

Visualizing a Pixel

Simulate a Sensor's View from Space

In this activity, you will:

- Measure and mark pixel boundaries
- Learn about spatial resolution, pixels, and satellite imagery
- Classify land cover types
- Gain exposure to ArcMap



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Visualizing a Pixel

Exercise: Simulate a Sensor's View from Space

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Summary of skills covered:

- Understanding spatial resolution
- Measure and mark pixel boundaries
- Learn about spatial resolution, pixels, and satellite imagery
- Classify land cover types
- Gain exposure to Landsat
- Gain preliminary exposure to ArcMap or a geographical viewer (ArcGIS Explorer)

Data needed:

Students will measure and 'map out' pixels from different sensors, including Landsat, MODIS, and aerial photography

Equipment and Software needed:

Hardware: Long measuring tape and marking cones (These items are available from VirginiaView / the Virginia Geospatial Extension Program). Contact John McGee (jmcg@vt.edu) or Jim Campbell (Jayhawk@vt.edu) for details.

Software: ArcGIS Desktop or other geographical viewer such as ArcGIS Explorer (optional)

Related book exercise (if applicable):

No text necessary.

Optional readings might include:

- "Earth as Art" (<http://eros.usgs.gov/imagegallery/>) can be used to provide an overview of what Landsat images at a 30 meter resolution look like. Furthermore, there is a description of each image.
- Various exercises from AmericaView's "Earth Observation Day" website (http://www.americaview.org/k-12-earth-observation-day#quicktabs_11%3D1)

Data Source:

None.

Objective

The goal of this lab is to help you visualize the dimensions of several types of pixels and to understand pixel values for land cover. During the lab, you will mark the extent of multiple pixels and classify the land cover encompassed by the pixel. You will better understand the concepts of spatial resolution and mixed pixels, appreciate the value of landscape-level analysis, and recognize the inherent errors in land cover classification.

Background

There are currently thousands of satellites flying around Earth. The satellites perform a variety of functions, such as monitoring the weather, observing other planets, or beaming phone and TV signals across the world. There are also many Earth science satellites in orbit. These satellites are **optical** forms of remote sensing, which means they take photos of the Earth as they orbit. In the field of environmental remote sensing, we often use these satellite images of Earth to visualize the current conditions and detect any important changes to the Earth's surface. In the United States, two of the most commonly used satellite programs are Landsat (URL: landsat.gsfc.nasa.gov) and the Moderate Resolution Imaging Spectrometer (MODIS).

Landsat is the world's longest continuous satellite mission program. NASA launched the first Landsat satellite in 1972, and there have been 7 others since to replace the satellites as they break down or are decommissioned. Landsat 8 launched in March 2013 (see Figure 1).

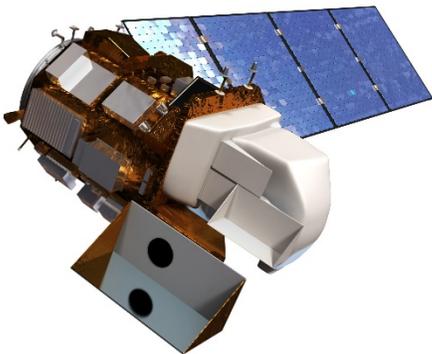


Figure 1: Landsat 8 Satellite
Courtesy: gallery.usgs.gov

Landsat's **spatial resolution** is the size of its **pixel**, 30m x 30m. When a satellite takes an image, the pixel is the smallest unit in the image; a pixel is a square that contains one color. This is the same as with cameras. As a result, anything smaller than the size of a pixel may be unidentifiable. Even an individual pixel may be difficult to interpret, but pieced together, the pixels form images. The satellite image in Figure 2 shows Hurricane Floyd in 1999; if you look closely, you can see many of the pixels that make up the image. Note how each pixel is one color.

The concept of pixels may be familiar to you from cameras. Some cameras have 3 Megapixels, while others have 10 Megapixels. This means that each image is made up of 3 million pixels or 10 million pixels. In theory, the more pixels that cover an area, the smaller each pixel will be and the more detail we can see when we look at the image.

MODIS takes similar images to Landsat, but has several key differences. First, instead of orbiting around Earth every 16 days, MODIS views the entire surface in 1 to 2 days. This cycle is much faster, and produces many more images! However, MODIS also has a lower spatial resolution. Instead of a 30m x 30m pixel, MODIS pixels range in size from 250m² to 1000m².

On the other hand, aerial photographs typically have a much higher spatial resolution than satellite images. These photos are taken by airplanes flying over the landscape. With today's technology, digital aerial photos can have pixel sizes of less than 5 cm!

Spatial resolution is critical to our ability to understand satellite images. We can identify a building, forest, or pond with a 30m² resolution, but we are not able to see people, cars, or other relatively small objects. With a 500m² resolution, we have even more trouble finding smaller features. We also often face the problem of **mixed pixels**. If the pixel area consists of a uniform land cover, we can identify it. When there are multiple land cover classes in a pixel, it can cause confusion. For example, if the image is of a forest, the pixels with trees may appear green. If the image is bare soil, we might see brown pixels. However, a pixel with forest and urban development will show a color that mixes the two land cover classes. It can be difficult to tell which land cover types combined to form that color, and even harder to estimate the amount of each land cover type present in the pixel.

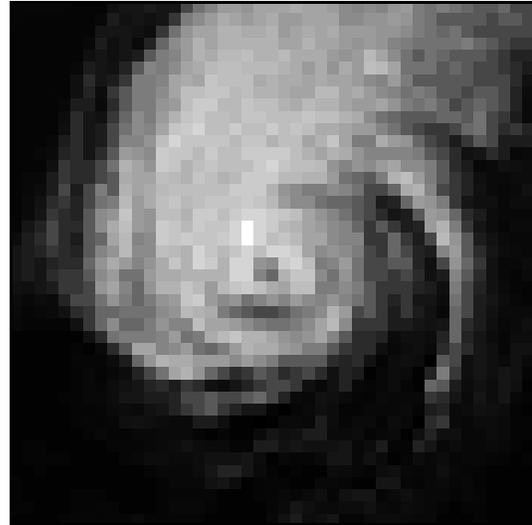


Figure 2: Satellite Image of Hurricane Floyd
Courtesy: <http://earthobservatory.nasa.gov>

Materials

- 4 plastic marking cones
- Metric tape measure
- Compass
- ArcMap software, Version 10.0 or higher (note that this exercise can easily be adapted for use by geographic viewers, such as GoogleEarth or ArcGIS Explorer)

Procedure

First, let's visualize the pixels from several aerial photographs:

1. Find an area with plenty of open, accessible space.
2. Place a cone on the ground in a location of your choosing. Use the tape measure to place the cones in a 1m x 1m square (see Figure 3).

This is a common pixel size for national agricultural aerial imagery. The US takes aerial photos with this spatial resolution over farmland to monitor crops.



Figure 3: Cone Arrangement for Pixel Visualization

3. Pick up 3 of the cones, while leaving one on the ground.

This cone is much larger than the potential resolution of today's high resolution digital photos. With this in mind, answer the "Aerial Photo" questions on the handout. Remember that each pixel is a single-colored square, so no details smaller than the pixel can be seen.

Now we will visualize a Landsat pixel:

4. Place a cone on the ground. This will serve as the corner of your Landsat pixel.
5. Use the tape measure and compass to measure 30m at a 90 degree angle from the first cone. Place the second cone at this location.
6. Repeat this procedure to place the other two cones in a square. This is an example of a Landsat pixel as seen from the satellite. Since Landsat orbits the Earth in a consistent pattern, the satellite takes images with approximately the same locations every orbit. Your pixel may not match the exact location of a real Landsat pixel, but the size dimensions are the same.
7. Let's do a land cover analysis now. Looking at your pixel, what types of land cover are within its boundaries? Some examples of land cover classes are forest, non-forest vegetation, human development, or water. Fill in Table 1 based on your estimates of the pixel's land cover types, and answer the questions on the handout.

Next, we will visualize a 500m² MODIS pixel. Since each side of a MODIS pixel is approximately 5 lengths of a football field, we would need a really large area to set up our cones! Instead, we will use the computer.

8. Open the "Pixels.mxd" file in ArcMap. You should see a high resolution aerial image of Southwest Virginia, with a "MODIS" polygon on top. The MODIS polygon is the size, shape, and location of a real MODIS satellite pixel.
9. Examine the land cover types within the pixel. Use the zoom buttons to explore the area.



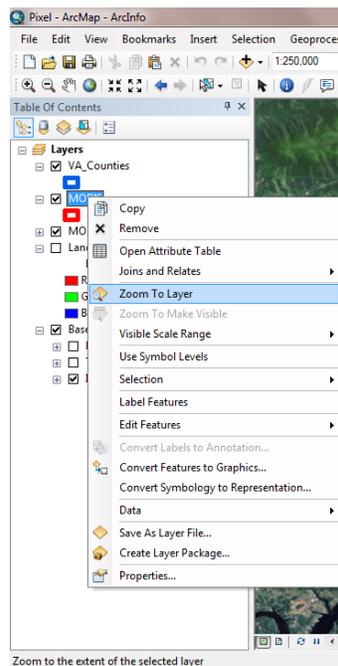
Fill in Table 2 and answer the remaining MODIS questions.

Now let's see an actual MODIS and Landsat pixel!

10. In the ArcMap Table of Contents, display the MODIS image by placing a check next to the "MODIS Image." Many single-color large squares should appear in the display; these are the pixels that make up the satellite image.
11. Zoom out many times. Keep your eye on the map scale bar (see below). When the map scale is around 1:100,000, the pixels start to cluster by color. Keep zooming out until you reach 1:250,000. By this point, you should be able to see what types of land cover classes result in particular color pixels. Check and uncheck the "MODIS Image" to verify your findings.



12. Next, let's take a look at a Landsat pixel. Right-click on the MODIS pixel and select "Zoom to Layer" to zoom back to the original scale.



13. Uncheck "MODIS Image" and check "Landsat Image." Notice how many Landsat pixels fit within the one MODIS pixel! This is because each Landsat pixel is only 30m², instead of 500m².
14. Slowly zoom out to a map scale of 1:25,000. Observe the patterns in the landscape. Check and uncheck the "Landsat Image" to see how different land cover classes look in a Landsat pixel.
15. With the Landsat image displayed, zoom out to 1:100,000. Check the "MODIS Image" one more time and notice the difference in detail. Answer the remaining questions in the lab.

Student's Answers

Aerial Photo Questions

1. Although better resolution images are possible, the US government believes 1m resolution is sufficient to monitor agricultural crops. Based on your pixel size, would more than one plant fit inside the 1m² pixel?

2. In the 1m² aerial imagery, would you be able to see the shape of the leaves on the individual plants?

3. In the 5cm aerial imagery, would you be able to see the shape of the leaves on the individual plants?

Table 1: Landsat Pixel (30m x 30m)

Land Cover Class	Percent of Pixel

Landsat Questions

4. Is your pixel of uniform land cover or can it be considered a "mixed pixel"?

5. Based on the percentages of each land cover type in your pixel, which land cover class do you think most dominates the Landsat pixel?

6. If you were viewing a satellite image in the visual spectrum, what color would your pixel appear? How would the other land cover classes affect the “average” color of your pixel? Why?

Table 2: MODIS Pixel (500m x 500m)

Land Cover Class	Percent of Pixel

MODIS Questions

7. Is your pixel of uniform land cover or can it be considered a “mixed pixel”?

8. Based on the percentages of each land cover type in your pixel, which land cover class do you think most dominates the MODIS pixel?

9. If you were viewing a satellite image in the visual spectrum, what color would your pixel appear? How would the other land cover classes affect the “average” color of your pixel? Why?

Critical Thinking Questions

10. Other than the examples listed above, what are some other land cover classes? Give several examples.

11. What are the pros and cons of using a satellite image vs. surveying the land in person? List at least 2 advantages and 2 disadvantages

Advantages	Disadvantages
• • •	• • •

12. When would a researcher prefer to use a Landsat satellite image instead of a MODIS image? When would a researcher prefer to use a MODIS image instead of a Landsat image?

13. Imagine you are a wildlife biologist studying the preferred habitat of a particular bird species. You have the GPS coordinates of where the bird has been spotted, but now you need a satellite image to evaluate the land cover. Which satellite image would you choose and why?

14. People sometimes complain that their privacy is being violated by the satellites taking photos of their homes. In light of the Landsat and MODIS satellites, respond to these concerns.
