STAR*net*

Hands-on

Tested & Approved STEM Activities

Anomaly Adventures

Through the Eyes of a Computer

Activity Guide

STAR*net*

Science-Technology Activities & Resources For Libraries

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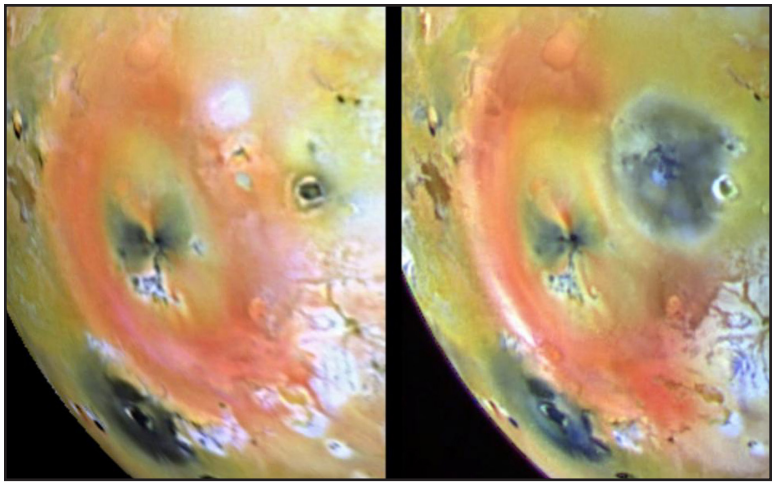
Anomaly Adventures



Activity Time

15-20 minutes

Intended Audience

Families or other mixed-age groups, including children as young as 4 years old *with assistance from an older child, teen, or adult*
School-aged children ages 6 and up
Tweens

Overview

Humans are excellent at spotting the differences between two images, but we need computers to help us explore the universe and study our own planet. Children compare space images to find differences — just like computers use the process of "anomaly detection."

Type of Program

- ☑ Facilitated hands-on experience
- ☑ Station, presented in combination with related activities
- ☑ Passive program
- ☐ Demonstration by facilitator

What's The Point?

- **Computers help us quickly compare information and find the differences (through a process called "anomaly detection").**
- **Earth and space scientists use computer algorithms to find differences in large sets of data — helping us better understand our world and our Universe.**

Facilitator Note: By playing simple "Find the Differences" puzzles, patrons develop computational thinking skills such as breaking down a big problem into smaller, more manageable problems to solve (e.g. comparing small sections of the images rather than looking at the whole image to detect anomalies).

Materials

For each facilitated group:

- ☐ "Find the Differences" images PowerPoint Presentation (download here: http://bit.ly/2Sa0Bjg)
- ☐ Computer and projector
- ☐ 1 copy of the "Find the Differences" images and answer key, printed in color on letter-size paper (below)

For each passive program/station:

- ☐ 1 or more copies of the "Find the Differences" images and answer keys, printed in color (below).

Preparation

Before the activity:

- ☐ For a facilitated program, project the "Find the Differences" image sets using a projector and screen
- ☐ For passive programming or stations, print the "Find the Differences" images sets — make sure you have enough for multiple people (a family, for example) to use them at the same time

Activity

1. Share ideas and knowledge

- Introduce yourself. Help the participants learn each other's names (if they don't already) through an icebreaker activity.
- Display the first "Find the Differences" image on the projector and invite everyone to find as many differences in the images as they can within one minute.
  - After one minute, ask how many differences people found.
  - Ask the participants to describe their process for finding the differences in the images. What strategies did they use?

Modification for Tweens:
For a more age-appropriate introduction activity, consider using the online "Teachable Machine" to demonstrate anomaly detection: https://teachablemachine.withgoogle.com/

- Explain that this exercise was an example of "Anomaly Detection!" Ask the patrons: what is an anomaly?
  - An anomaly is something that is unusual or does not fit the established pattern. It is something different from the rest.

Activity (continued)

- Display the second slide and discuss that the ways in which we detect anomalies have improved over time. We can use our eyes to search for differences between two photos, which takes time, but now we have developed algorithms that do the searching for us using computers!

Facilitator Note:
The process of detecting anomalies involves breaking the image down into smaller parts to compare them. By understanding how our brain recognizes differences, we can then translate that into computer algorithms that can find the anomalies faster and more efficiently! Encourage your patrons to verbalize their process of finding the differences to build this computational thinking skill.

2. Find the Differences!

- Show the "Discovery of Pluto" image to patrons and invite them to search for anomalies.

- Explain that in the past, astronomers compared images to look for anomalies to discover new planets, stars, nebulas, and other celestial objects. For example, Clyde Tombaugh discovered the existence of Pluto by studying pairs of photographs, such as these two. One of the objects appeared to move compared to the more distant stars as it orbited the Sun.

- Continue going through the images. As a group, analyze the images and point out the various anomalies and what they indicate — new planets, changes in landscapes, natural disasters. Notes are included in the PowerPoint presentation for each slide.

PowerPoint Presentation Note:
The slides are intentionally placed in order of difficulty, starting with most easy.

3. Conclude.

Draw on the participants' observations and reflections, and discuss the following questions:

- Describe your process for finding the differences. What are the different steps you take to identify the anomalies?
- Why do we want to detect anomalies?
- What are the real-world applications for anomaly detection? (facial recognition on Facebook, email spam filtering, detecting bank fraud, etc.)
- In what ways do you want computers to help us find differences?

Activity Modification:
This activity would also work great as a passive program where the images are printed as small posters for patrons to "spot the differences" while at the library or to take home. Or, the posters could be set up at different stations for patrons to rotate through.

Background Information

Discovery of Pluto

Clyde Tombaugh was an amateur astronomer with no degree in astronomy. He built his first telescope at the age of 20 in 1928 and used it to make observations of Jupiter and Mars. Tombaugh sent these images to Lowell Observatory hoping to receive feedback from professional astronomers, but he was instead offered a position at the observatory operating their new photographic telescope.

The telescope at the observatory contained a camera that would take two pictures of the sky on different days. Images of far-away stars and galaxies would stay unmoving in the sky, but closer objects could be identified by its "motion" across the sky by comparing their locations in the photos. Tombaugh would study each pair of photographs looking for the movement of objects.

On February 18, 1930, Tombaugh used a "blink comparator," a device that rapidly flipped back and forth between two photographs and noticed movement of an object across the sky. The Lowell Observatory confirmed his observations and announced the discovery of Pluto (now designated as a dwarf planet) on March 13.

Anomaly Detection Today

Newly developed image processing algorithms are being used to analyze archived photographs of distant stars to discover new planets by detecting orbital motion, similar to how Tombaugh and previous astronomers discovered planets. NASA scientists have also been comparing satellite images (see link below) of our Earth to study the rapid changes on our planet in recent years, often caused by urban expansion and climate change.

https://climate.nasa.gov/images-of-change?id=684#684-vavilov-ice-cap-glacier-accelerates

Next Generation Science Standards

Science and Engineering Practices

- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence

Disciplinary Core Ideas

- 4-PS4.C: Information Technologies and Instrumentation
- MS-PS4.C: Information Technologies and Instrumentation
- ESS1.A: The Universe and its Stars
- ESS1-4: Earth's Place in the Universe
- ESS3.C: Human Impacts on Earth Systems
- MS-ESS3-4: Earth and Human Activity

Crosscutting Concepts

- Patterns
- Cause and Effect
- Interdependence of Science, Engineering, and Technology
- Science Addresses Questions about the Natural and Material World
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Computer Science Teachers Association Standards

- 1A-DA-07: Identify and describe patterns in data visualizations, such as charts or graphs, to make predictions
- 1A-IC-16: Compare how people live and work before and after the implementation or adoption of new computing technology
- 3B-AP-08: Describe how artificial intelligence drives many software and physical systems

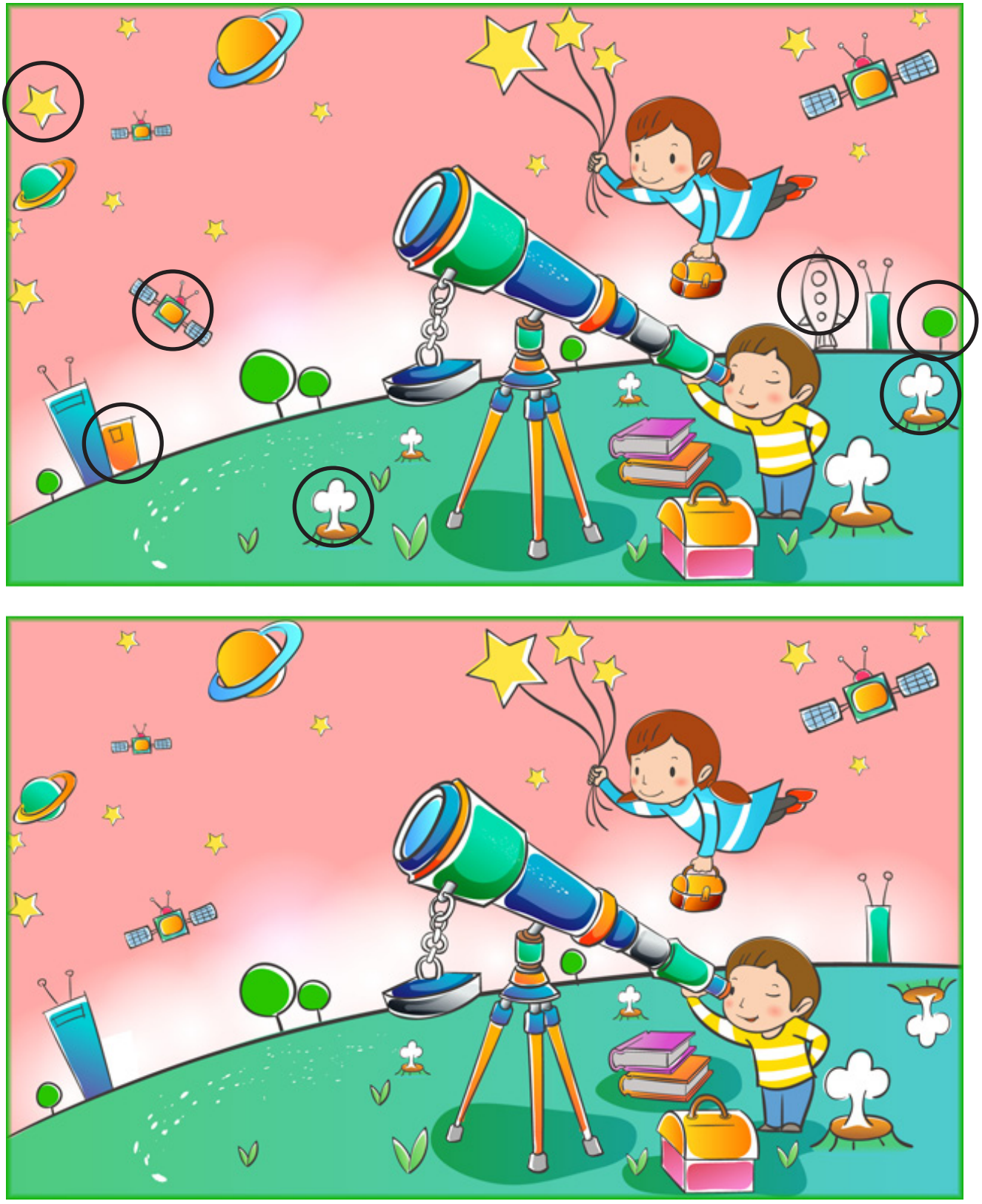
Find the Differences

How many can you find?

What is your process for finding the differences?

Answer Key

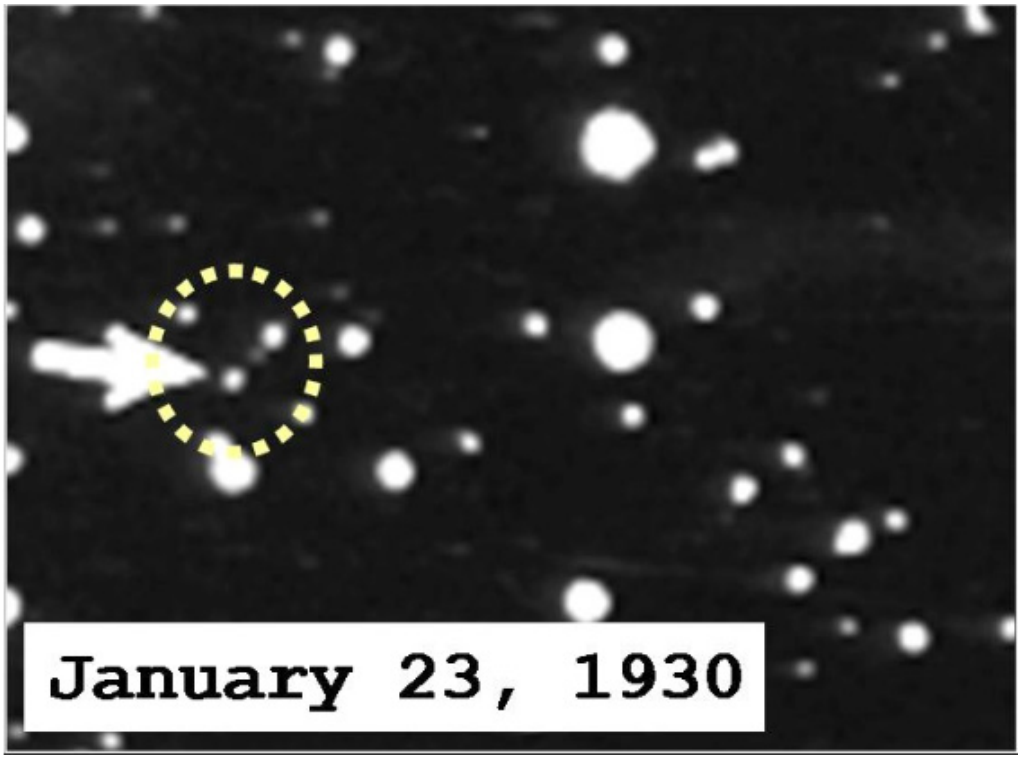
Warm-up Exercise

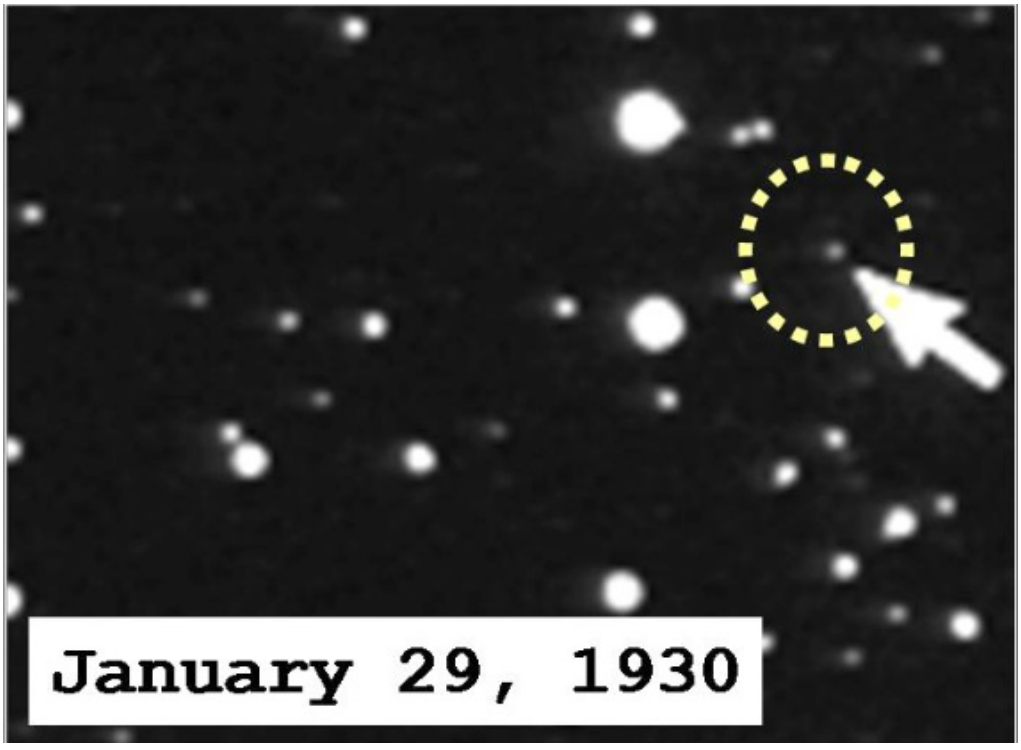


There are seven differences between the two images

Find the Differences

Discovery of Pluto

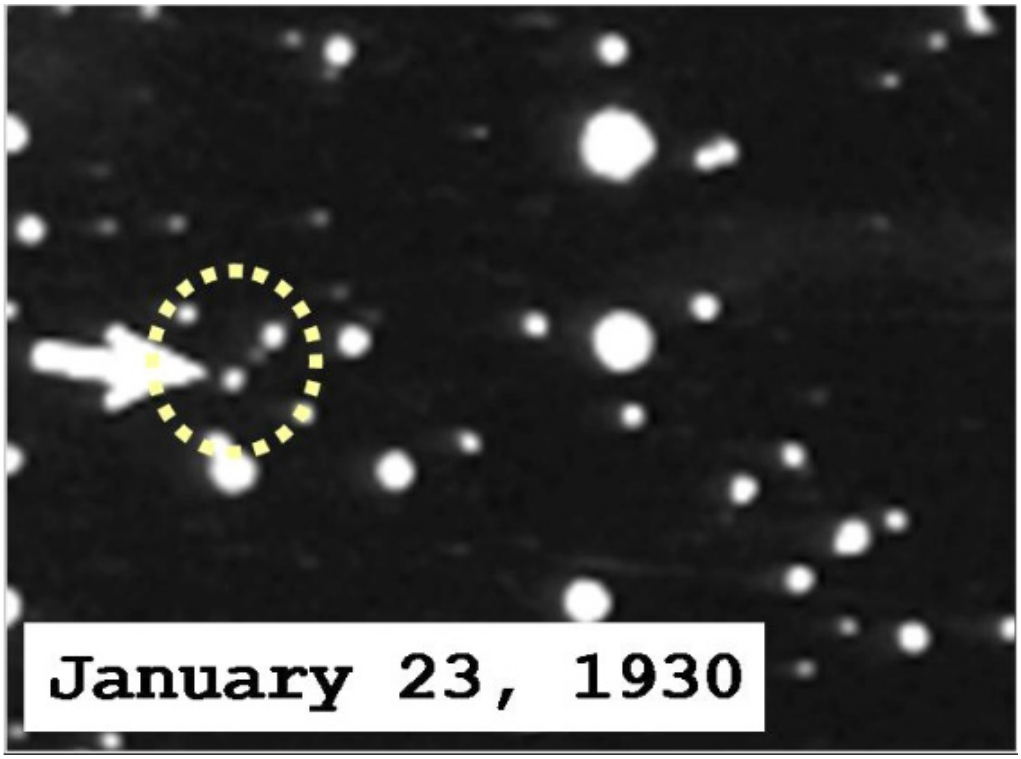


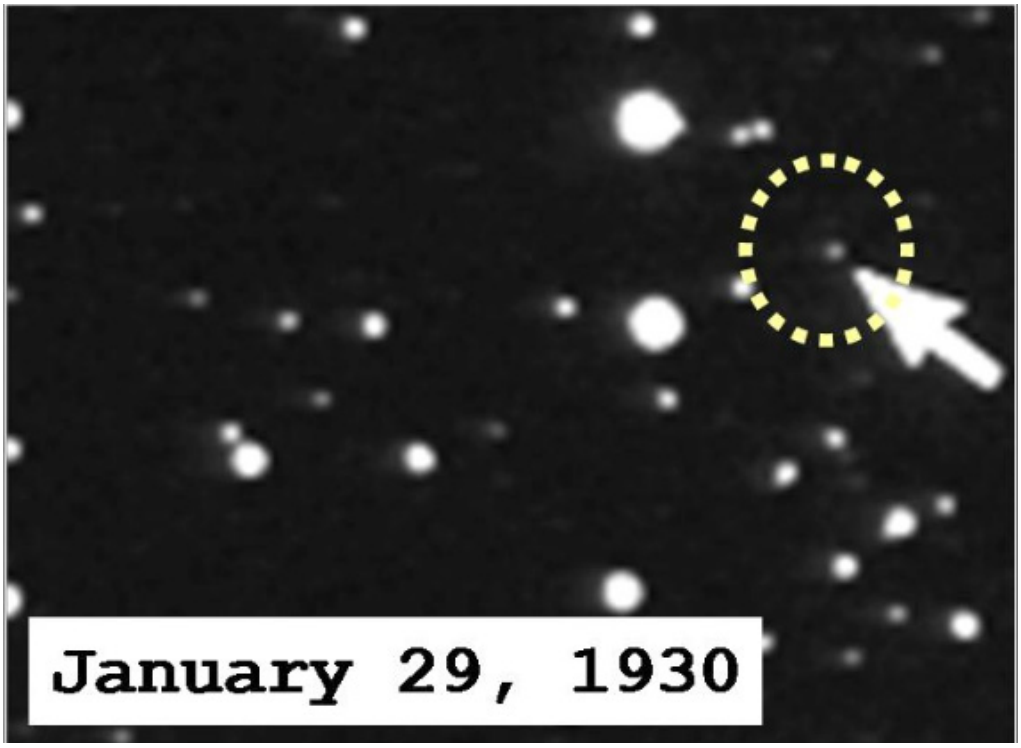


Would you be able to find the difference in these two images without it being pointed out to you? How would you try to discover new planets?

Answer Key

Discovery of Pluto

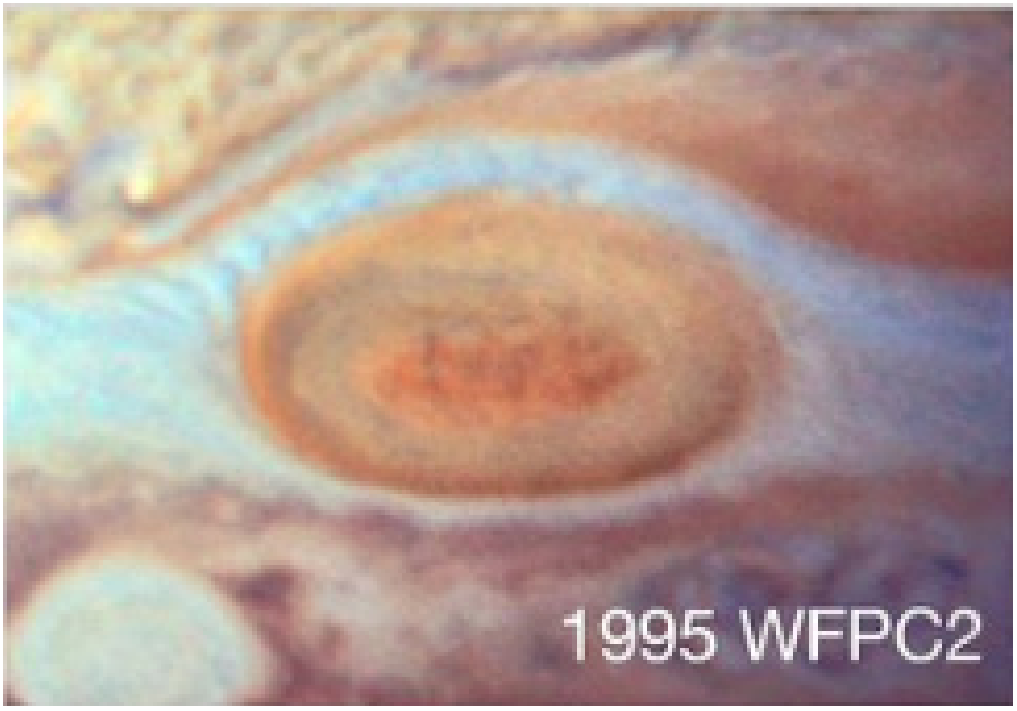


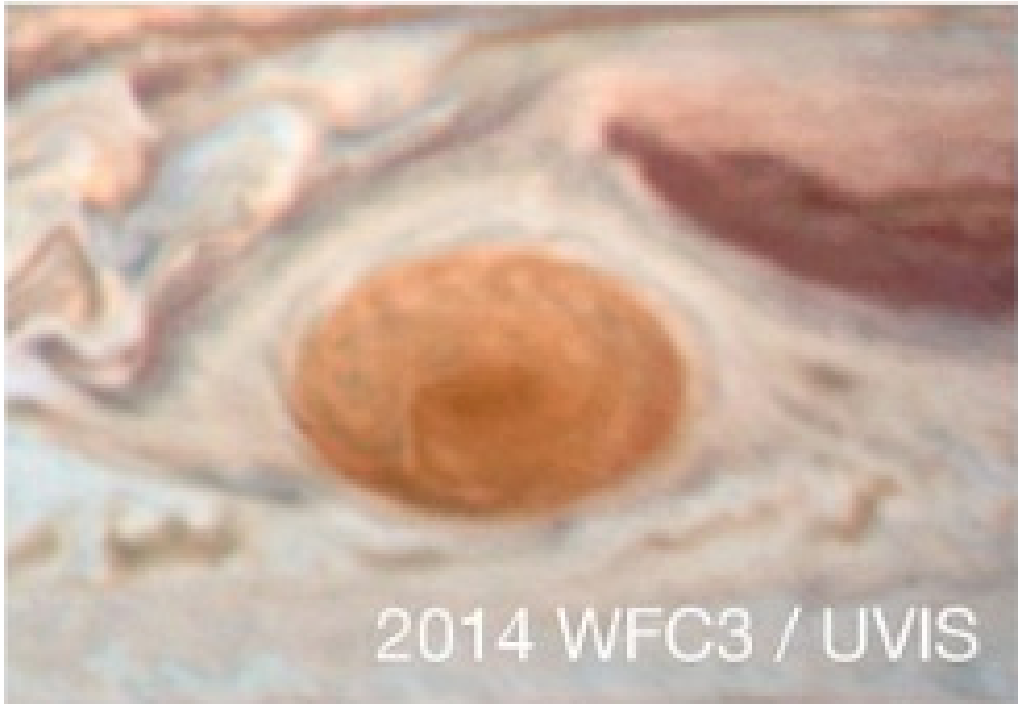


In 1930, Clyde Tombaugh used a "blink comparator," a device that rapidly flipped back and forth between two photographs and noticed an object in the sky changed its location. The Lowell Observatory confirmed his observations and announced the discovery of Pluto (now designated as a dwarf planet). New computer algorithms are being used to analyze old photographs of distant stars to discover new planets by detecting orbital motion, similar to how Tombaugh and previous astronomers discovered planets.

Find the Differences

Jupiter's Great Red Spot

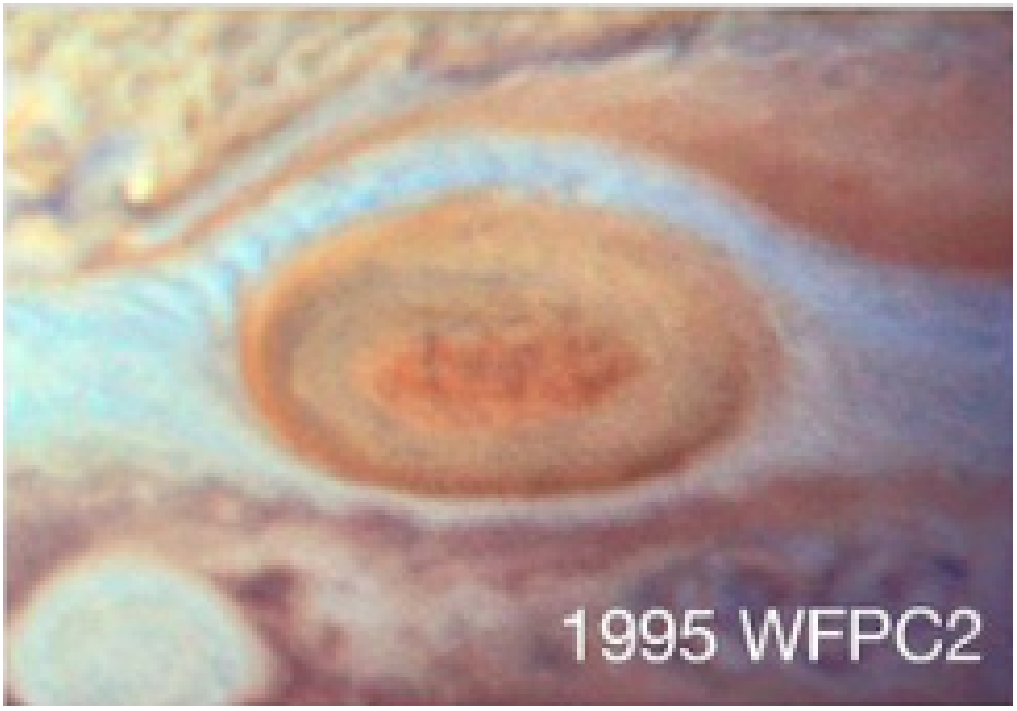




Focus on the Great Red Spot. Has it gotten bigger or smaller over time?

Answer Key

Jupiter's Great Red Spot

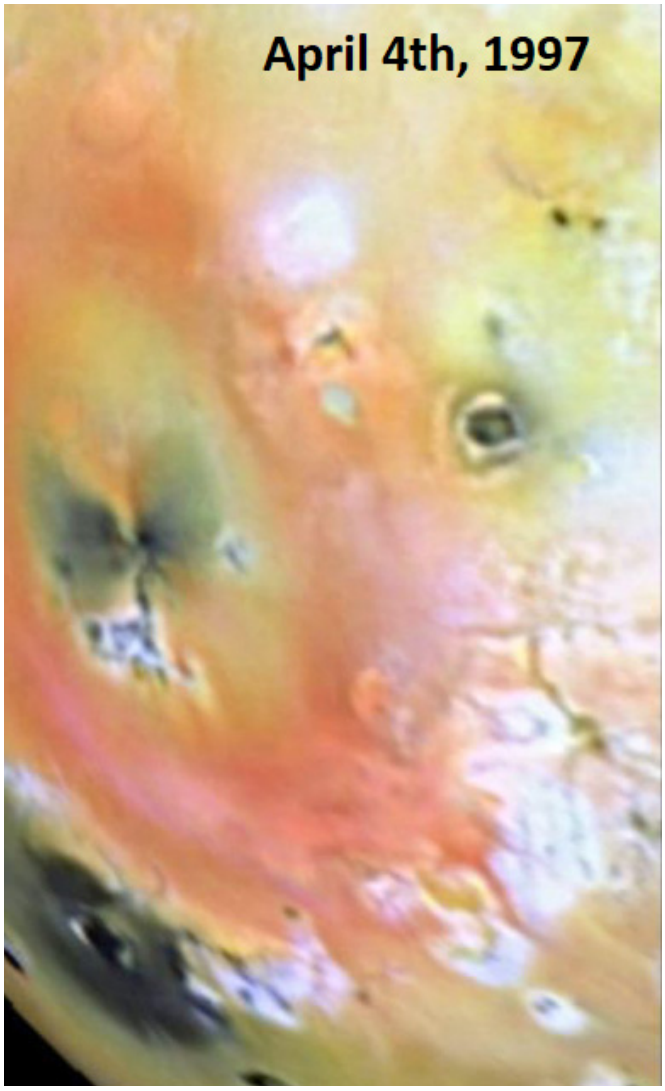


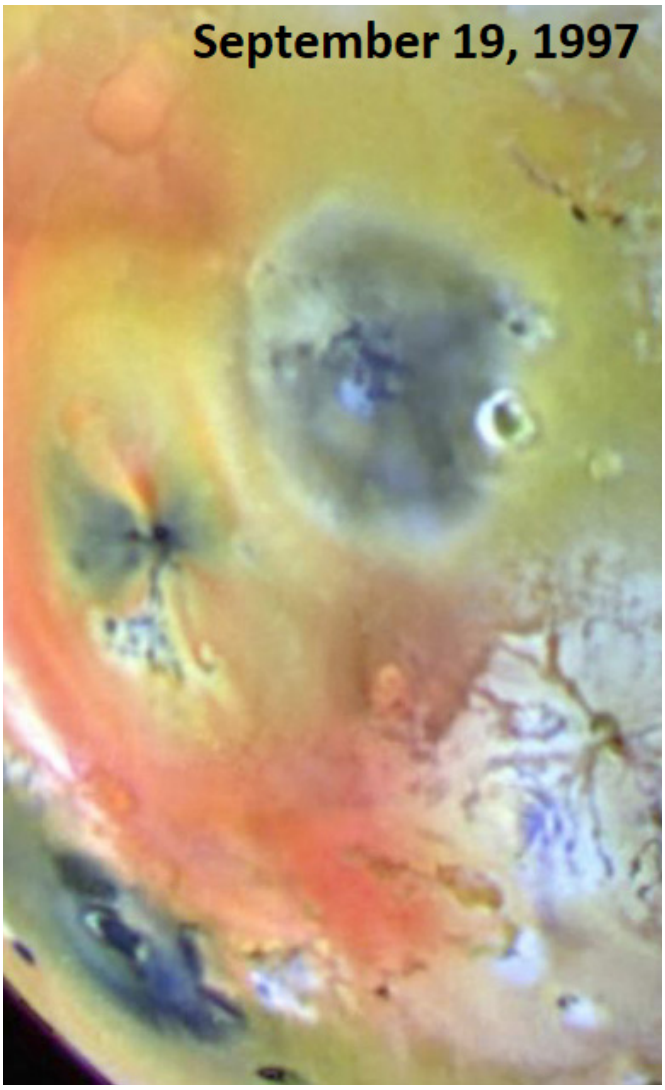
The Great Red Spot has gotten smaller

Scientists have been observing The Great Red Spot since the 1800s. It once was big enough to hold three Earths! Look closely at the Great Red Spot and how it's size has changed from 1995 to 2014…it's getting smaller! Nobody is sure how long the storm will continue to shrink or whether it will disappear altogether. Currently, it is big enough to hold just one Earth.

Find the Differences

Jupiter's moon, Io



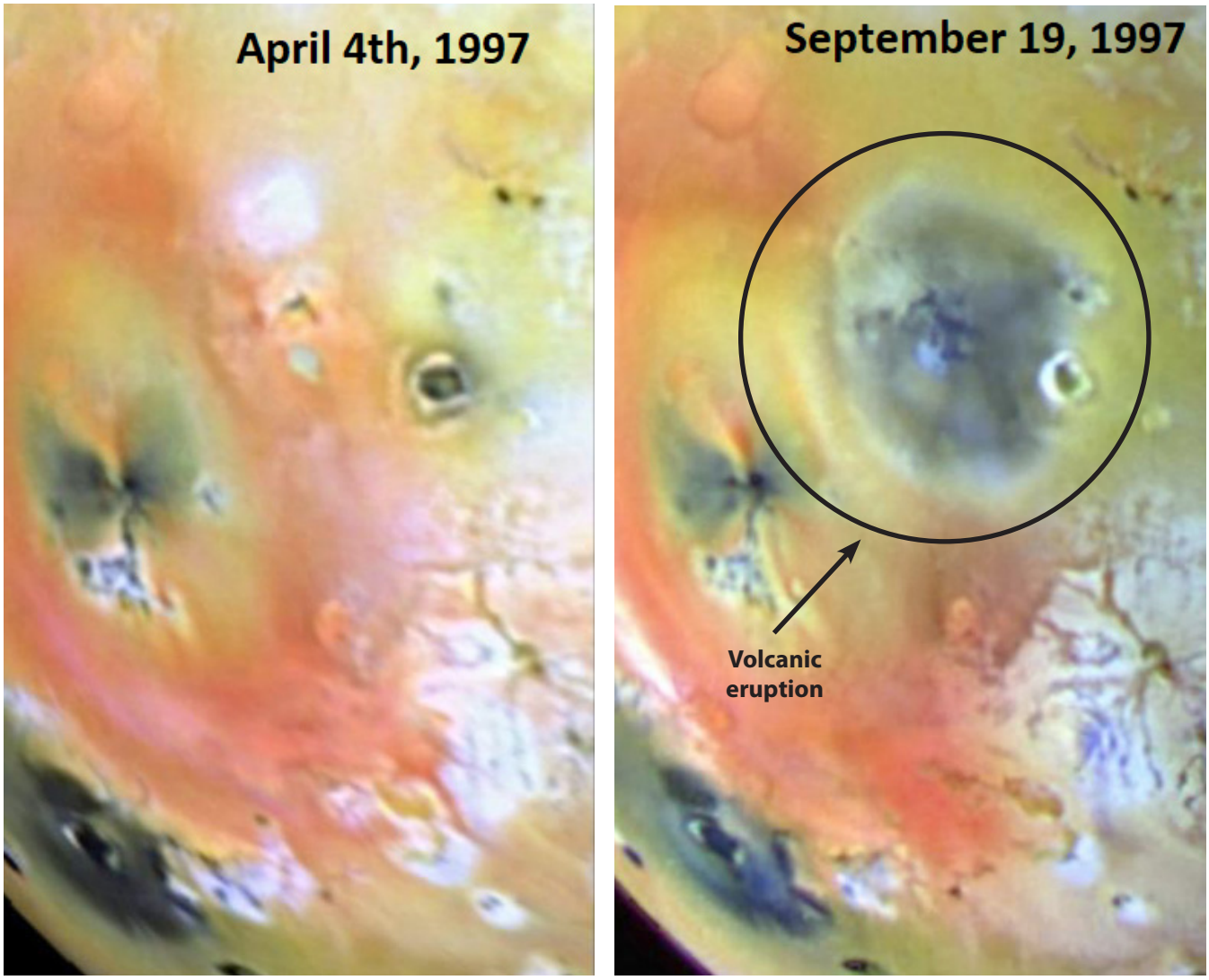


What is the biggest difference you notice between the two images?

What do you think caused the change?

Answer Key

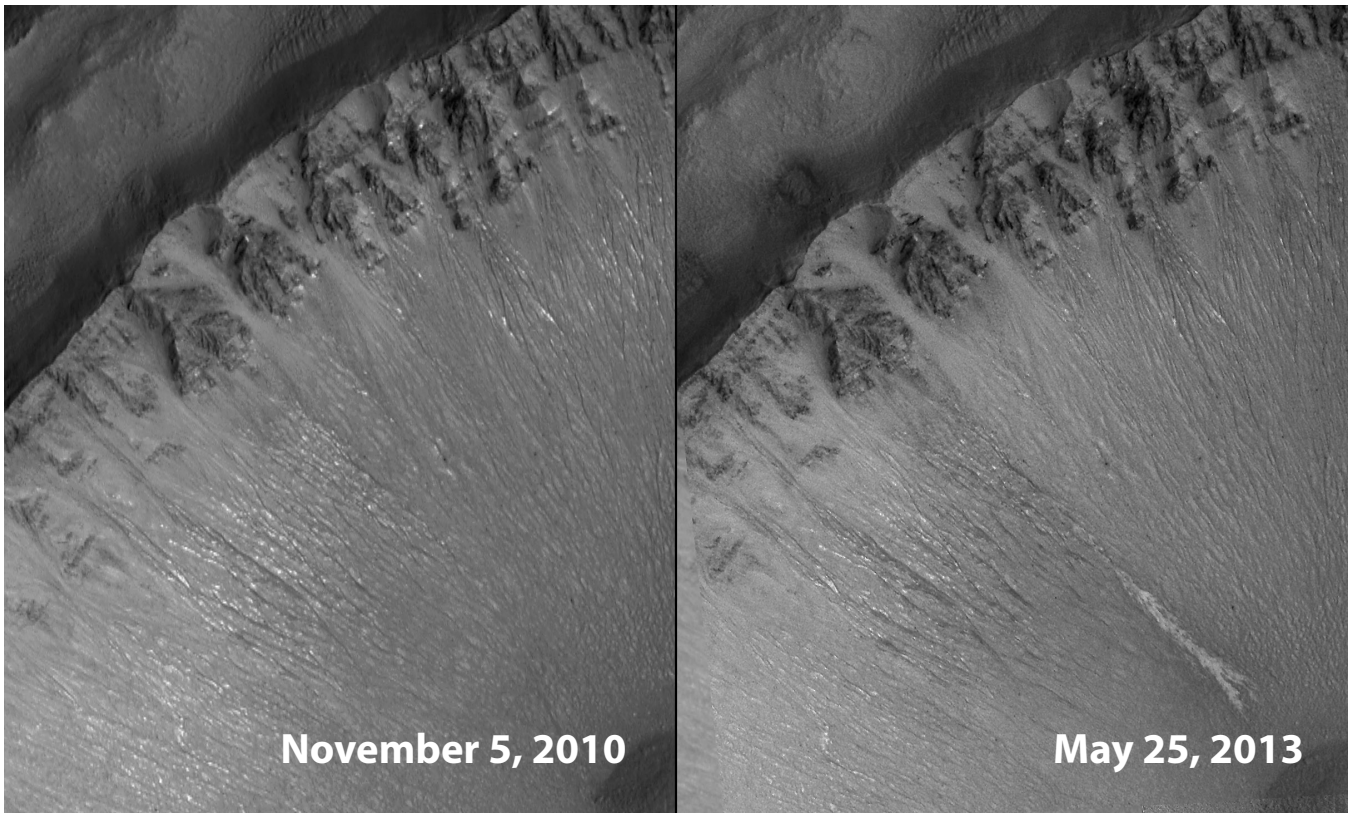
Jupiter's moon, Io



Io is one of Jupiter's moons, and it is the most volcanically active object in our Solar System! The change that you see in the second image was caused by a volcanic eruption.

Find the Differences

Mars

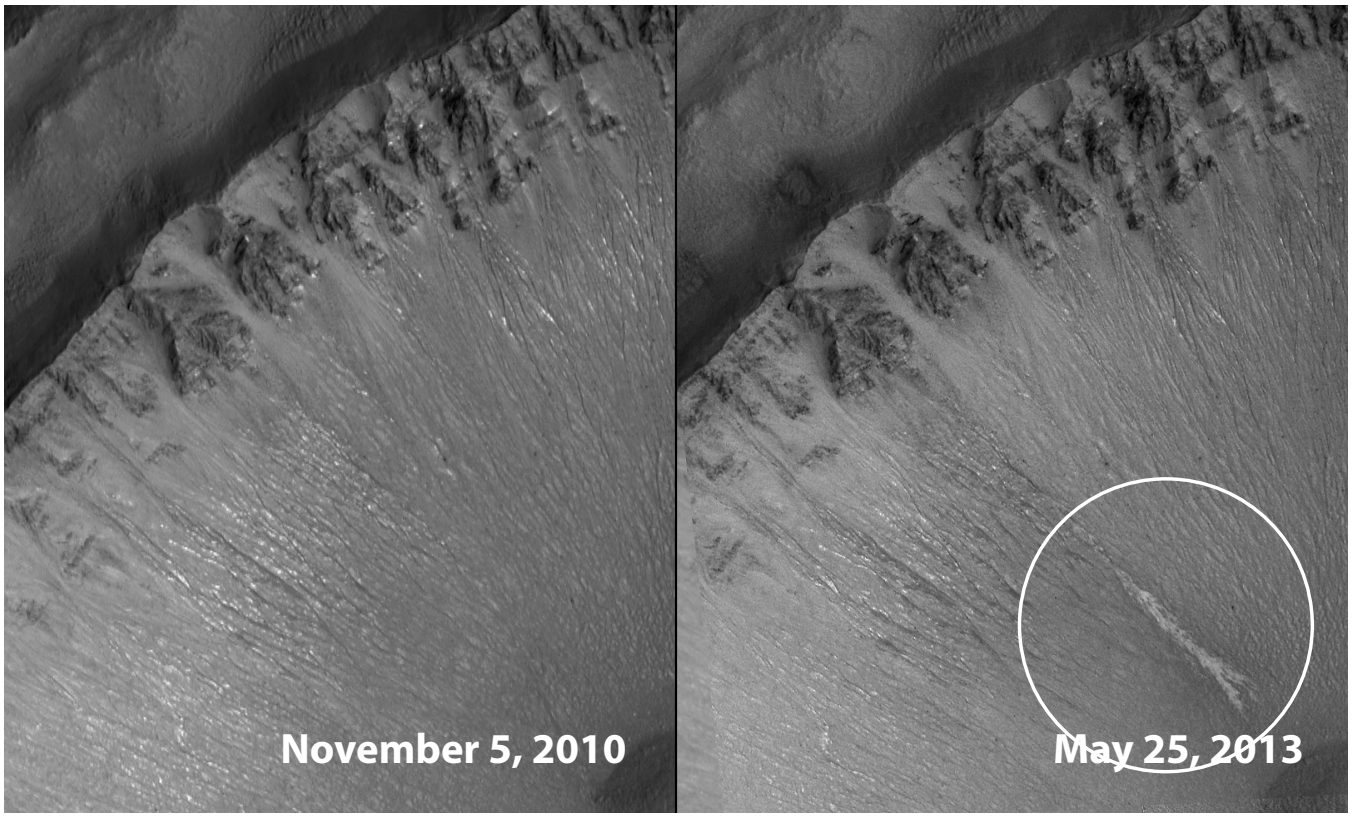


What is different about this crater on Mars?

What do you think caused this change?

Answer Key

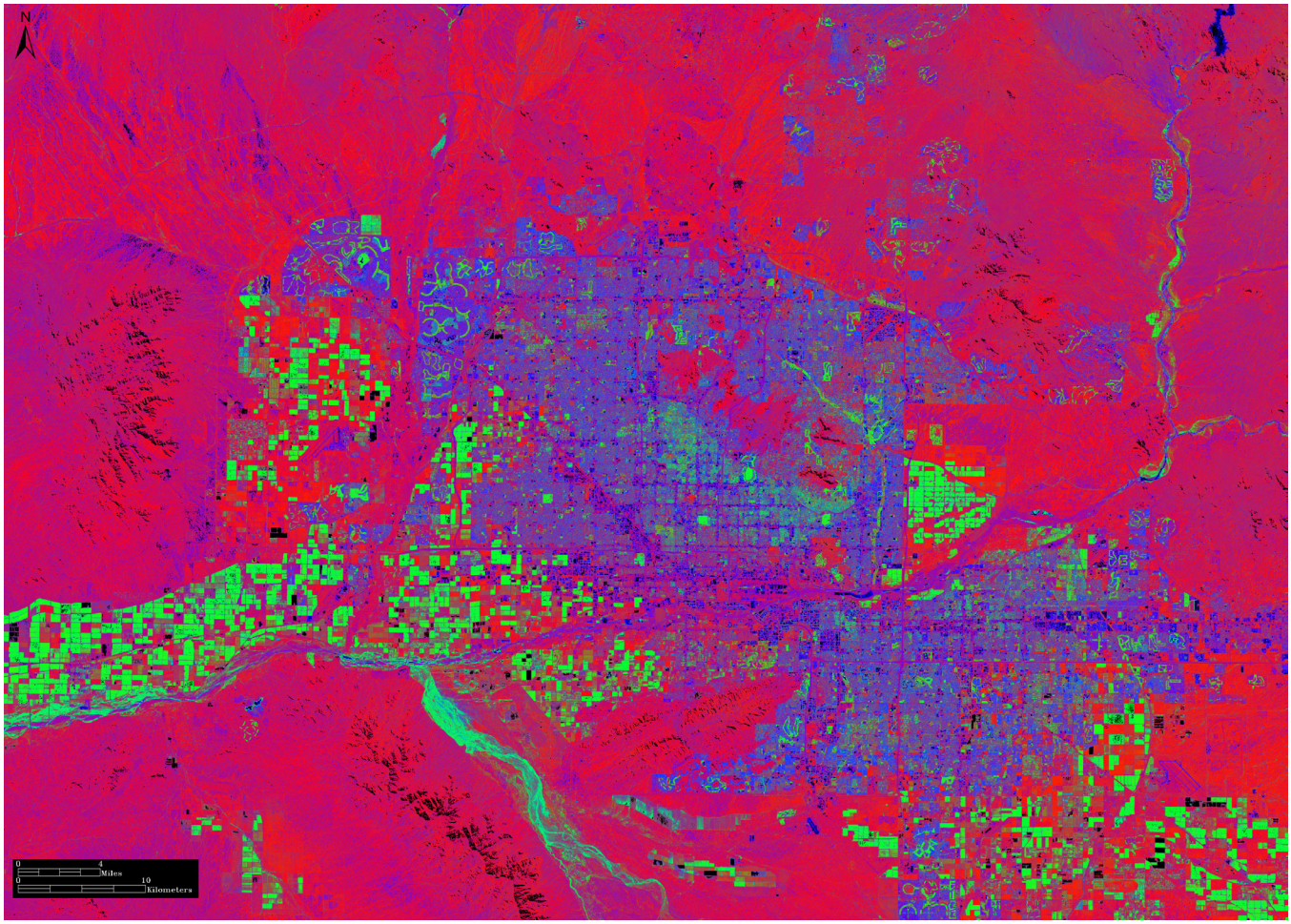
Mars



The mark that appears in the second image is a new gully channel in a crater. Some scientists think fluid cause the erosion.

Find the Differences

Phoenix Heat Map



* This is a false color satellite image using infrared to show heat

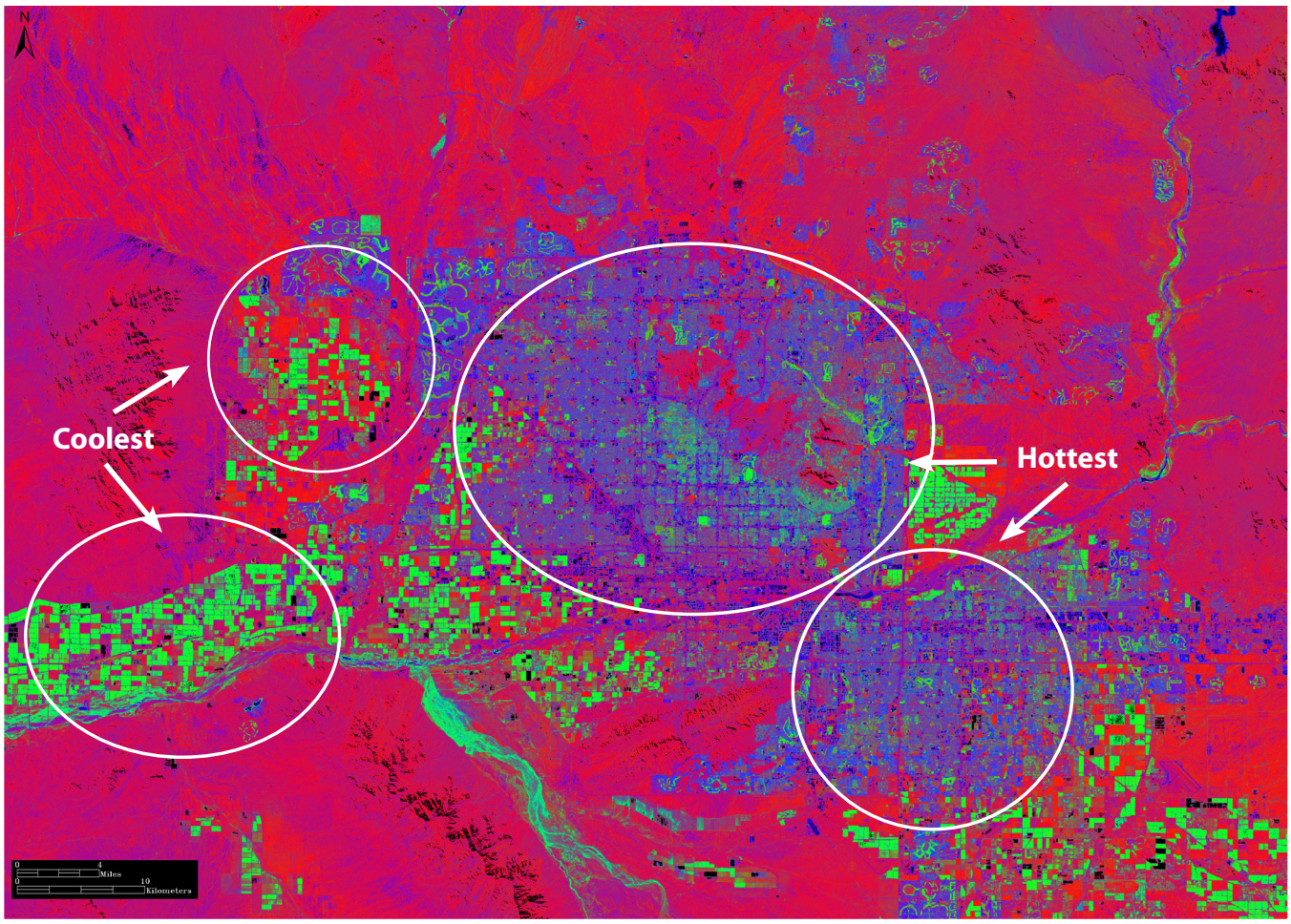
In this heat map of Phoenix, concrete and asphalt have been colored blue, land covered in vegetation has been colored green. Everything that has been colored red is soil.

Where do you think it is the coolest?

Where is it the hottest?

Answer Key

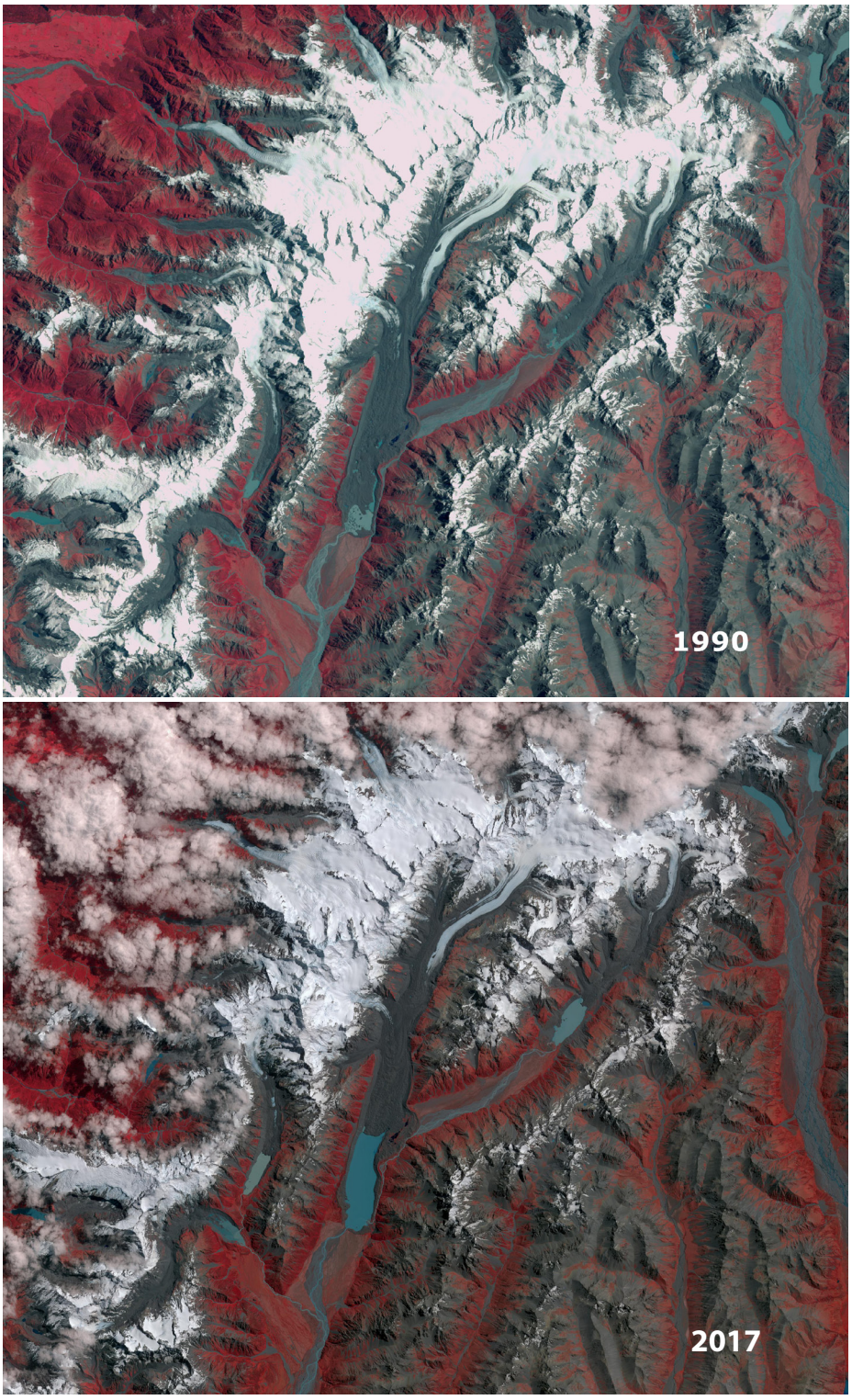
Phoenix Heat Waves



The blue areas (asphalt and concrete) are the hottest and the green a reas (trees and vegetation) are the coolest. The asphalt and concrete absorb heat throughout the day and then reradiate it back at night. People who live in these areas are more likely to get heat-related illnesses or death.

Find the Differences

New Zealand Glaciers

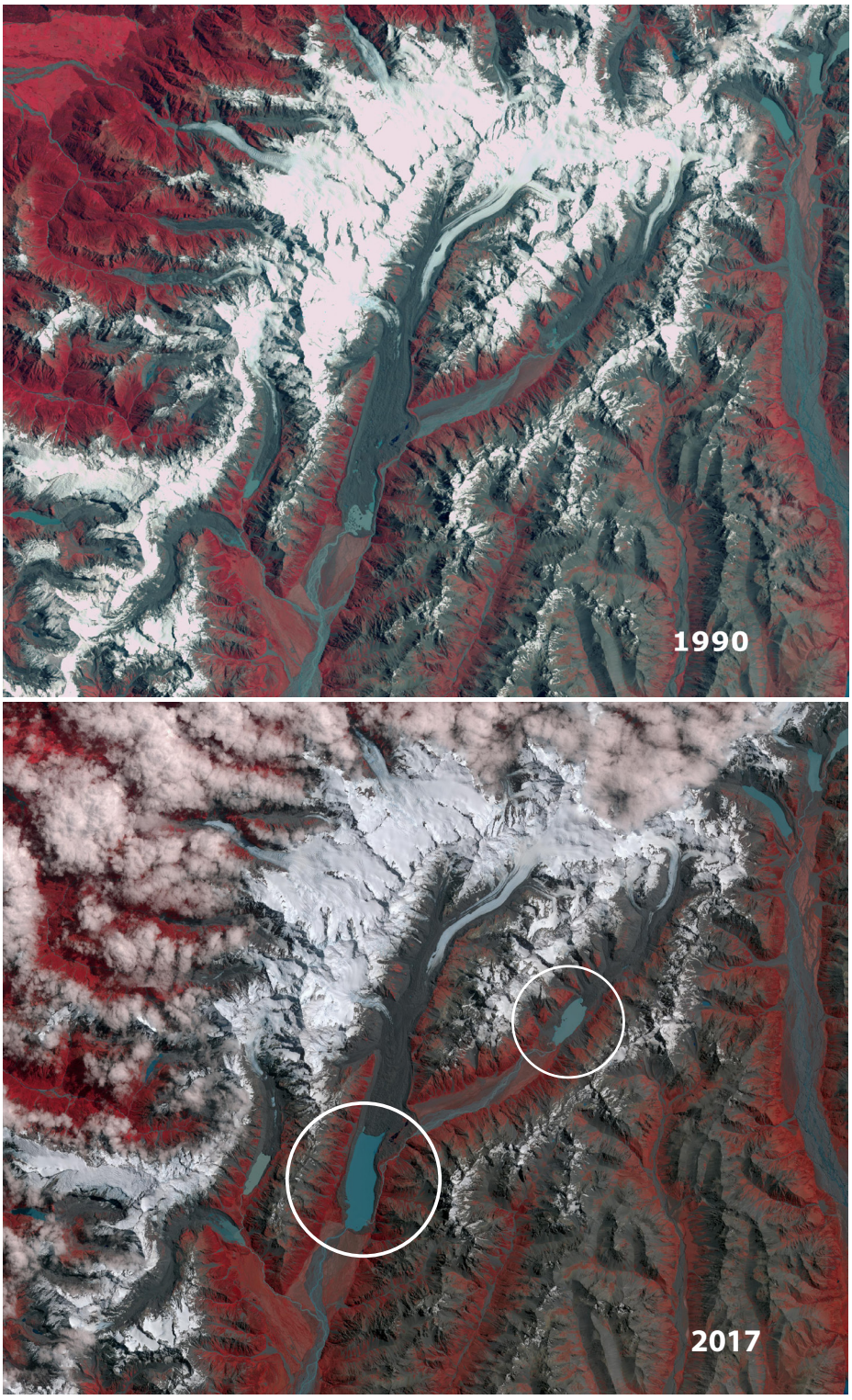


What changes do you notice between these two images?

What do you think caused the changes?

Answer Key

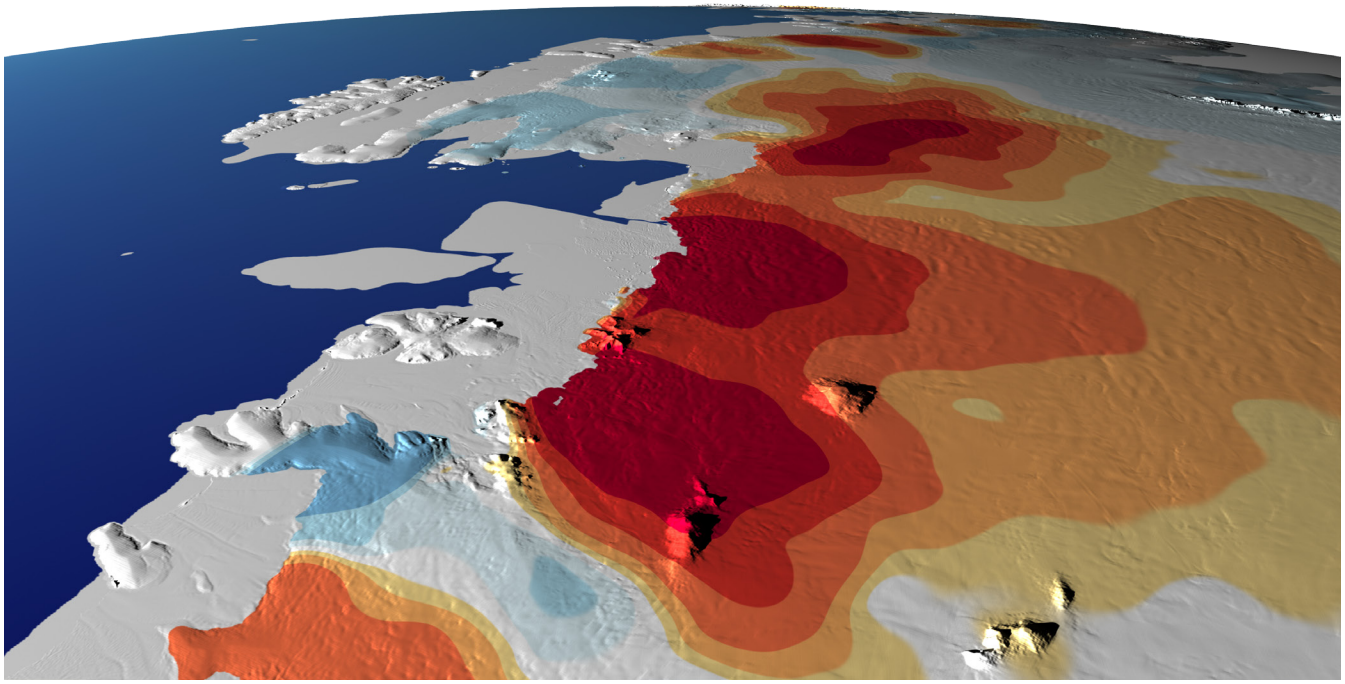
New Zealand Glaciers



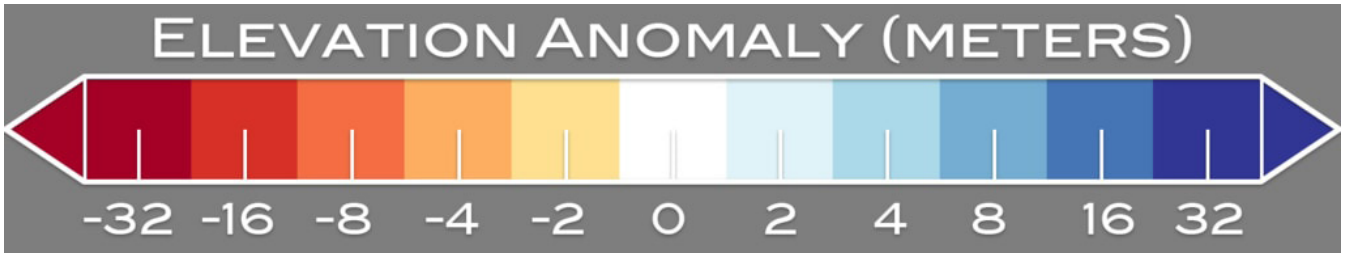
Two lakes appear in the second image where they were not in the first, which means the glaciers are melting. Warmer local and global temperatures cause glaciers to retreat (shrink).

Find the Differences

West Antarctic Coast



* Colors have been changed to show elevation changes

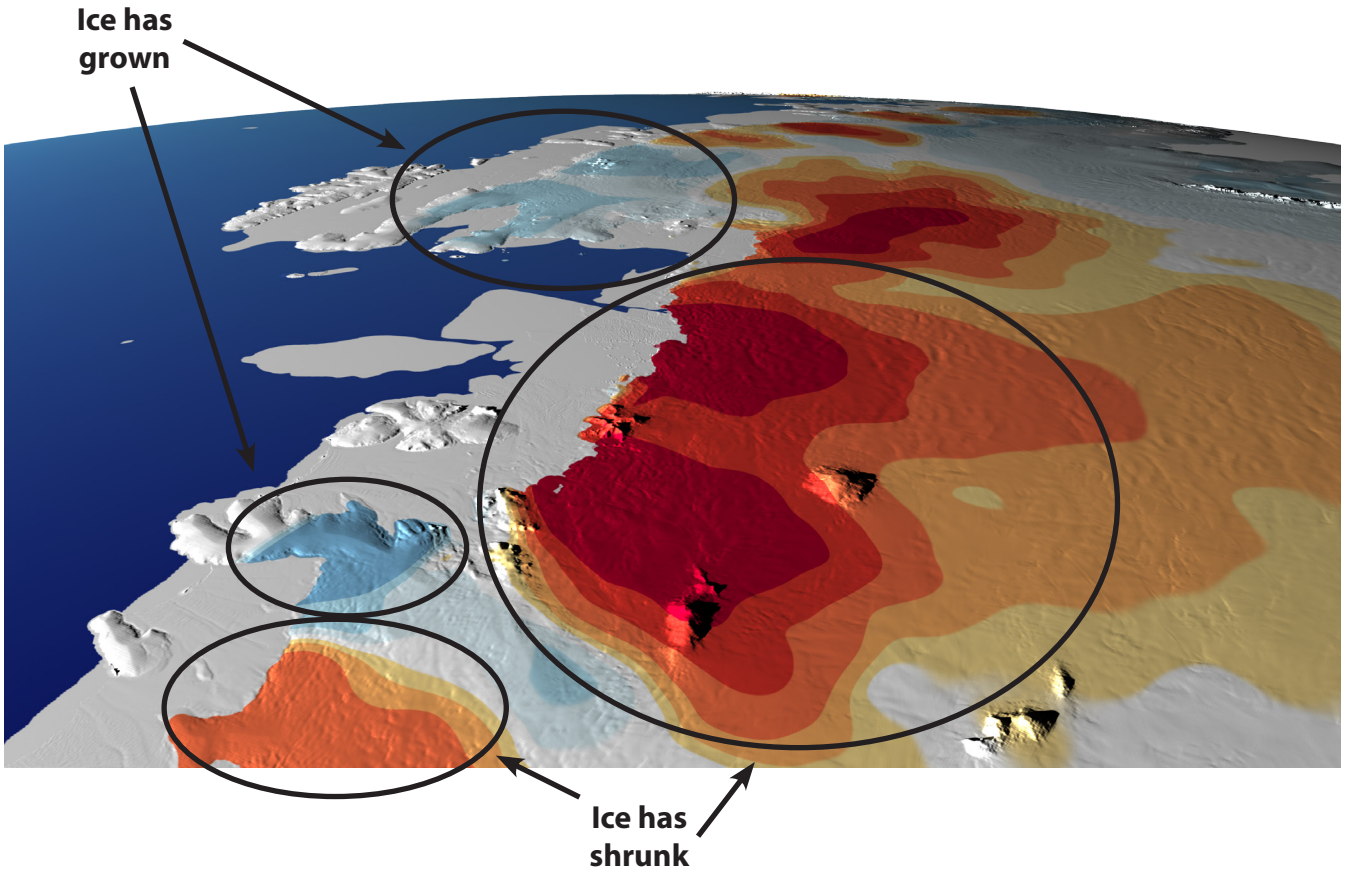


Elevation changes in this area have been mapped over the past 25 years. Color has been added to this map; deep red indicates areas where the ice has dropped in elevation, white indicates no change, and blue indicates areas where ices is growing. Using the scale above, what do you notice about how the ice has grown or gotten smaller?

Why is it important to study these types of changes?

Answer Key

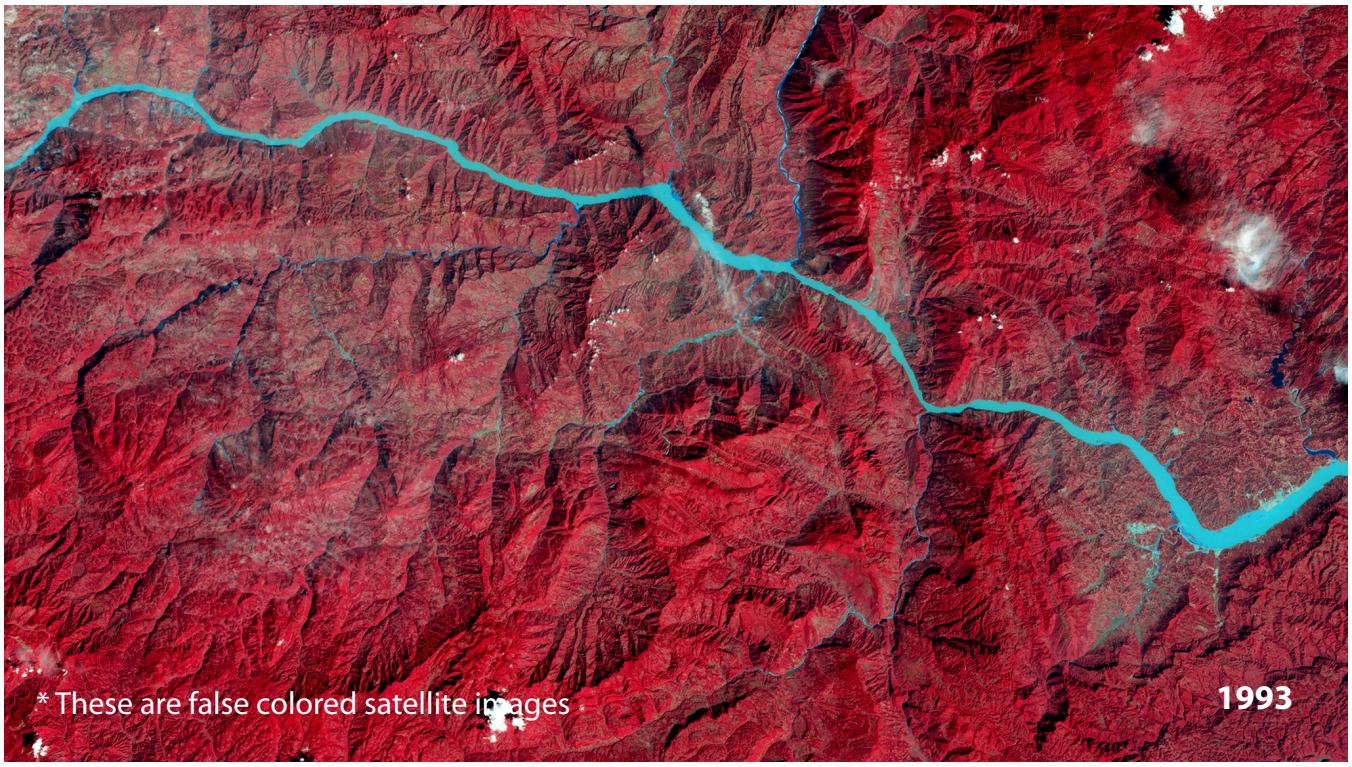
West Antarctic Coast

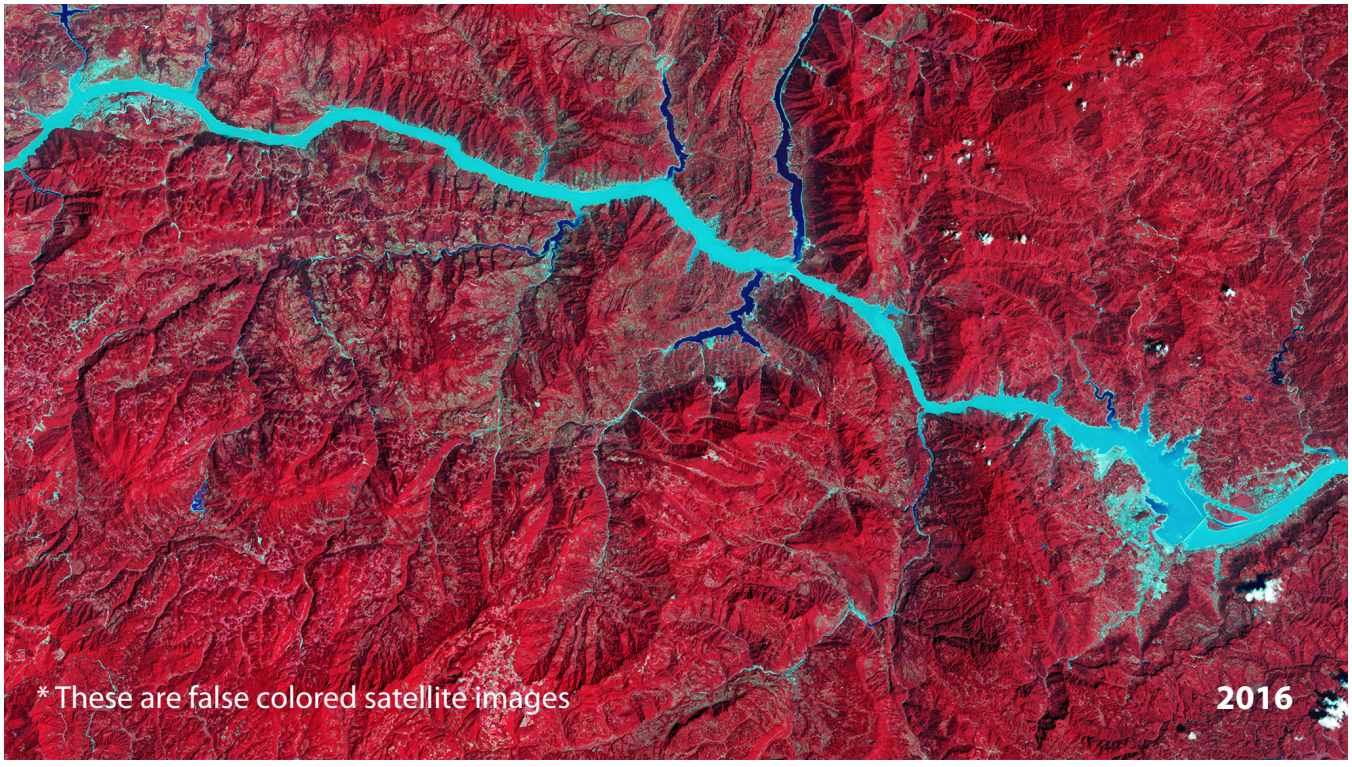


Huge amounts of land ice elevation data has been collected over the past 25 years to track the changes over time. This image shows large areas where the land ice has shrunk. It is important to study these changes so we can make informed decisions about protecting these habitats.

Find the Differences

A River in Central China

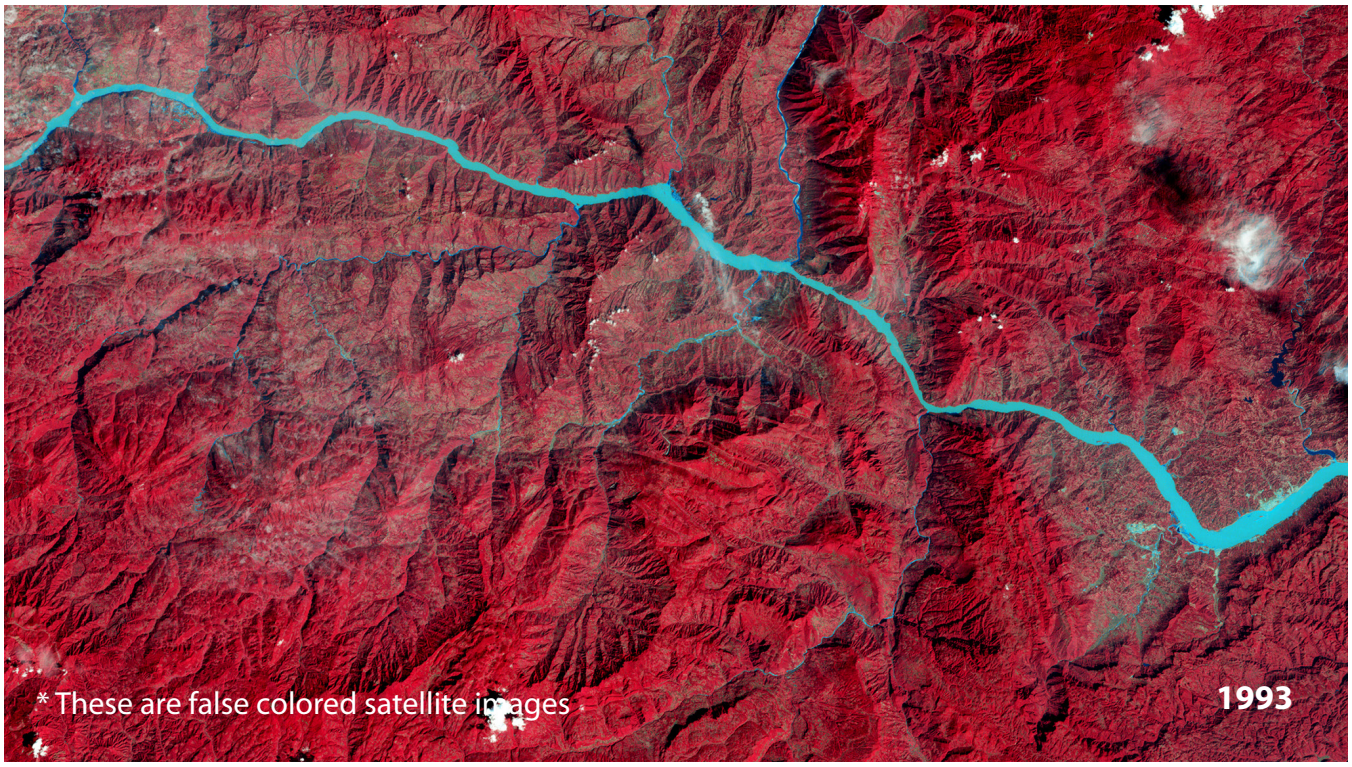


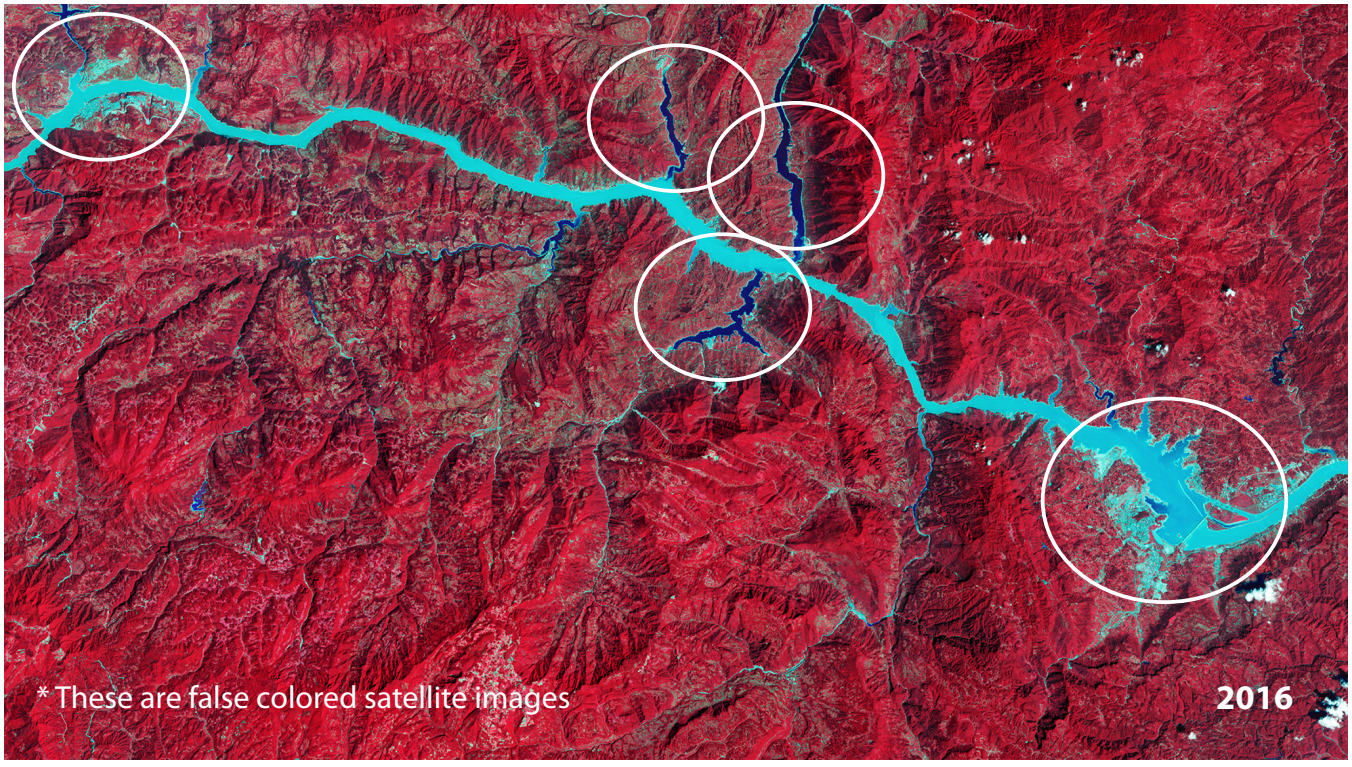


How has this river changed over time? What do you think caused the change? How could this change affect the land and people?

Answer Key

A River in Central China





The Three Gorges Dam was built on this river. Dams can be used to generate hydroelectric power, which provides electricity to communities in the area. However, they also cause destruction of river ecosystems by flooding the landscape.