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Cold Convection - The convection in a freezing lake

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Recent work has demonstrated that seasonally ice-covered lakes are warming at a faster rate, due to climate change, than those that do not. Also, it has become increasingly apparent that ice-covered lakes are dynamically active. Thus, there is a need to understand the dynamics of these lakes throughout the winter months, and the physical processes that control the heat fluxes in the liquid water beneath the ice. Field measurements of these lakes are sparse due to the additional challenges imposed by the cold weather conditions. We propose a set of laboratory studies of a freezing body of water, the analog to a freezing lake. By studying the induced convection in the laboratory setting, we hope to understand how scalar quantities convect in lakes during the winter.

We insulate the side walls of a ~ 0.5 m^3 water tank and place it in a large freezer such that only the top of the water in the tank is exposed to the cold atmosphere. Using a combination of temperature and velocity measurements, we quantify the convection within the tank as the surface water freezes. Temperature profiles within the water are similar to those observed in a natural lake with convection homogenizing the water column while the water temperature remains above the temperature of maximum density, and the formation of a stable reverse temperature stratification as the surface of the water starts to freeze. We analyze the rate of mixing within the water tank and measure the length scales of the convective cells. We compare the laboratory results with numerical simulations and conclude.