Remote Sensing

This activity is adapted from NASA Observatorium's Teachers' Guides "Earth – The Ever-Changing Planet" http://observe.arc.nasa.gov/nasa/education.teach_guide/earth.html and NASA Goddard Space Flight Center's "Imagers: The Adventure of Echo the Bat – Numbers to Pictures: How Satellite Images are Created" http://imagers.gsfc.nasa.gov
The Numbers to Pictures activity is part of a larger remote sensing curriculum. One activity is a computer interactive where students can track 'Echo's' migration through Arizona.

Introduction:

This activity will cover some basic color theory about primary colors, and additive versus subtractive color mixing and gives club members a chance to apply this knowledge in the field. Either of the 2 parts of this activity could be skipped for time or weather constraints. The 'color-by-number' activity mimics how satellite data comes in and is processed by computers. Satellites are equipped with sensors that each has 8 bits of memory, which means that there are 256 (0-255) different values that can be sensed by each sensor. With 3 sensors that can each distinguish 256 possible shades, there are 16.7 million colors that can be sensed using 3 x 8 or 24-bit color. Sea surface temperature is sensed with one 8-bit sensor so that there are 256 gradations of temperature that can be sensed. Usually the sensors are calibrated so that the temperature range is from 0.0˚C to 25.5°C. This covers most of the temperature variability in the ocean. Sensors can be calibrated differently to get the temperature range that the researchers think is most appropriate.

Materials:
(Materials in bold are provided by SMILE)
Flashlights (3 per group of 4)
Red, blue, and green theatrical gels
Tape
White paper
Multi-colored pipe cleaners
Color-by-number activity

Background:
Satellites

Satellites have sensors on them that measure the amount of electromagnetic energy reflected off the earth (or another planet) at specific wavelengths. Some of these sensors send out an electromagnetic wave and measure the returning wave that reflects off of the earth – these are called active sensors like the ones that measure altimetry. Other sensors are passive sensors and simply measure the radiation coming off the earth without sending out their own signal. Most optical satellite sensors are passive sensors.

Like on a digital camera, satellites have different sensors for different sections of the electromagnetic spectrum. A temperature sensor detects electromagnetic rays in the mid infrared zone: 3-8 μm (μm = micrometers = 0.000001m = 1 x 10^{-6}). A chlorophyll-a sensor detects a narrow band of green light that is given off by chlorophyll-a 667 nm (a type of chlorophyll produced by many marine algae). These properties are displayed in visible colors for ease of interpreting, but are not truly visible features. For satellite images in the visible range of the spectrum (400-700 nm, nm is a nanometer or 0.000000001m = 1 x10^{-9}) satellites use three cameras, a blue, a red, and a green, to capture the range of visible light. Satellites like the Landsat take images in this range. You can find Landsat images of your community at this website: http://www.bsrsi.msu.edu/.

In a 3 channel digital image (digital cameras and satellites take images like this) each pixel has 3 numbers associated with it: 0 – 255 in the red channel, 0 – 255 in the blue channel and 0 – 255 in the green channel. When the data from these three cameras are combined 16.7 million color combinations are created and can be distinguished. A pixel is the smallest complete sample of a digital image and is an abbreviation for **pi**cture **el**ement. An image from a digital camera creates a matrix of pixels each with its own intensity value. A matrix of pixels can also be called a *bitmap*.

Color Theory

Color theory is the study of how different wavelengths of light combine to make different colors. Different colored light is just electromagnetic energy traveling at different speeds with different wavelengths. When dealing with light color mixing is additive, which means that the beams of colored light add together to make white light. When working with additive color there are three primary colors **red, blue, and green**. All other colors (wavelengths) can be made using varying amounts of red, blue, and green light.

Subtractive color works in the opposite way and applies to solid objects. For example – a red shirt contains pigments that absorb all wavelengths of light EXCEPT the red light, which reflects back and makes the shirt appear red. Subtractive colors are used in painting and the primary subtractive colors are the familiar **red, blue, and yellow**. With the subtractive color process mixing equal amounts of the 3 primaries creates black.

Procedure:

The color-by-number exercise is first.

1. Split club members into groups of 4 and give each group 3 flashlights, tape, and a red, blue, and a green theatrical gel, and a piece of white paper.

2. Have club members tape gels over the face of each flashlight making sure that no white light leaks out.

3. Club members can take turns working the flashlights and recording the color combinations.

4. You can also practice color mixing on a NASA website: http://imagers.gsfc.nasa.gov/color/ this site has a cool program on color mixing. This is also on a CD so you can install the program onto computers at school if you want.

5. Darken the room as much as you can so that it is dark, but so that people can still see in the room.

6. Have club members shine all three flashlights on the piece of white paper so that the colors overlap. The recorder should note what colors are created in the overlapping areas. If they are not getting white light in the middle, make sure that each flashlight holder is holding it an equal distance away from the piece of white paper. Have no light = 0, full light = 9 and 5 = ~ ½ the amount of light. Brainstorm in teams ways to vary the intensity of light coming from the flashlights.

After leaving some time for investigation, have teams fill in the color chart

Color Created	Red	Green	Blue
Yellow	9	9	0
Magenta	9	0	9
Cyan (turquoise)	0	9	9
White	9	9	9
Black	0	0	0

Have teams hypothesize the number of different colors they can make using their flashlights. Let groups experiment with color mixing.

Numbers-to-colors:

Have teams use their flashlights to determine the colors in the digital image on the back of their color-mixing sheet. Either do this activity during club time or give it out as an extension of the activity.

<u>Sensing in the Field</u>

Before beginning this activity (pick a sunny day if possible) section off an area on your school grounds, preferably a grassy area. Scatter a known number of the red, blue, and green pipe cleaners around in the area. Make sure you do this before any of the club members see the area.

In this part of the activity group club members into 3 groups – one for each of the primary colors – red, green, and blue.

Distribute gels, pipe cleaners, and tape to each team so that each person can make a pair of glasses – one pair per person, with each group getting one color.

Here’s the set-up for the game: (make sure that the club members put their colored glasses on before seeing the area with the pipe cleaners)
Safety Note: While these glasses filter out some of the sun’s rays, they are not real sunglasses and people should be careful when they have them on – DO NOT LOOK DIRECTLY AT THE SUN.

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The rules:
Each group will pretend that they are one sensor on a satellite and that they will see the environment as a satellite sensor would.
Groups will search for pipe cleaners with their glasses on, only picking up pipe cleaners they can see with the glasses on.
Pick up all the pipe cleaners you can see.
After the time is up (10 minutes or until all the pipe cleaners have been found) have people take off the glasses and compare what colors of pipe cleaners each group has found.
Discuss why the different groups could only see some of the pipe cleaners. Could they find them all if all 3 groups worked together?