The Cryosphere Discussions

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Comment on tc-2021-73

Anonymous Referee #2

Referee comment on "Elements of future snowpack modeling – part 2: A modular and extendable Eulerian–Lagrangian numerical scheme for coupled transport, phase changes and settling processes" by Anna Simson et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-73-RC2, 2021

Simson et al. present rigorous development of a numerical model for coupled heat transport, vapour diffusion and settling in snow. I expected this to be a difficult paper to read, but I was pleasantly surprised by how readable and understandable it was. Because this is presented as a contribution towards snow model development rather than a full snow model, the test cases that can be considered are necessarily limited, but it is still disappointing that the paper contains no comparisons with observations at all.

Specific comments listed by line number:

2

The majority of models use non-deforming layers with ice and water moving between them and enforced conservation of mass.

18

Doesn’t the focus on snow water equivalent suggest that mass is the most important prognostic variable?

23

Bartelt and Lehning (2002) do use a Lagrangian coordinate system that moves with the ice matrix, but “Lagrangian coordinate system that moves with the ice matrix” is not

actually a quote from that paper.

57

Considering this motivation from Domine et al., demonstrating whether modelled vapour transport can produce the sort of density stratification observed in shallow Arctic snowpacks subject to high temperature gradients would be an important test case.

Table 1

c and v are not state variables in the thermodynamic system sense; they can be derived from known temperature, ice volume fraction and vapour density.

Excessive precision for latent heat of sublimation

129

Could note that the settling velocity was neglected in Part 1, equation 7

216

Better to write vapour density with the eq subscript hereafter.

220

Equation 10 differs from the corresponding equation 5 in Part 1. Checking units, the error is actually in Part 1.

Figure 2 caption

The last three sentences don’t really fit in a figure caption.

Table 2 caption

Case 8 is also fully coupled.

Figure 3

Why do the ice volume fraction and temperature axes run right to left?

Figure 4

An additional plot with vertical profiles of density at 0, 16 and 48 hours could be interesting. Compaction from 150 to 420 kg/m3 over 2 days at the base of a 50 cm snowpack seems high if there were to be a comparison with observations (but not as implausible as Figure 10).

Levels on plot (b) appear quantized but the colour bar is not.

Figure 7

Deposition rate would be better shown with a diverging colour scale centred on 0.

Reference to Figure 8 is missing in the text.

470

A layer-based snowpack model could be viewed as having computational nodes in the centres of the layers. Overburden on the top layer being half the layer's weight then makes more sense.

If using Vionnet et al. (2012) as an example, this two-layer, 50 cm snowpack is something that would not arise in Crocus; thin layers are maintained at the top and bottom of the snowpack for heat conduction calculations.

594

a0, a1, a2 and f all have units, which should be given. f is the gas constant for water vapour. This same formula was attributed to Mason (1971) in Part 1.

Minor corrections:

25

"has been well established"

56

“Both require”

57

“uses time steps on the order of 15 minutes or longer”

74

“do not take full advantage”

157

“depends on both the physical regime and computational feasibility”

161

“challenging to determine from experiments”

197

“In the remainder of this paper”

244

“results in the necessary accuracy”

253

“implemented in Python”

254

“but also allows”

305

“avoids numerically approximating”

309

The lengthy parenthetical clause “see for instance Sect. 3.4. in Bartelt and Lehning (2002) or its recent extension Jafari et al. (2020)” would be better inside parentheses than between commas.

317

“allows inferring the most plausible process model … given certain data”

319

“results in a mesh”

530

“without conceptual difficulty”

568

“While including potential phase changes”

598

Part 1 used capital Theta for the Heaviside function.

Appendix C

Matrix elements should be enclosed in brackets.