It's All About Image
Analyzing Thermal Images

Objectives:
Students will be able to :

- describe the difference between a thermal image and a visible light image of the same object or scene.
- determine the warmer and cooler areas of a thermal image by using a temperature scale.
- describe why different parts of the built environment gain and release heat at different rates over the day.
- describe the characteristics of an Urban Heat Island, a nighttime phenomenon.

Author:
Ecology Explorers Education team

Time:
40-50 min.

Grade Level:
6-9

Standards

AZ Science Strands
Inquiry; Nature of Science, Perspectives, Earth and Space Science

NGSS - Core Ideas
Earth's materials and systems; Biogeology; Human impacts on Earth systems; Conservation of energy and energy transfer; Information technologies

Practices
Explanations, and more

Specific AZ, Common Core, and NGSS standards on page 3.

Background:
Infrared is a type of light that we cannot see with our eyes. Our eyes can only see what we call visible light. Infrared light brings us special information that we do not get from visible light. It shows us how much heat something has and gives us information about an object's temperature. Everything has some heat and puts out infrared light. Even things that we think of as being very cold, like an ice cube, put out some heat. Cold objects just put out less heat than warm objects. The warmer something is, the more heat it puts out and the colder something is, the less heat it puts out. Hot objects glow more brightly in the infrared because they put out more heat and more infrared light. Cold objects put out less heat or infrared light and appear less bright in the infrared.

Thermal infrared images are detector and lens combinations that give a visual representation of infrared energy emitted by objects. Thermal infrared images let you see heat and how it is distributed. A thermal infrared camera detects infrared energy and converts it into an electronic signal, which is then processed to produce a thermal image and perform temperature calculations. Thermal imaging cameras have lenses, just like visible light cameras. But in this case the lens focuses waves from infrared energy onto an infrared sensor array. Thousands of sensors on the array convert the infrared energy into electrical signals, which are then converted into an image.

Facts about the Urban Heat Island In Phoenix:

- In the summertime, dark pavement surfaces may reach temperatures of **160°F**.
- Roofs can get to be **190°F**.
- **40%** of the urban surface cover in Phoenix is pavement; only **15%** of Phoenix's urban surface is covered by buildings.
- The average nighttime low temperature in Phoenix has increased by **8°F** over the last 30 years.
- For the months of May through September, the average number of hours per day with temperatures over **100°F has doubled** since 1948.
- Nearly **6%** of peak energy demand in the summer can be attributed to the rising temperatures of the urban heat island.
- In Phoenix, a pool loses the equivalent of its total volume every year through evaporation. Pools lose almost **½ inch of water per day** in June and July.

For more background information go to: https://ecologyexplorers.asu.edu/overview/urban-heat-island

Vocabulary:

infrared radiation - electromagnetic emissions responsible for heat, with longer wavelengths and less energy than visible light, but shorter wavelengths and greater energy than microwaves (from about 0.75 micrometer to 1000 micrometers)

thermographic cameras - devices that capture images of infrared radiation

thermal images - images of infrared radiation captured by thermographic cameras

Urban Heat Island - A metropolitan area which is significantly warmer than its surrounding rural areas. A night time phenomenon of increased temperatures in the Phoenix Metropolitan area.

Advanced Preparation:

Copy worksheets, download and print packets of images for each team.

Images #1: https://ecologyexplorers.asu.edu/docs/explorers/lesson_plans/5a_its_all_about_image_pictures_part1.pdf

Images #2: https://ecologyexplorers.asu.edu/docs/explorers/lesson_plans/5b_its_all_about_image_pictures_part2_sorting.pdf

Materials:

- teacher set of six thermal images
- individual copies of three Student Worksheets: Analyzing Thermal Images, Analyzing Thermal Images - Class Discussion, and Urban heat island KWT Table.

For each team of 2-3:

- Learner Packet 1: five daytime/nighttime thermal images

Recommended Procedure:

Engagement:

1) Show learners the six different thermal images taken of objects with infrared cameras. Hand out Student Worksheet: Analyzing Thermal Images

2) Facilitate a discussion to introduce the concept of thermal images taken by infrared cameras. Example guiding questions are below.

   - What object is depicted in the thermal image? Have students fill in their inferences on their worksheet.
   - How is this thermal image different than a "regular" picture?
   - What do the colors mean?
   - What part of the item in the thermal image is the warmest? The coolest?
   - What special information do these thermal images provide that we don't get from "regular" pictures?

3) Show learners the six thermal images again. Point out to the learners that the colors in each picture are not the same temperature; each picture has its own temperature scale.

   - What information can you get in a visible picture?
   - What information can you get from the thermal image?
   - Comparing one thermal image to another, what different temperatures are represented by the color red? yellow? blue?

4) Distribute Learner Packet 1: five daytime/nighttime thermal images to each team.

Exploration:

5) Learner Packet 1: Provide each team sufficient time to sort the thermal images into daytime and nighttime pictures. Each team will then write on the Student Worksheet - Analyzing Thermal Images the characteristics they used to sort the pictures. Teams will present their ideas to the whole group at the end of this experience.

Explanation:

6) Taking turns, each team will share with the whole group the characteristics they used to sort the thermal images into day and night images.

7) At this point, begin a discussion by first showing the correct matched day and night images to the learners. Hand out the Student Worksheet: Analyzing Thermal Images - Class Discussion and ask students to record their responses to the questions.

The following are possible questions to help students understand the Urban Heat Island.

- Which areas of the daytime images were the warmest? the coolest?
- Which areas of the nighttime images were the warmest? the coolest?
- Which surfaces stayed warmer in the nighttime images?
- Which surfaces cooled off in the nighttime images?
- Which images, night or day, appear the warmest?

- Why do some of the surfaces in the nighttime images retain their heat?
- Based on the images, how would you define the Urban Heat Island phenomenon?

Expansion:

8) Share facts about the Urban Heat Island with the learners from the background information. Encourage learners to fill out the "KWT" table by writing what they KNOW, what they WANT to know more about, and what they want to TELL others about the Urban Heat Island.

Evaluation:

Students will complete the group activities and individual worksheets.

Teachers may design a quiz or game using "mystery pictures".

Suggested questions are:

- Which surfaces in the image have the lowest temperatures? Highest temperatures?
- Is this a nighttime or daytime image?
- What is this image?

Extensions:

- Students can use the WANT column to make a research plan and investigate more about the phenomenon. They may use the TELL column of their KWT chart to create an outline for a report on Urban Heat Island. Then students can turn their outline into a poster, presentation, essay, article or news broadcast.
- Students can use the thermal images to brainstorm many possible impacts of heat in urban environments. Ask the students: How would heat sources in the photos (e.g. a concrete wall, dark glass on car windows) affect the structure and function of 1) living organisms (plants, insects, reptiles, birds, mammals, adults, children, human activities) and 2) non-living parts of the environment (soil, air, water, machines, streets and sidewalks, houses and buildings). Assist students to create graphic organizers symbolizing the relationships they brainstormed using words, shapes and arrows etc. Explain that the relationships are hypotheses, possible explanations. By illustrating these hypothesized relationships, the students have developed a model. Scientists make models to explain aspects of the world and test them by collecting data. (This is similar to the model developed in the Natural and Built lesson in this unit).
- Students can use the thermal images to brainstorm solutions to reduce effects of the Urban Heat Island. Ask the question, "What could you change about this scene to make the surfaces cooler? To make the surfaces radiate less heat at night? How would you go about making these changes?
- Have students read the ASU Chain Reaction magazine article "An Island in the Sun".

http://chainreactionkids.org/files/issues/6/chreact6_p16_19.pdf

- Have students discuss the article in small groups. Name at least two factors that cause the urban heat island. Name at least two factors that cool urban environments. Explain one special challenge for reducing urban heat island effects in a desert. Have students work is pairs, taking turns to describe to each other in their own words the diagrams with arrows on pages 18-19. Select students to share out with the class.

Standards:

Arizona Science Standards

S1-C1-GR5-PO1, PO2
S1-C1-GR6-PO2
S1-C1-GR7-8-PO1
S1-C1-GRHS-PO1, PO2
S1-C3-GR5-HS-PO1
S1-C3-GR5-PO5
S1-C3-GR6-PO2PO3, PO6
S1-C3-GR7-PO2, PO5, PO7
S1-C3-GR8-PO2, PO3, PO8
S1-C3-GRHS-PO1
S2-C2-GR6-7-PO3
S2-C2-GR8-PO1
S3-C1-GR5-7-PO1
S3-C1-GRHS-PO1, PO2, PO3
S6-C2-GR6-PO4
S6-C2-GRHS-PO9

NGSS Core Ideas

ESS2.A: Earth materials and systems
ESS2.E: Biogeology
ESS3.C: Human impacts on Earth systems
PS3.B: Conservation of energy and energy transfer
PS4.C: Information technologies and instrumentation

Practices

Asking questions
Using models
Analyzing and interpreting data
Constructing explanations
Engaging in argument from evidence
Obtaining, evaluating, and communicating information

Crosscutting Concepts
Patterns
Cause and effect
Scale, proportion and quantity
Systems and system models
Energy and matter; Flows, cycles, and conservation
Stability and Change

Common Core/ELA Literacy
RST7: Integrate content from diverse formats
SL1: Participate in collaborations and conversations
SL2: Integrate oral information

Common Core/Mathematics
Domains:
Number and Quantity
Measurement and Data
Math Practice 5: Use appropriate mathematic tools strategically.

Student Worksheet (#1)
Analyzing Thermal Images

Your instructor will show a series of images. Try to determine what the objects are in each image. Write your inferences below.

1._____

2._____

3._____

4._____

5._____

6._____

You will receive a packet of images. Sort the images into **Daytime** and **Nighttime**.

List the characteristics you used to put your images into the two categories.

Day **vs.** **Night**

Student Worksheet (#1)
Analyzing Thermal Images

You will receive a packet of images. Sort the images into **Daytime** and **Nighttime**.

List the characteristics you used to put your images into the two categories

Day	Night

Student Worksheet (#2)
Analyzing Thermal Images-Class Discussion

Based on the correctly sorted images and class discussion, answer the following questions.

1. Which images, night or day, appear warmer?

2. Which areas of the daytime images were the warmest?

3. Which areas of the daytime images were the coolest?

4. Which areas of the nighttime images were the warmest?

5. Which areas of the nighttime images were the coolest?

6. Which surfaces stayed warmer in the nighttime images?

7. Which surfaces cooled off in the nighttime images?

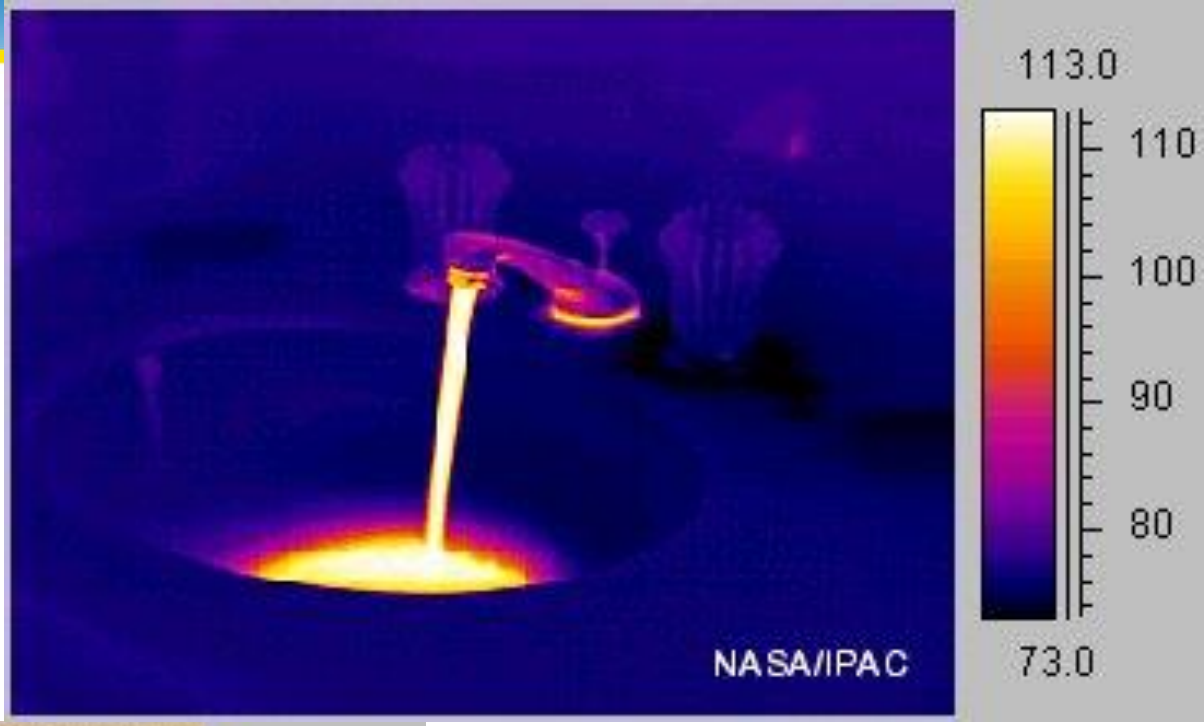
8. Why do some of the surfaces in the nighttime images retain their heat?

Student Worksheet
Urban Heat Island KWT Table

Now that you have been introduced to the Urban Heat Island phenomenon, write what you **KNOW**, what you **WANT** to know more about, and what you want to **TELL** others about the Urban Heat Island.

Know What do you already know about the subject	**What** What else would you want to know?	**TELL** What do you want to tell others?

It’s All About Image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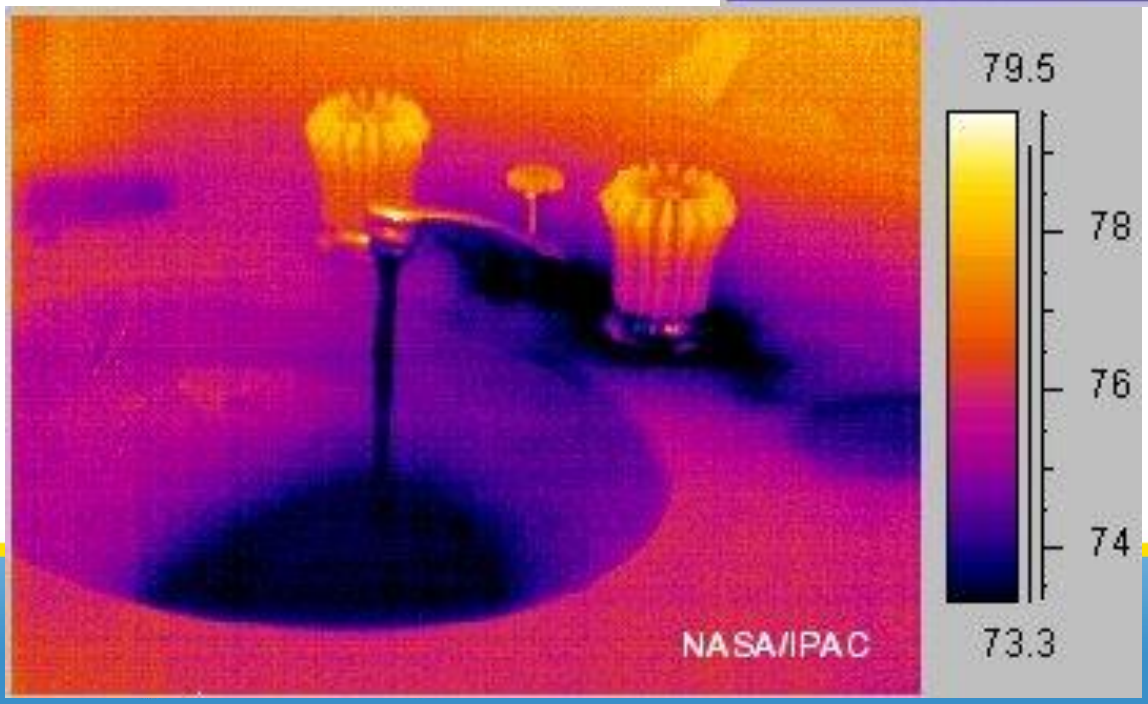
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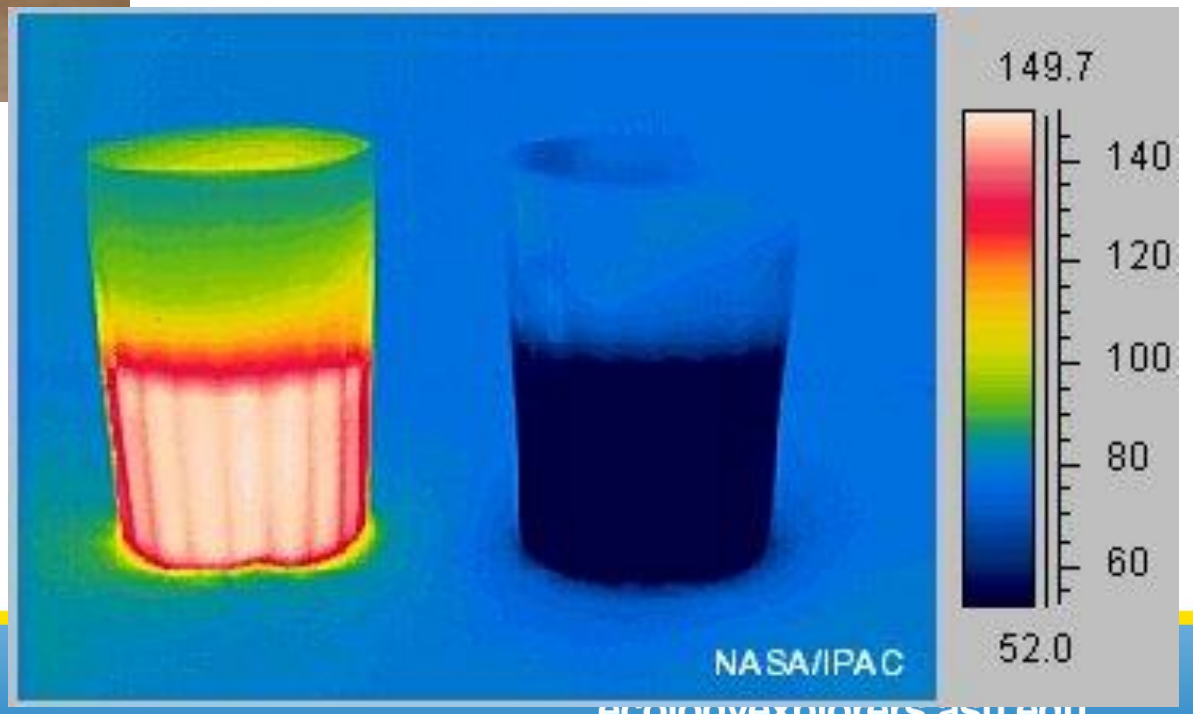
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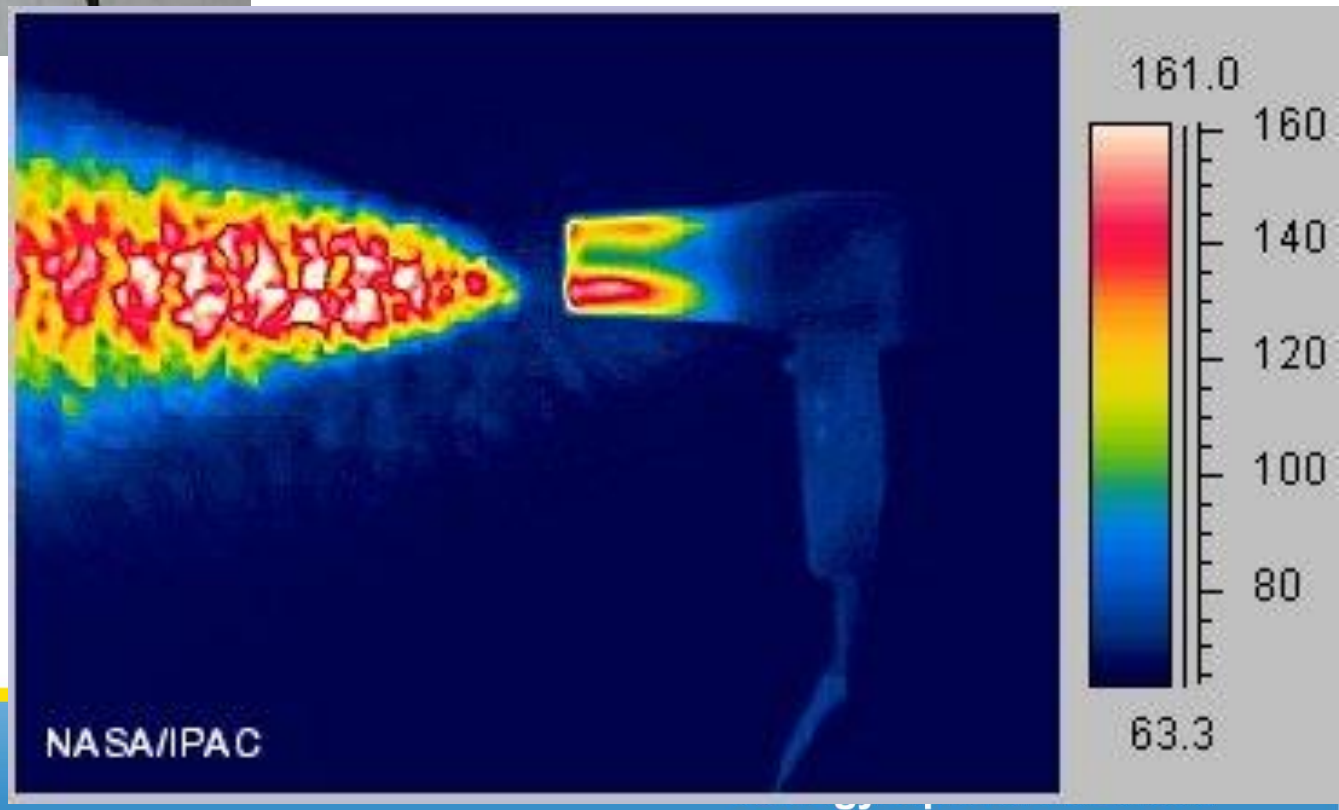
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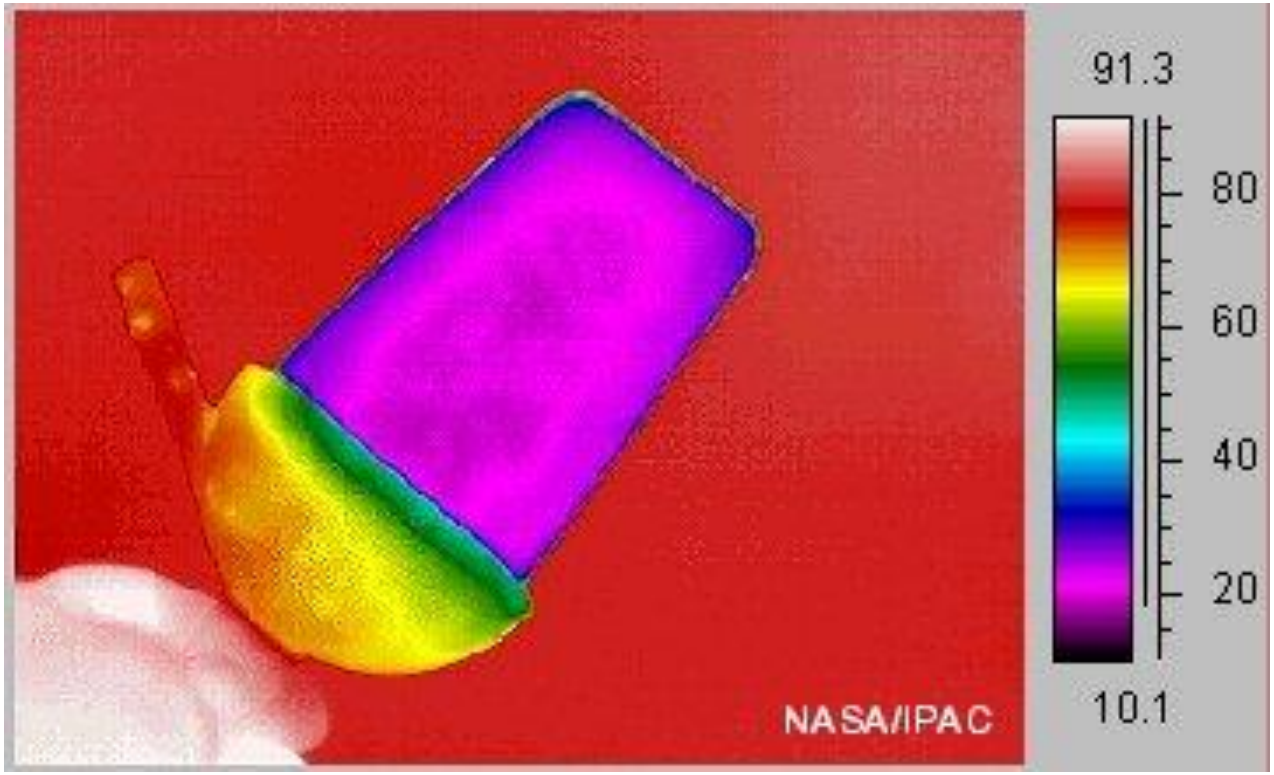
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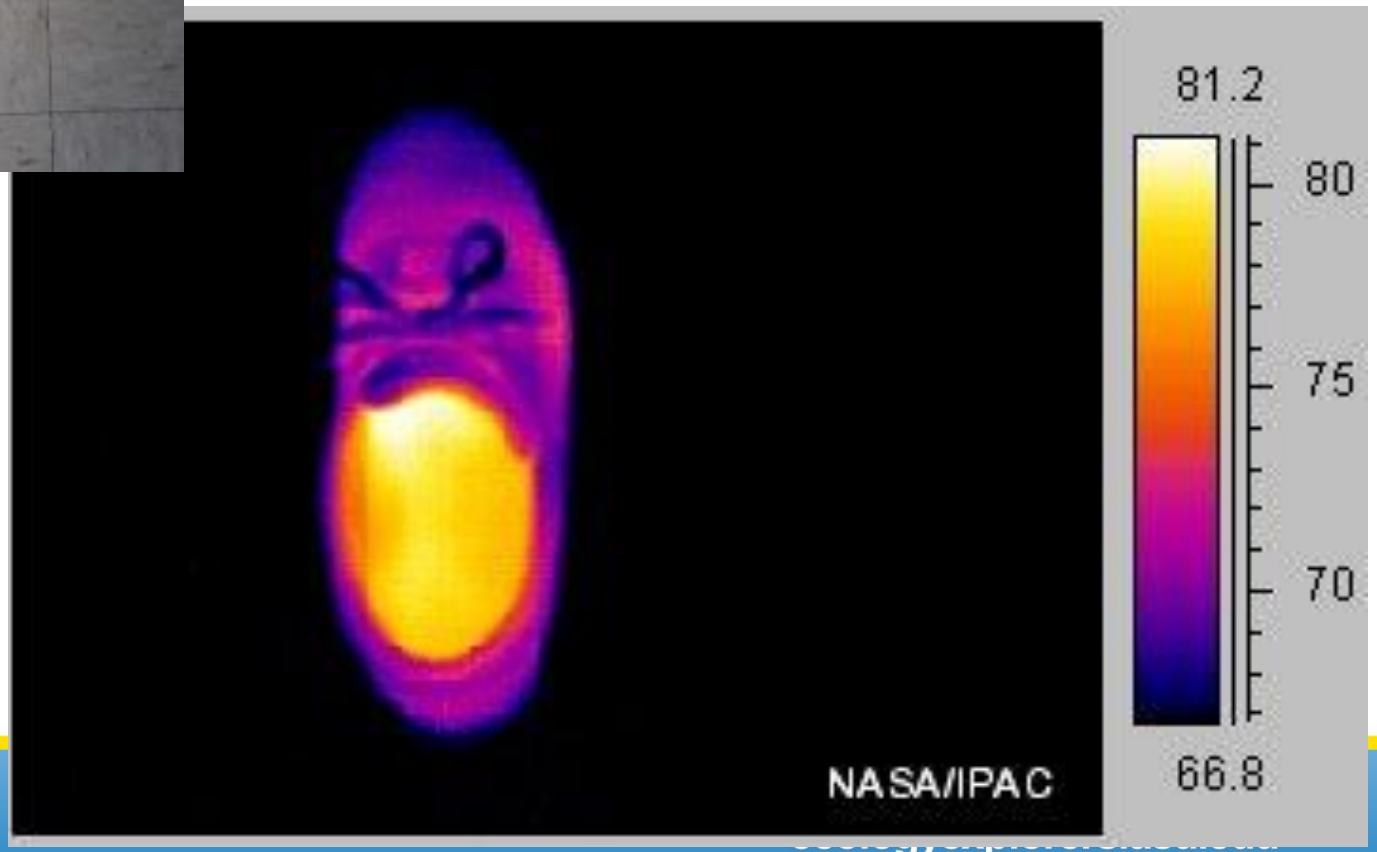
NASA/IPAC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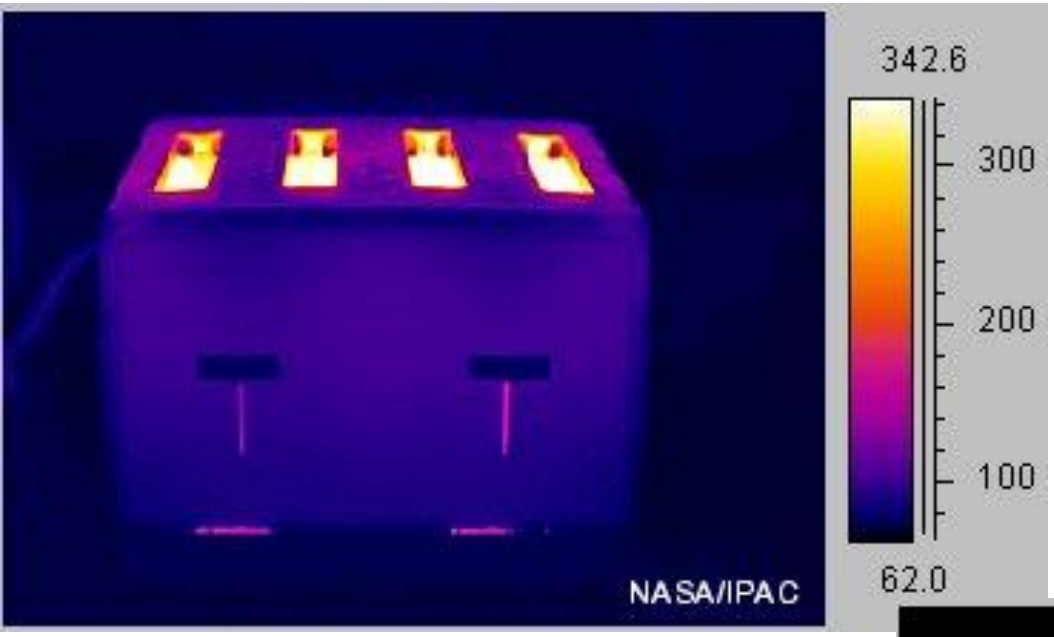
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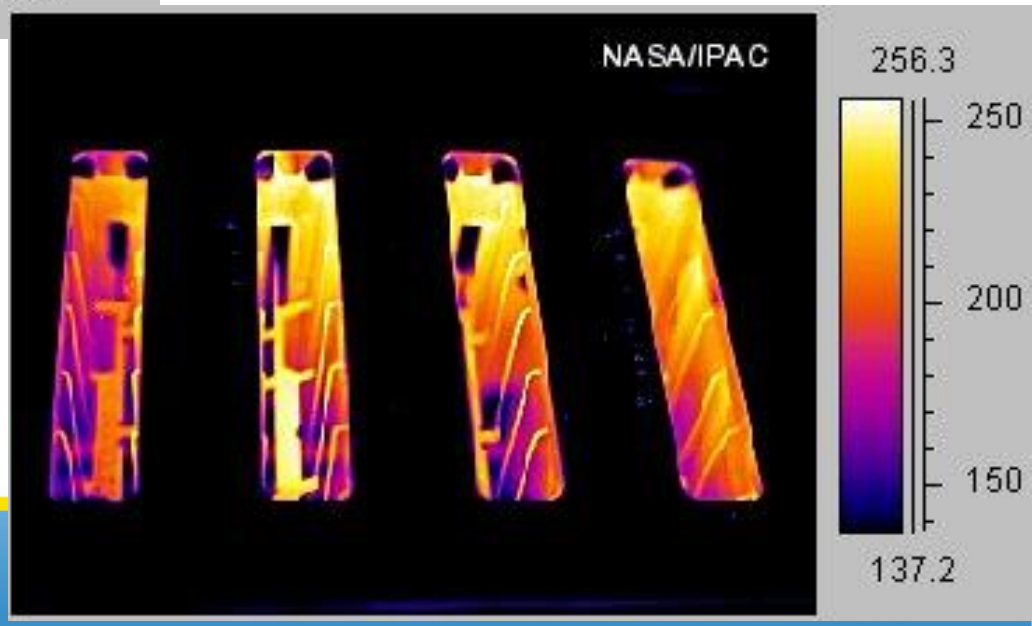
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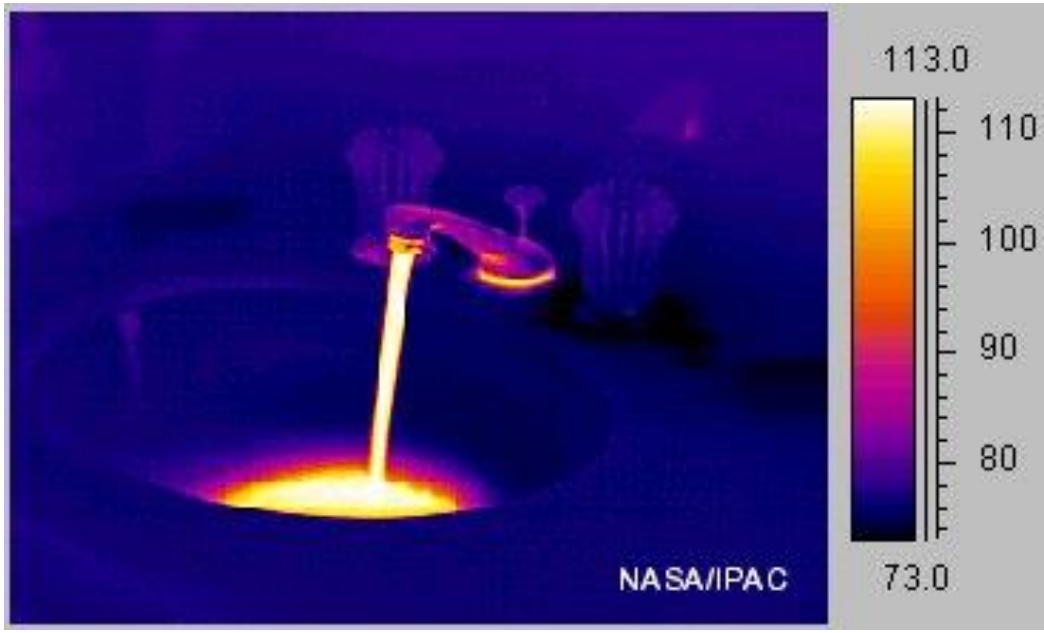
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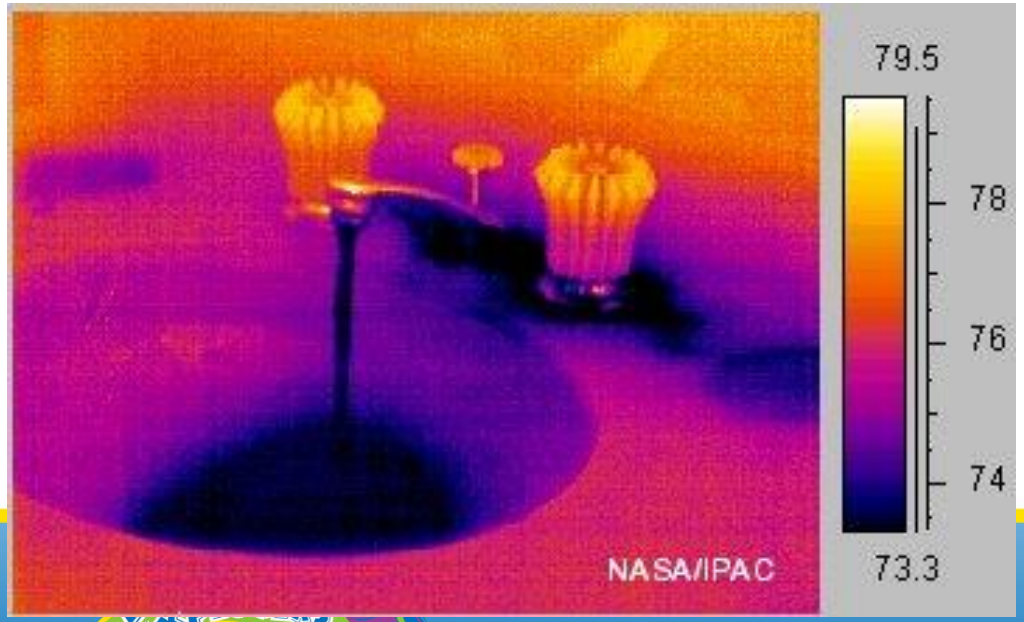
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73.3
NASA/IPAC

Chain Reaction Reading

- How To Catch a Wave

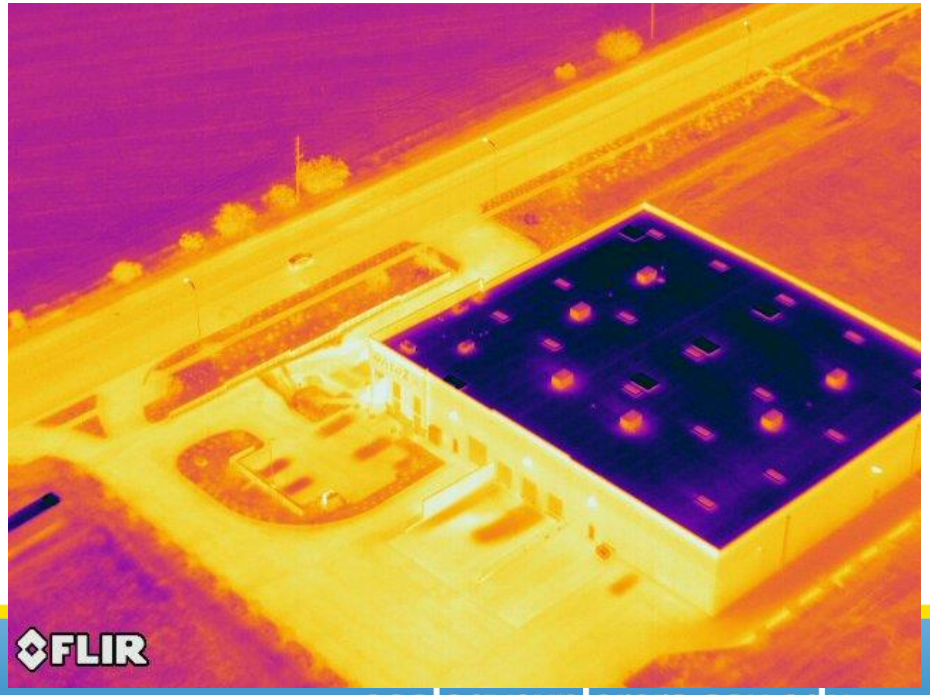
Which image was taken during the day (2pm)? night (11pm)?

- Images taken March 2008 via helicopter


Difference °C
Ref - Sp 0.0
FLIR
Dist = 500 Trefl = 15.6 ε = 0.96


FLIR


Difference
°C
Ref - Sp 0.0
FLIR
Dist = 500 Trefl = 15.6 ε = 0.96

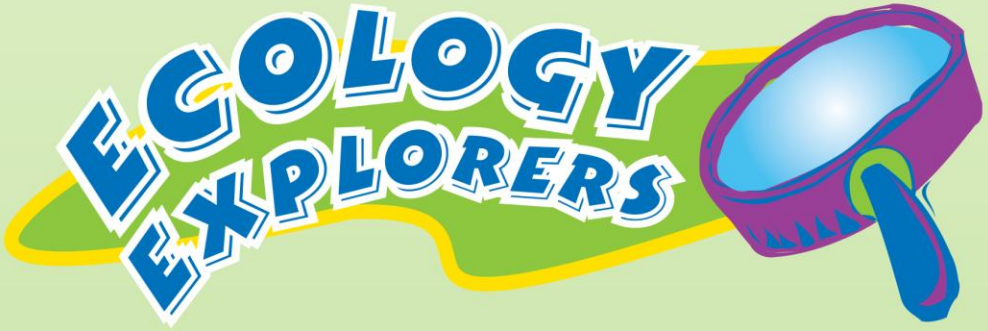

FLIR


Difference
°C
Ref - Sp 0.0
FLIR
Dist = 500 Trefl = 15.6 ε = 0.96


FLIR

Chain Reaction Reading

- Hot in the City.



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ASU JULIE ANN WRIGLEY
GLOBAL INSTITUTE of SUSTAINABILITY
ARIZONA STATE UNIVERSITY