesting, however, I am not quite convinced that the rather small snow melt in the central GrIS could have such a large impact on the cloud cover in the region. Any explanations on the mechanisms? Did the authors see an increase in surface heat and water vapor sources due to snow melting and albedo increase, which could enhance the cloud formation locally? Also, snow melting could also decrease snow albedo, so I am not sure if the change in spectral distribution of irradiance is large enough to cause the snow albedo increase as mentioned by the authors. More explanations and clarifications are needed.

9. The authors conducted model evaluation by comparing with several in-situ point measurements. I suggest including some regional scale evaluation of the model, particularly surface albedo, by comparing with satellite products (e.g., MODIS). Large uncertainty could exist in the comparison of 11-km model grid data with point observations.

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