Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11735, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11735
EGU General Assembly 2008
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Impact of the heat conductivity of snow on permafrost extent

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Despite increasing atmospheric temperatures, ground temperatures in some Arctic areas have not increased. We explore the possibility that this may be due to a climate change-induced increase in the heat conductivity of snow, which would result in a more efficient ground heat loss in the winter. The heat conductivity of snow is determined by metamorphic conditions in the snow, and a crucial variable is the temperature gradient in the snowpack, which will decrease under warmer conditions.

We have performed cold room experiments where similar snow samples were subjected to gradients of 40˚C/m and to isothermal conditions, at several temperatures. Under isothermal conditions, the heat conductivity increased from 0.10 up to 0.18 W/(m.K) after 5 months, while under gradient conditions, it decreased down to 0.06 W/(m.K). This indicates that a decrease in the temperature gradient in the snowpack may lead to an increase in the heat conductivity of snow, enhancing the heat loss of the ground in winter. Calculations using our experimental values show that climate-induced increases in heat conductivity can lower ground temperatures by several K. Global implications are briefly discussed.