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Experimental observations of the transport of brine and dissolved gases in sea ice

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A detailed knowledge of processes in sea ice is necessary to understand how sea ice behaviour both affects and is affected by our changing climate. As the extent of sea ice cover is modified due to anthropogenic climate change, it is important to understand how these variations will themselves contribute to feedback mechanisms in the climate system, particularly when considering the sources, sinks, and transport of CO_2 and other climatically important gases.

So that we can understand the effect that changing sea ice cover will have on the amount of CO_2 in the atmosphere and the oceans, we have to understand how gas transport occurs in sea ice. It is therefore necessary to understand the movement of the brines in which these gases are dissolved.

The mechanisms of sea ice formation have been well described previously, however, the processes and mechanisms of transport of brine and fresher sea water through the ice are not yet completely understood. As ice freezes from sea water, it behaves as a mushy layer in which the salts present are expelled into pockets of increasingly saline brine. These pockets link together at certain critical values of brine volume fraction, temperature, and salinity to form channels by which the dense brine can sink into the underlying sea water, so driving convective transport from the ice layer into the sea.

To analyse the influence of this convection on the transport of gases in ice, we will experimentally characterise convective patterns and instabilities in an ice-liquid two-layer system. We produce a quasi-2D ice-salt water interface within a Hele-Shaw cell by applying a gradient of temperature to a thin layer of saline water, cooling from the upper boundary. As the system cools, a freezing front develops, so forming a 2D model of the mushy layer.

Here we will present the methodology and preliminary results of visualisation of this process using optical imaging techniques. Schlieren and synthetic Schlieren imaging allow gradients of densities to be mapped due to their different refractive indices, and we can therefore potentially observe the downward flow of denser brine and upward movement of fresher water as the freezing front progresses. From these experiments we can provide qualitative observations of the transport mechanisms, and also analyse the onset of convection within these brine channels.