



## GOES-R EDUCATION PROVING GROUND



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### Title:

#### ***Spatial Resolution in Satellite Imagery***

### Purpose:

To explain the value and use of sensors such as the GOES-R Advanced Baseline Imager (ABI) to provide higher spatial resolutions in satellite imagery.

### Level:

The lesson is appropriate for primary, middle, and secondary school students. Some of the terminology will need to be adjusted for use in primary school. The mathematics may be more appropriate at middle and secondary school level.

### Student Outcomes:

- Observe satellite images at different resolutions.
- Define pixel density.
- Identify land, water, and atmospheric features.
- Define and demonstrate image analysis.
- Approximate the area of a particular feature.
- Explain the value and use of higher spatial resolutions.

### Prerequisites:

- Students should understand the satellite is the vehicle (bus), which carries the instruments/sensors that collect the data.

- Students should know a satellite image is a digital visualization that models data acquired by a satellite. Satellites give the numbers, and computers on the ground use those numbers to produce the models we “see.”
- Students should also know what “pixels” are and that satellite images are composed of pixels.

### Next Generation Science Standards:

The sets below from the Next Generation Science Standards (NGSS) are relevant to this lesson. Each one is a disciplinary core idea (DCI), science and engineering practice (SEP), crosscutting concept (CC), or a performance expectation (PE). The list is not exhaustive.

#### GRADES K-2

- Use a model to represent relationships in the natural world. **(K-ESS3-1)**
- Make observations (firsthand or from media) to collect data that can be used to make comparisons. **(K-PS3-1)**
- Use observations (first hand or from media) to describe patterns in the natural world in order to answer scientific questions. **(1-ESS1-1)**
- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. **(K-ESS2-1)**
- Scientists study the natural and material world. **(2-ESS2-1)**

#### GRADES 3-5

- A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. **(4-ESS3-2)**
- Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships. **(3-ESS2-1)**
- Describe and graph quantities such as area and volume to address scientific questions. **(5-ESS2-2)**
- Engineers improve existing technologies or develop new ones. **(4-PS3-4)**

#### GRADES 6-8

- Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. **(MS-ESS3-2)**
- Graphs, charts, and images can be used to identify patterns in data. **(MS-ESS3-2)**

#### GRADES 9-12

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **(HS-ESS2-2)**

### Preparation:

Print and cut out the six satellite images that are found at the end of this lesson. Since students will work in groups of 4-6, make a set for each group. It is recommended you number the images 1-6, as well as laminate them for increased durability. The resolutions of the images are in the following order: 8x5, 16x10, 32x20, 64x40, 128x80, and 1920x1080.

As a side note, the area of coverage for each image is 3500km x 2200km.

### Procedure:

1. Begin class by using the spatial resolution web applet (link below) developed by Tom Whittaker at the University of Wisconsin-Madison and Tim Schmit, NOAA NESDIS. This resource was developed specifically to help demonstrate connections between improved spatial resolution and image clarity. Using these images is an excellent way to pique the interest of the students, while also introducing the subject matter.

<http://cimss.ssec.wisc.edu/goes/webapps/whatsthis/overview.html>

2. Arrange students into groups (recommended 4-6 students per group).
3. Give each group Image 1 (lowest resolution image 8x5).  
DO NOT GIVE OUT ALL IMAGES AT ONE TIME.
4. Explain to the students that the image is low-resolution (8x5).  
Questions:
  - a) What does an 8x5 pixel image mean?
  - b) How many total pixels make up this image?
  - c) What are some of the different colors you see?
  - d) What surface features do you think are identified by each color?
  - e) Of what do you think this is an image?
5. Give each group Image 2, the next highest resolution image (16x10).
6. Explain to the students that pixel density is the number of pixels per area of coverage.  
Questions:
  - a) Has the pixel density increased or decreased?
  - b) How many total pixels make up this image?
  - c) How many more times is the pixel density than the first image?
7. Repeat for the remaining images, asking students to refine their observations until they correctly guess the image identity. The last image is at full resolution 1920x1080.

8. Now, have students compare Image 4 and Image 5.  
Question: What features seem to be more resolved at the higher resolution?
  
9. Have the students examine the eye of the hurricane using Image 5.  
Questions:
  - a) How many pixels do you count within the eye?
  - b) If each pixel covers an area of approximately 700 square kilometers, how many total square kilometers does the eye cover?
  
10. Have the students examine Image 6.  
Question: Would it be easy or difficult to count the number of pixels in the eye?
  
11. Explain to students that image analysis software is used to “count” pixels, the eye cannot discern. The result would be a more precise value of area.
  
12. Have students discuss the value of using a GOES-R instrument, such as the Advanced Baseline Imager (ABI), which has a spatial resolution four times that of current GOES satellite instruments.

Extension/Challenge/Variation:

1. The equation to find area of a circle is  $\pi r^2$ . Challenge the students to calculate the area of the hurricane’s eye and compare it to “counting” pixels. The students will need to determine the scale [km per pixel]. Each image covers an area of 3500km x 2200km.

2. Here is a variation of the spatial resolution lesson that can be used in both elementary and middle school. It is an excellent introduction to satellite imagery. Students learn a satellite image is a digital visualization made of numbers. These numbers correspond to shades of gray, or colors. The computers on the ground receive the satellite data and produce visual models and images. Working in small groups, students receive “data” from satellites in the form of index cards with numbers on them. A template will show which numbers go where. Templates could correspond to actual satellite images. The numbers represent the data sent to the ground from the instruments on the satellite. A sample template is pictured to the right.

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 2 | 3 |
| 1 | 1 | 1 | 2 | 3 | 3 |
| 1 | 1 | 2 | 2 | 3 | 4 |
| 2 | 2 | 2 | 2 | 2 | 2 |

Then, students learn the numbers correspond to specific “colors”. Using a key, the students place colored cards over the numbers. Students then stand back and try to “visualize” what the satellite saw. What could the colors represent? How much easier would it be if the image were made of more index cards and different shades of the colors? After group and class discussion, teacher can show real satellite photo on which the card assembly was based. Starting at low resolution and working up, students can guess what the actual photo is and reflect on what they thought it was, based on their initial card set-up. Once students understand these basic concepts, more complex spatial resolution lessons can be taught.

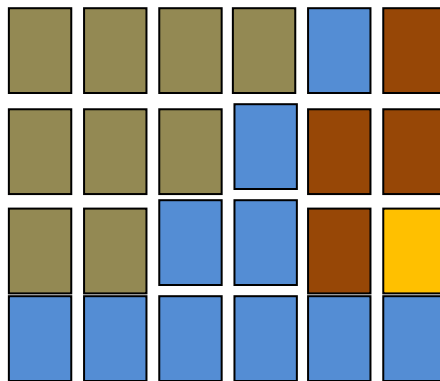


Image 1 (8x5)

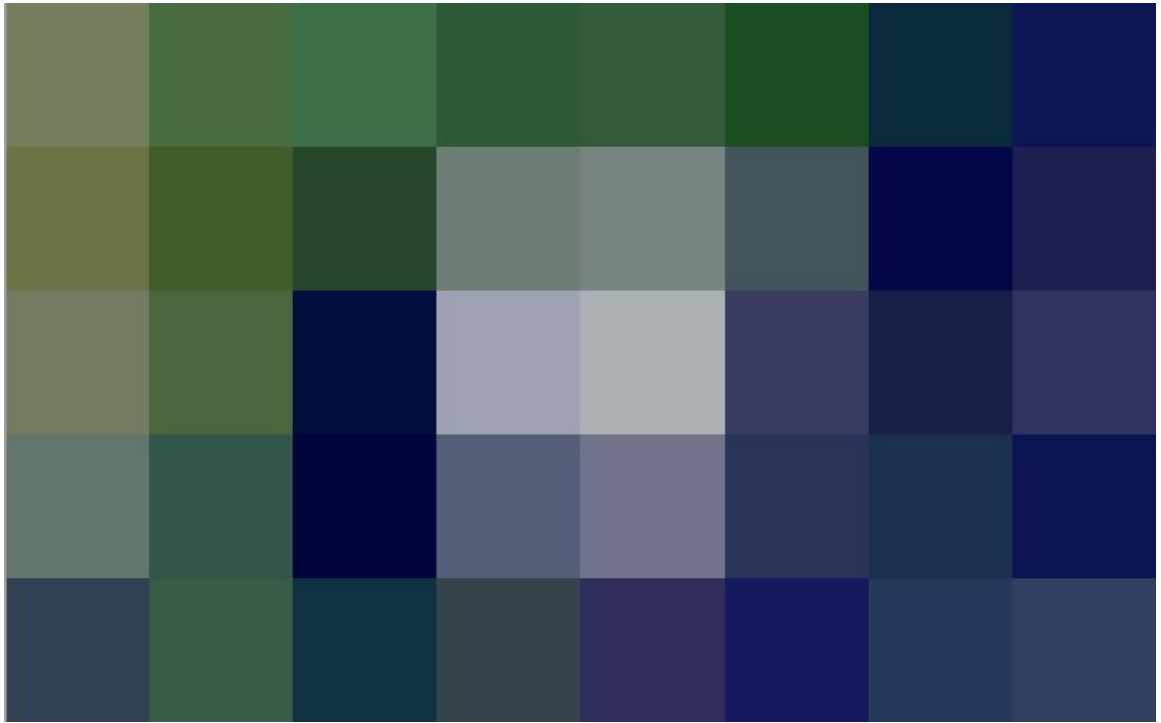


Image 2 (16x10)

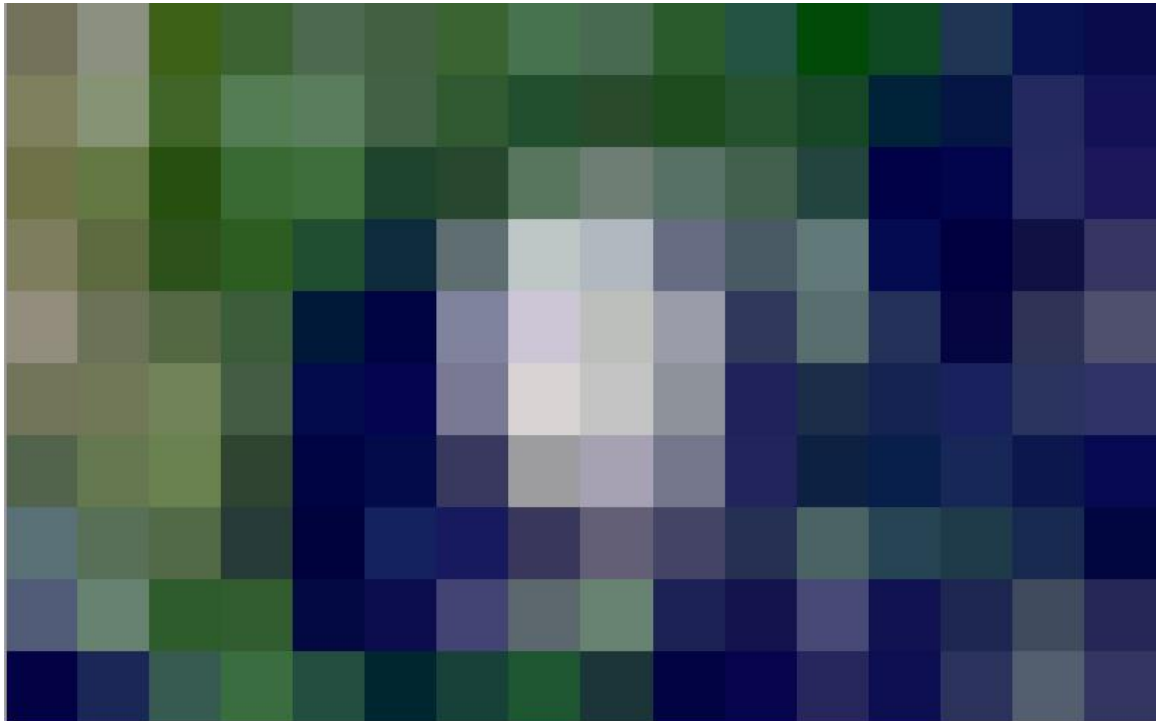


Image 3 (32x20)

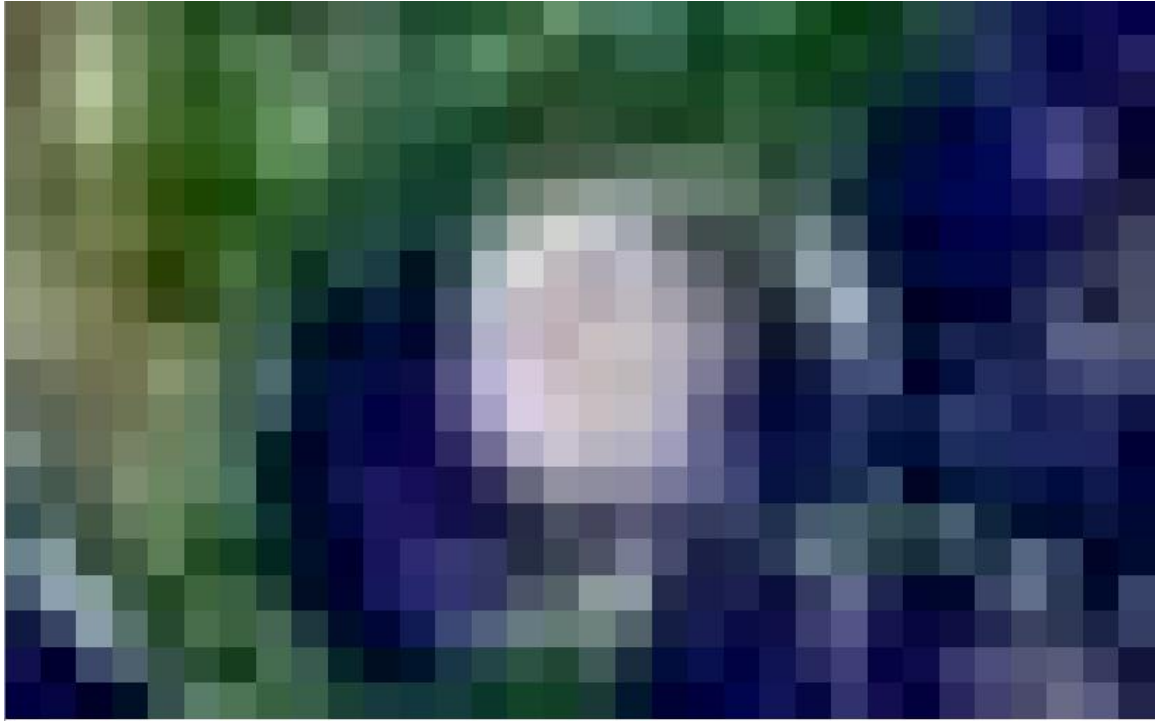


Image 4 (64x40)



Image 5 (128x80)

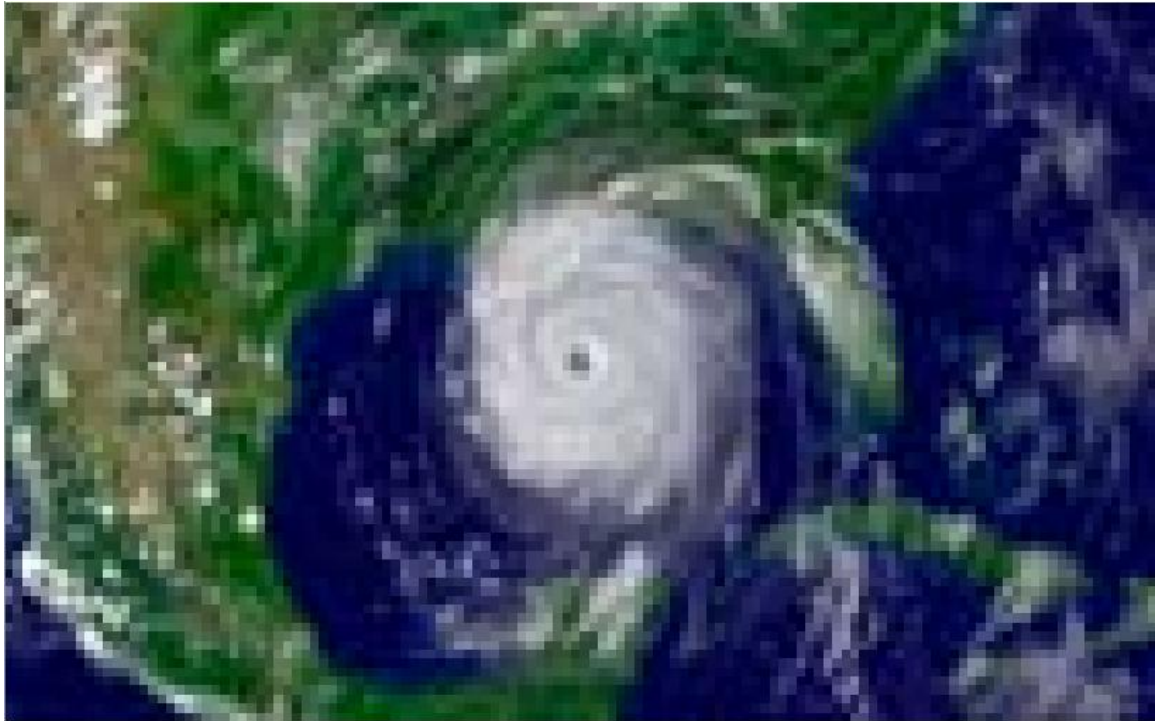


Image 6 (1920x1080)

