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The Cryosphere Discussions

Interactive comment on "Thermal conductivity of anisotropic snow measured by three independent methods" *by* F. Riche and M. Schneebeli

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We would like to thank the reviewer for her/his comments. Here, we answer the main questions raised by the reviewer.

We agree with the reviewer that an anisotropic artificial material with structural properties close to snow would be ideal. However, such a material could not be found. We therefore focused first on a thorough comparison with isotropic materials, and then extend the study to the anisotropic case.

Concerning the measurements of the anisotropy, we used the theory presented in Grubbe, K. et al. (1983) and Brigaud, F. & Vasseur, G. (1988) for the needle probe. The theory developed there is physically well founded.

For the simulation, if we consider that the simulation computes a correct value of thermal conductivity in one direction (i.e. vertical direction), it will also be able to compute it in another direction (you just need to rotate your sample, and run the simulation again). The anisotropy is then directly calculated from these two computed values. For this reason, we did not make additional experiments to control the anisotropy values of thermal conductivity.

We will modify the sections about latent heat and anisotropy (as also suggested by the other reviewer), in order to clarify the importance of these two effects. We agree that porous media can be isotropic. We will reformulated it in the text.

P1843 Convection could be a source of error in the case of the needle probe, as very high temperature gradients are produced locally. Convection in the heat flux plate setup was prevented by the small thickness of the snow layer and the relatively small temperature gradient. (See thesis E. Greene, The thermophysical and microstructural effects of an artificial ice layer in natural snow under kinetic growth metamorphism, 2007, ISBN: 9780549039419, Chapter 4 (Grashoff number)).

P1846 micro-CT analyzes: we can reformulate it. Actually here, we simply mean every analysis we did, using the micro-computed tomography measurements of the snow samples.

P1846 r-18-19: yes, that is true the thermal conductivity can not be 0 $\mathrm{W\,m^{-1}\,K^{-1}}$. Actually, we should consider the lower boundary condition as the thermal conductivity of air (0.024 $\mathrm{W\,m^{-1}\,K^{-1}}$).

Reference thermal conductivities of material such as granular sea salt or agar gels are known. However, they vary depending for example of the size of the salt grain, the percentage of agar in the agar gel or the temperature. For this reason, we did not want to focus on these values and to speculate why our values are exact or slightly bigger or smaller. The goal of the figure 2 is to compare the thermal conductivity measurements in homogenous and porous materials, carried out with the needle probe and the heat flux plate. We observed that needle probe measurements are too low in non granular porous materials such as the sea ice block. See also: Thomas, H., and J. Ewen (1986), A reappraisal of measurement errors arising from the use of a thermal conductivity probe, Journal of Heat Transfer, 108, 705–707.

P1847 All our experiments were conducted at -20°C, so no melting could take place, even for the needle probes. We checked the temperature of the needle probes, the maximal temperature was -17.2°C.

P1849 The heat flux plate setup can be found in Köchle, B. Thermal conductivity of snow, master thesis. Karl-Franzens Universität Graz, 2009. The thesis is however not available on the internet, and we will add a sketch of the system in the revised paper.

P1850 None of our snow samples was wet, so we did not have to consider phase change. We did not consider Hallet (1993), as we are not close to the melting point (experiments carried out at -20°C) We only considered ice and air phases, as in Calonne et al. (2011).

Comments about style, language or minor issues are considered in the revised manuscript and the detailed point-by-point response will be sent together with the revised manuscript.

Interactive comment on The Cryosphere Discuss., 6, 1839, 2012.