Ocean Eddies

Overview

Students will observe and analyze satellite images to identify ocean eddies.

Concepts

- An *eddy* is a loop of *current* that is cut off from the main current, or a small, spinning current. They are comparatively small, short-lived *circulation patterns* in the ocean.
- Eddies are ocean features that can be easily seen from space by *infrared sensors*.
- There are *warm-core eddies* and *cold-core eddies*. Warm-core eddies trap and transport a variety of different kinds of animals within them. Cold-core eddies carry greater *biomass*, but less diversity of species. Cold-core eddies trap nutrient-rich water and transport both nutrients and plankton.

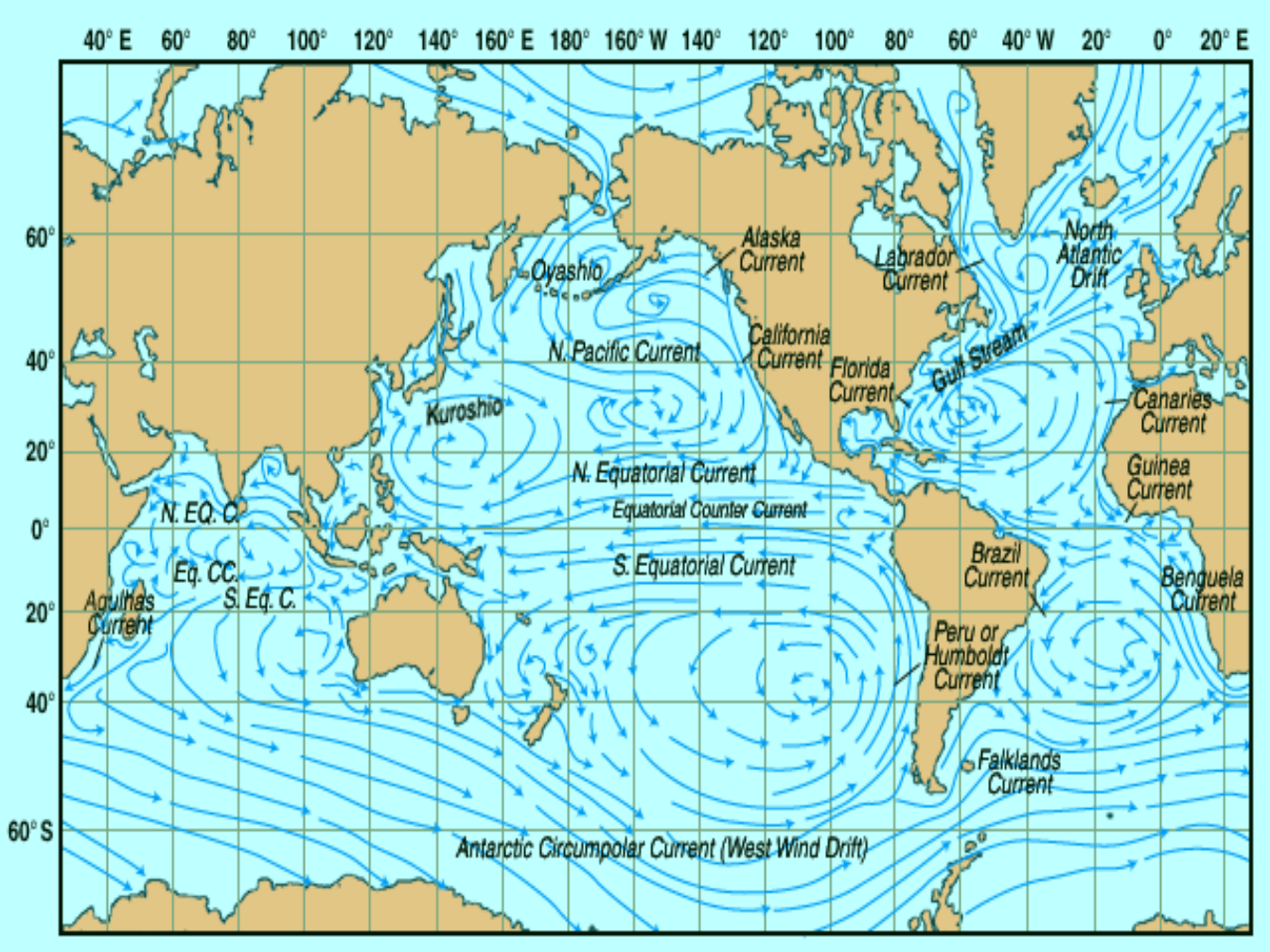


Figure 1: Global map of *geostrophic* currents. Note the Gulf Stream in the Atlantic Ocean east of the U.S. flowing northeastward.

Materials

- Color or black-and-white prints of Figure 2, one for each group of students.

Preparation

Ideally, students should study the color version of Figure 2, either on screen, or preferably via color prints. If they use the screen version they can write their findings, as called for in the activity, on black and white prints of Figure 2. Note that Figure 1 can be used to promote a general discussion of ocean currents.

Procedure

Engagement

Eddies are comparatively small, short-lived circulation patterns in the ocean, like weather patterns in the atmosphere. They can easily be seen and tracked from space by infrared and other sensors. They often split off from strong currents such as the Gulf Stream. Look at the world current map [Fig.1] and find the *Gulf Stream*.

Activity

1. Look at the thermal infrared satellite image [Fig. 2] and identify the Gulf Stream on the image. Locate several circular features in or near the Gulf Stream. These are eddies.
2. Use the temperature scale [Table 1] to determine the relative temperature difference between the centers of various eddies and the surrounding water. Label the image with different temperatures. Where is the water warmer and where is it colder? Which eddies have colder cores and which have warmer cores?
3. Use the model shown in Movie to determine whether each eddy is turning clockwise (CW) or counterclockwise (CCW) and label them. Use the satellite image [Fig. 2] and the global map current [Fig. 1] to try to predict where the eddies drifted during the weeks and months after the image was taken.
4. Warm-core eddies trap and transport a variety of different kinds of animals within them; cold-core eddies carry greater biomass (more organisms) but less diversity of species than their warm-core counterparts. Discuss how these eddies might move nutrients and *phytoplankton*, and occasionally large animals--such as fish, sea turtles, and Portuguese Man-O-War jellyfish--into different parts of the Atlantic.

Explanation

Ocean eddies can move at speeds of about 0.5 *knots* (about 0.9 kilometers or 0.6 miles per hour) and may occasionally persist for many months. Eddies can be over 300 km (about 200 mi) in diameter. Such large eddies can be seen easily from space by thermal infrared sensors.

Figure 2 shows the Gulf Stream and many eddies. The Gulf Stream separates two distinct water masses. The northwest water mass, or nearshore water, is colder and more fertile than the water that is to the southeast of the Gulf Stream (called the Sargasso Sea). The nearshore water has a temperature of less than 10°C (50°F), while the temperature of the Sargasso Sea ranges from 15°C to 25°C (59°F to 77°F). To form an eddy, water is “kidnapped” from one side or the other of the Gulf Stream. In general, whether an eddy is cold-core or warm-core depends on which side of the Gulf Steam the water came from [Movie].

A cold-core eddy is a ring of Gulf Stream water that flows counterclockwise around a cold, less salty mass of water. It is formed when a branch of the Gulf Stream meanders and captures a piece of colder

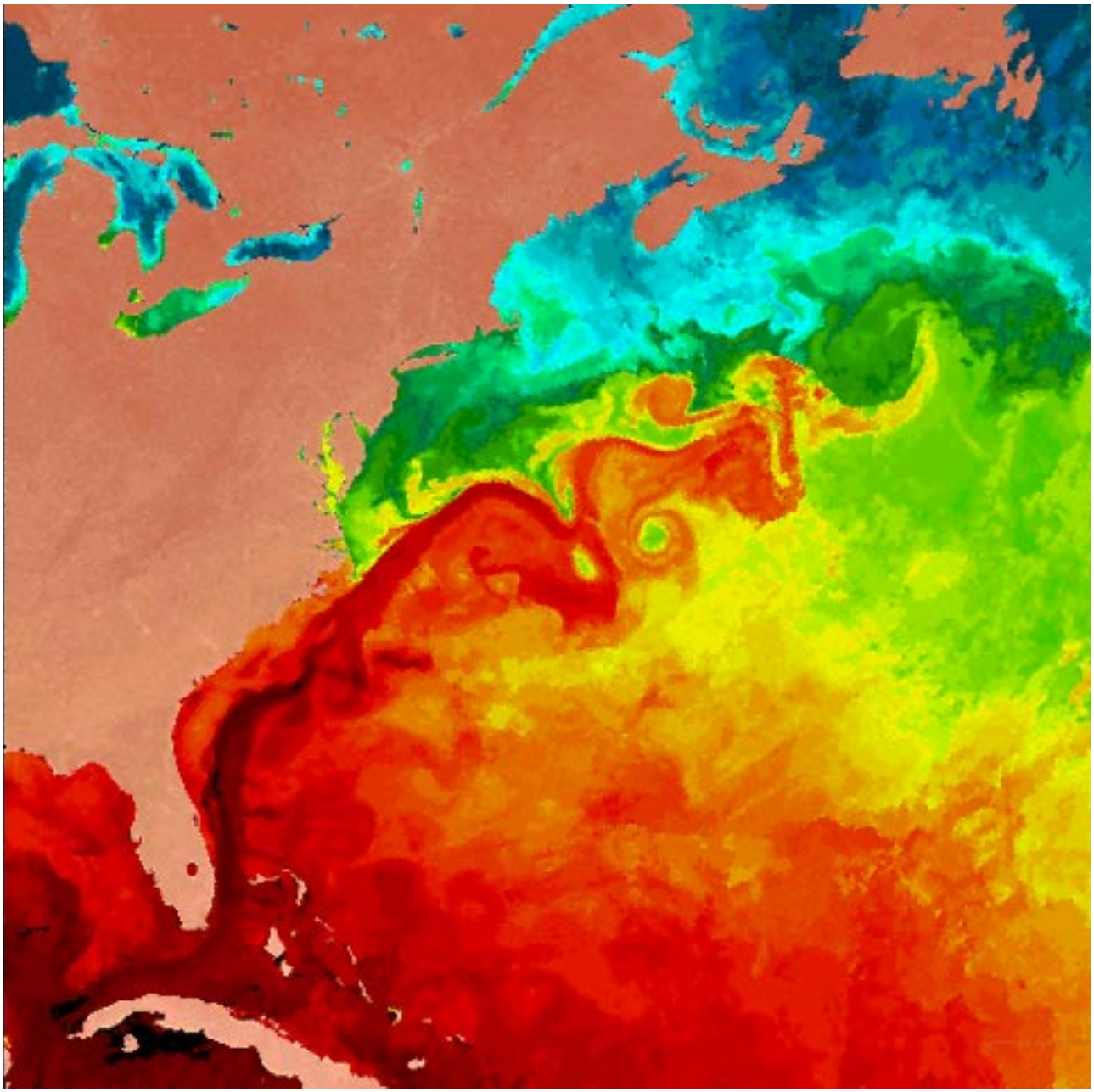
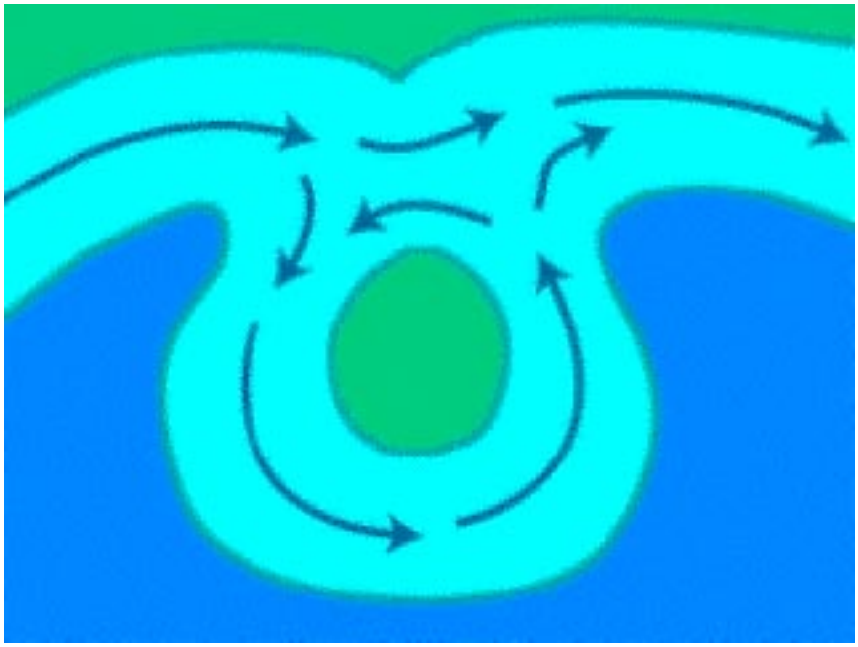


Figure 2: Thermal infrared image of the Gulf Stream. Colors are false colors representing various sea surface temperatures (Table 1).

Table 1: False colors and temperatures for Figure 2.

Color	Temperature (Celsius)
Reds and Oranges	24° to 28°
Yellows and Greens	17° to 23°
Light Blues	10° to 16°
Dark Blues	2° to 9°



Movie. **Spinning eddies**. The equivalent of atmospheric storms, ocean eddies are spun off from currents. In this model, the Gulf Stream separates cooler water in the north from warmer water in the south. The Gulf Stream develops a loop that traps cold water in. This can completely separate to form a cold-core eddy.

water from the northwest. A cold ring can be tracked for months before it dissipates into the water east of the Gulf Stream. A warm-core eddy forms when the edge of the Gulf Stream moves into the colder water and separates into a warm-core, clockwise flow. This eddy drifts towards the coast and usually is dissipated within a few months as it collides with the shallow continental shelf.

A cold ring traps the nutrient-rich water from north of the Gulf Stream and transports both nutrients and plankton into the relatively barren Sargasso Sea. There are fewer *phytoplankton*--the microscopic plant life at the bottom of the food chain--in the Gulf Stream and the Sargasso Sea than in the colder waters off the coast of the northeast United States and Canada.

EXTENSION

In the atmosphere, "weather" consists of the random eddies in the air flow. These atmospheric eddies are called "highs" and "lows." The world's oceans have their own weather, consisting of random eddies, usually spun off of ocean currents. Eddies may be thought of as a type of oceanic weather. They play an important role in ocean circulation, Earth's climate, and biogeochemical systems.

Eddies can affect human pursuits, such as offshore oil drilling operations. Also, some marine mammals and large fish like to feed near the edges of cold-core eddies. The TOPEX/Poseidon satellite is able to locate eddies and the average sea-surface height changes they cause in the Gulf of Mexico and elsewhere.

To learn more about eddies' motion over time, access the Gulf of Mexico Near-Real-Time Altimeter Data home page on the World Wide Web (http://www-ccar.colorado.edu/~realtime/gom-real-time_vel). At this site you can choose any "analysis date" after April 26, 1996 and create sea surface height maps with arrows that show how currents and eddies were flowing at that time. First, choose a month, day, and year from the "pull down" menu. Then click on "SEND VALUES" at the bottom of the page. (Hit "OK" if you get a warning message). After a minute or two, a small picture of the TOPEX/Poseidon satellite should appear. Click on it and you will get a color-coded image of the Gulf of Mexico sea surface height and currents. (An example is found as Figure 4.)

Use your knowledge about eddies to predict where oil drilling operations may be hampered by warm-core, clockwise-spinning eddies that **raise sea level** above average. Also try to predict where marine mammals and fish might he found at the edges of cold-core, counterclockwise -spinning eddies that **drop sea level** below average. Try to locate the Loop Current which is north of Cuba, as well. Do you think the Loop Current is connected to the Gulf Stream?

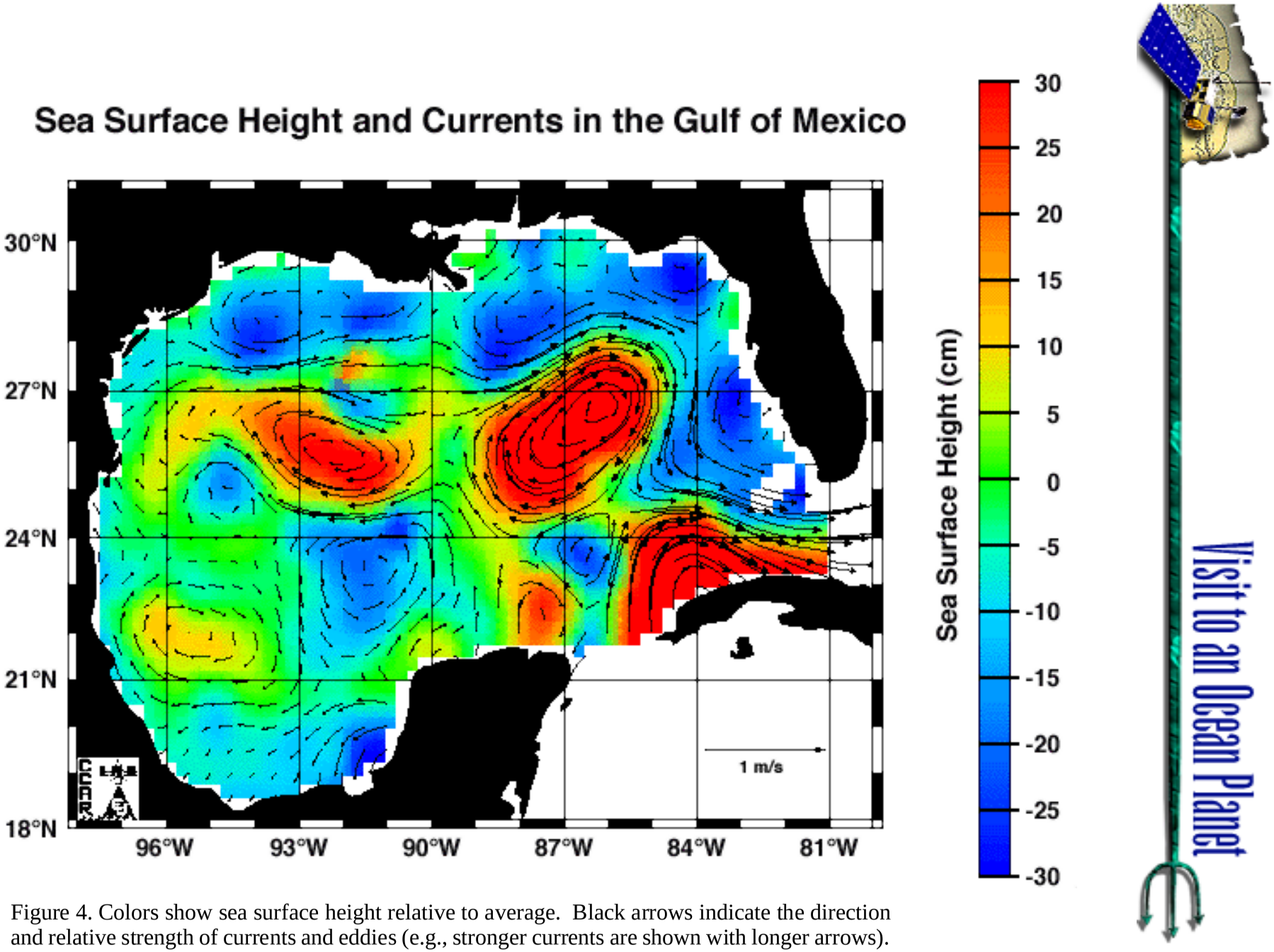


Figure 4. Colors show sea surface height relative to average. Black arrows indicate the direction and relative strength of currents and eddies (e.g., stronger currents are shown with longer arrows).

VOCABULARY

anomaly	*biomass*	*cold-core eddy*
current	*eddy*	*geostrophic*
Gulf Stream	*infrared sensor*	*knot*
ocean circulation pattern	*phytoplankton*	*warm-core eddy*

SOURCE

Adapted from Gulf of Maine Aquarium “Find Eddy” at http://octopus.gma.org/space1/eddy.html.