Predicting Temperature
Inferences About Thermal Images

Objectives:
Students will be able to :

▪infer which areas are warmer and cooler in a thermal image.

▪describe the characteristics of an Urban Heat Island, a nighttime phenomenon.

▪explain how living organisms contribute and respond to temperature differences in an urban environment

Author:
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Time:
30 min.

Grade Level:
6-9

Standards

AZ Science Strands
Inquiry, Nature of Science, Social Perspectives, Life Science

NGSS - Core Ideas
Earth materials and systems; Weather and climate ; Biogeology; Human impacts; Interdependent relationships; Ecosystem dynamics, functioning, and resilience; Conservation of energy and energy transfer

Practices
Models, and more

Crosscutting Concepts
Stability and Change, 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. Infrared images have been used to study temperature patterns in Phoenix.

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 1**00°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:

Students should be familiar with the difference between visual and thermal images. The lesson It's All about Image provides a good foundation for this lesson.

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

Materials:

- individual copies of Student Worksheet: Predicting Temperatures from Thermal Images
- for each group of 2-3 students: IR/Visible Photo: eleven warm/cool thermal/visible light images (for all images see https://ecologyexplorers.asu.edu/docs/explorers/lesson_plans/4a_predicting_temp_pictures.pdf)

Recommended Procedure:

Engagement:

1) Ask students: what affects the temperature in different microclimates? Review with students what they understand about temperatures in urban environments.

2) Ask students: what are the differences between visual and thermal images? Provide background on infrared radiation (heat) and thermal images.

Exploration:

4) To each group of 2-3 students, pass out IR/Visible photos: eleven warm/cool thermal/visible light images.

5) Have teams look at the visible pictures first. Then provide sufficient time for them to predict the warmest and coolest part of each picture. Each team will write their predictions on the Student Worksheet: Predicting Temperatures from Thermal Images.

6) The learners will then look at the thermal images of the same visible pictures and identify the warmest and coolest part of the picture using the thermal temperature scale provided on each picture. From their observations, have students write in the correct answers in the table on their worksheet.

Explanation:

7) Ask students: were your predictions correct? Why or why not? Ask students: which items in the images will contribute most to the Urban Heat Island, Why?

8) Have students choose one thermal image that contains at least one living organism and one built object. Observe the temperature differences between living and non-living items in the image. Write a possible explanation for these differences. Students will need to think about the heat capacity of natural and built materials, as well as water content, insulation and plant evapotranspiration.

9) Ask: how does the living item affect the non-living item and vice versa? Have students brainstorm as many interactions as possible.

Expansion:

10) Now encourage students to imagine three animals living in the area of this photo: an ant, a lizard and a rabbit. For each animal, guide students to discuss and describe how it would behave and respond to temperature in this area and explain their reasoning. You may help students to think about differences such as endotherms/ectotherms, exoskeleton/scales/fur, burrowing/climbing/basking, habitats/microclimates etc.

Evaluation:

Students will complete all activities and worksheets.

Extensions:

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-C2-GR7-8-PO1, PO6
S1-C3-GR7-8-PO1, PO2
S1-C3-GR7-PO7
S1-C3-GR8-PO3, PO8
S2-C2-GR7-PO3
S2-C2-GR8-PO1
S3-C1-GR7-PO1
S3-C3-GR7-8-PO1, PO3
S3-C4-GR8-PO1
S4-C1-GR7-PO1

NGSS Core Ideas

ESS2.A: Earth materials and systems
ESS2.D: Weather and climate
ESS2.E: Biogeology
ESS3.C: Human impacts on Earth systems
LS2.A: Interdependent relationships in ecosystems
LS2.C: Ecosystem dynamics, functioning, and resilience
PS3.B: Conservation of energy and energy transfer

NGSS Practices

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

NGSS 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: Integration of knowledge and Ideas
WHTS1: Write Arguments
SL1: Comprehension and Collaboration

Common Core/Mathematics

Domains:
Number and Quantity
Measurement and Data
Math Practices:
4. Model with mathematics.
8. Look for and express regularity in repeated reasoning.

Student Worksheet (#1)
Predicting Temperatures from Thermal Images

For each image try to predict the warmest and coolest part of each picture. Then look at the thermal images of the same visible pictures and identify the warmest and coolest part of the picture using the thermal temperature scale provided on each picture.

Image	Predicted Coolest Spot	Predicted Warmest Spot	Coolest Spot and Temp.	Warmest Spot and Temp.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Which predictions were correct?
Which predictions were not correct? Explain.

Which items in the images will contribute most to the Urban Heat Island, Why?

Student Worksheet (#2)
Inferences About Thermal Images

Choose one thermal image that contains at least one living organism and one built object.
Observe the temperature differences between living and non-living items in the image.
Think about the material the object is made of. How do the materials insulate or conduct heat? How are the items affected by the sun?
Think about the body functions of living organisms. How do they use water and other methods to survive extreme or changing temperatures?
Write a possible explanation for the differences in temperature between living and non-living items in your chosen image.

Describe how the living item affects the non-living item and vice versa? Brainstorm as many interactions as possible.

Imagine three animals living in the area of this photo: an ant, a lizard and a rabbit.
Describe how each animal would behave and respond to temperature in this area. Explain your reasoning.