Teacher Guide: Coastal Winds and Clouds

Learning Objectives

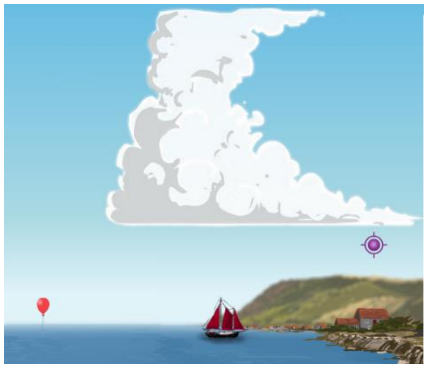
Students will …

- Observe wind patterns and temperature variations in a coastal region.
- Explain why sea breezes and land breezes occur.
- Use a weather probe to observe convection currents.
- Explain the origin of clouds and thunderstorms in a coastal region.

Vocabulary

condensation, convection, convection current, land breeze, sea breeze

Lesson Overview



If you have ever gone for a walk near the ocean, you may have noticed a refreshing breeze blowing in from the water. This is a *sea breeze*, a common occurrence in warm coastal regions. Late at night, the circulation of air is reversed, resulting in a *land breeze* blowing out to sea. Sea breezes, land breezes, and related weather phenomena can be explored in the *Coastal Winds and Clouds* Gizmo.

The Student Exploration sheet contains two activities:

- Activity A – Students observe temperature variations in marine air and inland air. Students can then make a connection between temperature and wind.
- Activity B – Students document temperature patterns and convection currents during the day and at night.

Suggested Lesson Sequence

1. **Pre-Gizmo activities** (variable)
   To demonstrate the fact that hot air rises, light a large candle. Hold a pinwheel about six inches above the candle. As the hot air rises, the pinwheel will begin to spin. Discuss why hot air is less dense than cold air, and ask students to name other examples of hot materials rising while cool materials sink.

   If your school is located near the ocean, ask students to walk near the shore on a warm afternoon to observe the ocean breeze.

2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:

   - Why doesn't marine air change temperature as much as inland air over the course of 24 hours? [The ocean doesn't change its temperature as much as the land because water has an enormous specific heat capacity.]
   - What must be true for a sea breeze to occur? What must be true for a land breeze to occur?
   - Why does warm air tend to rise? [Warm air is less dense than cold air.]
   - How are hot air balloons related to sea and land breezes?
   - How does convection relate to the formation of clouds?
   - Would you expect to experience sea breezes during the winter? Why or why not? [Sea breezes are not very common in the winter because the marine air is warmer than inland air most of the time.]

5. **Follow-up activity: Coastal and inland climates** (45 – 60 minutes)
Divide students into groups of two and ask each group to choose a pair of cities. Each pair should include a coastal city and an inland city that is at approximately the same latitude and elevation as the coastal city. Using the Internet, students can look up the average high July temperature and the average low January temperature for each city. See the **Selected Web Resources** on the next page for helpful websites.

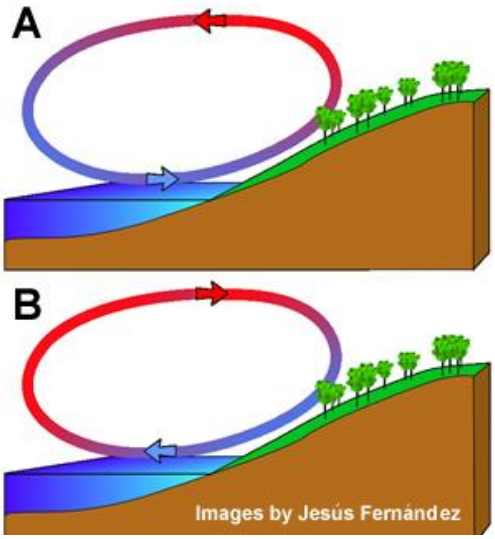
   For example, here is data for the coastal city of San Francisco and Sacramento, located about 100 miles inland:

City	Average July high temp.	Average January low temp.
San Francisco	71 °F	41 °F
Sacramento	94 °F	37 °F

   In this case, the moderating effects of the ocean on San Francisco's climate are easy to see. Other suggested pairs include Boston and Amherst, MA; Virginia Beach and Richmond, VA; Los Angeles and Palm Springs, CA; and Seattle and Spokane, WA.

Scientific Background
All of the phenomena illustrated in the *Coastal Winds and Clouds* Gizmo are ultimately caused by *convection*. Air consists of billions of molecules of nitrogen, oxygen, and other gases that are in constant random motion. If a region of air is heated, the average speed of molecules will increase. This will cause the region of heated air to expand and become less dense. The heated air tends to rise as cooler, denser air flows into the space. A *convection current* is a circular flow that results when a fluid is heated, rises up, cools, and then sinks back to its starting point.

The *specific heat* of an object is the amount of energy required to increase its temperature. The ocean has a higher specific heat than land, and therefore it heats up and cools down much more slowly than the land. During the day, the land will warm up more quickly than the ocean, and the air over the land will be warmer. The air over the land will tend to rise up, and air from the ocean will rush in to fill the space. The result is a convection current shown in figure A, and a sea breeze will be felt by people standing near the coast.



At night, the land will cool down more quickly than the ocean, and the air over the ocean will be warmer than the air over the land. As a result, the air over the ocean rises and a land breeze is felt at the surface. The resulting convection current is shown in figure B.

When warm air rises rapidly, it also cools down. The cooling of moist air results in *condensation* and cloud formation. As the *Coastal Winds and Clouds* Gizmo shows, the largest clouds form when the circulation of air in the convection current is most rapid. This occurs around 3:00 P.M. for the sea breeze and around 6:00 A.M. for the land breeze.

Environmental Connection: Wind power

One of the most promising sources of clean energy is wind power, generated from turbines placed in windy areas. Current wind farm development has focused on three areas:

- Ridgelines and mountainous areas are windy because air accelerates as it goes over a topographic high.
- Offshore areas are windy because the ocean offers very little resistance to moving air.
- Nearshore areas are windy due to the differential heating and cooling of land and sea, resulting in reliable sea breezes and land breezes.

The main problems with wind power are cost, noise pollution, and aesthetics. Large wind farms may be considered noisy or unsightly and opposed by local residents. Wind turbines also are expensive to build and install, although once they start running they cost little to maintain. Currently the world's leader in wind power is Denmark, which generates about 20% of its electricity via wind. Most of Denmark's wind farms lie in nearshore or offshore regions.

Selected Web Resources

Average temperature data: http://countrystudies.us/united-states/weather/
Land and sea breezes: https://climate.ncsu.edu/edu/k12/breezes, http://www.bom.gov.au/nsw/amfs/Sea-Breeze.shtml
Offshore wind: http://www.ewea.org/policy-issues/offshore/, http://www.windpoweroffshore.com/
Wind power in Denmark: http://en.wikipedia.org/wiki/Wind_power_in_Denmark

Related Gizmos:
Hurricane Motion: http://www.explorelearning.com/gizmo/id?427
Weather Maps: http://www.explorelearning.com/gizmo/id?430