Effects of stratification on the dissolution of a vertical ice-face: effect of Rayleigh number

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Numerical simulation is performed to investigate the effect of ambient stratification on a vertical ice face dissolving into cold and saline water. The three coupled interface equations are used, along with the Boussinesq and non-hydrostatic governing equations of motion and equation of state for seawater, to solve for interface temperature, salinity and melt rate. The main focus is on the rate of dissolving of ice at ambient water temperatures between 0 $^{\circ}C$ and 4 $^{\circ}C$ and salinity around 35 psu and the dependence on stratification (as characterizes many sites around Antarctica). In order to examine the process and scaling we use very strong stratification and vertical scales much less than those in the oceans.

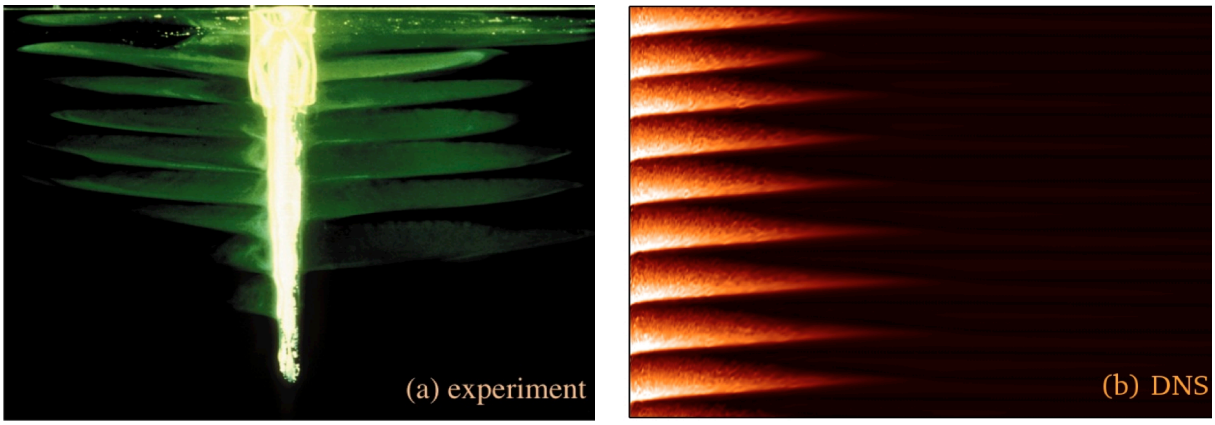

Figure 1: (a) The formation of double-diffusive convective layers in a linear salt gradient against a melting vertical ice block. Fluorescein dye was frozen into the ice block prior to the experiment and follows the melt water, revealing thermohaline intrusions (Huppert & Turner, 1978). (b) 3D DNS solution (salinity anomaly field) for an ice wall in a box 1m height with a linear salinity gradient (buoyancy frequency $N = 0.15$ rad/sec).

The melt water spreads out into the interior in a series of nearly horizontal layers, as seen in previous laboratory experiments (Huppert & Turner, 1978) as shown in figure 1. Our simulation also shows boundary layer next to the ice face is dominated by turbulent motons. The layer thickness depends on the ambient density gradient and the difference of density between the freezing point (interface temperature) and the ambient water temperature. For a small 1m hight box the layers are laminar and results for layer depth are in agreement the experimental results. However, for significantly higher ice walls the layer scaling differs as a result of turbulent mixing. The layers also have a significant effect on the dissolution rate. Many parts of the ocean around Antarctica are stratified mainly by salinity, which can influence the melting rate in complex manner. The temperature and density structures

found under Pine Island Glacier show several layers having a vertical scale that is explained by this study.