

Interactive comment on “Impact of water vapor diffusion and latent heat on the effective thermal conductivity of snow” by Kévin Fourteau et al.

Anonymous Referee #2

Received and published: 23 February 2021

The stated purpose of the paper is to provide a simplified analysis of the contribution of latent heat to the thermal energy flux in snow, and notably to quantify to what degree heat conduction can or cannot be decoupled from latent heat and vapor transport. This paper is based on theoretical and numerical modeling. They focused on two limiting cases, considering the kinetics of deposition and sublimation of water vapor to be either very fast or very slow. Their stated aim was to quantify the contribution of latent heat to the effective thermal conductivity.

The theoretical analysis leads in to the numerical calculations, and the results of the calculations generally confirm the work of other authors. The authors show that the fast kinetic hypothesis might be suited to snow during temperature gradient metamorphism, however they admit (line 387) that further work remains to be done before a robust

C1

assessment can be made about heat and mass transport in snow should be made using the slow kinetic hypothesis, the fast kinetic hypothesis or an intermediate case. In this regard, the narrative in the abstract and in the section entitled 'conclusions' do not seem to clearly convey the actual situation.

While this investigation involved a significant amount of detailed work, the results confirm results that other authors have obtained; this manuscript does not add new understanding of the subject. It has long been understood that sublimation and condensation are key issues in vapor transport; the calculations in the paper show that, but there is not definitive new knowledge presented. The results of the calculations show differences between the slow kinetic hypothesis and the fast kinetic hypothesis, but the slow case had been shown in other papers, and the work on the kinetic case is inconclusive. The narrative in their stated conclusions and in the abstract seem to overstate the results.

Specific comments

1. The first sentence in the Abstract erroneously states that “it is generally thought that heat conduction and latent heat transport are independent processes. . .”, however the claim that people think they are independent is clearly not true, because obviously both are driven by temperature and temperature gradient. This sentence needs to be replaced by some factual statement.

In the abstract, the claim made in lines 9-11 are misleading, in particular the abstract omits the finding that further study would be required before robust conclusions about mass and heat transport in snow should be treated by the fast kinetics, slow kinetics, or intermediate hypothesis, as stated later in the paper.

2. Continuing on through the early part of the paper, it is evident that the first sentence in the abstract is a chronic problem continuing in the paper. The authors could instead describe their investigations as an effort to identify under what conditions the effective thermal conductivity is mostly controlled by the ice with interstitial air, and when the

C2

effective thermal conductivity is mostly controlled by latent heat effects – this is a valid thing to do, without making the claim that the two processes are thought to be independent. Especially the stated aim of the paper in lines 36-37 should be re-cast, in order to eliminate the focus on decoupling the processes, and instead focus on a description of evaluating the relative contributions of the two processes. (An analogy would be to dimensionless numbers in fluid mechanics – the objective is to indicate relative strength between two different mechanisms) The narrative and continued emphasis on decoupling tends to lessen the credibility of the paper for those who appreciate physics.

3. In reading carefully through the whole paper, while this investigation involved a significant amount of detailed work, definitive new results with impact are lacking; this manuscript does not add new understanding of the subject. It has long been understood that sublimation and condensation are key issues in vapor transport. The paper does not have any robust conclusions about whether mass and heat transport in snow should be treated by the fast kinetics, slow kinetics, or intermediate hypothesis.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-317>, 2020.