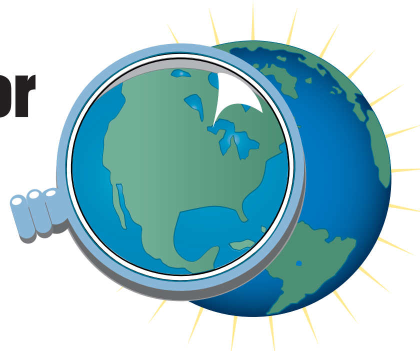
How does remote sensing search for the geographies of the past?



Investigation Overview

Students explore how a radar sensor detects previously unknown ancient sites in Guatemala. They find relationships between remotely sensed images and ground-level photographs of a site and recognize the role of geography in understanding the physical and cultural features of a region. Students discover the differences among aerial, oblique, and ground-level images. This investigation includes a culminating activity that requires access to computers and the Internet.

Time required: Three 45-minute sessions

Materials/Resources

Copies of the following for each student:
- Log 1: Gaining different perspectives
- Briefing 1: Background on the Petén and ground truthing
- Log 2: Ground truthing in the Petén
- Briefing 2: Ground truthing and the geography of sites
- Log 3: Checking it out on the ground
- Log 4: Ground truthing
- Log 5: Writing your own ground-truthing log
- Log 6: In conclusion

Student world atlas (one per student)
Colored pencils
Lined paper (or graph paper) for each student
One ruler for each student
One three-dimensional object (blocks or doll house furniture works well) for each group of students

Content Preview

Remotely sensed images and photographs have different perspectives: aerial, oblique, and ground level. An aerial view is referred to as "bird's eye." An oblique view is an angled view. Ground truthing, also called referencing, is the exercise of field work to verify the interpretation of imagery.

Classroom Procedures

Beginning the Investigation

1. Display a three-dimensional object in front of the class. Ask how it appears from different angles. Introduce the terms aerial view, oblique view, and ground-level view using the object to demonstrate the three perspectives. Have students follow the procedure outlined in **Log 1**.

Geography Standards

Standard 1:* *The World in Spatial Terms

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Describe the essential characteristics and functions of maps and geographic representations, tools, and technologies.

Standard 4:* *Places and Regions

The physical and human characteristics of places

- Analyze the physical characteristics of places.
- Analyze the human characteristics of places.

Geography Skills

Skill Set 2: Obtain Geographic Information

- Systematically observe the physical and human characteristics of places on the basis of fieldwork.

Skill Set 4: Analyze Geographic Information

- Interpret information obtained from maps, aerial photographs, satellite-produced images, and geographic information systems.

Skill Set 5: Answer Geographic Questions

- Make generalizations and assess their validity.

2. Introduce the term "ground truthing." After using maps, documents, and remotely sensed images, geoarchaeologists need to verify features observed on an image. They search on the ground for features seen from above.

3. Distribute **Log 2** and **Briefing 1** and **2**. Ask students to read **Briefing 1** and answer the comprehension questions as an opening for discussion about ground truthing. Discuss the following points with students.
   - High resolution images are more accurate than low resolution images because they can detect and measure smaller features.
   - On the ground, research teams rely on local maps and people to help them locate features on images.
   - Global positioning systems (GPS) are used to pinpoint exact latitudes and longitudes of sites.
   - Ground truthing is tedious and even dangerous. Many ancient sites in Central America are covered with dense forest with no access to them. In some areas, geoarchaeologists have met hostile populations.

Developing the Investigation

4. In preparation for the next activity, ask students to read **Briefing 2**. Read and discuss the various perspectives of viewing an object featured in **Briefing 2**.

5. Distribute **Log 3** and atlases. Organize students into groups to complete the chart. When students have completed the chart, distribute **Log 4**. Students will match the photographs and remotely sensed images to the locations in the chart. When they have completed the last column by noting ground-truth evidence from the photos, discuss the importance and value of ground truthing and remote sensing to geoarchaeological research.

6. If you wish to have students complete an Internet-based research project, continue with this final portion of the investigation. Review some guidelines and suggestions for writing a field research log in **Log 5**. Refer to the readings about the Petén and review the ground-truthing expedition. Select an archaeological site for each research team, other than the Petén. (Suggestions: Chaco Canyon in New Mexico, Arenal Region in Costa Rica, Ubar in Oman, Angkor in Cambodia, Mirador in Guatemala, Zeugma Project in Turkey—See Additional Resources.) Using Internet resources, students should imagine they are a team of geoarchaeologists sent to ground truth the images. The groups should create a log about their ground-truthing experience, including remotely sensed images, maps, descriptions, photos, sketches, and personal experiences during the field experience.

Concluding the Investigation

7. Students present their ground-truth logs to the class.

8. Students complete **Log 6**.

Background

Aerial View

A bird's eye view, looking straight down on an object, is an aerial view. This is similar to flying in an airplane and looking out to see rooftops. Maps and remotely sensed images from space are often aerial views.

Ground-Level View

When looking at the side of an object or a building from eye level, you get a ground-level view.

Oblique View

When looking at objects or buildings at an angle, usually from above, where you see a side and the top, you have an oblique perspective.

Global Positioning System (GPS)

A global positioning system is a device that pinpoints the location of the unit by latitude and longitude. The location is reported in decimal units. The GPS unit receives signals from satellites. Reception from satellites, however, is dependent on whether the satellites are in appropriate positions.

Geoarchaeologists use GPS to accurately locate larger features. Locating features is difficult when field maps are inaccurate or outdated.

Evaluation

Log 2

1. b
2. d
3. c
4. a
5. b
6. T
7. T
8. F
9. F
10. T

Log 3

Preparing to visit a site: Use the chart below as a key.

Log 4

Photo identification:

Arenal Region, Costa Rica—Photo B
The Petén, Guatemala—Photo A
Ubar, Oman—Photo D
Angkor, Cambodia—Photo E
Zeugma, Turkey—Photo C

1. What do these sites have in common?
Answers vary. Suggested responses: Transportation (footpaths, canals, rivers/bridges) seem to be important to all cultures for trade and communication. All are ancient cultures which have disappeared. People are able to adapt to hostile environments. All had large buildings without the aid of today's technology.
2. How does remote sensing help geoarchaeologists find features common to all ancient sites?
Answers vary. Suggested responses: Unusual variations in the texture or color of a remotely sensed image may indicate human disturbance beneath tree cover or deserts.

	Climate/ Precipitation	Climate/ Temperature	Vegetation	Elevation/ Terrain	Ground-Truth Evidence
Cambodia	Tropical rainy Seasonal rainfall 150+ cm/yr	Always hot 21-32 °C (70-90 °F)	Broadleaf evergreen	Coastal plain, low relief 0-305 m	Much vegetation; water
Costa Rica	Tropical rainy over 200 cm/yr	Always hot 21-32 °C (70-90 °F)	Broadleaf evergreen	Mountainous, narrow coastal plain 0-610 m	Vegetation
Guatemala	Tropical rainy Seasonal rainfall 100-200 cm/yr	Hot summer, mild winter 21-32 °C (70-90 °F)	Broadleaf evergreen	Mountainous, narrow coastal plain 0-3050 m	Many trees, tree areas
Oman	Dry–desert under 25 cm/yr	Always hot 21-32 °C (70-90 °F)	Broadleaf deciduous, shrubform in groups or patches, other areas lacking vegetation	Coastal plain, low relief, some hills 0-610 m	Dry, sandy soil, no vegetation
Turkey	Dry steppe to Mediterranean Seasonal rainfall Great variability 25-150 cm/yr	Hot summer, cool winter 10-32 °C (50-90 °F)	Grass (in steppe); mixed deciduous and needle leaf	Mountainous 610-1525 m	Dry with sparse trees

Log 5
This activity is meant to be creative. Students are encouraged to research sites and read archaeology logs.

Check for
- accuracy of information;
- inclusion of remotely sensed information;
- information about the ancient culture; and
- use of current technology, like GPS and GIS, radar, etc.

Log 6
Answers vary. Here is a suggested answer:

1. Archaeological truth means using evidence of the past to reconstruct culture. Written documents, if available, provide data for reconstructing the past. However, in cultures which have disappeared, often evidence is lacking to prove the existence of the culture or to reconstruct ways of life.

   Until recently, geoarchaeologists relied on aerial photographs, sketches and maps, and written and oral stories to locate past cultures.

   Remote sensing is changing how geoarchaeologists search for evidence. By using false color images, they can highlight specific features and detect things never before seen. For example, dense vegetation prevented geoarchaeologists from being able to locate Mayan ruins in Central America. Through use of remote sensing, geoarchaeologists locate ruins never before seen. Microwave radar helps geoarchaeologists "see" into porous soils, leading to discovery of old caravan routes and settlements.

   Remote sensing helps geoarchaeologists decide where to send out ground-truthing expeditions to verify features seen in the images. Then "digging" begins. Remote sensing adds greater flexibility and accuracy to how geoarchaeologists search for the past.

2. Geography helps to understand the terrain, vegetation, and climate of regions. Also, climate factors indicate how well a site may be preserved. Dry sites are usually better preserved than wet sites. Landforms may also be important. Some sites are buried in volcanic ash. Other aspects of geography, like map skills, help geoarchaeologists interpret remotely sensed images.

Additional Resources

Angkor, Cambodia
http://www.jpl.nasa.gov/radar/sircxsar/angkor.html
Photos: http://www.csulb.edu/~kkeo/angkor/P024.html

Arenal Region, Costa Rica
http://www.ghcc.msfc.nasa.gov/archeology/arenal.html
Photo: http://www.ghcc.msfc.nasa.gov/archeology/arenal.html

Chaco Canyon, New Mexico
http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html
Baker Aerial Archaeology's Chaco Project
http://www.mia.com/~jaybirdAANewsletter?ChacoPage2.html
Chaco in the News, Conservation Group: Chaco Canyon endangered
http://members.aol.com/mjhinton/chaco/chaconews.htm
Chaco Culture National Historical Park
http://www.cr.nps.gov/worldheritage/chaco.htm
http://www.nps.gov/chcu/roads.htm

The Petén, Guatemala
http://www.ghcc.msfc.nasa.gov/archeology/peten.html
http://www.ghcc.msfc.nasa.gov/archeology/peten_deforest.html
Photos: http://www.ghcc.msfc.nasa.gov/archeology/peten_groundtruth.html

Ubar, Oman
http://www.jpl.nasa.gov/radar/sircxsar/ubar1.html
Photos: http://observe.ivv.nasa.gov/nasa/exhibits/ubar/ubar_4.html

Zeugma, Turkey
http://www.ist.lu/ele/html/department/zeugma/home.html
http://www.ist.lu/ele/html/department/zeugma/remote.html
Photos: http://www.ist.lu/ele/html/department/zeugma/remote.html
http://www.ist.lu/ele/html/department/zeugma/html/photos/z04.htm

Module 4, Investigation 3: Log 1
Gaining different perspectives

You will need
- colored pencils,
- lined paper (or graph paper), and
- a three-dimensional object (supplied by your teacher).

1. Place an object on the floor. Look at it from directly overhead. Sketch it.

   This is an aerial view. Airplanes, satellites, the Space Shuttle, and the International Space Station can take aerial views of objects on Earth.

2. Place an object on a flat desk or table top. Stand to the side of the object. You should see both the top and one or two sides of the object. Sketch it. Add perspective to capture the shape more correctly.

   This is an oblique view. Airplanes, satellites, the Space Shuttle, and the International Space Station can also take oblique views of objects on Earth.

3. Kneel or sit down so you are looking directly at the side of the object. You should not see the top of the object. Sketch it.

   This is a ground-level view. Airplanes, satellites, the Space Shuttle, and the International Space Station do not take this type of view of Earth. It is what is typically seen by human eyes.

Module 4, Investigation 3: Briefing 1
Background on the Petén and ground truthing

The Petén, Guatemala
The Petén, northern Guatemala, was once inhabited by a population of several million Maya before the population collapsed in the 9th century A.D. The 7th and 8th centuries were the height of the Mayan civilization; by 930 A.D. only a few scattered houses remained. Scientists think that at the time the population collapsed, the Maya had deforested much of their region. Now after centuries of regrowth, the Petén is the largest tropical forest in Central America, but once again, it is experiencing rapid deforestation as new settlers invade the area. The old sustainable techniques used by the native population are being abandoned in favor of more destructive monoculture and cattle raising. These new methods also contribute to the destruction and looting of unrecorded archeological sites.

Today remote sensing and geographic information system (GIS) analysis are used to address issues in Maya archeology as well as to monitor the effects of deforestation. The ancient Maya successfully adapted their agricultural methods to their environment, but even so, they finally overused their resources. Current inhabitants are threatening to do the same thing in less time with a smaller population. Scientists are using remote sensing and GIS to learn from the past to protect the resources of the future, but they cannot rely only on remotely sensed data. By studying remote sensing images of the Petén, scientists can see

- different types of vegetation,
- the pattern of deforestation,
- Mayan roads that lead to unrecorded sites, and sometimes
- archeological sites themselves.

Sometimes it is necessary to go to the jungle to verify what they see in the remote sensing images. This is called ground truthing.

Maya Biosphere Reserve
Central American countries have established dozens of national parks, including the Petén. Change-detection analysis, using satellite data from 1986 to 1997, shows increasing deforestation, but the large size of the forest makes it hard to monitor and protect. Satellite imagery is proving to be a valuable monitoring tool. The Maya Biosphere Reserve was established in 1990 through an agreement between three neighboring countries, Mexico, Guatemala, and Belize. The reserve represents the largest continuous tract of tropical forest remaining in Central America. Besides forest, the reserve also contains extensive, environmentally important, seasonal, freshwater wetlands (bajos).

When settlers clear and burn the rain forests for agriculture, the thin soils quickly erode, and as a result, the flora and fauna are destroyed. Archeological sites are damaged by the fires' heat and by the erosion. The newly cleared landscape also makes undiscovered archeological sites more visible and accessible to looters. For the reasons mentioned previously, protecting the rain forest almost always protects the archeological sites too.

Ground Truthing in the Petén
Ground-truth information, often referred to as "reference data," involves the collection of measurements or observations about objects, areas, or phenomena that were remotely sensed. This ground-truth information can be used by social scientists in two ways: first, the data can aid in the interpretation, analysis, and validation of the remotely sensed data; second, it helps in understanding the socioeconomic forces behind human-produced, land-cover modifications.

Ground truthing is expensive and time consuming. In recent years, even though the cost of computer hardware and software for remote sensing has dropped, the costs of ground-truth activities have increased because airfare, lodging, vehicle rental, food, labor, and other costs have risen. Recent advances in GPS receivers and digital data field recorders have helped keep costs down because they make researchers much more efficient while they are in the field.

In order to create an accurate reference data set, scientists have to visit as many sites as possible in remote and rugged Petén. Typically, they change locations each day. They do not remain at a site or village to excavate archeological features—they simply map and verify their existence. Some of the challenges encountered by the field workers included logistical and communication problems, equipment failure, poor map quality, physical stress, and unfriendly local inhabitants. Once a research team was captured and held at gunpoint for several hours before being released.

Logistics are probably the biggest fieldwork problem. Often team members are the first professionals to visit an archeological site. A logistics coordinator schedules, in advance, the jeeps, boats, aircraft, mules, horses, and workers that will help the team get to its destination. Since many areas of the Petén do not have telephones, a Guatemalan team member must make arrangements for the rentals with local people weeks or months in advance. The more inaccessible the location, the more difficult the arrangements. Once the logistics have been coordinated, the field missions last two to three weeks. As the mode of travel switches from jeeps to boats to horses and mules, it is critical that the dates, times, and locations be arranged in advance so that the vehicles, guides, and animals are there to help the team get to its destination. Sometimes the team encounters road and pathway hazards such as downed trees and extremely muddy conditions.

Occasionally, teams are met with suspicion regarding their true purpose. Teams have successfully combated this situation by showing the local residents a large number of satellite images, explaining how the imagery is used, and by leaving a copy with the local residents. Only through years of exposure and word of mouth do teams gain acceptance and support for their activities from the local inhabitants. Many local people have become so educated about satellite imagery and GPS units that they can help teams interpret some of the features and anomalies on the images. Having a Guatemalan on the research team is a real benefit.

GPS measurements are very helpful to the field researchers. In 1988, when there were fewer satellites in orbit, and the receivers were not as good, teams often found themselves climbing a temple at midnight to determine their position because the satellites were in position only between 1 and 4 a.m. In addition, the dense rain forest vegetation sometimes interfered with the satellites' signals. Today readings can be taken at any time. More satellites and better GPS receivers allow field workers to collect more data with greater accuracy, but even with all the latest technology, there are still hazards.

One problem is the inaccuracy of available maps. Often lakes, rivers, archeological sites, and cultural features are not located where the map indicates. If information from these inaccurate maps is incorporated into a GIS, it will lead to faulty predictions. This problem is solved by constantly comparing GPS measurements, imagery, and maps to eliminate any errors. But even this doesn't help when the names on the maps are not the same as those used by local inhabitants.

Protecting the Petén

As teams studied deforestation in the Petén, they tried to distinguish between new forest clearings and regrowth. They are now expanding their activities to include information about the decisions that lead to land-use change and land conversion. Teams are in the process of interviewing local farmers and ranchers to address the scientific issues of deforestation rates and trends in land-use conversion. Through the interviews, the scientists hope to learn how farmers decide the amount of land they convert to pasture or shifting to agriculture, how they decide the amount of land they cultivate and the amount they leave fallow, how forest fragmentation affects the environment, what are the spatial characteristics of cleared land, and what are the socioeconomic characteristics of the farmers. These data will be correlated to provide better analytical information for future land-management decisions—and to help save archaeological sites, known and unknown.

Module 4, Investigation 3: Log 2

Ground truthing in the Petén

Read Briefing 1. Check your understanding by answering these questions.

1. The Petén is a __________.
   a. city in Guatemala
   b. a tropical rain forest in Central America
   c. the name of a national park
   d. a temple

2. The Petén, today mostly uninhabited, was the home to __________ during 7th–9th centuries.
   a. Spanish conquistadors who conquered the native population
   b. many endangered animal species of the tropical rain forest
   c. the Aztec Indians
   d. several million Maya

3. Sites of this ancient culture are difficult to locate today because __________.
   a. the buildings were burned and left as rubble
   b. the buildings were made of wood and have long since decayed into the rain forest floor
   c. the tropical rain forest has grown over the buildings and paths and cannot be easily seen either on the ground (forest is too thick) nor from aerial photographs (vegetation covers it)
   d. new cities have been built over the old sites, and agricultural and industrial areas cover the ancient remains

4. Ground truthing means to __________.
   a. collect measurements, data, and objects in locations that were remotely sensed
   b. ask native populations in the region to tell the truth as they relate stories about the ancient culture
   c. look at maps and pictures of an area
   d. use many remotely sensed images of different types to gather information

5. Ground truthing is expensive and time consuming because __________.
   a. computers, used to record the data, are very expensive and difficult to carry
   b. costs of travel, lodging, guides, and food are expensive, and arrangements are not always easy to make
   c. geoarchaeologists must stop to excavate the site before continuing
   d. the remotely sensed images are expensive, and it takes years to learn how to interpret the image before you can ground truth it

Indicate whether the following statements are true or false.

______ 6. Ground truthing aids in interpretation, analysis, and validation of the remotely sensed data.

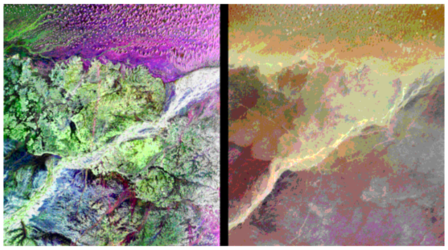
______ 7. Global positioning systems (GPS) provide flexibility and accuracy in pinpointing exact locations.

______ 8. Following the ancient footpaths is an easy task since modern-day inhabitants have kept them clear for the tourists.

______ 9. All native people welcome geoarchaeologists who ground truth because they bring new knowledge about the ancient inhabitants and their ancestors.

_____ 10. One problem with ground truthing is that local maps may be inaccurate.

Module 4, Investigation 3: Briefing 2
Ground truthing and the geography of sites



http://www.jpl.nasa.gov/radar/sircxsar/ubar1.html

http://observe.arc.nasa.gov/nasa/exhibits/ubar/ubar_4.html

Objectives
In this part of the investigation you learn how and why a geoarchaeologist ground truths features detected on remotely sensed images. You match geographical information to archaeological sites and photographs of archaeological sites to aerial views.

Part I
Ground Truthing
A geoarchaeologist's job is to discover and explain historical sites. After using remote sensing, the geoarchaeologist travels to the site to discover what is on the ground and to excavate (dig) for more information to assemble the pieces of history, geography, and culture. This process is called ground truthing. The geoarchaeologist matches remotely sensed data with exact features on the ground.

With global positioning systems, the objects and features can be accurately mapped. Photographs are taken to study geographical and cultural features.

By comparing locations and features on the ground with those in the image, geoarchaeologists are better able to interpret the remotely sensed images.

If an unknown feature appears on a remotely sensed image—say a rectangular red object—ground truthing may determine what it represents. If it is a temple, then other rectangular red objects on the same image are interpreted as temples.

The Geography of a Site
When traveling to a country to ground truth an image, geoarchaeologists need to know what conditions to expect. Climate influences how well sites may be preserved. A dry region preserves artifacts. A wet climate could encourage deterioration and vegetation that covers the features. On one ground-truthing expedition to Guatemala, geoarchaeologists reported accidentally finding ruins about three meters from the road. The vegetation was so thick they could not see the temple ruins from the road. Vegetation had also grown over the site so it was hidden from any airplane search. The temple was difficult to pinpoint on the remotely sensed image due to the scale and inaccuracy of the local maps. Researchers wondered how many other ruins they may have missed.

Knowing the terrain is also important when ground truthing. Geoarchaeologists need to know elevation and ruggedness to plan for special equipment or vegetation.

Module 4, Investigation 3: Briefing 2
Ground truthing and the geography of sites

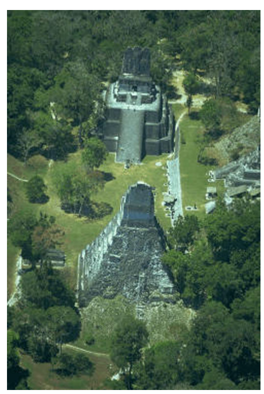
Part II
Types of Images
There are three types of images:

- **Ground-level views**—used to show how an object in an aerial view looks on the ground.
- **Oblique views**—may be taken from an angle (usually above), giving a partial side view of a site. The oblique view provides a sense of shape and features of buildings.
- **Aerial views**—taken from directly above allowing objects to be seen from the top down. The advantage of an aerial view is that you can see patterns not visible in a ground view.

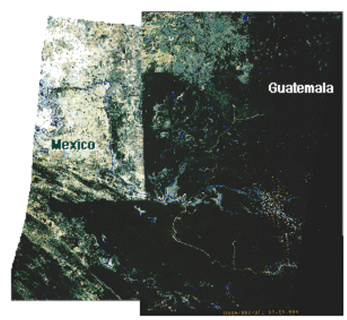
Examples of Images
Below are three images taken of the Petén, a rain forest in Guatemala. The ground-level view provides a sense of the shapes and heights of the trees. The oblique view reveals a larger space with buildings. You see some features of the buildings (like steps), their sizes, the distances between them, and their relationship to one another. The aerial view shows a much larger region. No small features are clear, but there is a pattern showing the edge of the rain forest (the straight line between the light area and the darker green area).

A Ground-Level View

An Oblique View



An Aerial View



Deforestation in the Petén

http://www.ghcc.msfc.nasa.gov/archeology/peten.html

Module 4, Investigation 3: Log 3
Checking it out on the ground

Preparing to Visit a Site
Archaeological sites are located in these countries:

- Cambodia
- Costa Rica
- Guatemala
- Oman
- Turkey

Use an atlas to locate the five countries and complete the chart using information in the atlas to understand the physical geography of each country. For example, a climate map helps you identify the precipitation and temperature.

After completing the chart, analyze the photographs and remotely sensed images found in Log 4. Match each photo and image to a country below.

Using the information obtained from these data, complete the last column by listing supporting visual evidence. What information from the images did you use to ground truth?

	Climate/ Precipitation	Climate/ Temperature	Types and Quantity of Vegetation	Elevation/ Terrain	Ground-Truth Evidence
Cambodia					
Costa Rica					
Guatemala					
Oman					
Turkey					

Module 4, Investigation 3: Log 4
Ground truthing

Matching Ground Photos with Historic Sites
Below are site photos taken at ground level or oblique angles. These are followed by aerial images and descriptions of the sites. Under the site description write the letter of the photo(s) that shows what feature is found at this site. You may want to consult an atlas to identify climatic conditions and vegetation in different regions to help you interpret which photos match which sites.

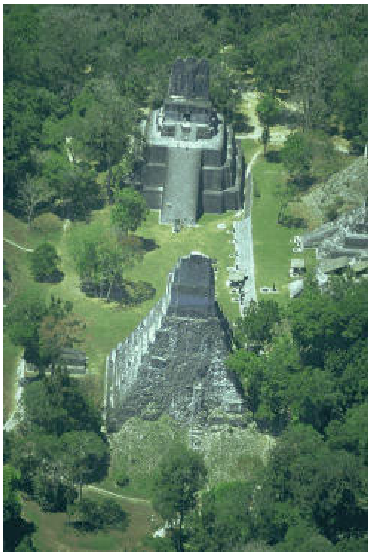


Photo A

Photo B

Photo C

Photo D

Photo E

Module 4, Investigation 3: Log 4
Ground truthing

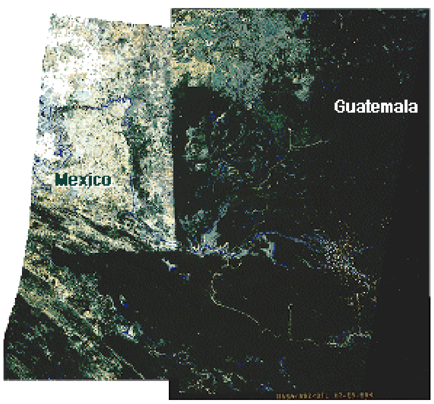
Arenal Region, Costa Rica
TIMS image of footpaths

http://www.ghcc.msfc.nasa.gov/archeology/arenal.html

The people in this area appeared to live in small groups that adjusted to shifting living locations because of frequent volcanic eruptions. Footpaths wound through the hilly terrain.

The description of the Arenal Region matches Photo_________.

The Petén, Guatemala



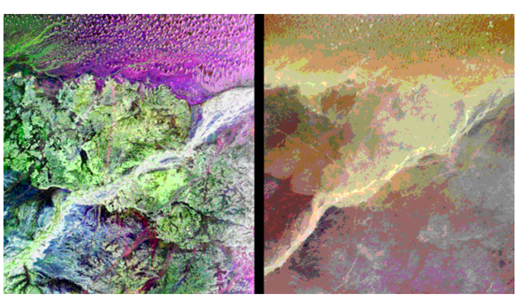
Deforestation in the Petén

http://www.ghcc.msfc.nasa.gov/archeology/peten_groundtruth.html

This region is rich in Mayan history. Old buildings were found covered by dense rain forest. Several sites have been cleared and the structures rebuilt for tourists. Connected by footpaths, the cities have step pyramid temples with broad courts for games.

The description of the Petén matches Photo_________.

Ubar, Oman
SIR-C radar image



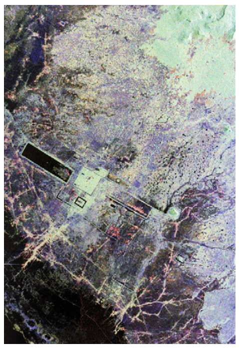
http://www.jpl.nasa.gov/radar/sircxsar/sc-ubar1.gif

Ubar was an ancient city along the frankincense trade route. Although this area is very dry today, more water was available in ancient times. Water was stored in deep caverns, indicating periods when water supplies fluctuated.

The description of the Ubar matches Photo_________.

Module 4, Investigation 3: Log 4
Ground truthing

Angkor, Cambodia
SIR-C/X-SAR radar image

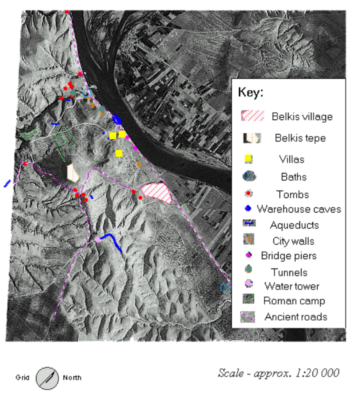


http://www.jpl.nasa.gov/radar/sircxsar/angkor.html

This region is covered today by thick rain forest. Only radar penetrates the tree cover to reveal evidence of human occupation. This was once a city and religious center for at least one million Khmer people. They built temples that reflected both Hindu and Buddhist influence. There is evidence of an extensive irrigation system.

The description of the Angkor matches Photo_________.

Zeugma, Turkey
KVR image



http://www.ist.lu/html/projects/de/Zeugma/gis1.html

This region was part of the ancient Greek and Roman Empires. At one time it was the best way to cross the Euphrates River. As transportation routes shifted farther south, this area lost its importance. The reservoir created behind the dam is expected to cover fields of pistachio trees and evidence of various empires.

The description of Zeugma matches Photo_________.

1. What do these sites have in common (besides being ancient)?

____

____

____

2. How does remote sensing help archaeologists find features common to all ancient sites?

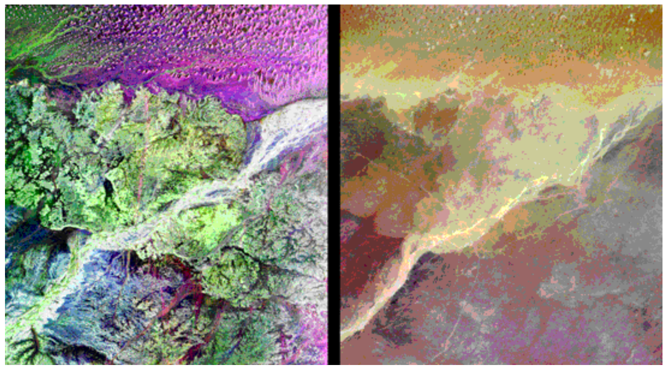
____

____

____

Module 4, Investigation 3: Log 5

Writing your own ground-truthing log



http://www.jpl.nasa.gov/radar/sircxarsar/ubar1.html

Objective

In this part of the investigation you research an archaeological site and create a ground-truthing log to explain what is discovered at the site.

The regions listed below are well documented by remote sensing and ground-truthing photos. With a little research on Internet sites, your group will be able to create a ground-truthing trip and write a field log.

Imagine that your group has been sent on a one-week trip to ground truth the images of your selected site. Prepare a log, which includes the remotely sensed data, a map, and a description of your trip: where you went and what you found day by day. Describe the physical and human characteristics of the region and the evidence found of prior human occupation. Include photos, sketches, and descriptions of interviews and encounters with the local population. Be accurate.

Below is a sample field log model to get you started.

Sites to choose from:

- Chaco Canyon in New Mexico
- Arenal Region in Costa Rica
- Ubar in Oman
- Angkor in Cambodia
- Mirador in Guatemala
- Zeugma Project in Turkey

Our group was sent to ______________________________.

It is located at _____________________________________. (latitude/longitude)

Some objects/colors in the remotely sensed images we studied are:

____

____

Module 4, Investigation 3: Log 5

Writing your own ground-truthing log

Things we need to know before our trip:

Climate during this time of the year: ______________________________

____

Expected terrain: ______________________________

____

Vegetation: ______________________________

____

Native population, language, special cultural features: ______________________________

____

____

Our team member: ______________________________
(include photos if you like)

Daily log (for one week from landing at the airport to leaving)
Include: what you did on each day
what you looked for
who you met
who you interviewed
what you discovered

Our trip was a success! We discovered ______________________________

References

Angkor, Cambodia
http://www.jpl.nasa.gov/radar/sircxsar/angkor.html
Photos: http://www.csulb.edu/~kkeo/angkor/P024.html

Arenal Region, Costa Rica
http://www.ghcc.msfc.nasa.gov/archeology/arenal.html
Photo: http://www.ghcc.msfc.nasa.gov/archeology/arenal.html

Chaco Canyon, New Mexico
http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html

Baker Aerial Archaeology's Chaco Project
http://www.mia.com/~jaybird/AANewsletter?ChacoPage2.html

Chaco Canyon endangered
http://members.aol.com/mjhinton/chaco/chaconews.htm

Chaco Culture National Historical Park
http://www.cr.nps.gov/worldheritage/chaco.htm
http://www.nps.gov/chcu/roads.htm

The Petén, Guatemala
http://www.ghcc.msfc.nasa.gov/archeology/peten.html
http://www.ghcc.msfc.nasa.gov/archeology/peten_deforest.html
Photos: http://www.ghcc.msfc.nasa.gov/archeology/peten_groundtruth.html

Ubar, Oman
http://www.jpl.nasa.gov/radar/sircxsar/ubar1.html
Photos: http://observe.ivv.nasa.gov/nasa/exhibits/ubar/ubar_4.html

Zeugma, Turkey
http://www.ist.lu/zeugma
http://www.bbc.co.uk/science/horizon/Zeugma_info.shtml

Module 4, Investigation 3: Log 6
In conclusion

Remote sensing is used to help geoarchaeologists locate sites of past human occupations. Scientists continue to improve ways of enhancing images to better detect human and physical features.

Write answers to the following questions in the spaces below. If you have completed one or more of the investigations, include information from them to help you answer the question.

1. How does remote sensing help the search for archaeological sites?

2. How and why is geography important to understanding remotely sensed images and archaeological sites?