

Electrical Signature of the Percolation Threshold in Sea Ice

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ABSTRACT: Fluid flow through sea ice governs a broad range of geophysical and biological processes in the polar marine environment. For example, the evolution of melt ponds and sea ice albedo, which is important in climate modeling, is constrained by drainage through the porous brine microstructure. However, for brine volume fractions below about 5%, columnar sea ice is effectively impermeable to fluid flow. In two different experiments conducted in the Arctic and Antarctic, we have found that this critical fluid transition exhibits a strong electrical signature, with sea ice resistivity rising sharply over three orders of magnitude near the brine connectivity threshold. The data are accurately explained by percolation theory, with the same universal critical exponent which captures fluid permeability. These results enable us to connect specific electrical profiles to important processes such as melt pond formation and drainage, CO₂ pumping, and the flux of nutrients which sustain biomass build-up.