Fluids Lab
COESSING 2020
Temperature, Salinity, and Ocean Density!

Motivation

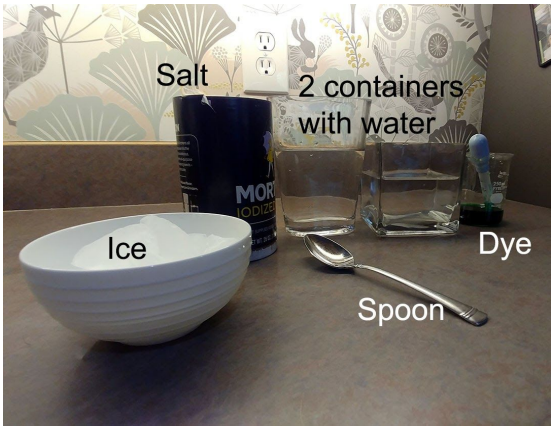
Ocean density depends on temperature *and* salinity. As temperature increases, the density decreases. (Warm water is *less* dense than cold water.) As salinity increases, the density increases. (Salty water is *more* dense than freshwater.) Ocean stratification (the change in density with ocean depth) depends on both the temperature and salinity of the water. When the density stratification is unstable (dense water resides over less dense water), the ocean 'convects' (sinking of dense water) and mixes the ocean. This lab explores the effects of temperature and salinity on ocean density and convection.

Figure 1: Photo of a tabular iceberg from NOAA's photo library (credit: Dr. David Demer)

One source of temperature and salinity changes in the ocean is meltwater from ice: sea ice, icebergs (Fig. 1), glaciers, and ice sheets. In high-latitude regions, meltwater is a major factor influencing stratification and convection. Throughout Earth's geologic history, evidence suggests that the addition of fresh meltwater perturbs the global thermohaline circulation by altering convection in high-latitudes. Convection at high-latitudes is driven by formation of dense surface waters via cooling with the atmosphere and brine rejection during ice freezing. Meltwater creates a barrier to surface dense water formation and can slow deep convection.

Experiment

Supplies: two clear containers, water, salt, food coloring[1], spoon, and ice cubes



1. Partially fill two containers with freshwater room temperature water.
2. In one container, mix roughly 2 spoonfuls of salt for every liter of water. Stir until dissolved. Let the fluid settle.

3. Add a handful of ice cubes to the top of each container. Wait a moment until about half the ice has melted.

[1]If you can't find food coloring try using tea (room temperature) or hibiscus water (bissap flower). Just be sure that the colored water has not been sweetened as sugar affects density too!

5. Now place some dye (either with a dropper or using a spoon) carefully on remaining ice.
6. Observe where the dyed water is going and how its movement varies in the freshwater container compared to the salt water container. Which system is convecting? Try to explain the observed difference based on what you know about how temperature and salinity affect ocean density.

Salt Water Freshwater

<u>Thinking More</u>

Think about the implications of this simple experiment on the real ocean, particularly in polar regions.

- Does meltwater come to rest near the surface or will it sink? (Remember the ocean is salty!)
- Is the resulting solution more or less stable to convection?
- Since convection (sinking of dense water) helps drive the themohaline circulation in the ocean (https://gpm.nasa.gov/education/videos/thermohaline-circulation-great-ocean-conveyor-belt), what do you expect to happen as more meltwater is added to the ocean under a changing climate?

**This activity is based on content from Oregon State University's Fluid Earth class (OAS530).*