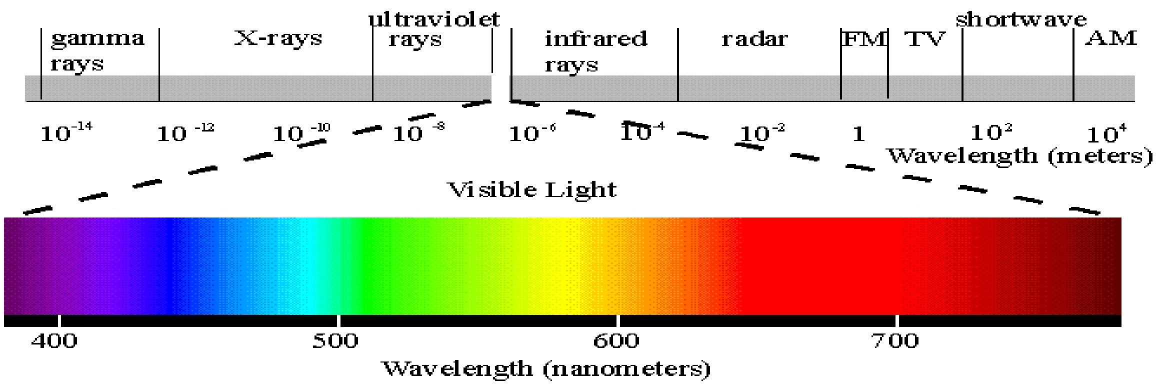
The SMILE Program
January Teachers' Workshop, 2005

A Quick Review of Remote Sensing

In Mapping Your School we talked about satellite remote sensing. Now that we are able to look at actual data from a satellite we need to learn more about how they work so we can understand what they show us.

The satellite sensors in our case are AVHRR (Advanced Very High Resolution Radiometer) which provided our Sea Surface Temperature, and SeaWiFS Sea-viewing Wide Field-of-View Sensor (SeaWiFS) which provided our chlorophyll data. These sensors collect brightness values in the electromagnetic spectrum both in side and outside the visible spectrum in what are called "bands". In the electromagnetic spectrum visible light is between 700 nanometers (abbreviated nm) to approximately 400 nm.

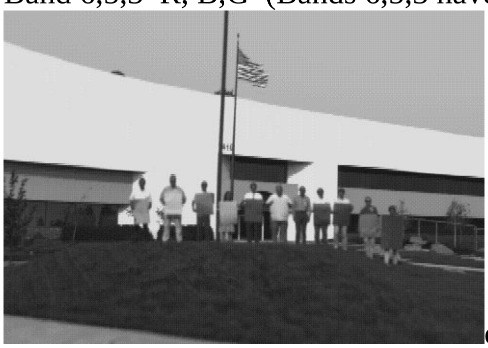


The electromagnetic spectrum with the visible light section enlarged to show visible light.

Although humans are not able to see outside of the visible spectrum scientists and engineers have been able to construct sensors that are able to detect wavelengths of light we are not able to see with the human eye. It is also possible to build a sensor that detects many different ranges of light (called bands) such as 200-300 nm, or 300-400 nm. Plants are very good reflectors of near infrared light which is in the 1000nm range. Sensors can then be designed to have a band that collects brightness values on and around the 1000nm range. An image made from this band will be a good way to assess vegetation on a global scale.

Example images of Bands collected by the SeaWiFS Sensor

Band 6,5,3 R, B,G (Bands 6,5,3 have been combined to make a true color image)



ch1

ch2

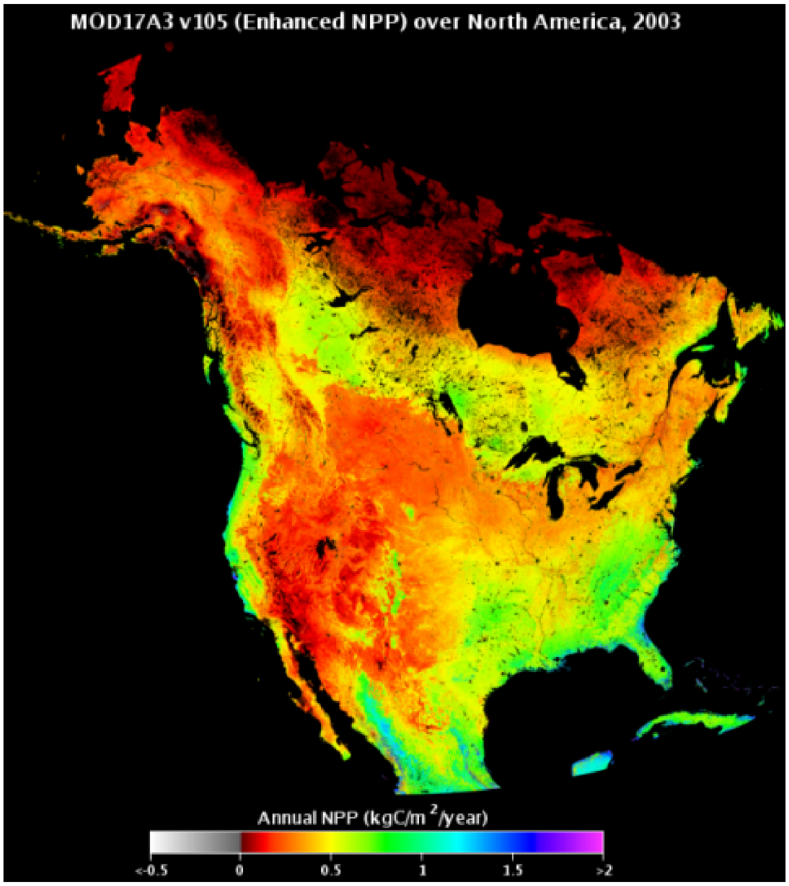
ch3

ch4

ch6

ch7

All these images were taken by the SeaWiFS sensor of the researchers who designed it before it was launched. The black and white images are some of the bands that the sensor collects data in. Each band picks up the color cards being held by the scientists differently. The data from each different band can reveal something different about the area that is scanned by the sensor.

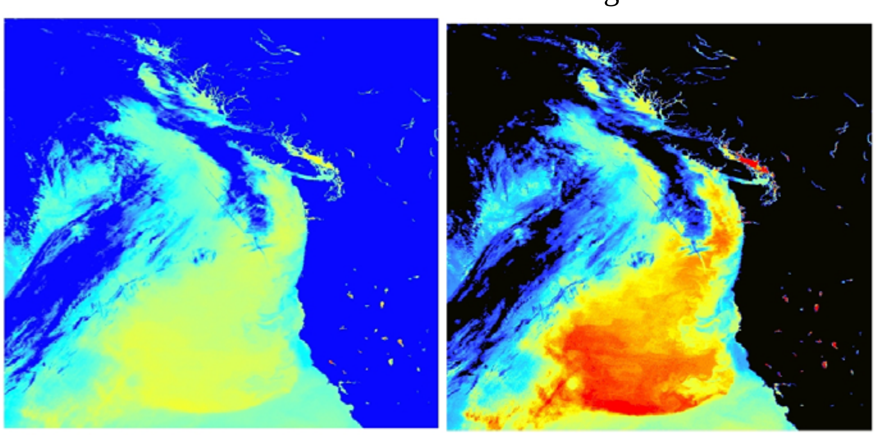


This is an Image from MODIS that collected Near Infrared radiation reflected from plants. The colors were then applied to the image so that higher areas of production are in green and blue. Lower values of production are in red and orange.

A satellite collects information in a band (ex 200-400nm) and then gives each pixel a brightness value on a scale from 0-255, because for many years that was the maximum number of color values that a computer monitor could display.

Contrast Stretching:

In the case of the sea surface temperature data we need to apply a contrast stretch to the image in order to make the image a useful display. In the Sea Surface example 0-255 has been designated to represent 0^{o} C to 25.5^{o} C. A value therefore of 180 would equal 18.0^{o} C. The ocean right off the Oregon coast during the summer (which is when the data in the IMS is from) does not include all the values from that scale. Most of the values are clumped between 2^{o}C to 15^{o}C. If we tried to show these values with a color range that gave a color to each value from 0-255 we wouldn't see the interesting variation in the data just off our coast.



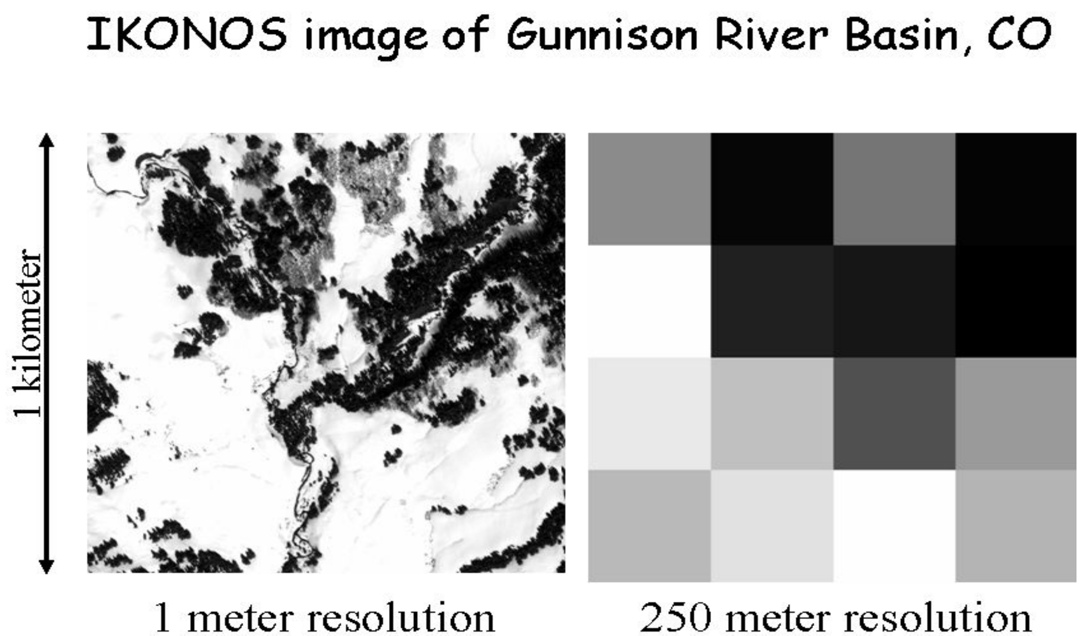
The image on the left has not been stretched and because most of the variation in temperature is in a small range it does not show up well. In the right image, the color range has been stretched over a smaller range of values where most of the data in this image occurs.

If we perform a contrast stretch we give the values of 2-15 the entire range of colors and the values on the outer margins, because in quantity there aren't very many they get lumped under one or two colors. This brings out the subtle variation in temperature that are most interesting to view and can show us important areas in the ocean for production of plant and animal life (more on this later).

The SST images in the IMS site have been contrast stretched. If you look in the legend you will notice that the range of values for each image is slightly different. August is 3.6 to 20.2, June has a range from 2.3 to 14.7.

What is the appropriate resolution for your study?

Resolution is the amount of area on the ground that one cell in a grid represents. A one meter resolution grid as shown below has a much higher level of detail because each cells value was collected from a 1m x 1 m area on the ground. In the other image each grid cell was collected from an area 250 m x 250 m on the ground.



What is the appropriate resolution for a study? For example: an urban planner would require images with a high level of detail because small differences in property lines and potential actions/hazards/development from one property can affect adjacent property owners.

Another Example: In the ocean, conditions are constantly changing; a high resolution image of an area would only be valid for a brief snapshot in time. Researchers may be interested in a particular phenomena but capturing such fine scale interactions multiple times would be very difficult to capture and analyze due to the dynamic nature of the ocean. Ocean researchers are more interested in learning about large scale ocean processes. Over an expanse such as an ocean where conditions are constantly changing, lower resolutions are sufficient for large scale research.

How do we know that what the satellite is telling us is accurate?

We need something to calibrate the sensors output to. This process is called ground truthing and is very important to be aware of because all instruments have varying amounts of error associated with their measurements. In order to ground truth a sensor, scientists must collect data on the ground and compare it to satellite images of the same period of time to calibrate what the sensor is recording.

The Plankton Layers for June and August were both collected by a research ship towing a fine mesh bag through the water to collect samples. The data was collected at a number of depths, which is very important because a satellite sensor can only see the surface and a few meters in to the water.

At the present time GIS software is just now beginning to be able to handle data collected in 3-D. The IMS software is a simpler version of the full strength GIS software it is not able to handle 3-D data. Because of this there are a number of data points stacked on each other because they were a taken in one location. If the data point is selected a number of different water depths that the samples were taken appear in the water depth column. By looking at the numbers in the data table we can begin to get an idea at what depths the samples were taken, and the associated abundance of phytoplankton but a vertical profile would be a more useful tool for looking at this data set.

For additional Remote Sensing Information see the following links:

SeaWiFS (Chlorophyll concentration)**:** http://seawifs.gsfc.nasa.gov/SEAWIFS/TEACHERS/
This site has some very good material on the SeaWiFS sensor.

http://seawifs.gsfc.nasa.gov/SEAWIFS/IMAGES/GROUP2.html This a good set of images to understand the idea of how a sensor collects data in bands (The same and a few more than the images on page 2)

AVHRR (Sea Surface Temperature) http://edc.usgs.gov/guides/avhrr.html
Some more information on AVHRR

USGLOBEC http://globec.oce.orst.edu/groups/nep/outreach/tas/index.html This portion of the main USGLOBEC site has a daily log written by John Hercher, a high school science teacher from South Salem. It profiles what it's like to work aboard a research ship and includes video clips from some of the scientists who were collecting the data that we have been looking at in the IMS site.