

Natural and forced convection turbulent boundary layer along a melting vertical ice face

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This study undertakes an experimental investigation of turbulent natural and forced convection boundary layers adjacent to melting vertical ice faces. Vertical velocity profiles are measured within the melt plume of the ice shelf in a laboratory experimental set-up (c.f., figure 1a) using the molecular tagging velocimetry (MTV) technique for various ambient temperatures and currents for a fixed far-field salinity of 34 g/kg. MTV utilises a thin ultraviolet laser beam to excite the phosphorescence that is captured by a gated intensified camera separated by a short time interval. This method also allows direct estimates of the friction drag as well as the melt rate. This, in turn, is utilised to appraise the three-equation parametrisation that is frequently used in ocean modelling, and we suggest some improvements to the exchange velocity modelling. Furthermore, we find that the usual laboratory modelling of ice shelf melting process as a ‘single’ buoyancy source might not represent the underlying physics, rather this melt boundary layer is influenced by two sources of buoyancy: (i) freshwater buoyancy fluxes from melting and (ii) cooling (negative) buoyancy fluxes due to the low temperature of meltwater compared to ambient water. These sources introduce opposing buoyancy forces that dominate different regions of the boundary layer due to dissimilar diffusivities of each scalar. The opposing buoyancy also seems to result in a reduction of the entrainment coefficient (compared to plumes with a single buoyancy source), which is an important input parameter for melt plume modelling.

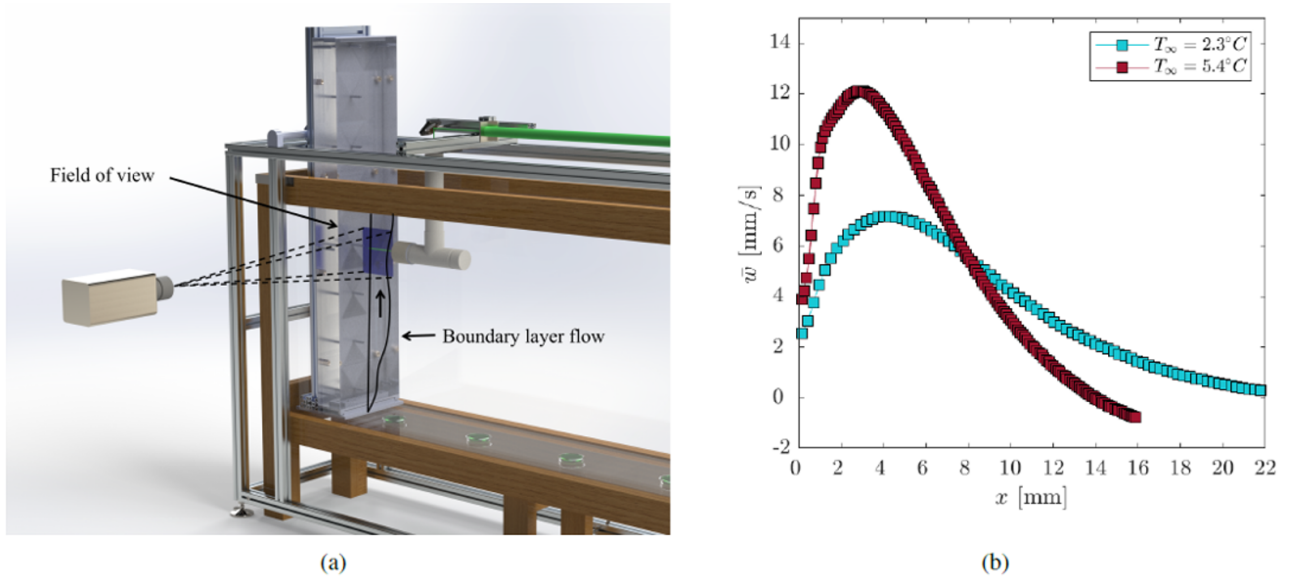


Figure 1. (a) Schematic of the laboratory experimental setup for natural convection. (b) Mean vertical velocity profiles of turbulent natural convection boundary layer for ambient temperatures of 2.3°C and 5.4°C and constant ambient salinity of 34 g/kg.