Measuring Vegetation Health
http://mvh.sr.unh.edu

May 2007

Teacher Guide to Spatial Investigations of Remote Sensing

Looking at a satellite or aerial photograph requires a student to think about how a view of something familiar, for example, of a student's school building viewed from the street, alters when seen from above. We experience this somewhat on the nightly news, when we see the weather report and the clouds above the geographic US with state outlines. Many students have had the experience of being on an airplane, and so can understand that as you go higher, features on the earth become smaller, and that the roof of a building may appear to be just a rectangle when viewed from above. It is important for the student to understand how a scale of feet or miles on an image can help you understand what you are seeing. The concept of "zoom" is commonly used in many video games, as well as on digital cameras and digital picture display programs, browsers and even Microsoft Word. Zooming is used in this student hands-on activity which requires only that the student be able to view a power point file.

What you need

What you do NOT need is the internet once you have downloaded the files.
For a teacher presentation to the whole class:

- Access to a computer to run the power point
- Load two powerpoints onto the computer – a download from http://mvh.sr.unh.edu from Data->Remote Sensing-> What can you see from 400 miles above Earth?
  - SpatialA.ppt
  - SpatialB.ppt
- LCD projector
- Download the student exercise sheet:
  - Either plan to project the Spatial_StdntEx _screen.doc file
  - **OR** Make copies of Spatial_StdntEx _big.doc (which has space for answers)

For student investigation:

- Computer lab or laptops for students to use
  - Load the powerpoints onto the computers or a server ahead of time
- **OR** Call on students to operate the teacher's computer

There are two power points provided from website download. The first, SpatialA.ppt, is intended for teacher projection, but could be used in a student computer lab with teacher narration for the first 9 slides. The written student exercises begin at slide 10.

The second powerpoint, SpatialB_IKONOS.ppt, can be used by an individual student, or a student group. There are three areas of focus within the powerpoint, so 3 student groups could be set up.

The Layout of the Powerpoint

There are sections to the powerpoint SpatialA.ppt. The first section is a general introduction to spatial aspects of satellite imagery, and several terms are discussed. There are 9 slides in this section, and you, the teacher, can go over this section with your students. You may point out the new vocabulary to your students. There is a glossary at the end of this document. The second section is about a particular imagery from the MODIS instrument on the TERRA or AQUA satellites, which is a coarse resolution type of image. But the MODIS images are able to cover the whole globe every 2-3 days. The imagery chosen for this analysis happens to be of New England. There are 7 MODIS slides, which allow the student to zoom forward or backward if he is the operator of the computer mouse controlling the powerpoint file. The third section uses images from a finer resolution instrument called the Landsat Thematic Mapper. Again there is the capability for the students to zoom forward or backward. There are 6 Landsat slides. The final section is an image from the IKONOS satellite, of Boston, Massachusetts. It is the highest resolution image that we present, and it has the option to not only zoom, but for the student to decide whether they will look at Logan Airport, the Bunker Hill monument or the Museum of Science. All three can be viewed, or the class could be divided into groups with separate questions for each group to answer based on one of these points of interest.

The Student Interaction

There are scale bars and zoom buttons on slides 10-23. Students are asked questions related to using a scale bar. The student should be able to describe the advantages or limitations of each of the three images: the MODIS, the Landsat and the IKONOS with regard to its spatial characteristics. You may wish to compare the satellite images to a map of the area and discuss where they are similar or different. The images are presented in true color (red-green-blue) but in reality, there are other wavelengths of light collected by these instruments which can also tell us things about the image. The spectral investigation of a satellite or aerial photograph image is the subject of other activites that can be found on the Measuring Vegetation Health website of materials.

Student Learning Goals

This powerpoint and associated materials give students practice in viewing satellite imagery of land features and relating it to maps. Scale is used for measurement and the calculation of the relative size of objects in the image. Three different satellites that look at the same general area are compared for their spatial characteristics. The distance between two fixed areas on the map (e.g. two cities) does not change because you have zoomed in or out.

Proposed Classroom Time

Day 1 (15 minutes): Teacher introduction of first 9 slides. Hand out Glossary or give link to downloadable glossary document.
Day 1 continue, or Day 2 (30 minutes): Students work on zooming slides 10 through 22, the MODIS and Landsat images. Students write answers to questions related to slides 10-22. The Teacher can also request a drawing of how many Landsat pixels fit in a MODIS pixel, and similarly another drawing for how many IKONOS pixels fit in a Landsat pixel. Gridded graph paper could be used.
Day 2 or Day 3 (30 minutes): Students zoom the IKONOS images to particular features in Boston. Students write up 3 things they notice in their investigation, including their answer to the yellow box question in their slides' focus.

National Science Standards

Technology and Measurement (from middle and high school)

8ASI1.3 Use appropriate tools and techniques to gather, analyze, and interpret data. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

12ASI1.3 Use technology and mathematics to improve investigations and communications. A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.

12ASI2.3 Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.

The following **U.S. National Geography Standards** are supported by this activity:

The World in Spatial Terms: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Links to Other MVH satellite activities or images

Remote Sensing Information:
http://mvh.sr.unh.edu/mvhinvestigations/remote_sensing_inv.htm
Landsat Imagery of the conterminus United States:
http://mvh.sr.unh.edu/Landsat/
Digital cameras:
http://mvh.sr.unh.edu/mvhtools/dig_cam_intro.htm
Free Software to view/analyze satellite or digital photographs:
http://mvh.sr.unh.edu/software/software.htm

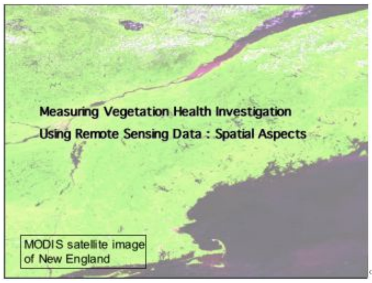
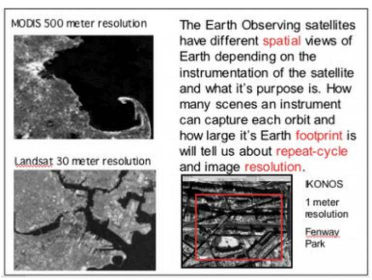
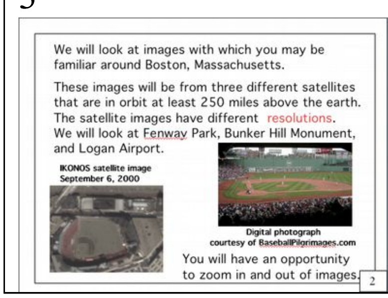
Materials provided with this activity

Student exercises A and B
Glossary of Spatial Remote Sensing terms
Powerpoint introduction to Remote Sensing
Powerpoint for IKONOS satellite
Information sheet for MODIS satellite
Information sheet for Landsat satellite
Information sheet for IKONOS satellite

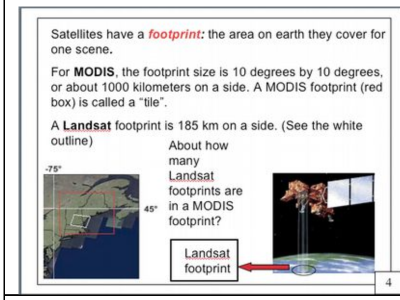
The Slide Content

What follows is a short conversation about each slide. The questions on the student worksheets will have space for student answers, and the answers given here may not be the only appropriate answers. Please feel free to let us know what direction your classroom discussions take. (spatial_contact@mvh.sr.unh.edu)

Bold text after the regular text question or statement represents potential student or audience response.

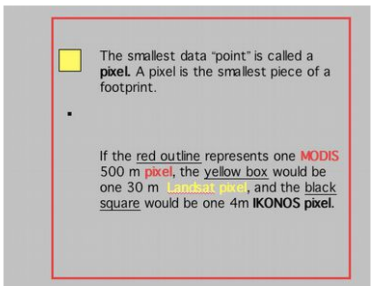
Slide	Questions and Discussion about the slide
1  	What can you identify in this MODIS satellite image? How is this like maps you have seen in an atlas, or different? (elicit responses) **The view is of New England from Canada down to Long Island, New York, but the picture appears stretched horizontally. It is a satellite view. The colors on this image are not like an atlas – there are white streaks that are clouds, the city areas appear to be pink, and the water parts are not blue. Boston and Monteal are identifiable.**
2  	The blue words are from a glossary of remote sensing terms. Each image is in some sense the "best" picture you can get from that particular satellite instrument. In IKONOS you can see streets and cars, in the Landsat one, you can see bridges, the airport landing strips, and in MODIS, you can see proximity of ocean to mountains, extent of urban areas. What do you think the terms mean: spatial, footprint, repeat cycle? **Spatial refers to the scale of the object you are viewing, and could also refer to the projection. Have you ever seen a polar projection of Antarctica? It appears to be "round".** **Footprint is the view on the surface of the earth of a single satellite image. It may be described by its length and width in units of distance, like 185 kilometers by 175 kilometers.** **Repeat cycle refers to how much time it takes for the satellite orbiting the earth and taking the "next picture" and the next, etc to reach the same part of the Earth. It could be days or weeks. Have students check the glossary handout for these words.**
3  	Here is Fenway Park baseball stadium from an IKONOS scene. The scene has fine resolution. It is Sept of 2000, with 22 games to go in the season. What do you think resolution means? **Resolution can be "fine" meaning you can see detail, and some small things, like the pitching mound. But you cannot see the individual seats, for example. "Coarse" resolution would be more like the first slide where you can only identify rivers or points of land jutting out from the continent.**

4



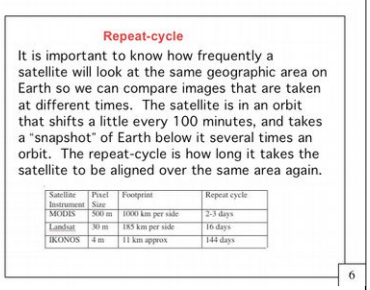
The footprint of Landsat is the white outline. Ask your students to estimate how many white boxes can fit in the blue box, the outline for one MODIS scene (tile). **One Landsat scene is about 200 km "square" and so 5 could fit along the MODIS tile width dimension of 1000 km, and 5 along its height. So that would be about 5x5 = 25 Landsat scenes in one MODIS tile. Have your students try this on graph paper or with to scale cut-outs.**

5



The resolution of a remotely sensed scene is usually given as the size of its smallest component: a pixel. MODIS has a 500 m pixel, Landsat has a 30 m pixel, and IKONOS a 4 m pixel in RGB (red-green-blue) wavelengths. Different resolutions have different advantages and disadvantages. What do you think some are? There are actually more detailed black and white images for Landsat at 15 m and for IKONOS at 1 m. We call this data band panchromatic.
One disadvantage if the image's resolution is high (pixel size is small), is that you can't cover as much ground area in a scene because there would be too many pixels in it. But in the coarse resolution (big pixel size – like MODIS) you can't see detail, like your school building, for example**.**

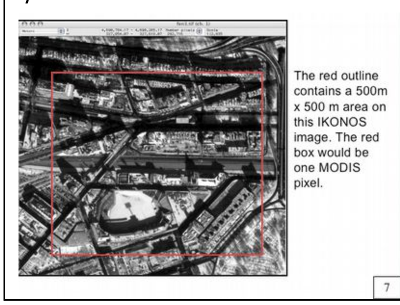
6



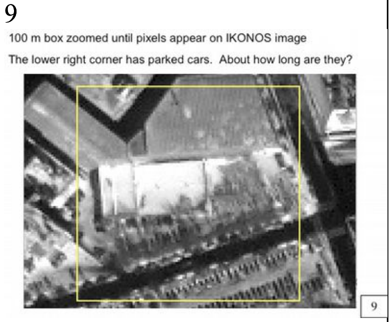
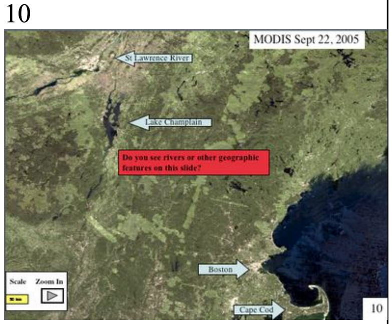
Satellite Instrument	Pixel Size	Footprint	Repeat cycle
MODIS	500 m	1000 km per side	2-3 days
Landsat	30 m	185 km per side	16 days
IKONOS	4m /1m	11 km	144 days

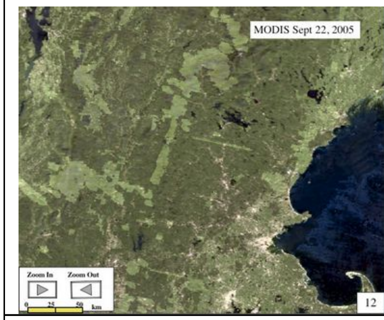
Discuss with your students what a large pixel size means. How long is 500m? (note that it is a half km) Could they walk this distance? How does this compare with a mile? Could they pick out Fenway park on a MODIS image?
Kilo means 1000, so 1 km = 1000m. 500 m is half a km. 1 mile is roughly 2 km. Or half a km (500m) would be about 1/4 mile. You could walk 500 m, but it would take 10-15 min. They could not pick out Fenway on a MODIS image.

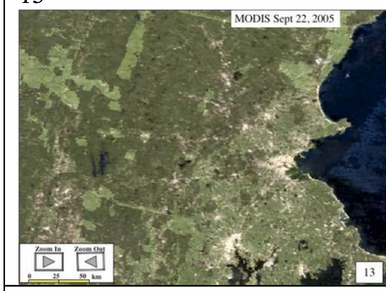
7

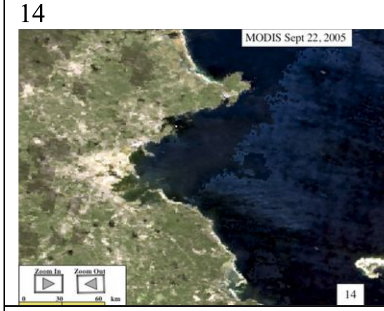


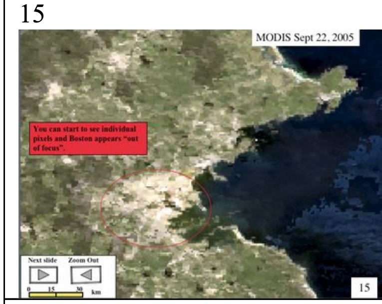
How does 500 meters compare to the distance between bases at Fenway?
You can fit about 15 in-fields along one MODIS pixel (90 ft between bases is about 30m , so about 3 in 100 m– no outfields, no bleachers, etc - and in 500m, 5 x 3). They can also see that the blue box is much bigger than Fenway.

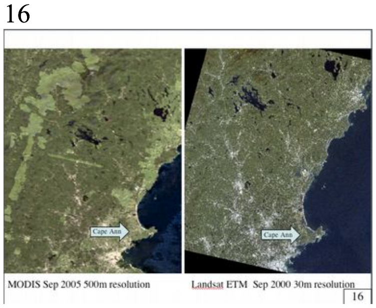
8  	We will look at a smaller box – 100 meters. How does this compare to the distance between bases? Ask students what they can see in this 1 m IKONOS image at about its best resolution **100 m is 3 times longer than the distance between bases. 100m is close to the length of a football field (100 yds) (1 m approx = 1 yd = 3 ft) You can see streets versus big highways, buildings, some big cars or trucks on the highway.**
9  	Notice the cars in the lower right hand corner parking lot of this zoomed IKONOS image. About how long is a car in meters? How many IKONOS pixels would that be? **A car could be 7-10 ft long, or 2.5-3.5 meters long. In the panchromatic (1 meter pixel size) , this would be about 2-3 IKONOS pixels.**
10  	Use the Zoom In (slide 11). Check what geographic features you are familiar with. If you don't know what a cape is, check the glossary. **There is a Cape to the North of Boston (Cape Ann, Gloucester), a large waterbody in the middle, several ME and NY lakes.** How can you find a city? **Cities are light colors on the satellite image. Non city areas in Sept still have leaves on trees, and much of the area looks green.** Zoom back out. (slide 10) Use this scale bar and estimate the distance from Boston to Cape Cod. About how many hours would that take to drive there at 50 mph average speed? **Note scale is in km, speed in mph. Mileage is about 60-70 miles to the beginning of the cape (100-150 km). Approximate driving time is about 1.5 hrs. The student exercise sheet gives the conversion 1 km ~ .625 mi.**
11  	Zoom in or out to look at some particular features. These zooms were made to keep Boston within the image. Point out the image date and the new scale bar. Measure the distance between Boston and Cape Cod. **The end of the slide 11 scale bar is now 100 km, but the 50 km mark is longer on slide 11 than on slide 10. The scale bar may have different numbers, but the distance will not change between Boston and Cape Cod. The distance is still about 60-70 miles.**

<table>
<tr>
<td>12


</td>
<td>This image is at about the best resolution for a MODIS scene - no pixelation occurs here. What does pixelation mean?
After eliciting responses from the class, a “teacher” answer may be given. Pixelation is when you can see the square edges of a pixel in the image. It does not look smooth. It looks jagged.</td>
</tr>
<tr>
<td>13


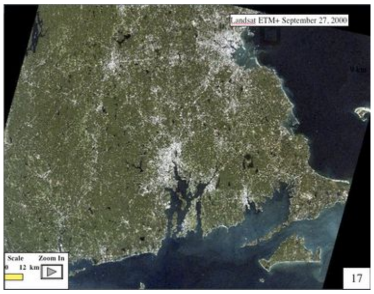
</td>
<td>Do you recognize anything special in this image?
A large body of water. (it is Quabbin Resevoir – Boston’s water supply) There are several cities 4-6 – light colored. (Boston, Fall River MA, Springfield MA, Providence RI) Rivers are hard to see but students may find one north of Boston, and you can see urban vs rural areas.</td>
</tr>
<tr>
<td>14


</td>
<td>What can you see here?
It’s beginning to look quite fuzzy. You can see some “squares” – pixels. We see the tip of Cape Cod - it looks like an island, but the “arm” is cut off, Cape Ann (Gloucester). There are different colors in the ocean. This could be due to depth of the ocean and runoff in the shallow bay areas. The “white” area of Boston is larger. The scale bar is different than on slide 13.</td>
</tr>
<tr>
<td>15


</td>
<td>This is a 3.5 zoom factor. That means a single 500 m pixel cover 3.5 pixels on the screen. Zoom factor is in the glossary. How is the scale bar different in this slide?
The scale bar length is about half that of the previous slide.</td>
</tr>
<tr>
<td>16


</td>
<td>These two images are about the same scale. Cape Anne is about the same size on each. However, the MODIS is at its best resolution, and the Landsat can be zoomed in to show much more detail. See the next section of slides.
Students may notice that the Landsat image has much more white area. Developed areas like highways and bridges are not able to be seen well at 500 m resolution because they are much less than 500 m wide, but on Landsat at 30 m resolution, the concrete is now very visible for large highways and buildings when zoomed.</td>
</tr>
</table>

17



This is nearly the full path row scene 12-30, acquired Sept 27, 2000. Boston is in the upper right, an island is in the lower right. What else can you recognize?

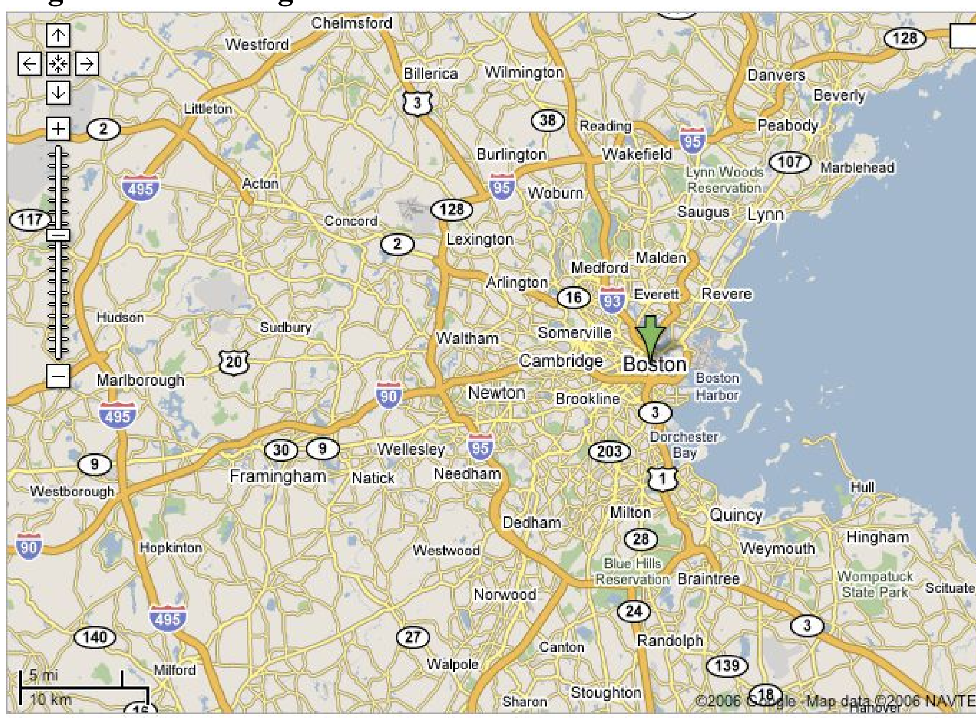
There are at least 5 large cities. (Worcester MA, Boston MA, Fall River MA, New Bedford, MA, Providence RI) There is a large reservoir at the left edge of the image. The ocean is to the south and East.

Notice the scale. What happens to the scale as you zoom to slide 18 and back?

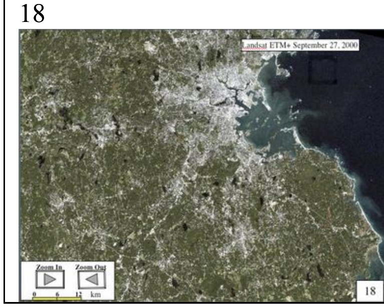
The numbers on the scale bar get smaller as you zoom in. The teacher could bring in a road map for comparison.

How does the scale bar on the image compare with that on the Google map below?

The scale bar on the slide ends at 12 km, and is shorter in length than the Google scale bar which ends in 10 km.



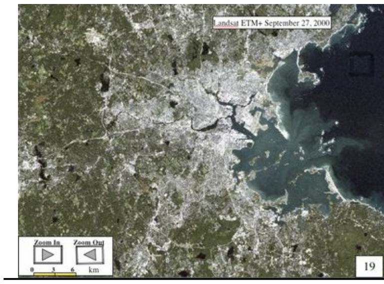
18



Notice that the scale bar has much shorter distances on it - 12 km vs 50 km for MODIS images. What can you see that you didn't see in the previous image?

Rt 128/95 - the ring road around Boston, islands are clearer, Logan airport is just starting to appear. Zoom back and forth to compare with slide 19.

1719119



We are zooming into Boston. Can you see the airport runways?
Airport runways are barely visible in Boston.
Notice the date of this image. No sign of fall color yet. You may recognize some rivers or lakes, some islands and peninsulas, and the big highways.
The image was taken in September, just as the MODIS one was, but in the year 2000.

20

Notice that the scale bar has much shorter distances on it - 12 km vs 50 km which is more typical for a MODIS image. What can you see that you didn't see in the previous image?
Rt 128/95 - the ring road around Boston, islands are clearer, Logan airport is just starting to appear. Zoom back and forth to compare with slide 19.
Now you can see the airport pretty clearly, and the urban vs vegetated areas. Can you see more than one airport? The "X" seems to be an identifying characteristic for an airport.
There are two airports. One is west of Boston.
Can you see lakes- how many?
I see about 35 – lumping "ponds, lakes, reservoirs"

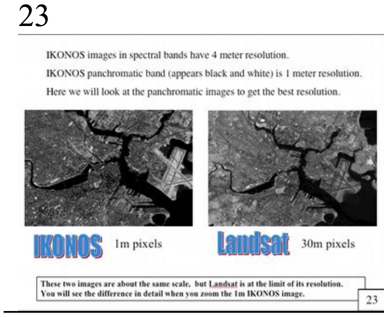
21

What are the squiggley lines?
Airport terminals. You can also see pier features.
What is the white line in the river?
It is probably a boat or a boat and its wake.
Use the scale to estimate the length of the longest bridge.
The longest bridge is the Massachusetts Ave Bridge (near MIT). It appears to be about 1 km (.6) miles long. You can see round circles north of the airport. This is an area of oil storage tanks.

22

Now we have zoomed to the limit of resolution of the Landsat image. This image is pixelated. We can't see anything smaller than 30 meters (100 ft) on a side. We'll look at another satellite image with higher resolution - IKONOS. It has 4 meter resolution. If we looked at 1 Landsat pixel, how many pixels would that become on an IKONOS image?
About 49, since there would be 30/4=7 IKONOS pixels on a side) and 7 x 7 = 49.

23



Looking at side-by-side images of Boston from Landsat and from IKONOS, ask you students what differences they notice?
The IKONOS image looks "sharper" than the Landsat one, even as a small thumbnail type of image here.
Now have students open the power point IKONOS-Spatial.ppt, or the teacher may do the investigation with help from students who come to the front of the room to use the mouse. The image was acquired Jan 14, 2000.

Glossary for Spatial Investigation, Measuring Vegetation Health

cape: a strip of land projecting into a body of water. A **headland** is an area of land adjacent to water on three sides. Large headlands may also be called peninsulas. Florida is a peninsula. When headlands dramatically affect the ocean currents they are called capes.

footprint: A designated area, usually a rectangle, on the surface of the Earth affected or covered by a satellite instrument for a single "image" taken by that instrument.

IKONOS: an Earth observing satellite/instrument launched in 1999 with 4 and 1 meter resolution.

image: Data representing a two-dimensional scene. A digital image is composed of pixels arranged in a rectangular array with a certain height and width.

Landsat : a series of satellites that has viewed Earth since the 1970's. We currently have Landsat 7 and Landsat 5 orbiting.

latitude : The angular distance north or south of the earth's equator, measured in degrees. Lines of latitude on the globe are parallel to the equator.

longitude: The longitude of a point on Earth is the angular distance from the Prime Meridian which passes through Greenwich, England, and through the North and South poles. Lines of longitude all pass through the poles.

MODIS: MODIS is an instrument on board the Terra and Aqua satellite providing data about the Earth's land and oceans and atmosphere. The instruments were launched in 1999 and 2002 respectively.

panchromatic: Panchromatic imagery refers to black and white imagery exposed by all visible light.

path/row: a grid scheme similar to latitude-longitude devised by Landsat to identify all the scenes on the globe that Landsat covers. The path is the vertical component, and the row the horizontal component.

pixel: The information stored for a single grid point in the image. The complete image is a rectangular array of pixels. Each pixel may consist of one or more bits of information, representing the brightness of the image at that point and possibly including colour information encoded as RGB triples.

remote sensing: to analyze without touching.

repeat cycle: Repeat cycle is the amount of time needed for a satellite to travel around the Earth back to the exact same location. While a single orbit for most Earth pointing satellites is about 90 – 100 minutes, the repeat cycle will vary depending on the instrument's footprint.

resolution: Resolution is a measurement of the output quality of an **image**, usually in terms of samples, pixels, dots, or lines per inch.

RGB – an abbreviation for Red-Green-Blue, the colors of light mixed on computer monitors and televisions to form all colors on the screen.

scale bar: A bar included in the margin or legend of a map or image showing the relationship of distances on the map/image with those on the surface of the Earth.

scene – the picture you see of the land area focused on for a single "snapshot" in time from a remote sensing instrument.

spatial: The aspects of remote sensing related to size and distance on the image of a ground scene on Earth.

tile – the term used in MODIS for a scene. For MODIS, it is normally 10 degrees by 10 degrees in latitude/longitude.

zoom to enlarge (zoom in) or reduce (zoom out) a particular focus in a digital image; for example a flower at zoom in might show the detail of its petals, stamens, even pollen particles. At zoom out, you might see just a flash of color if the flower is brightly colored, or you may not be able to distinguish a single flower from a bed of identical flowers – for example a field of sunflowers.

zoom factor: A multiplier to determine the amount of enlargement of a specified screen rectangle, called a pixel.