National Aeronautics and Space Administration
Goddard Space Flight Center

Moderate Resolution Imaging Spectroradiometer (MODIS)

Monitoring Sea Surface Temperature, Chlorophyll Concentration and Photosynthetic Activity

What can Scientists learn by Remote Sensing the Channel Islands from Space?

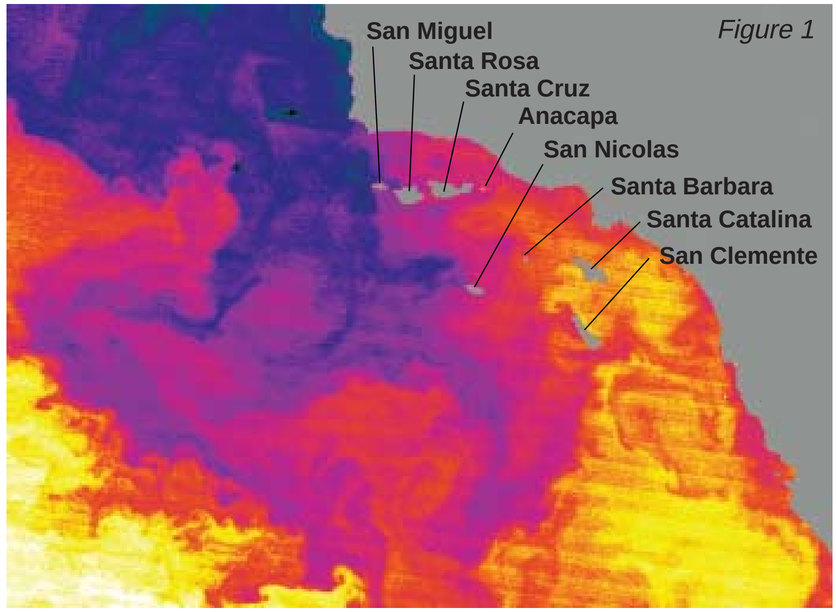

Figure 1

What is the general sea surface temperature around each of the Channel Islands?

Low — Moderate — High

10 — 12.5 — 15 — 16.5

Sea Surface Temperature (degrees C)

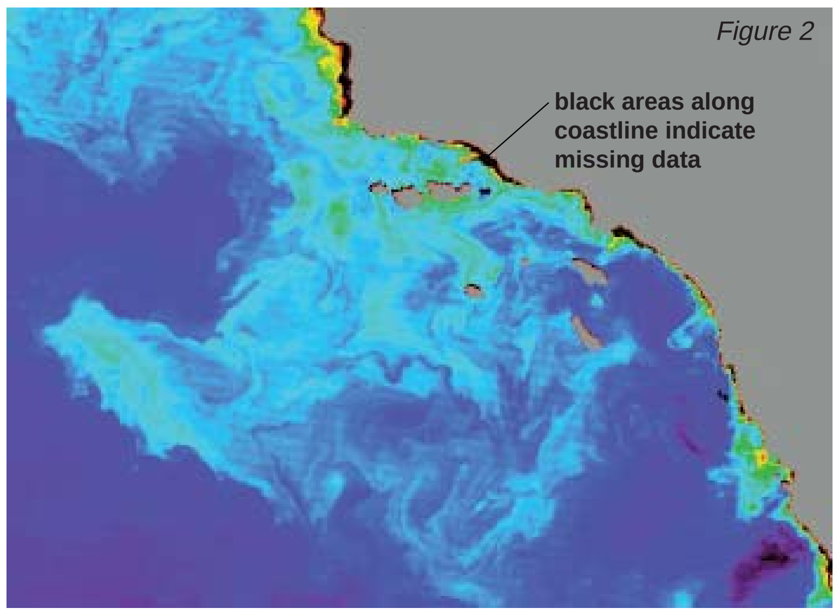

Figure 2

Where is the chlorophyll concentration lowest? Highest?

Low — Moderate — High

0.0 — 0.5 — 1.0 — 1.5

MODIS Chlorophyll (mg/cm^3)

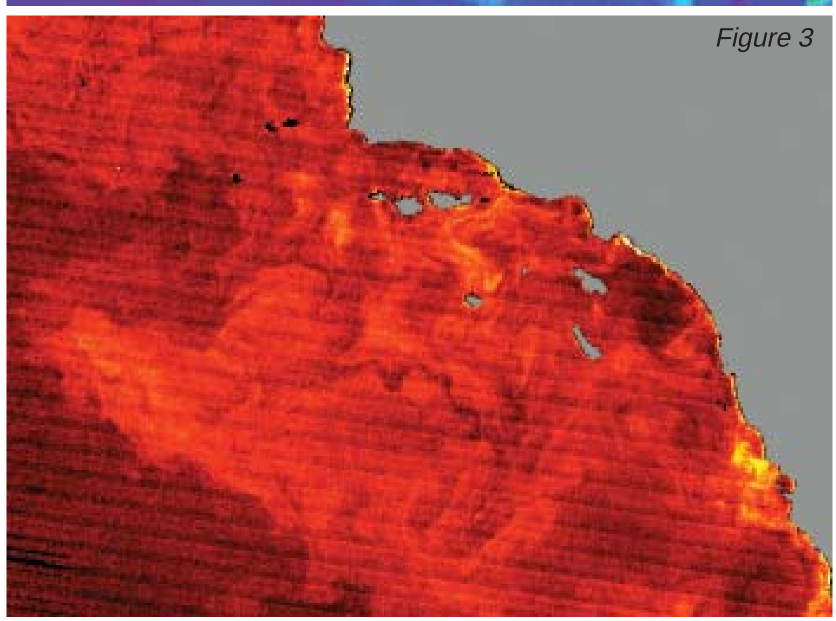
Figure 3

Which areas show higher fluorescence indicating low photosynthetic activity?

Low — Moderate — High

0.0 — 0.01 — 0.02 — 0.03 — 0.04 — 0.05

MODIS Chlorophyll Line Height ($W/m^2/\mu m/sr$)

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About These Images

A new sensor orbiting the Earth aboard NASA's Terra and Aqua satellites is now collecting the most detailed measurements ever made of the ocean's surface environment. Like a sophisticated thermometer in space, the Moderate Resolution Imaging Spectroradiometer (MODIS) can measure sea surface temperature every day over the entire globe. The sensor also allows scientists to produce global, daily maps of the location and abundance of microscopic marine plants (phytoplankton) near the ocean surface. Ultimately, MODIS is helping Earth scientists advance studies of how our world's oceans and atmosphere interact in ways that drive weather patterns and, over the long term, define our climate and impact life.

MODIS is sensitive to five different wavelengths, or "channels," for measuring sea surface temperature. Both night and day, the sensor measures the thermal infrared energy (basically heat) escaping the top of the atmosphere at each of these five wavelengths. These data allow scientists to measure the surface temperature of the ocean accurate to within a quarter of a degree Celsius (0.25°C). Scientists can then produce false-color maps showing even small variations in the ocean's temperature all over the globe (See Figure 1). These maps are particularly helpful in monitoring large-scale temperature changes, such as during an El Niño.

There is often a direct relationship between sea surface temperature and biological activity in the ocean. False-color images from satellite sensors can help us to see and better understand this relationship. By precisely measuring ocean color, scientists can determine where concentrations of phytoplankton are floating in the sea's surface layers as well as how much of the organism (in milligrams per cubic meter) is present in a given bloom. Like land-based plants, phytoplankton contain the pigment chlorophyll—used for photosynthesis—that gives them their greenish color. Chlorophyll preferentially absorbs red and blue wavelengths of light and reflects green light. From outer space, MODIS can distinguish even slight variations in color that our eyes cannot detect. The ocean over regions with high concentrations of phytoplankton will appear as blue-green or green, depending upon the type and density of the phytoplankton population there. This allows scientists to produce false-color maps showing where there are high and low concentrations of chlorophyll (See Figure 2).

Thanks to advances in technology, MODIS provides scientists with improved measurement capabilities over previous satellite sensors. For instance, MODIS can better measure the concentration of chlorophyll associated with a given phytoplankton bloom. Also, for the first time from a space-based sensor, MODIS can measure fluorescent light emitted by phytoplankton. Fluorescence measurements provide scientists the ability to gauge the health of a given bloom. During photosynthesis, phytoplankton absorb sunlight. But when they are under stress, phytoplankton no longer photosynthesize and begin to emit absorbed sunlight as both heat and fluorescent light. So, in summary, MODIS' fluorescence measurements allow scientists to quantify photosynthetic activity within the ocean. Scientists can produce false-color maps showing where they observe fluorescent light being emitted from the ocean (See Figure 3), which they can visually compare to maps of chlorophyll and sea surface temperature, or other variables, to look for patterns of change.

This series of MODIS false-color images was produced using data acquired on January 24, 2002, over the California Channel Islands in the Pacific Ocean.

For the Classroom - A Check Up for Plants

Grade Level: 5-8

Materials (for Class demonstration or per group of students)

- Fresh Cut Spinach Leaf/Green Leaf or Green Plant
- UV Light (Recommend Pet Store Iguana UV Light Bulb)
- Darkened Room

It is difficult for human eyes to detect plant stress until visible signs of physical damage appear, such as a change in color, spots, holes, or the deterioration of leaves. Once these signs appear, intervention is often too late. An early warning sign that a plant is under stress is "fluorescence," whereby instead of taking in sunlight to engage in **photosynthesis**, the process by which plants take in sunlight, water, carbon-dioxide and nutrients to make food, the plant instead emits light energy in the form of heat and fluorescence. The following experiment will allow students to observe plant fluorescence:

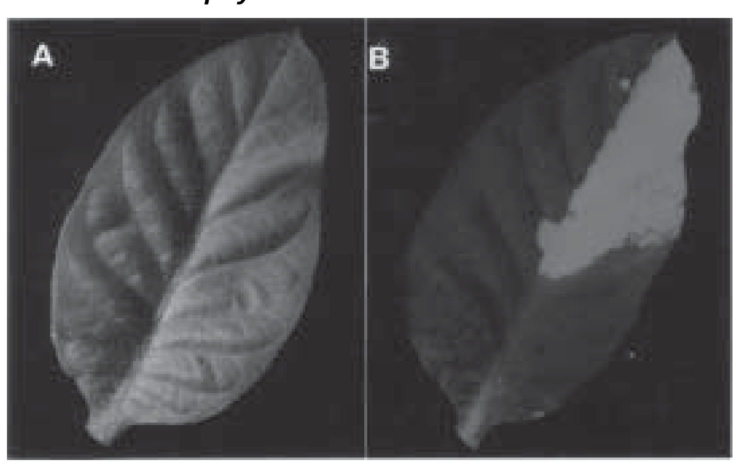
Procedure

1. Use a fresh cut spinach leaf or excise a green leaf from a healthy green plant. (Note that the leaflgilbert@pop200.gsfc.nasa.gov will still be photosynthetically active for a while.)
2. Illuminate the plant or leaf using a black UV Light in a darkened environment.
3. Observe the red fluorescence of the plant or leaf as it is first hit with a jolt of light containing too many electrons for the plant or leaf to absorb all at once. The electrons not transferred by the plant or leaf are emitted as fluorescence or heat.

Question: What factors could cause plants to be under stress?

Improved models of phytoplankton productivity are essential for scientists to understand how much atmospheric carbon dioxide (CO_2) can be absorbed by ocean plants. Additional activities can be found at: **http://earthobservatory.nasa.gov/Laboratory/ICE/**

Induced Chlorophyll Fluorescence - Tobacco Leaf



(Krause and Weis, 1988)