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Fluid and electrical transport processes in sea ice

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Fluid flow through sea ice mediates a broad range of geophysical and biological processes, such as biomass build-up sustained by nutrient fluxes, the evolution of melt ponds and summer ice albedo, CO_2 exchanges, snow-ice formation, and the evolution of the salt budget. However, for brine volume fractions below about 5%, columnar sea ice is effectively impermeable to fluid flow, which controls these processes. In two different experiments conducted in the Arctic and Antarctic, we have found that this critical transition in fluid flow exhibits a strong, characteristic electrical signature. Sea ice conductivity data are accurately explained by percolation theory, with the same universal critical exponent of 2 which captures the behavior of the fluid permeability. Our findings lay the foundation for electromagnetic monitoring of transport phenomena in sea ice, which can help track key transitions in the state of polar sea ice and improve projections of its fate and impact on ecosystems. We electrically classify various layers in sea ice in terms of their fluid flow properties, thus connecting specific electrical signatures to important processes such as melt pond drainage, CO_2 pumping, and nutrient fluxes. We will also briefly discuss related work on electromagnetic inversion for connectedness data on the brine inclusions in sea ice, the influence of EPS on brine inclusion statistics and transport properties, and evidence for higher percolation thresholds in granular ice.