

Geosci. Model Dev. Discuss., referee comment RC2  
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## **Comment on gmd-2022-28**

Charles Amory (Referee)

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Referee comment on "A wind-driven snow redistribution module for Alpine3D v3.3.0: Adaptations designed for downscaling ice sheet surface mass balance" by Eric Keenan et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-28-RC2>, 2022

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### **General comments**

This paper describes a new computational chain for downscaling the surface mass balance (SMB) over ice sheets, by combining the snowpack model SNOWPACK driven by MERRA2 reanalysis with an offline coupling between the wind downscaling model WindNinja and the wind redistribution model Alpine3D. This numerical design, while maintaining attractive computational costs, provides promising results by partially resolving the spatial variability in SMB due to wind redistribution of snow along a 130-km long transect in West Antarctica along which radar-derived SMB retrievals are available. Sensitivity to horizontal resolution and to a prescribed, yet influential parameter not constrained by observations, is explored. The proposed method is innovative and clearly fits with the scope of GMD, some limitations are addressed and the work is put in perspective of future developments. Furthermore, the study is concise and very pleasant to read. I think the paper deserves publication after the authors have addressed the following comments. I would particularly advise further discussion of the limitations of the modelling approach, notably regarding lacking suspension, atmospheric sublimation, feedbacks with the atmosphere and the attribution of the spatial variability in SMB to mostly saltation transport, in order to reach the level of rigour of the other discussion elements of the manuscript.

### **Specific comments**

Abstract, L1: Snow accumulation is more the resultant of the SMB than a component of the SMB. The actual main components that lead to snow accumulation are snowfall, condensation/deposition and wind-driven snow deposition. Would you please reformulate a little to get this clearer?

L24-26: You should mention atmospheric sublimation as a source of surface mass loss when defining the SMB. Currently the definition in the first paragraph only describes wind redistribution.

L39-40: Would this assertion still be valid knowing that blowing snow layers can extend up to hundreds of meters above ground in Antarctica (Palm et al., 2017)? I find this assertion actually quite questionable, and one can expect the ratio of saltating to suspended snow mass to depend a lot on the area considered, and then to be very specific to the local snowpack, topographic and atmospheric conditions, or to the boundary conditions of the experiments. I did not find the materials in the referenced literature necessary to support such a statement. Gromke et al. (2014)'s results, which are based on wind tunnel experiments of limited dimensions, would not account for the well-developed blowing snow layers of hundreds of meters in depth, in which transport in suspension most likely dominates over saltation. Besides, these numbers are actually not demonstrated by Gromke et al. (2014), but just mentioned in the introduction and borrowed from Kind (1990), with no reason to consider it universally valid, especially when translated into an Antarctic environment. Moreover, contrary statements can be found in the literature. See for instance Bintanja (2000) p345: "*Most of the snow transport occurs when snow is in suspension, with the saltation transport becoming rapidly less important as wind speeds increase (Pomeroy and Male, 1992; Mann, 1998).*". Please nuance and adapt your sentence accordingly.

L44: "recent" appears twice.

L80-84: How did you choose those lapse rates, particularly that of ILWR?

L164: Another limitation that you might also consider to discuss is the net domain-integrated erosion-deposition balance equal to zero, due to the absence of transport off the continental margins in this approach, which might be of some significance at the coastal grid points over steep continental margins. I also recommend to elaborate on the expected consequences of 1) assuming that the saltation mass flux accounts for both the contribution of suspension and saltation and 2) not taking into account atmospheric sublimation and its influence on surface sublimation, at least qualitatively, and more particularly for continental-scale simulations for which these processes are believed to be responsible for significant ablation at the surface. We can expect several other processes (vertical advection and sublimation of suspended particles, local turbulence and synoptic wind not related to local topography) to contribute to the net erosion/deposition balance and thus to the spatial variability in SMB. For instance, could they play a role in the discrepancy between modelled and observed SMB described in Sect. 3.2?

Section 2.4: Could you add to the text a recall on if and the, how, snow (microstructural) properties (sphericity, radius, bond radius, density, albedo) are altered by deposition of wind-driven snow?

L174-177: One could expect more info on the initialization procedure of SNOWPACK here, not provided in Sect. 2.3. How long is the spin-up before the period studied? Does the initialization procedure also account for the possible influence of erosion and deposition on the firn column? You could also refer to Keenan et al. (2021) and mention the reasonable agreement found with observed firn temperature and density profiles to strengthen your argumentation there.

Section 3.2: To evaluate the benefits of a newly-implemented parameterization, it is usually recommended to compare two simulations, one with and one without. By doing so with two Alpine3D downscalings, you could then quantitatively disentangle the contribution of erosion-deposition from that of SEB to the spatial variability in SMB, and attribute part of the enhanced variability and performance that is due to the modelled erosion-deposition process.

L307: "Simulations results" of what ? please specify.

L316: This sentence could be rewritten to present a more correct definition of SMB. You could for instance refer to as "Net snow accumulation" to describe mass gain, as SMB is not necessarily positive.

Conclusion: I think briefly recalling that atmospheric sublimation and suspension are both omitted in your calculation chain would make the conclusion more exhaustive.

## References

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