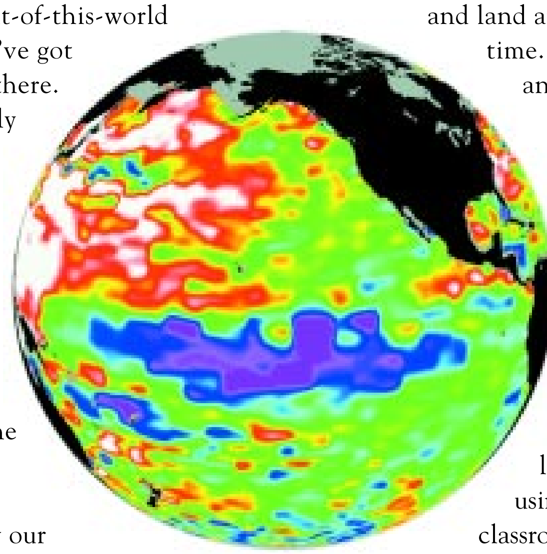
Eyes in the Sky: The BIG PICTURE

by Lisa Renadette Young and Kristen M. Kusek

Wouldn't it be neat to wow your Earth science students with a field trip to outer space? They could see how dynamic air, land, and water systems interact to make the planet we call home. Some day it may be possible to embark on a literally out-of-this-world field trip; until then we've got the Internet to take us there.



The Internet certainly has made our world a much smaller place. Thanks to the many satellite images that are available free-of-charge from NASA and other government agencies, you can present students with the "big picture" of global systems that affect our environment, especially our oceans.

Scientists mount high-tech sensors on satellites to gather information about the Earth. (See Figure 1 for a list of satellites.) Two significant advantages to using satellites for ocean research are repeatability and coverage. A satellite sensor can regularly repeat its daily measurements; scientists use this information to assemble time series data and answer questions about weather patterns, productivity cycles, pollution, and climate change. Like a child's growth chart, time series data help us see patterns, make predictions, and develop long-term plans.

Satellites also help us measure large ocean and land areas over short periods of time. Some satellites can cover an entire ocean in less than an hour or the entire globe in just one day! In contrast, we could send out thousands of ships at once and many days later would have only sampled a tiny portion of the oceans.

Boost your students' learning experience by using satellite imagery in the classroom. In the activity starting on page 24, students assume the roles of research scientists. They work in groups and analyze satellite imagery to investigate the effects of El Niño, algal blooms, and other large-scale phenomena related to the oceans. Their mission is to get the big picture and share their findings with their classroom community through presentations featuring satellite imagery.

ONLINE EXTENSION

For more ideas about using distance imaging in your classroom, NSTA members can log on to www.nsta.org/pubs/scope.

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The mission

Each team of researchers will investigate the oceans using satellite imagery. Students will access satellite images provided on the Making Waves website (waves.marine.usf.edu): click on the "Oceans from Space" link; then click on "Science Scope article." This activity is designed to take about one week of class time. Prior to the activity, you may want to review the electromagnetic spectrum with your students. Also, check out the Making Waves website for lots of facts on remote sensing.

Internet resources

- University of South Florida's Remote Sensing Laboratory website: paria.marine.usf.edu
- The Tech Museum of Innovation's Satellite Site: www.thetech.org/hyper/satellite
- National Climatic Data Center's Get/View Online Satellite Data website: www.ncdc.noaa.gov/ol/satellite/satellitedata.html
- NASA's Observatorium: observe.ivv.nasa.gov/nasa/earth/earth_index.html
- NASA Goddard Space Flight Center's Photo and Movie Gallery website: pao.gsfc.nasa.gov/gsfc/gallery/index.html

Acknowledgement

The authors would like to thank Nancy Doolitte for her contribution to this article. Nancy is a former math and science middle school teacher and is the curriculum designer and webmaster for the University of South Florida (USF) Making Waves outreach

FIGURE 1 **Satellites**

Ocean Topography Experiment (TOPEX)/Poseidon

The TOPEX/Poseidon satellite was launched in August 1992 with a deceptively simple mission: to map ocean topography. The radar altimeter aboard the TOPEX/Poseidon satellite measures sea surface height with an accuracy of 5 cm or better. That's pretty amazing for an instrument that orbits 1,330 km above the Earth.

Advanced Very High Resolution Radiometer (AVHRR)

The AVHRR sensor is deployed on the National Oceanic and Atmospheric Administration's (NOAA) polar-orbiting satellite. It is used primarily for studies involving temperature measurements such as ice and snow studies, sea-surface temperature, forest fires, and hurricanes.

Coastal Zone Color Scanner (CZCS) and Sea-Viewing Wide Field Sensor (SeaWiFS)

Pure ocean water looks deep blue. Throw in a few million phytoplankton and the water starts to look a lot greener (like all plants, phytoplankton absorb blue and red light, but reflect green). Other materials in the water can change its color as well: dead plant material gives water a yellow-brown cast, and suspended sediments scatter light in complex ways. SeaWiFS and CZCS are both referred to as "Ocean Color" sensors. They can detect minute differences in ocean color. They are far more sensitive than the human eye. SeaWiFS, launched in 1997, is a follow-up to CZCS, which collected data from 1978 to 1986. Using ocean color data, we can determine the concentration of phytoplankton and other materials in the ocean. This helps us to better understand things like pollution and the ocean's primary productivity. Phytoplankton blooms can easily be detected and tracked using this satellite.

Synthetic Aperture Radar (SAR)

SAR is basically a radio antenna in space that emits very rapid pulses of energy. This allows SAR to collect as much information as an antenna of much larger size. Because SAR emits its own source of EM radiation, it is considered an "active" remote sensor. As mentioned in the section on oil spills, SAR can "see" through clouds and can collect data day or night. These features make SAR useful for monitoring glaciers and sea ice, ocean waves, coastal erosion, and disasters such as fires, floods, volcanic eruptions, and oil spills.

Landsat

Landsat is actually a series of satellites starting with the first Landsat in 1972 to Landsat 7 launched in August of 1999. As the name implies, Landsat was originally designed for terrestrial uses. However, oceanographers have found its array of visible and infrared channels useful in coastal and sea-ice studies.

ILLUSTRATION COURTESY OF NASA'S JET PROPULSION LABORATORY

Eyes in the Sky

Materials

- computers with Internet access
- folder for each group
- colored pencils or crayons, scissors, paper, overhead transparencies, overhead pens, and other presentation materials such as poster board on which to paste/tack printouts of satellite images or student drawings
- oversized monitor for classroom presentations (optional)

Procedure

Day one: Introduction to project

- Your teacher will assign you to a group of 4–5.
- Each group will investigate one of the following areas of oceanographic research via remote sensing: El Niño; harmful algal blooms; storms and sea level rise; natural disasters and oil spills; or coral reefs. Each group should have a different topic. You will draw these topics randomly out of a hat.
- Read the background information and questions for your topic, which begin on the next page. You are responsible for your topic only.
- Create a group project folder to hold all the materials related to this activity. You may decorate your folder to represent your topic. Include this sheet, any notes you take, and pages you print off the Internet.
- Within your group, assign each person a role and discuss your group plan.

Day two: On the Web

Spend this class time conducting research on the Internet. The Making Waves website (*waves.marine.usf.edu*) will be your primary source of satellite images; however, you are encouraged to search other sites for additional information on your topic (see Internet resources).

Day three: Wrap up and discussion

Finish your research during the first half of class. During the second half of class, your teacher will describe the parts of a presentation (i.e., introduction, body, and review/Q&A). Your teacher will discuss what a quality presentation entails and may even demonstrate a "good presentation" for you.

Day four: Assembly

Assemble your presentation. Prepare visual materials; be sure all your topic questions are answered; decide what each group member will present. Be sure you include the following in your presentation:

1. basic background information on your assigned topic;
2. answers to topic questions;
3. appropriate satellite imagery and other visual materials to support your conclusions; and
4. information on which areas of oceanography—geological, biological, physical, and chemical—relate to your topic.

Day five: Presentations

Present your research findings to the class. Presentations should last 5–10 minutes. Your classmates and your teacher will use the rubric on the next page to assess your presentation.

Assessment rubric

Rate each group's presentation in each of the following areas on a scale of 1–10 (10 being the highest).

Amount of time:	1 2 3 4 5 6 7 8 9 10
Visuals used:	1 2 3 4 5 6 7 8 9 10
Topic well defined:	1 2 3 4 5 6 7 8 9 10
Presentation matches topic:	1 2 3 4 5 6 7 8 9 10
All group members presented materials:	1 2 3 4 5 6 7 8 9 10
Group folder created:	1 2 3 4 5 6 7 8 9 10

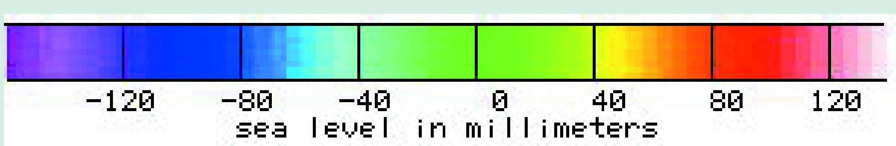
Topic questions

Find your topic below, read the brief introduction, and answer the questions that follow. The first two or three questions relate directly to the satellite images provided or suggested; the social science question is meant to stimulate thinking, questioning, and creativity. Use the Making Waves website and any other useful websites to help you find your answers. You will address these questions in your final presentation. **Except when noted, all the images you need to answer the questions can be found on the Making Waves website (*waves.marine.usf.edu*).**

El NiÒo

In the past few years, El Niño has become a popular news topic and has been implicated in everything from floods in the western United States to mild winters in the northeast. Five satellite images that show sea surface height can be used to understand the natural climatic phenomenon known as El Niño, which is basically an interannual warming of the eastern tropical Pacific Ocean. The images you will use are from the 1997–1998 El Niño.

When viewing these images, you need to understand that the height of the sea surface corresponds in part to the temperature of the water: warmer water is "higher" while colder, denser water is "lower." See the temperature scale below in which purple is the coldest and red is the warmest.



During El Niño, warmer water sloshes across the equator from the western Pacific Ocean and moves toward the Americas by east-blowing winds. Study the five images to gain an understanding of how El Niño develops, and answer the following questions:

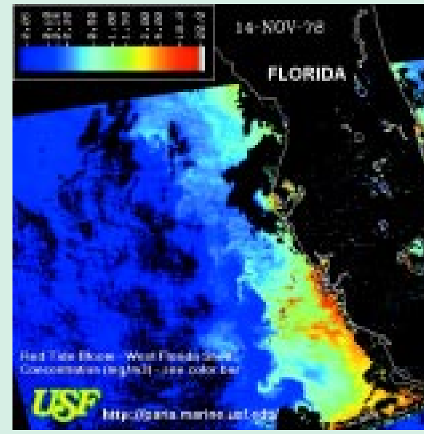
1. What can you infer from the images about the relationship between sea level height and El Niño?
2. What can you infer from the images about the relationship between temperature and El Niño?
3. *Social science:* What effect does El Niño have on the fisheries in Peru?

Harmful algal blooms

Algal blooms are natural phenomena that occur when a host of factors including sunlight, nutrients, and water temperature encourage the growth of one species of phytoplankton (tiny ocean plants) over others. Algal blooms are considered harmful if they produce toxins that adversely affect sea life or humans. For example, *Gymnodinium breve,* a common bloom species along the west coast of Florida, produces a neurotoxin that can contaminate shellfish and make beachgoers cough. Blooms also create areas of anoxia (oxygen depletion), which can lead to massive fish kills. Impacts on public health, local ecology, and tourism underscore the need to study and monitor harmful algal blooms. Algal blooms are tough to monitor directly from the water, but satellites can help. Satellites that measure ocean color, such as the Sea-

Eyes in the Sky (continued)

Viewing Wide Field Sensor (SeaWiFS) and CZCS (the predecessor of SeaWiFS), are ideal. The 1978 image of a *G. breve* bloom off the southwest coast of Florida is one of the first ever obtained by CZCS. The red, orange, and yellow areas indicate high phytoplankton concentration. Study this image and answer the following questions:



1. Which Florida cities likely experienced the most severe effects of the 1978 red tide bloom? How can you tell from the image?
2. Blooms typically start 10–40 miles offshore and are moved inshore by the action of currents, winds, and tides. The Florida Loop Current runs south along the west coast of Florida. Can you predict what an earlier image of the 1978 bloom looked like? (For example, where may it have originated?)
3. *Social science:* What negative effects do you think harmful algal blooms have on the economy of Florida?

Storms and sea level rise

Satellite sensors are lifesavers when it comes to hurricanes. Sensors help us determine the strength and speed of a hurricane. More importantly, they help us make predictions about its path so people who live in the projected storm track can evacuate to a safe location if necessary.

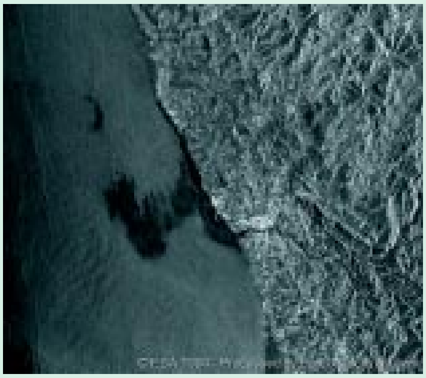
In August 1992, Hurricane Andrew ripped through the Bahamas, Florida, and Louisiana. It was one of the most destructive hurricanes in United States history and the most expensive on record. Damages in the United States exceeded $25 billion. Considering the destructive force of Andrew, the direct loss of life was remarkably low: three died in the Bahamas and 23 died in the United States. The combination of preparations and evacuations minimized the death toll.

In 1954, before Doppler Radar and satellite storm tracking systems, a hurricane similar in intensity to Andrew hit the United States with far more deadly results. Hurricane Hazel made landfall at Myrtle Beach, South Carolina and caught residents off guard. By the time Hazel fizzled out in Canada, it had killed approximately 350 people. So remember, the images of hurricanes you see on the evening news are more than pretty pictures; they can be lifesavers. Answer the following questions using the information provided:

1. Observe the image of Hurricane Andrew. Next, go to *rsd.gsfc.nasa.gov/rsd/images/HugoPersp.html* and examine the image of Hurricane Hugo. Compare the size of Hurricane Andrew to that of Hurricane Hugo, which hit in 1989.
2. Go to *paria.marine.usf.edu* and click on the "AVHRR Images" link. What is the current temperature of the water in the ocean area over which Hurricane Andrew formed?
3. What factors are favorable for the formation of a hurricane? Go to *www.goes.noaa.gov* and click on the East CONUS Infrared (IR) image. According to this image, what does an IR image of the tropical Atlantic look like today? Explain why you would or would not expect a hurricane to form in the Atlantic today.
4. *Social science:* About 80 percent of all people live in coastal communities. If you were a developer, would you build condominiums along the waterfront? Why or why not?

Natural disasters and oil spills

Oil spills might be considered more of an “unnatural” disaster, but their impact on the environment is real nevertheless. Surprisingly, major spill events make up just a small percentage of oil pollution overall, but they can be devastating. Satellite imagery is often indispensable in the case of major ocean oil spills such as tanker accidents; we use it to measure the extent of a spill and predict its movement.



Check out the Synthetic Aperture Radar (SAR) image, which shows an oil spill along the coast of Portugal. The image was taken two days after the Panamanian oil tanker, *Cercal,* hit a rock and spilled about 1,000 tons of crude oil into the Oporto harbor. The oil quickly spread offshore. The city of Oporto is shown as a cluster of white dots on the coast. The oil appears darker because oil is slick and scatters back less light than the rough sea surface. Other radar sensors can also detect oil slicks, but in this case, the SAR instrument was ideal because it operates well in the rainy, foggy weather that characterized the day of the oil spill. Its radar waves pass through clouds uninterrupted, unlike visible or infrared waves.

Answer the following questions about natural disasters and oil spills:

1. What information would you need to be able to predict where an oil spill would move?
2. Go to the Making Waves website (*waves.marine.usf.edu*) and view the three images that show Mount St. Helens (Washington) before and after the eruption in 1980.

- What is the total area shown in the first image?
- How much forest was left after the eruption?
- What percentage of the forest was lost as a result of the eruption?

3. *Social science:* Compare the losses you think would occur from an oil spill to the losses from a volcanic eruption in terms of animal populations, local economy, and land area.

Coral reefs

Coral reefs are typically found in clear, shallow water. Often they can be viewed from space with sensors that use visible and near infrared wavelengths. These satellites help us map reefs, monitor changes in sea-bottom habitats, and look for signs of disease or trauma in the reef community.

Scientists first used satellite remote sensing in 1975 to study the Great Barrier Reef. However, use of this technology has taken off only recently, especially in the study of reefs located far offshore, which are difficult to visit.

The Carysfort Reef is located in the Florida Keys Marine National Sanctuary. Observe the two Landsat images taken from this reef in 1984 and 1999. Using these photos answer the following questions:

1. Compare the two Landsat images. What spatial difference do you notice between the 1984 image and the 1999 image?
2. Besides disease (black-band disease and white plague disease) and a lack of coral recruitment to sustain coral growth, this reef has declined largely because algae is “beating out” the coral for substrate on which to attach. There are a lot of algae because the spiny sea urchin, which eats algae, has died off. Explain the difference in algae cover between the 1984 and 1999 images. Given your understanding of the ecological relationship between the spiny urchin and the algae, what would happen on land if there were no wolves around to prey on the deer in Montana?
3. *Social science:* Why is it important to save coral reefs? Do you think divers should always be able to visit any coral reefs they want?