EFFECTIVE MEDIUM APPROXIMATIONS FOR SNOW THERMAL AND AC ELECTRICAL CONDUCTIVITIES

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ABSTRACT

The goal of this research was to develop a physical model to explain how the thermal and AC electrical conductivities of snow are affected by fundamental geometric attributes of its microstructure. There are two criteria by which we judge the attributes. First, we must be able to observe them directly in nature so that conductivity can be predicted in the absence of measurements. Second, they must have physical meaning so that conductivity can be quantitatively linked to natural metamorphic transformations that are know to cause changes in conductivity. Existing models require geometric simplifications that are so dramatic that they are unable to be directly linked to observable characteristics of snow and thus can not be used as predictors or be validated experimentally. Furthermore, these geometric simplifications are too extreme to permit the modeling of changes in thermal conductivity that arise from snow metamorphism.

We introduced an effective medium approximation from random resistance network theory and showed that it can be used to identify precisely the real geometric quantities that determine thermal and AC electrical conductivities and to model changes in conductivity that occur in nature. Theoretical results from this approximation are in general agreement with reported values of thermal conductivity, but none of the reported values are accompanied by the required geometric information, so we carried out a laboratory investigation.

We developed an apparatus to measure the thermal and AC electrical conductivities of snow. We used it to show that the effective medium approximation gives useful predictions of those conductivities. We also observed changes in conductivity with microstructural changes. We have concluded that effective medium theory explains the relationship between snow microstrucure and conductivity. It provides an essential link between observable characteristics of snow and our theoretical understanding of physical processes that occur in this material.