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Interactive comment on “Understanding Snow Bedform Formation by Adding Sintering to a Cellular Automata Model” *by* Varun Sharma et al.

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Snow bedforms cover large parts of the polar regions of Earth. Sintering, the mechanism by which snow hardens over time, clearly influences bedform dynamics. The authors have studied the effects of sintering by adapting a cellular automaton model, ReSCAL, and have discovered that it limits the maximum streamwise length (MSL) of snow dunes. The authors also show a good awareness of the strengths and limitations of ReSCAL. The simulations they use are well designed, and the analysis is appropriate and thorough. Their simulation methods and results both agree well with my field observations, and I firmly believe that the processes they have modelled are real.

I’ve submitted this comment because I have studied snow dunes extensively in the

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field, and want to ensure that the editor and future readers know that this study models reality well. I am pointing this out in a comment, rather than leaving it up to the authors, since most of the work was not published when the study was written, and I believe it is pertinent to point out the observations that strengthen their case.

I have also done some work with ReSCAL and have a few technical suggestions. I am not associated with the authors, but since this is not an ’extra’ comment, not requested by the editor, I have tried not to suggest anything burdensome.

Yours, K. Kochanski

Comparison to field data Thorough validation is clearly beyond the scope of this study, but I would like the authors and editors to see that these results capture important aspects of reality.

Fig. 6a, in which a dune is trailed by a patch of newly-sintered snow, looks a good deal like larger snow dunes I have observed in the field. See Figs. 2 and 6 of https://www.the-cryosphere.net/13/1267/2019/tc-13-1267-2019.html.

Most of the simulations used here represent the rare case in which snow dunes form well, without the influence of sintering, then begin to sinter abruptly. This happens occasionally in reality - I have one field example where dunes stop moving instantly when the temperature rises to 0, as in Fig. 6b (see https://www.youtube.com/watch?v=vFEwMPtO0pY) - but is probably rare.

Under constant temperature conditions, I expect that real snow dunes grow gradually but continuously like sand dunes grow. This has not been modelled or well-documented in the field, but if it’s true, dunes will grow from nothing up to the MSL, when they will lose mass by sintering and grow no further. In this case, the MSL will be not only the maximum size of snow dunes but they usual size of well-developed dunes. This makes the MSL more important than the current text suggests.

Specific comments on ReSCAL *Sintering mechanism* I was not clear, from Fig.

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1 or the text, how your sintering mechanic is implemented. All existing ReSCAL transitions use doublets, or pairs, of cells (as shown in Fig. 1a) but your illustration of sintering uses single cells (Fig. 1d). Did you adapt ReSCAL to use single-cell transitions? If you used a doublet transition, this is important, because it would imply that your sintering mechanic works differently when snow is in contact with air or ground than with snow.

Scaling ReSCAL ReSCAL has three units: a length scale l0, a time scale t0, and a stress scale tau1. These units are the only way to convert ReSCAL results to real lengths, speeds, times, and forces. Getting them right is of critical importance and is the only way that this work can be applied to real snow or compared to field data. Moreover, since the values of tau1 and t0 vary between simulations, getting the tau1/t0 conversions right is the only way that these simulations can be compared to one another.

- The values in Table 1 and Table 2 must have uncertainties, and these uncertainties must be correctly propagated from l0 to tau1 and t0. In my experience with ReSCAL, reasonable values for l0 vary by a factor of 2-3 with snow grain size and density, and values for tau1 and t0 vary more. - The authors' value for l0 is about 50% too high. On p9 line 30, the authors calculate l0 by using a fairly low value for air density (1 kg/mˆ3, equivalent to freezing air at some ~2000m elevation) and the highest possible value for snow density (910 kg/mˆ3, the density of solid ice). This also shows up in the results; the authors have barchan snow dunes that are as much as 1.6 m high, when all the real dunes I've seen or read about are < 1m. - Since the value of l0 is used non-linearly to obtain the value of t0, the values for t0 will also be too high. - Adjusting l0 and t0 will also change all of the sizes/speeds listed in the text of the paper, and (in most cases I checked) will give better results when the authors compare their model to reality.

Correcting these values will allow the authors to get more accurate results, that better resemble reality and can be appropriately compared with field data, without needing to run more simulations or repeat their analysis.

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References On p27 l5 you but cite raw data where I think you mean to cite the relevant published study (doi=10.1029/2018GL077616). If you do wish to cite a dataset you used, then (a) that’s good practice, and (b) please include the full citation with the doi (10.5281/zenodo.1253725) so readers can find it too.

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