The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-72

Anonymous Referee #1

Referee comment on "Elements of future snowpack modeling – Part 1: A physical instability arising from the nonlinear coupling of transport and phase changes" by Konstantin Schürholt et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-72-RC1, 2021

Schurholt et al. show that coupled equations for heat transport, vapour diffusion and ice mass conservation in snow permit wave solutions in density. The linear stability analysis is nice work that, together with numerical solutions of the nonlinear equations, demonstrates that these are true mathematical solutions and not numerical artefacts. The setting is limited to be somewhat short of a full snow thermodynamics model, and the question of how mm-scale waves in solutions of the continuous equations relate to a bicontinuous material with mm-scale structure remains open.

Specific comments by line number:

5

Is FEniCS widely enough known to name in an abstract without explanation?

16

No physically based snow model would neglect vapour transport between snow and the atmosphere in its mass balance. What is commonly neglected is internal vapour transport in the snow (which does not directly influence overall mass balance) and vapour exchange with the soil.

107

What value is used for Beta? Calonne et al (2014) describes its measurement as a challenge.

Table 1

Units of vapour pressure are incorrect, and this should be vapour density. Incorrect units for D0. Use scientific notation in place of 2e-5.

172 (and hereafter)

Set vector u in boldface italic.

185

Superscripts n and n+1 should be inside the parentheses on the lhs of equation 9.

219

could note H = 1 m

220

The description in Calonne et al. (2014) is much easier to follow than equation (13): the surface temperature decreases linearly from 273K at t=0 to 263K after 5 hours and then remains constant.

Why is T at z = 1 m only slightly below 270K after 10 hours in Figure 1?

Figure 1 caption

Transient temperature decrease at the boundary, not an increase

Condensation rate would be a more intuitive profile to show in place of “rhs energy eq.”.

229

Hansen and Fosllien (2015) envisaged this as a snowpack containing an ice crust. The solid ice at the base of the snowpack was imposed to prevent vapour entering from below.

244

No comparison is made with tomography experiments, so why choose such a small snow depth?

250

Incorrect units of sigma^2.

252

300K snow in Figure 3 is passed without comment. A full snow model (and, indeed, nature) would not permit this.

255

Advection of the ice crust by sublimation and deposition was already apparent in Scenario

2.

283

Is there a missing ice density in equation 24?

300

Deff *is* linear in ice volume fraction for the Calonne model.

305

The oscillations at the boundary in Figures 3 and 4 are clearly numerical artefacts and are not the ones of interest in the following. They are reminiscent of instabilities in an unstable numerical solution of the linear advection equation and could be controlled (as actually shown in 6.1).

310

What were ne and dt in Figure 4? What is the time in Figure 5? Why are the oscillations on the sublimating side of the crust not apparent in Figures 3 and 4?

Figure 5

Units of dt should be given in the legends.

444

Why is this a “nasty coincidence”?

550

Vapour density is required

553

Error in exponent for a0 value. All of these parameters have units.

Minor corrections:

25

“have been used for a long time”

31

“revisited the problem”

49

Richards equation

61

“design”

179

“implementation in”

346

“PDE system (26)”

383

“density modulation in the layer-transition region”

407

“a stand-alone solver in the open source software”

534

“comes into play”