A Network Model for Fluid Transport Through Sea Ice

Megan Morris and Ken Golden
Department of Mathematics

The transport of fluid through porous sea ice is an important process affecting a broad range of problems in polar biology, oceanography and geophysics. The brine microstructure of sea ice, including the size, shape, and connectedness of the inclusions, controls fluid transport. The geometry of the pore microstructure varies significantly with temperature. In collaboration with Professor Jingyi Zhu, we have developed a simple pipe network to model the transport of fluid through the porous microstructure of sea ice. The radii for the two-dimensional model were chosen randomly from distributions of measured cross-sectional areas of brine inclusions in sea ice. For slow fluid flow through the system, the model is equivalent to an electrical resistor network, which is solved using a fast, multigrid method. This method numerically approximates the effective resistance (correspondingly, fluid permeability) of the system, along with the local electric potential (fluid pressure) at each of the nodes. The permeability results from this network model are consistent with rigorous bounds recently found on the vertical fluid permeability of sea ice and with laboratory data.

The successful result from our 2-dimensional network model has encouraged us to continue our work in modeling fluid transport. We are currently working to expand the model to a 3-dimensional case.

Further, we plan to apply the methods developed here to fluid transport in the human body, specifically in the alveoli of the lungs and capillaries of the cardiovascular system.