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WAVY TEMPERATURE DISTRIBUTIONS IN SNOW (ABSTRACT)

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Introduction: The process of heat transfer in snow is important in such fields of snow science as snow avalanches, thermoinsulation by snow in agriculture, permafrost and global energy exchange between the atmosphere and ground in northern regions. Theoretical and experimental results of investigations in this field have been published by Z. YOSIDA (Contrib. Inst. Low Temp. Sci., 7, 19, 1955), J.C. GIDDINGS and E. LACHAPELLE (J. Geophys. Res., **67**, 2377, 1962), and Y.-Ch. YEN (J. Geophys. Res., **70**, 1821, 1965). The purpose of such works was mostly determination of numerical values of the heat conductivity and water vapor diffusion coefficient in snow, required for any snow related physical calculations. However, published values of these physical quantities vary over a wide range and are sometimes even not in agreement with theory. The purpose of the present experimental work was to understand the mechanism of simultaneous heat and water vapor transfer in snow by systematic measurements of temperature distributions, density and structure change in snow under an applied temperature gradient.

Experimental procedure and results: The experiments on heat and water vapor transfer in snow were done in a cold laboratory of the Institute of Low Temperature Science. The experimental runs were done with naturally compacted snow of density about 350 kg $\cdot$ m^{-3} and screened snow of densities from 200 up to 500 kg $\cdot$ m^{-3}. Heat and water vapor fluxes were built in snow by sudden heating of one end of sample with initially uniform temperature and maintaining a temperature difference between the opposite ends for a prolonged period of time. The length of a sample was 10, 20, 30 or 40 cm. Fine thermocouples were installed to measure temperatures in several points on the central axis of the sample, parallel to the direction of heat transfer. More details of the experimental set-up and results are reported elsewhere (S.A. SOKRATOV and N. MAENO, Snow Engineering: Recent Advances, ed. by M. IZUMI *et al.* Rotterdam, Balkema Publ., 49, 1997). The obtained result could be expressed as a non-linear steady state temperature distribution in snow under temperature gradient, convex toward the warmer ends of snow samples. This result is explained by the simultaneous transport of heat and water vapor.

In some snow samples, especially in the shortest ones (10 cm), there were found some noticeable waves on temperature distribution curves. The measurements showed that the temperature distribution is not always monotonic in the direction of heat flux, but could fluctuate under some conditions. To study this phenomenon in more detail we did several runs of experiments with shorter distances between thermocouples. 30 cm snow samples with density 400 and 500 kg $\cdot$ m^{-3} were used in these experiments, and heat and mass fluxes were built up in the horizontal or vertical (upward warm or downward warm) direction to check the possible effect of convection. These experiments showed that waves were formed in all the experimental runs and the wave length was about 5 cm. The waves appeared during the first 10 min of heating and did not change their positions during the run.

This new finding strongly suggests that the process of heat and mass transfer can not be described by a simple conductive and diffusive mechanism. As waves were formed both in horizontal and vertical snow samples their formation can not be explained by possible convection in snow. Possible reasons for the wave formation could be the temperature increase of ice grains by the latent heat release due to condensation of supersaturated water vapor at the end of any one wave. The alternation of evaporation and condensation zones in the direction of heat transfer could explain the wavy character of temperature distributions. This explanation is in agreement with our obtained wavy density distributions. However, more experiments and careful analyses are necessary to determine the quantitative physical mechanism of wave formation in relation to the applied condition (temperature and temperature gradient) and snow properties (porosity, pore size, structure, etc.).

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