The Cryosphere Discuss., 6, C2120–C2124, 2012
www.the-cryosphere-discuss.net/6/C2120/2012/

The Cryosphere Discussions

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

F. Riche and M. Schneebeli

schneebeli@slf.ch

Received and published: 6 November 2012

We would like to thank the reviewer S. Morin for his detailed and useful comments. Here, we answer the main questions raised by the reviewer. 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.

Concerning the general comments, and the novelty of the manuscript: to our knowledge, it is the first time that the three main methods used to measure effective thermal conductivity in snow are compared with the same snow (i.e. the same microstructure), except from the differences in sampling volume. We believe that this is an essential step to clarify the precision and uncertainties introduced by the different methods and to exclude the effects caused by variable microstructure. This sheds new light on the differences observed between different parameterizations, as discussed e.g. by Sturm et al (1997) and Sturm et al. (2002). In contrast to Calonne et al (2011), our paper directly compares different methods, which is an important step for the future development of field methods. We also show that thermal anisotropy can not be neglected for most snow types. In addition, we show that the traditional use of the needle probe leads to substantial systematic bias except in snow with no thermal anisotropy. As our data set included more snow samples of more developed temperature gradient metamorphism, the fit of our data is significantly different than the one of the dataset of Calonne et al (2011). We note that this is an important consideration comparing different studies, as the microstructure could not be characterized in the detail necessary to discriminate such effects previously.

Concerning the discrepancy in the tables of the supplementary material: the supplementary Table 1 was erroneous on the first and second line (caused by copying), this will be corrected in the revision. However, Table 2 is correct. It is important to notice that the weighted density indicated in Table 1 and 2 could be slightly different from the local density (i.e. within the observed volume) of the micro-computed tomography measurements. This local density is used in Fig. 1 (new Figure). We consider local density, which is an effect of spatial variability, as the reference value for the thermal conductivities derived from computer simulation. The difference between gravimetric density and the local density of the sub volumes measured with the CT is below 15%.

We added a synthesis of the reported results comparing existing similar data. In more detail, we added the data of former studies (Izumi & Huzioka, 1975, Calonne et al., 2011) in Figure 2 (old Fig. 6 in the original manuscript) for the anisotropy of thermal conductivity. For the thermal conductivity itself, a new subsection in “Results” was created where we discuss and compare these different datasets and we added the data of Calonne et al. (2011) to our Figure 1. This figure underlines the importance of the substantial thermal anisotropy in the snow. This new section compares the data of this study with the study by Calonne et al. (2011). It also mentions the importance of thermal anisotropy by trying to parametrize one component of the thermal conductivity (kz) compared to the average effective thermal conductivity. Furthermore, statistical methods were homogenized through the linear regression curve with the root mean square error, and the significance. All figures were modified and are now in color with the corresponding ICSSG colors.

As a last point, concerning the title, we agree with the reviewer that the title was not precise enough. We will change the title of the manuscript to “Thermal conductivity of snow measured by three independent methods with consideration of anisotropy”. We choose not to write “effective” thermal conductivity because it makes the title unnecessarily longer, as all thermal conductivity measured in snow is effective. We clarify this point in the paper.

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

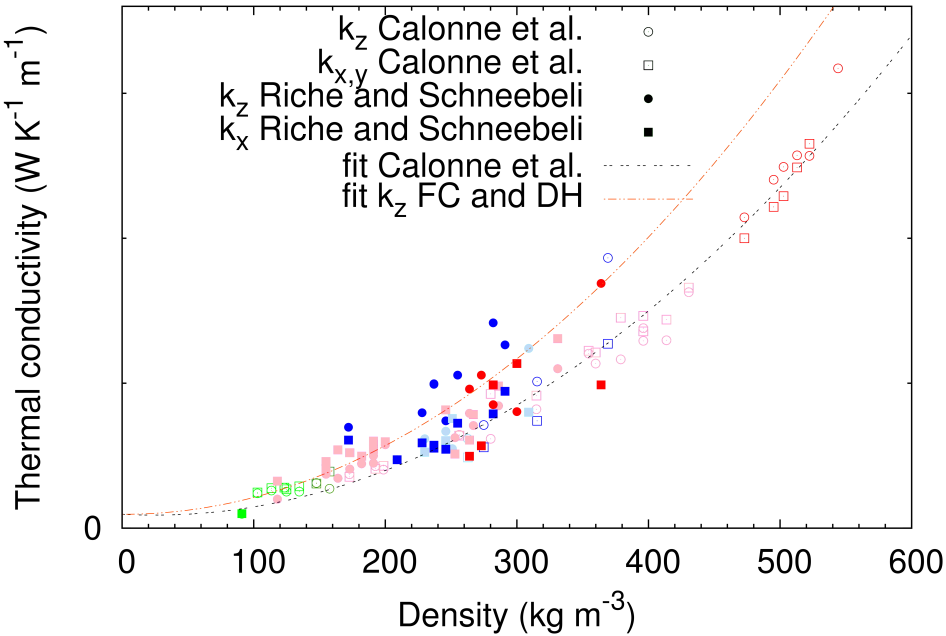

Fig. 1. Thermal conductivity with respect to density. Details see text.

TCD

6, C2120–C2124, 2012

Interactive Comment

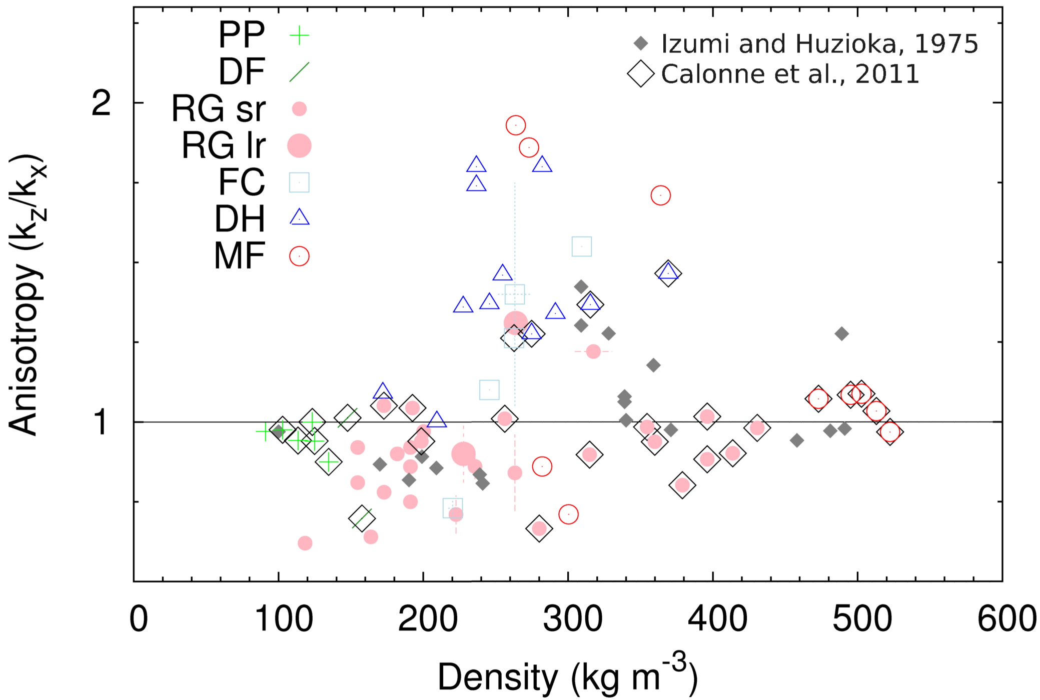

Fig. 2. Anisotropy factor of different snow types a function of density. The anisotropy measured by Izumi and Huzioka (1975) and by Calonne et al. (2011) are also indicated.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper