Fluids Lab
COESSING 2020
Exploring Ocean Transport

Motivation

Ocean currents (Fig. 1) transport more than just water. Warm waters 'advected' (transported) from low latitudes (e.g., tropics) to high latitudes (polar regions) are a major component of the Earth's energy balance. High-nutrient waters upwelled from the deep feed growth of phytoplankton and productivity, contributing to the global carbon cycle. Currents also carry particulates and pollutants such as debris, oil spills, and plastics. Currents can also connect ecosystems by exchanging larval fish and other species. Marine plastic pollution has received global attention, as we are starting to recognize the scale of the impacts of plastics on all countries and the environment. Marine plastics threaten ocean health, food security (e.g., though harm to fisheries), and coastal tourism. The details of how the ocean transports plastics will depend on the density and size of the plastic. This lab focuses on understanding the advection of small particulates like most plastics in the ocean. When waters meet (or converge), marine plastics accumulate and can sink if their size and density allow for vertical motion.

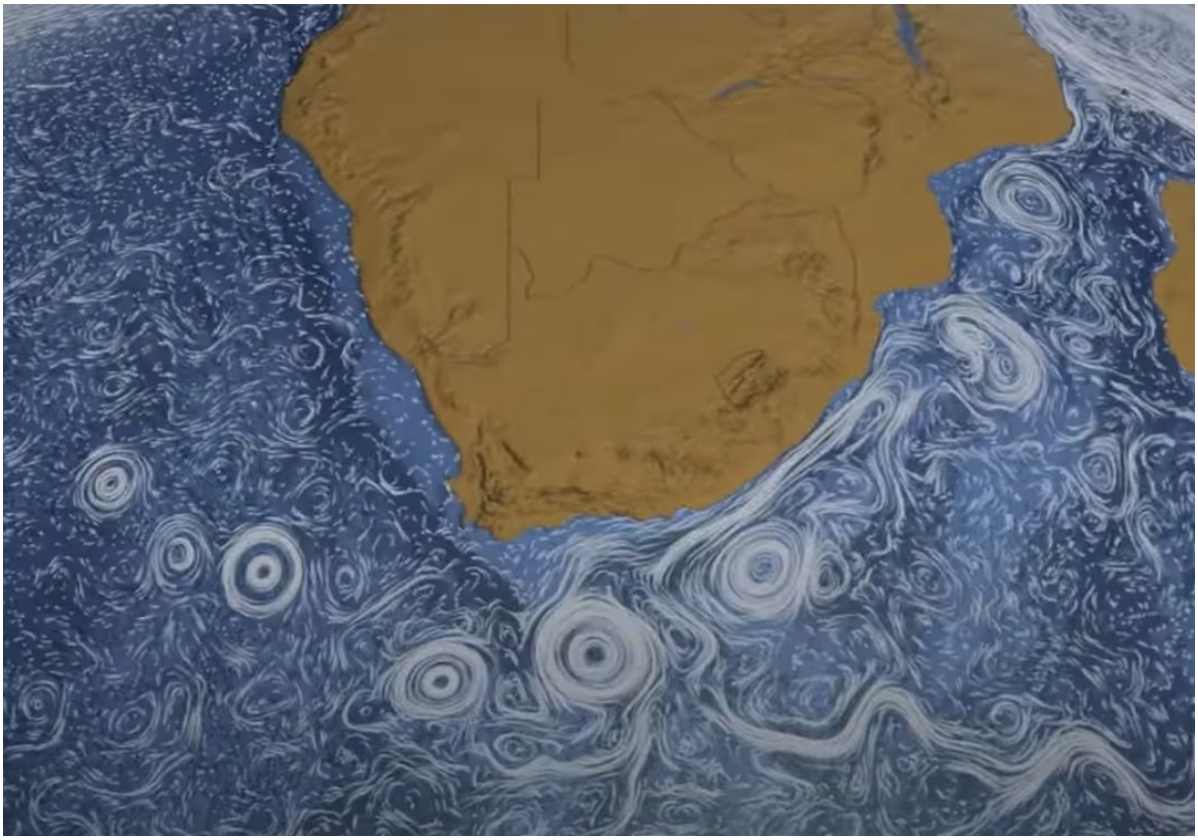

Figure 1: Snapshot visualizing ocean circulation off South Africa
(https://www.nasa.gov/topics/earth/features/perpetual-ocean.html)

Experiment

Supplies: glass cup, water, spoon, and pepper

1. Partially fill a glass with water. Once the water comes to rest, sprinkle pepper at the top. Where in the glass (top, bottom, interior) does the pepper settle?
2. Take the spoon and stir the glass in a circular motion for a few seconds. Examine the motion of the pepper in the glass. What happened to the location of the pepper?

Summary: When we stir the fluid, water and pepper near the surface move to the edges where the water and pepper sink. At the bottom of the cup, water and pepper accumulate ('converge') at the center. Here, water "upwells" back to the surface (although the now immersed pepper stays at the bottom of the cup due to its higher density). At the end of the experiment, you should see a neat pile of pepper at the bottom-center of the cup.

Before Stirring

After Stirring

Thinking More

Consider the image to the right showing debris from the 2011 Japanese tsunami (Photo courtesy of the U.S. Navy Pacific Fleet from NOAA's 2011 Fisheries Year in Review). *Why is the debris accumulating at the surface?* You will need to think about the surface currents and the density of the debris.

Ocean currents that converge at the surface lead to an accumulation of floating debris. These areas are also associated with downwelling into the ocean interior. Depending on the density and size of the debris, these regions can also transport pollutants deeper into the ocean. In the subtropics, large-scale wind patterns lead to broad regions of surface current convergence where floating marine plastics tend to accumulate.

**Many of these activities were inspired by Mirjam Glesser's Kitchen Oceanography projects found at https://mirjamglessmer.com/kitchen-oceanography/.*