USGS
science for a changing world

Student Guide

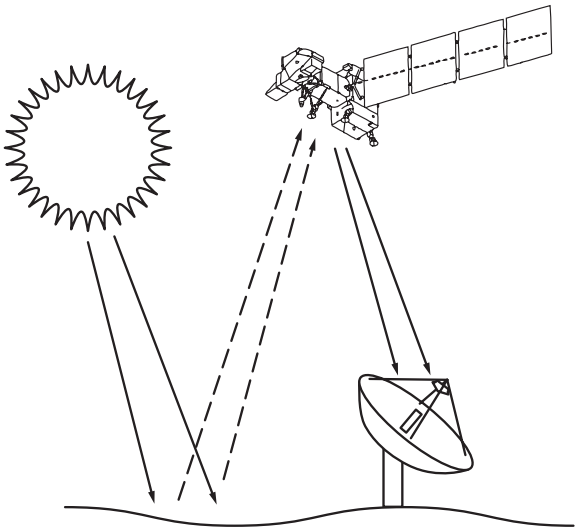
Tracking Change Over Time—Understanding Remote Sensing

1. What is remote sensing?

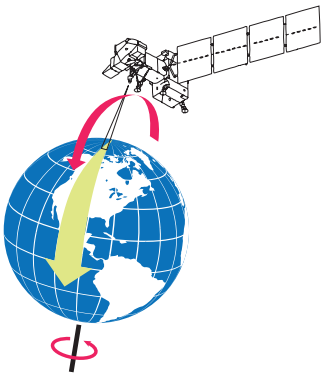
Remote sensing means observing something from a distance. Satellites in space observe the Earth from a distance and help scientists study large tracts of land and how that land changes over time.

Optical remote sensing satellites use reflected light to detect electromagnetic energy on the Earth's surface. The level of energy is represented by the electromagnetic spectrum, which is the range of energy that comes from the Sun. The light from the Sun that we can see is only a small part of the electromagnetic spectrum and includes the colors of the rainbow. Satellite sensors can detect light that we can't see.

The electromagnetic energy reflects off the Earth's surface and up to the satellite sensor, which collects and records information about that energy. That information is transmitted to a receiving station in the form of data that are processed into an image.



While there are many Earth-observing satellites, these lessons focus on the Landsat series of satellites. The Landsat satellites are in a polar orbit, which, along with the Earth's rotation, allows them to image most of the Earth. As a Landsat satellite revolves around the Earth, its sensor "sees" a certain portion of the Earth's surface. As the satellite orbits the Earth from pole to pole, it appears to move from east to west because of the Earth's rotation. This apparent movement allows the satellite to view a new area with each orbit.



Landsat Uses:

- Geographers look for changes on the Earth's surface that need to be mapped.
- Foresters need information about what type of trees are growing and if they have been affected by disease, fire, or pollution.
- Environmental scientists detect, identify, and follow the movement of pollutants such as oil slicks on the ocean.
- Geologists are interested in finding valuable minerals.
- Farmers monitor how crops are growing and if they have been affected by drought, floods, disease, or pests.
- Ship captains plot the best route through polar ice packs.
- Firefighters send out crews based on information about the size and movement of a forest fire.

U.S. Department of the Interior
U.S. Geological Survey

General Information Product 133
Version 2.0, March 2016

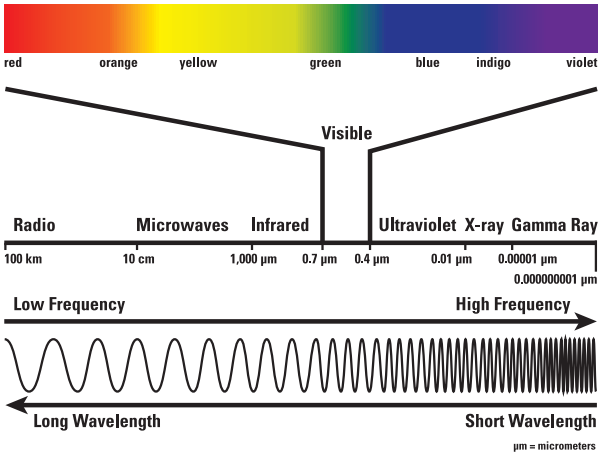
2. How do satellite sensors work?

We can only see an object because light bounces off of it and to our eyes. Human eyes can detect only visible light—the colors of the rainbow. Satellite sensors can also detect ultraviolet and infrared light.

The sensors record this information in different portions of the electromagnetic spectrum, which is measured in wavelengths. Landsat satellite sensors detect both visible and infrared light.

When satellite images are made, these "invisible" types of light are assigned visible colors to represent them. That is why some satellite images have strange colors.

Electromagnetic Spectrum



3. What can you see in a satellite image?

In this image of Bellingham, Washington, you can see a river (A), urban areas (B), agricultural areas (C), and forest (D). See if you can find the following features in the image:

- airport
- river sediment
- bay
- lake
- major streets
- highway
- logging clear-cut areas
- golf course
- cleared area for power lines

4. The Landsat series

Since 1972, the Landsat series of Earth-observing satellites has been imaging Earth's land areas. Landsat represents the world's longest continuously acquired collection of space-based moderate resolution land remote sensing data. Landsat imagery provides a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also invaluable for emergency response and disaster relief.

The Landsat satellites are launched by NASA at Vandenberg Air Force Base, California. Once the satellite is in orbit, the U.S. Geological Survey (USGS) is responsible for processing and storing (archiving) the satellite data. The USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, SD, archives and distributes the satellite data.

Satellite	Launched	Decommissioned
Landsat 1	July 23, 1972	January 6, 1978
Landsat 2	January 22, 1975	February 25, 1982
Landsat 3	March 5, 1978	March 31, 1983
Landsat 4	July 16, 1982	June 15, 2001
Landsat 5	March 1, 1984	2013
Landsat 6	October 5, 1993	Did not achieve orbit
Landsat 7	April 15, 1999	Still operating
Landsat 8	February 11, 2013	Still operating

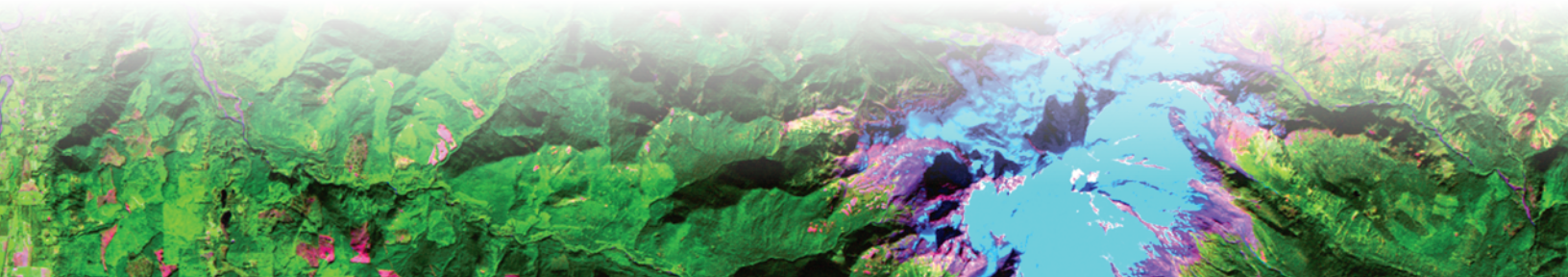
The two Landsat satellites currently operating are Landsat 7 and Landsat 8. They are in a polar orbit 705 kilometers (438 miles) above the Earth's surface. They complete one orbit every 99 minutes, for 14 ½ orbits per day. This means it takes 16 days for each satellite to obtain imagery over the entire globe.

5. Identifying Changes over Time

The Landsat satellite image collection is valuable because it shows change over time of the Earth's land surfaces. Look at these two images and find at least five things that have changed between the two time periods.

Landsat 5, Salt Lake City, Utah, August 31, 1985.

Landsat 8, Salt Lake City, Utah, September 19, 2015.



6. Types of Change

Brainstorm examples of short-term and long-term changes to the Earth's surface.

Short-term changes	Long-term changes

- Which of these changes are likely to affect your life and why?
- How could these changes be studied?
- What are the advantages and disadvantages of how these changes can be studied?
- How can images from remote sensing satellite sensors help us study landscape changes on the Earth's surface?

7. What is a pixel?

The resolution of the Landsat satellite data we are using is 30 meters. That means one pixel is equal to a square 30 meters by 30 meters, which is about the size of a baseball diamond. For example, one Landsat 5 image contains about 35 million pixels—that's about 35 million baseball diamonds!

Let's see how a low-resolution image compares to a high-resolution image. On the blank grids, try to create the letter R on the 5x5 grid. Only whole squares may be used; no diagonals or partial filling allowed. How well does this work? Try a grid with more squares/pixels. Which grid works best for this task, the 5x5, 10x10, or 30x30? Which one produces the best picture?

The 30-meter resolution of Landsats 7 and 8 works well for observing landscape changes over time. Bigger pixels wouldn't provide enough detail, and smaller pixels would be too much data to be practical to work with. Remote sensing scientists refer to this as moderate resolution. Other Earth-observing satellites, such as NASA's Terra and Aqua satellites, have lower resolutions, up to 1 kilometer. And France's Satellite Pour l'Observation de la Terre (SPOT) has higher resolutions, up to 2.5 meters.

0	1	2	3	4	5
1					
2					
3					
4					
5					

0	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														
11																														
12																														
13																														
14																														
15																														
16																														
17																														
18																														
19																														
20																														
21																														
22																														
23																														
24																														
25																														
26																														
27																														
28																														
29																														
30