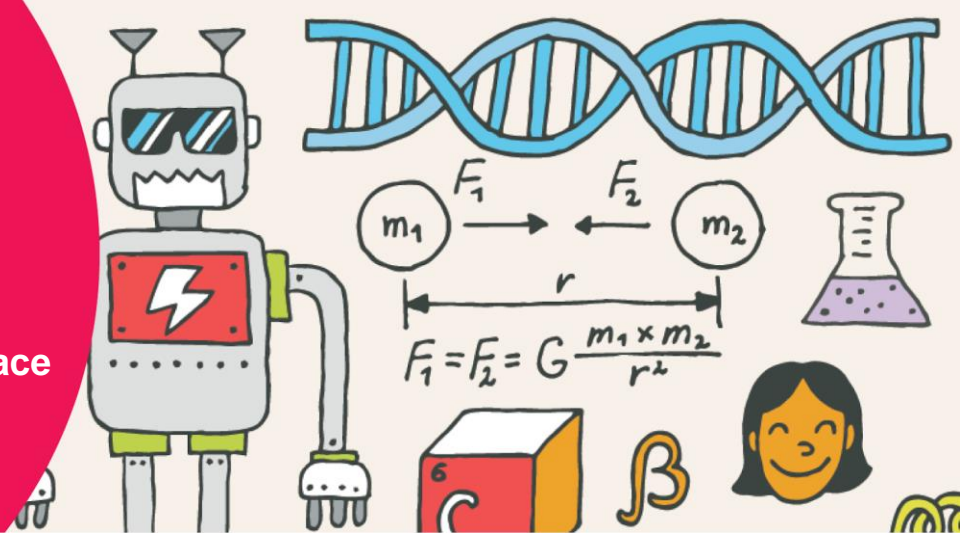


Earth in Focus

Digital Learning Kit Interpret Images of Earth from Space



How to Interpret Images of Earth from Space

BACKGROUND

Earth Observation

We have been observing Earth from space for many years. Over this time, the technologies used to do so have changed dramatically. The very first picture of Earth from space was taken on October 24th, 1946 from a rocket 105 Km above the ground. The rocket, from World War II, had the warhead replaced with a package of scientific instruments including a 35mm motion-picture camera that was set to snap a picture every 90 seconds. The images were dropped back to Earth in a tough steel canister.

Our technologies and capabilities have certainly improved since the first picture was taken. The iconic “The blue marble” taken by astronauts aboard the Apollo 17 in 1972 was the first full view of the Earth and was taken while Apollo was on its way to the moon. In more recent times, satellites a little closer to Earth, about 824 Km up, take composite images of Earth allowing for more detail, taking pictures as they repeatedly orbit the Earth. Since the first satellite was launched in 1957, many have been sent into space to collect data about the Earth. We have progressed from only being able to take photographs of Earth to collecting complex information such as temperature, concentrations of atmospheric gases, exact elevations of land and sea levels, and much more.



Credit: Canadian Space Agency

Remote sensing refers to the collection of data from a distance. Many different types of sensors, on different types of platforms, can be used to observe the Earth from above. Types of platforms that are used to perform Earth observation include drones, airplanes, stratospheric balloons, and satellites. The term “remote sensing” is most often used to imply Earth observation from a satellite.

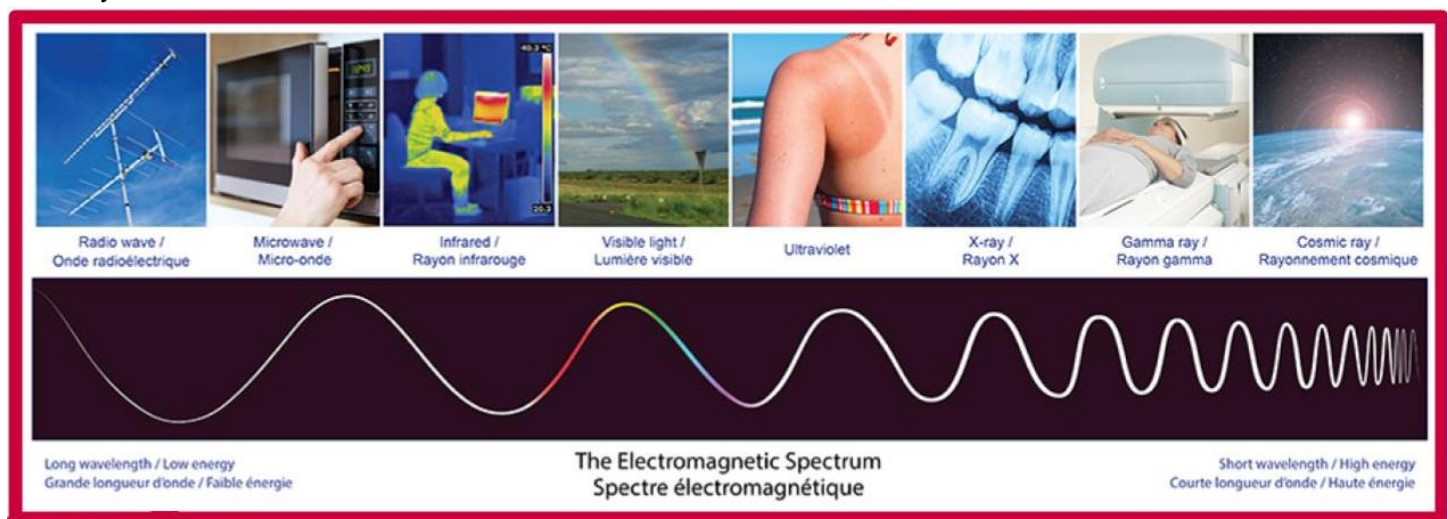
The first Earth observation satellite was a weather satellite called TIROS 1 (Television Infrared Observation Satellite). It was launched by NASA in 1960 and equipped with cameras to take images of Earth’s atmosphere. This led to the development of real-time video surveillance for other purposes, such as geographic observation and military intelligence.

Later, the first satellite devoted to monitoring land - Landsat 1 - was launched by NASA in 1972.

Earth observation (or EO) is the term given to the collection of information about our Earth systems via remote-sensing technologies. EO can include both space-based as well as ground or air-based data.

Canada launched its own Earth Observation (EO) satellite, RADARSAT-1, in 1995 followed by its successor, RADARSAT-2 in 2007. In 2019, the RADARSAT Constellation Mission (RCM) was launched. It consists of three identical satellites that work together to observe Earth as never before. RCM is designed to provide effective solutions in three main areas: maritime surveillance (ice, surface wind, oil pollution and ship monitoring), disaster management (mitigation, warning, response and recovery), and ecosystem monitoring (agriculture, wetlands, forestry and coastal change monitoring.)

Scientists have been asking questions about Earth's systems and collecting data from satellites to study Earth's changing environment for many years. Engineers help design instruments to get the measurements needed to help answer scientists' questions, giving us a variety of instruments used to get the big picture of our Earth system.



Credit: Canadian Nuclear Safety Commission

As was already mentioned, different sensors are used to observe the Earth. Satellites orbiting the Earth carry sensors that measure data using different sections of the electromagnetic spectrum.

Electromagnetic energy travels in waves and spans a broad range, from very long radio waves to very short gamma and cosmic rays. Humans can see only a small portion of the spectrum - this portion is called visible light and is what astronauts and their cameras would observe. Satellites use a broad range of the spectrum to study the Earth. Remote sensing of Earth most frequently uses energy in the visible, infrared (IR), and microwave portions of the spectrum.

- Gamma Rays or Cosmic rays: are not used to study the universe.
- X Rays: are used to photograph and study the sun.
- Visible light: is used to take true colour images of the Earth and its features.
- Infrared: is used to view and track hurricane paths, since it is not affected by cloud cover, and for measurements of the Earth's land and sea surface temperatures.
- The microwave portion of the spectrum is the most useful for Earth observation remote sensing. Microwave instruments are able to sense much longer wavelengths. Microwaves are able to penetrate clouds which can completely block a satellite's view in the visible and infrared spectrums. They are used to observe clouds, precipitation, and water vapour, monitor land and sea surfaces and perform atmospheric profiling of temperature and humidity.
- Radio waves have the longest wavelength and lowest frequency. RF sensors can provide continuous coverage, day and night, irrespective of the cloud coverage. RF remote sensing provides data on weather forecasts, climate change, and disaster management among others.

Supplemental Information

Satellites can include active or passive sensors. **Passive sensors** detect natural energy that is emitted (released) or reflected by the object that is being observed. (For Earth observation sunlight would be the most common source of energy being measured by passive sensors.) **Active sensors** provide their own source of energy to illuminate the objects they observe. The sensor will detect and measure the energy that is reflected back from the target. Different sensors are equipped to measure different parts of the electromagnetic spectrum. For example, our eyes (passive sensors) can only detect wavelengths that are part of the visible spectrum (the colours of the rainbow) but some satellite sensors can also detect ultraviolet and infrared light among others.

Activity: How to Interpret Images of Earth from Space

Learning outcomes

To demonstrate to students how it can be difficult to interpret an image of Earth from space.

Introduction

In recent years, the general public has been lucky to have much more access to photos from space and satellite images. Google Earth and space agencies around the world provide us with images of Earth from space. We can see how cities are changing, the effects of storms in far away places or at home, and even see how crops are growing. Really understanding the images though isn't always as easy as it may seem. Sometimes, without proper context, our eyes can play tricks on us!



“My Wife and My Mother-in-Law” from 1915 is a famous optical illusion showing both a young woman facing away, looking over her right shoulder and an old woman looking down and to the left. The old woman’s nose is the young woman’s side of face and chin. The old woman’s mouth is a choker on the young woman.
(Credit: William Ely Hill, Wikipedia)

Astronauts can be disoriented in space especially at the beginning of their mission. For this reason, they are trained extensively to be able to orient themselves relative to Earth and to identify features. Knowing how to look at the Earth also provides them with an important psychological advantage of remaining connected to home. During their training astronauts are reminded that what they will be recording will be used for scientific purposes and will contribute to research being done around the world.

There are some key tips to help us make sense of what we are seeing.

- **Look for scale** – some images may be very detailed and zoomed in to one specific area while others are the opposite show a wide-angle view of an entire ecosystem.

In this image we could think we were looking at a pond in the Caribbean when in actual fact it is an image focussing on a very large area with one of the Great Lakes (Lake Ontario) in the centre and includes part of Lakes Huron and Erie and shows Chatham, London, Niagara Falls, Toronto, part of Algonquin Park, Kingston and beyond as well as part of NY state including Buffalo, Rochester, Syracuse and Watertown. (Credit: NASA)








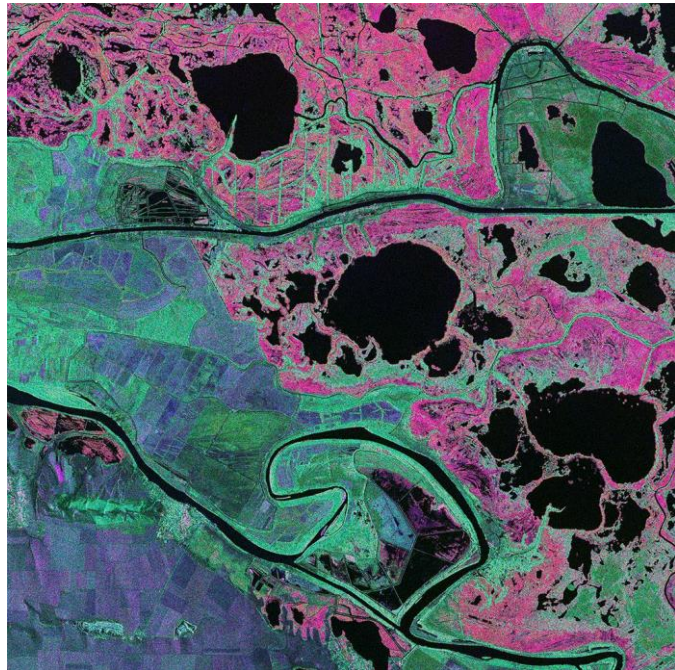
- **Look for patterns, shapes and textures** – bodies of water (lakes, rivers, etc.) are often the easiest to identify; farms will often have regular geometric shapes, geological shapes may be easy to find (circular volcanoes and craters, long wavy lines of mountain ranges).

Credit: Dr. Jiali Shang, Agriculture and Agri-Food Canada

- **Define the colours** – the colour in images will depend on what kind of light the satellite instrument measured. True-colour images use visible light and are similar to what you would see from space. False-colour images incorporate infrared light and may take on unexpected colours – since infrared light is ‘invisible’ to human eyes these types of light are assigned visible colours to represent them. In a true colour image plants are usually different shades of green but land used for agriculture may often be much brighter than natural vegetation. Sunlight reflecting off water makes it look gray, silver or white.

It would be very difficult to tell what you were looking at in this image without a guide to show you the meaning of the colours

	Bog		Fen
	Marsh		Swamp
	Shallow / Open Water		



Credit: Canadian Space Agency

- **Find north** – try to figure out what you are looking at by identifying features and whether other features are north or south of that etc.
- **Consider your own knowledge** – this is probably the most helpful in identifying key features and requires lifelong learning and practice.

Instructions

There are many ways to direct this activity and adjustments can be made by age:

- The activities are on the accompanying slides and can be projected to be completed as a class activity.
- Students can be assigned the activities online through Google Forms.
- Questions can be printed and students can work alone or in groups.
- Images can be used for many different types of activities: describe the image; identify features in the image; etc.



Go Further

- For older students, satellite images can be used to determine distances between features. Instructions to do so can be found on the Natural Resources Canada website. [Measure This \(Northern Saskatchewan\)](#)

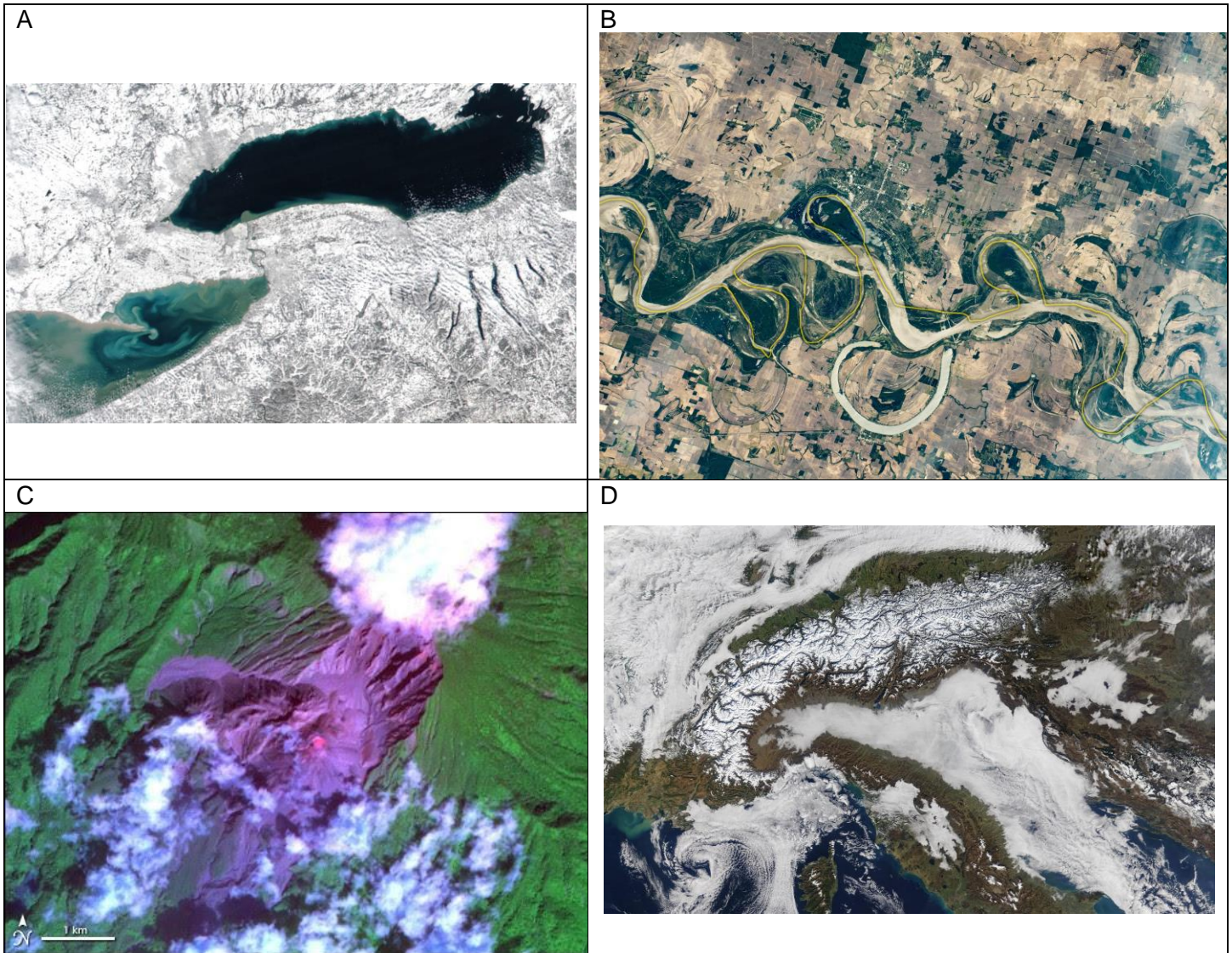
EN: <https://www.nrcan.gc.ca/maps-tools-and-publications/satellite-imagery-and-air-photos/satellite-imagery-products/educational-resources/measure-northern-saskatchewan/measure-northern-saskatchewan/9471>

- Landsat science NASA resources : <https://landsat.gsfc.nasa.gov/outreach/resources>

Interpret the Image

*Comprehensive descriptions of images have been included in this activity to support learning for individuals with low vision or who are blind. These can be removed from your copy if they are unnecessary.

1. Which image shows a large river?



A: A large dark blue area in the top right corner is surrounded by grayish white with another large light blue area in the bottom left corner.

B: A serpentine brown line crosses the picture from left to right surrounded by a brown and green landscape

C: A purple protrusion is surrounded by green hills. There are some white balls of fluff spread out in the bottom portion of the image with a higher density of white fluff in the middle top.

D: Swaths of white seem to cover a green landscape. The central portion of white is branched and resembles a long skinny cauliflower.

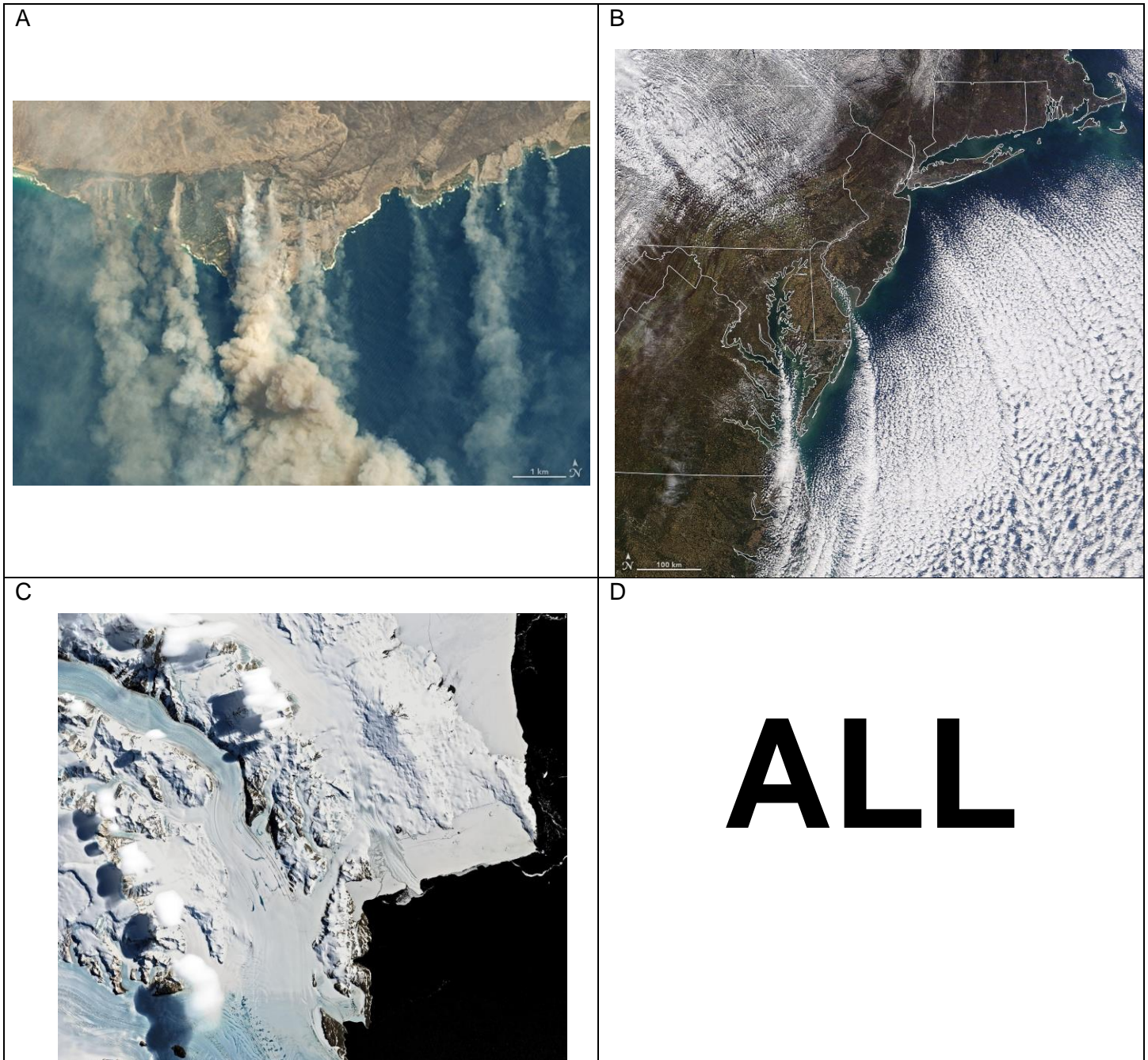
2. What is being shown in this image?



Image Description: the image is all in tones of grey. There are 3 small black circles near the centre of the image. Each hole is surrounded by roundish circles of increasing size in different shades of grey to white. Two more of these grey circular type shapes appear in the bottom left corner of the image. There are wavelike lines adjacent to some of the circles. At the right of the image there is a lighter grey section, with lighter and darker colours within, that seems to be following a stream type of shape.

- A. Unexpected boulders in the desert
- B. Curious circles in Arctic sea ice
- C. Solid cloud cover with unexplained breaks
- D. Crab holes on the beach at low tide

3. Which satellite image shows smoke?



A: Plumes of brownish clouds originating in points on a brown landscape are spreading out over blue water.

B: Plumes of white clouds appear like a blanket with a green coastline visible between them. One of the plumes is over blue water and the other is over green land.

C: Snow and water meet on a coastline in some mountains. There are what look like cotton balls along the tops of the mountain ridges.

D: ALL

4. What are the circles in this image?



Squares and rectangles of varying shades of green cover the landscape. Many of these have distinct circles within them in shades of brown and green.

- A. Golf course with multiple sand traps
- B. Agricultural fields that have had a controlled burn
- C. Agricultural fields with some irrigated using a centre-pivot system
- D. Land that has been strip mined

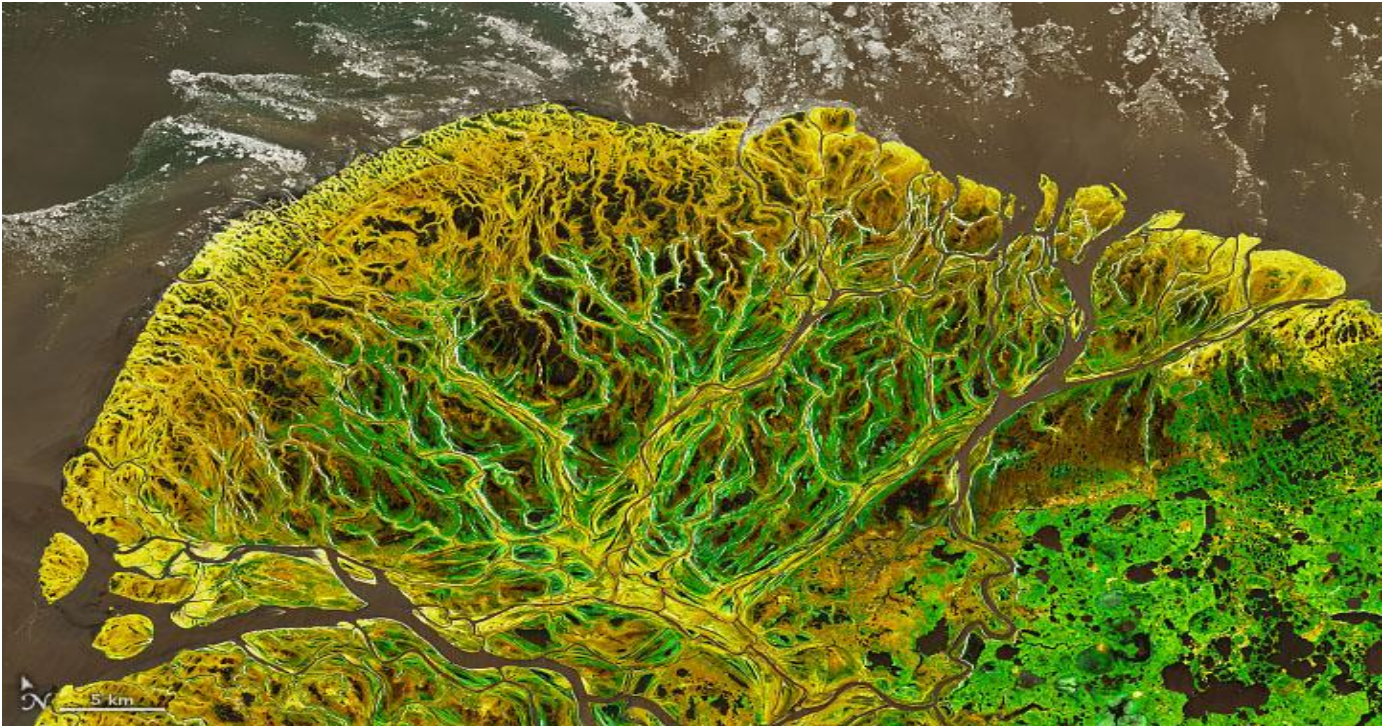
5. What is the grey/silver area in this image?



A grey/silver S shape goes from right to left in the top half of the image. Protruding below this shape are greyer/silver branches that branch off into smaller and smaller branches. Above the S shape is brown and below it, between the branches, is green. There is an icon in the bottom left corner denoting North is towards the upper right corner.

- A. Frost on the ground
- B. Arctic Ice
- C. Water
- D. Sediment from a flood

6. What is represented by the light-brown/ yellowish colours?



The background of the image is a tan/beige with chalky white colours smudged along the top border. Taking up most of the space is a form that resembles a broccoli floret. The beige background is visible through the 'branches' the colours range from bright greens in the centre and bottom right to bright yellow at the tips of the floret branches.

- A. Dead vegetation
- B. Fungus spores
- C. Tree branches
- D. Sponges

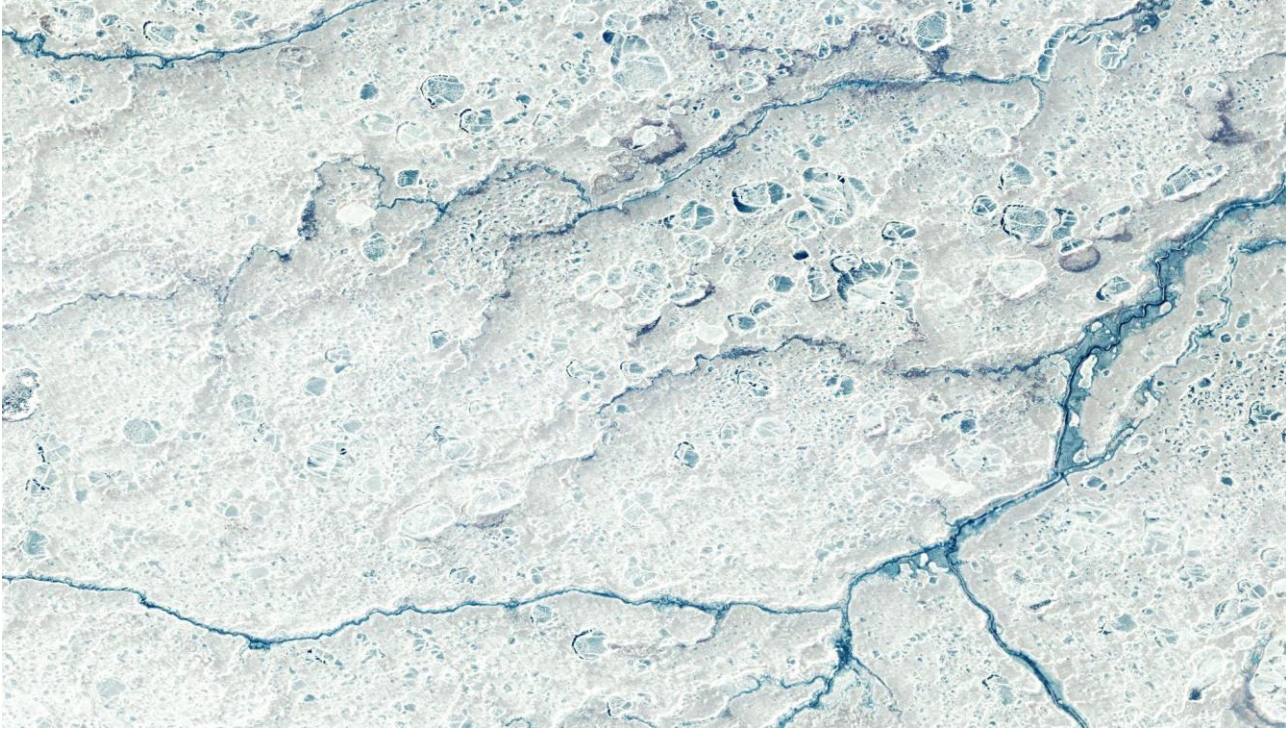
7. What is the red in this image?



A dark background is divided nearly in half, top to bottom, by a squiggly gray line representing the coast line of Iceland along the North Atlantic Ocean. In the centre, left to right, on the land near the coast there is a bright red, cloud type, almost circular area. In the top right of the red cloud is a bright orange line which resembles an upside-down Y.

- A. The sun through the clouds
- B. An erupting volcano
- C. A wildfire
- D. Lightning

8. What is shown in this image?



A mainly white image with veins of turquoise/blue running through it. On closer inspection there are roundish areas that resemble salt crystals which range from being bright white to the same turquoise colour as the linear veins.

- A. Road salt that has dried
- B. Ice covering lakes and bogs
- C. Powdered sugar candy
- D. Dried skin

9. What is shown in this image?



The image is dominated by a light turquoise circular form on a dark blue background. The turquoise circle has a tan and white thin border around most of its entirety with a small portion on the bottom left missing. At this point the dark blue bleeds into the turquoise circle. At the bottom right, inside the turquoise circle, there is a small green/tan oval shape that is also outlined in with the same tan and white thin border.

- A. A crater caused by a meteor
- B. An iceberg
- C. An atoll
- D. A jellyfish

10. What is shown in this image?



- A. An alien with a metal detector
- B. A water treatment facility
- C. A scientific research centre
- D. A diamond mine

Image Credits for “Interpret the image”

1	A	https://earthobservatory.nasa.gov/images/146183/east-coast-snow-and-lake-erie-color
	B	https://earthobservatory.nasa.gov/images/147001/meandering-mississippi-river
	C	https://earthobservatory.nasa.gov/images/7366/santa-maria-volcano-guatemala
	D	https://earthobservatory.nasa.gov/images/91658/snow-and-clouds-around-the-alps
2		https://earthobservatory.nasa.gov/images/92030/curious-circles-in-arctic-sea-ice
3	A	https://earthobservatory.nasa.gov/images/146132/fires-ravage-kangaroo-island
	B	https://earthobservatory.nasa.gov/images/145867/cloud-streets-over-the-atlantic
	C	https://earthobservatory.nasa.gov/images/147772/curious-clouds-in-the-transantarctic-mountains
4		https://earthobservatory.nasa.gov/images/49352/agricultural-fields-near-perdizes-minas-gerais-brazil
5		https://earthobservatory.nasa.gov/images/5988/lake-nasser-egypt
6		https://earthobservatory.nasa.gov/images/148464/yukon-kuskokwim-in-colorful-transition
7		https://earthobservatory.nasa.gov/images/148282/a-curious-case-of-clouds-in-iceland
8		https://www.planet.com/gallery/#!/post/manitoba-20161109
9		https://www.planet.com/gallery/#!/post/kure-atoll
10		https://www.planet.com/gallery/#!/post/diavik-20160921

Solutions to “Interpret the Image”

- B: The winding Mississippi River** - image taken by an astronaut aboard the ISS. The yellow lines have been added to show the current state boundary between Arkansas and Mississippi. April 2, 2020
 Other images:
 - A: The Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite acquired this image. The lower lake is Lake Erie and the upper one is Lake Ontario. The swirls in Lake Erie are in shallow areas where it is easier for wind-driven waves to stir up sediment from the bottom to bring it to the surface. January 20, 2020
 - C: The Santa Maria Volcano in Guatemala. Image taken by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite. The image is made from a combination of light visible to human eyes and infrared light, and shows a hotspot at the summit of one of the volcano's vents (highlighted in red/pink). January 10, 2007
 - D: Image taken by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite of snow cover and low clouds around the Alps. January 29, 2018
- B: Curious circles in Arctic Sea ice**
- A: Fires ravage Kangaroo Islands in Australia**
 Other images:
 - B: Cloud streets over the Atlantic
 - C: Curious clouds in the Transantarctic mountains

- 
4. **C: Agricultural fields with some that have been irrigated using a centre-pivot system**
 5. **C: Water** - In this astronaut photograph taken from the International Space Station, the water of Lake Nasser stands out from its surroundings due to sun glint. The Sun's light reflects off the water's surface and into the camera lens, giving Lake Nasser an iridescent sheen. Sun glint is a common phenomenon in satellite images as well as astronaut photographs. Astronaut photo from the ISS, Egypt January 23, 2005
 6. **A: Dead vegetation** - The vivid landscape is captured in these images acquired with the Operational Land Imager (OLI) on Landsat 8 on May 29, 2021. The images are composites, blending natural-color imagery of water with a false-color image of the land. For example, you can easily distinguish areas of live vegetation (green) from land that is bare or contains dead vegetation (light brown) from the network of sediment-rich rivers and ponded flood water (dark brown). A sprinkling of thermokarst lakes are also part of the scene
 7. **B: An erupting volcano** - Later that night, OLI acquired a false-color image of the same area (right), showing the infrared light emissions from the Fagradalsfjall eruption. Though it is not erupting explosively, the volcanic system has spewed plenty of hot lava since the start of the eruption in late March 2021. Activity from one of the cones intensified in late April, with fountains of lava reaching hundreds of meters into the air.
 8. **B: Ice covering lakes and bogs**
NORTHERN MANITOBA, Canada on Nov 9, 2016 Source: PlanetScope
In Northern Manitoba, autumn ice covers the lakes, rivers and peatland near the shore of the Hudson Bay.
 9. **C: An atoll**
KURE ATOLL, Hawaii, USA on May 12, 2016 Source: PlanetScope
Kure Atoll is the northernmost coral atoll in the world, a former volcano, and the oldest part of the Hawaiian Island Chain still above water.
 10. **D: A diamond mine**
DIAVIK, Canada on Sep 21, 2016 Source: PlanetScope
The Diavik Diamond Mine gouges deep into the sub-arctic tundra of Canada's Northwest Territories. Since opening in 2003, over 100 million carats of rough diamond have been extracted from the mine.

Tracking Changes

1. What is the most significant change you see in these two images?



August 1986 / août 1986



July 2020 / juillet 2020

This slide shows two images of the same location for comparison. The top left quarter of the images area beige with serpentine lines that seem like they are elevated running throughout. Otherwise, the images are dominated by white. In the image on the right some of the white seems broken up or has disappeared. Below where the white was we can see a turquoise blue colour. In the top right corner part of the white seems to have broken up and moved away from the rest.

- A. Erosion of soil due to climate change
- B. Melting of glacier ice
- C. A large section of glacier has broken off
- D. Volcanic ash being washed away

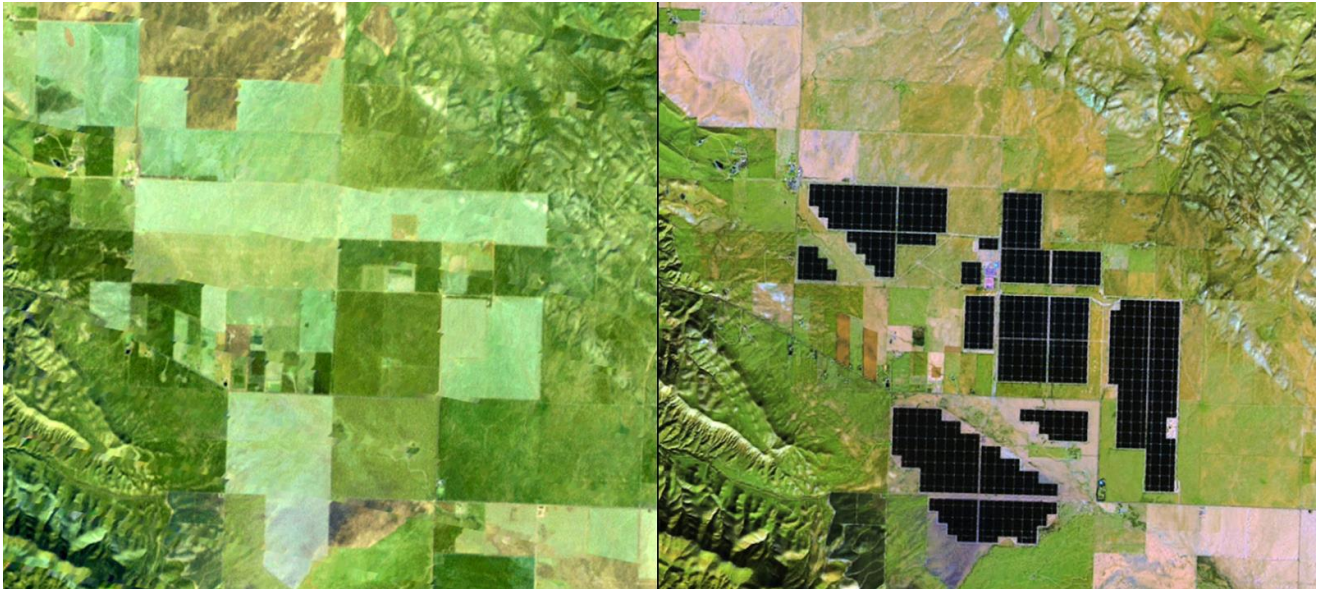
2. What caused the changes in these two images?



This slide shows two images of the same location for comparison. On the left, there is an image of a lake surrounded by hills, with some green fields on the southern shore. On the right, the lake has shrunk by 50%, and the terrain is generally brown.

- A: Drought
- B: Flooding
- C: Hail Storm
- D: Fire

3. What caused the changes in these two images?



This slide shows two images of the same location for comparison. The image on the left shows several green fields, shown as green rectangles of various shapes and shades of green. On the right, the image is partially covered by black squares, which are gathered into five clusters, covering approximately 25% of the image.

A: Construction of an airport

B: Construction of an athletic facility

C: Construction of artificial lakes

D: Construction of a solar farm

4. What caused the changes in these two images?



This slide shows two images of the same location for comparison. On the left, the image shows a hilly, partially forested area, with several small roads that lead into the dark green forested area. In the right image, the area around those roads is no longer green but is now mainly brown.

A: Drought

B: Flooding

C: Christmas tree harvest

D: Construction of a factory

5. What caused the changes in these two images?



This slide shows two images of the same location for comparison. In the left image in the centre of frame, there is an island with a small, dark blue lake in the middle. The island is vibrant green, surrounded by dark blue of the water. More land is visible on the left side of the image, as well as another small island on the right side. In the image on the right, the island is no longer vibrant green but a light brown, and the lake in the centre of the island is a teal colour. There are also many clouds visible in this image.

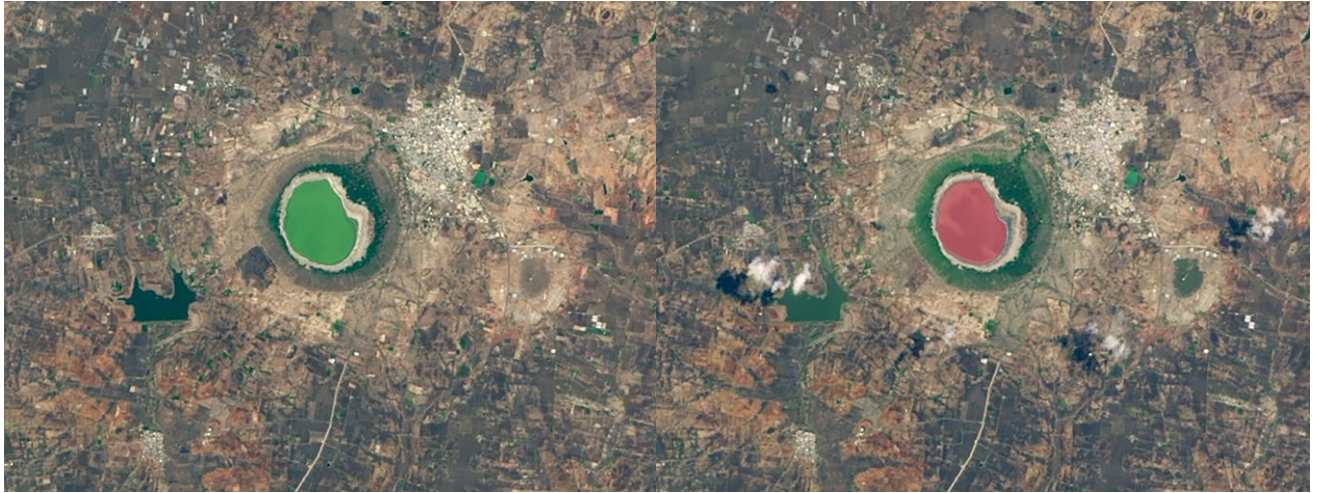
A: Drought

B: Eruption of a volcano

C: Construction of an artificial island

D: Tornado

6. What caused the colour change in the lake?



This slide shows two images of the same location for comparison. In the image on the left, circular bright green area is the main focus. It seems mainly surrounded by dry, brown land with the exception of the area immediately surrounding it which is green with vegetation. In the image on the right, the central circular area is now bright pink.

- A: Increase in microorganisms due to drought
- B: Addition of chemicals to monitor water levels
- C: Congregation of migrating flamingos
- D: Overabundance of shrimp

7. What caused the changes in these two images?



This slide shows two images of the same location for comparison. In the image on the left, we see a coastline of land, which runs diagonally across the frame from the bottom left to the upper right corner. The land is mainly grey, and the water is almost black. The image on the right shows the same coastline, but new islands are visible, which are in shapes like palm trees and the continents of the world.

A: Construction of an airport

B: Alien activity

C: Construction of artificial lakes

D: Construction of artificial islands

8. Which picture depicts the river in the Fall?



This slide shows four images of the same location for comparison.

Upper left image: This image is mainly white with snow cover, with a river winding indirectly from the bottom left corner to the upper right corner. The river is also white, likely with ice.

Upper right image: In this image, the land surrounding the river is mainly brown, with some areas of dark brown. The river is narrow and appears to have some sand banks which are visible above the water in some areas. The water is green in colour.

Bottom left image: In this image, the land surrounding the river is mainly brown, with some areas slightly darker brown than other. The river is narrow. The water is brown.

Bottom right image: In this image, there is some brown land, but the areas closest to the river is green and black. The river is wider than in the other images. The water is brown.

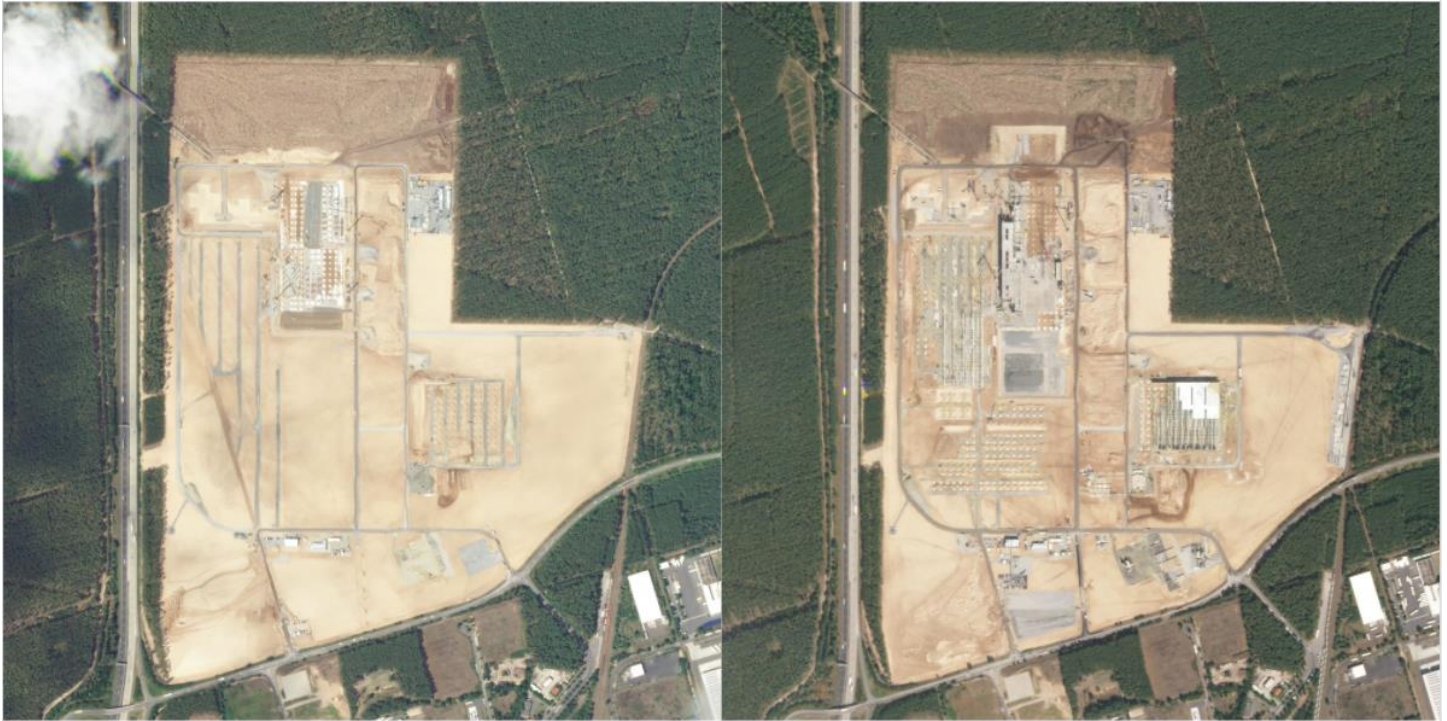
A. A

B. B

C. C

D. D

9. How much time do you think has elapsed between these two images?



This slide shows two images of the same location for comparison. The images appear to be green fields with some roadways running through them. The centre portion of the images is dominated by a sandy coloured L-shaped area. In the left image this area seems to have several gray lines which look like roadways, 5 buildings or so and 2 rectangular areas with white dots inside them. The image to the right seems to have structures built in the areas where the dots were and has 4 more areas with white dots within them. Along the bottom of the image there are now more buildings than in the first image.

- A. Around 6 months
- B. About a season
- C. Around one week
- D. Around one month

10. What caused the changes in these two images?



October 10, 2020 / 10 octobre 2020



April 28, 2021 / 28 avril 2021

This slide shows two false-colour images of the same location for comparison. In the image on the left, the river, which is coloured bright blue, has several islands and points of divergence and convergence. It is a meandering river, cutting across land, which is coloured pink and red. In the image on the right, the river no longer meanders, and is very full. Islands of land are no longer visible in the river, and the river is much wider.

A: Construction of artificial islands

B: Drought

C: Fire


D: Snow melt causing flooding

Image Credits for “Tracking Changes”

1	https://earthobservatory.nasa.gov/images/147350/spalte-splits
2	https://climate.nasa.gov/images-of-change/?id=686#686-chiles-lake-aculeo-dries-up
3	https://climate.nasa.gov/images-of-change/?id=541#541-topaz-solar-farm-installation-california
4	https://climate.nasa.gov/images-of-change/?id=709#709-christmas-tree-harvest-in-ashe-county-north-carolina
5	https://climate.nasa.gov/images-of-change/?id=720#720-taal-volcano-ash-coats-philippine-island-of-luzon
6	https://climate.nasa.gov/images-of-change/?id=740#740-indias-lonar-lake-changes-color
7	https://climate.nasa.gov/images-of-change/?id=467#467-artificial-islands-united-arab-emirates
8	https://www.planet.com/gallery/#!/post/four-seasons-on-the-green-river
9	https://www.planet.com/gallery/#!/post/tesla-gigafactory-berlin-construction
10	https://www.planet.com/gallery/#!/post/rise-and-fall-of-the-brahmaputra-river

Solutions to “Interpret the Image”

1. **C: A large section of glacier has broken off**
The Spalte Glacier (in northeast Greenland) once branched off from its parent glacier, Nioghalvfjærdsbrae, which is the Arctic’s largest remaining ice shelf. In 2020, Spalte completely split off from its parent and crumbled away into numerous icebergs.
2. **A: Drought.** Chile’s Lake Aculeo dries up. This was caused by a lack of rain, caused by climate change and natural cycles in rainfall patterns, along with losses related to irrigation and increased water consumption due to population growth.
3. **D: Construction of a solar farm.** Topaz Solar Farm installation, California. This is one of the largest solar farms in the US and can produce enough electricity to power 160, 000 homes. It has 9 million solar panel over about 25 square kilometers (It would probably take more than 4 hours to walk quickly around the outside edges of the installation)
4. **C: Christmas tree harvest.** These images compare a Christmas tree farm in Ashe County, North Carolina, before and after a substantial number of trees were harvested.
5. **B: Eruption of a volcano.** The Taal volcano, in Taal Lake on the Philippine island of Luzon, erupted on Jan. 12, 2020. During the weeks that followed, wet, heavy ash fell back to Earth, turning the lush green landscape (2019 image) a grayish brown (2020 image). As the ash dried, it hardened from a mud-like consistency to that of cement, damaging most of the island’s crops and other vegetation.
6. **A: Increase in microorganisms due to drought.** Over the span of a few days in June 2020, Lonar Lake in west-central India changed from green to pink. Warm, dry weather had evaporated a significant amount of the lake’s water, leaving salts behind. Scientists speculate that with the increased salt concentration, a rapid rise in the numbers of salt-loving microorganisms caused the color change.
7. **D: Construction of artificial islands.** The city of Dubai is situated along the Persian Gulf in the United Arab Emirates. In 2001, work began to create artificial archipelagos along Dubai’s shoreline. The results are visible in the 2012 image.

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8. **B. Fall.** Over the course of a year, the landscape along the Green River in northern Utah changes dramatically. In spring C, melting snow in the river's headwaters tint the river with sediment. A few months later (D), water overflows the river's banks, invigorating the adjacent wetlands. Low water in the fall (B) exposes sandbars, while winter (A) brings snow to the whole region.
 9. **D. Around 1 month.** The construction outside of Berlin marks Tesla's first major centre in Europe. In these two photos from July 6 to Aug 17, 2020 it is possible to see the transition from building foundations to roofing on the buildings.
 10. **D. Snow melt causing flooding.** The image on the left shows a river in India after it has begun to recede after summer flooding (Oct 10, 2020) the image on the right shows the river as melting snow raised the level (April 28, 2021). Red indicates thriving vegetation, gray and brown means exposed soils and blue indicates water.