Educational Product
Educators Grades 5–12
LS-2002-12-003-HQ

Exploring Earth from Space
With International Space Station (ISS) EarthKAM Photography

Lithograph Set and Instructional Materials

Students participating in NASA's ISS EarthKAM (International Space Station Earth Knowledge Acquired by Middle School Students) program have taken thousands of photographs of Earth from space. Photographs taken by the ISS EarthKAM program offer a compelling, inquiry-based avenue for students and teachers to explore and better understand Earth.

This guide suggests a variety of ways in which ISS EarthKAM photographs can be integrated into inquiry-based learning activities that enhance the learning and teaching of science, geography, mathematics, and technology.

This Exploring Earth from Space lithograph set includes the following:

- Educator’s guide with student information sheet and worksheet
- 14 lithographs:
  - ISS EarthKAM Photography
  - Earth Features Seen from Space
  - Andalusia, Spain
  - Buenos Aires, Argentina
  - Cloud Patterns
  - Colorado River
  - Creative Agriculture in Response to Limited Water
  - Ganges River Delta
  - Gazankulu Homeland, South Africa
  - Nile River Delta
  - Northeast Coast of Australia
  - Río Salado, Argentina
  - San Jose, California
  - Tibetan Plateau
Introduction

NASA’s ISS EarthKAM program offers a unique opportunity for students across the United States and around the world to take images of Earth from space. Using the tools of modern technology—including the Internet and a digital camera mounted on the International Space Station (ISS)—EarthKAM students are able to take stunning, high-quality photographs of our planet. This lithograph set includes a sampling of these ISS EarthKAM images.

This guide provides suggestions for introducing space-based photographs of Earth to students, shows how to identify and analyze key features within these lithograph images, and outlines a variety of activities that can be integrated into the teaching of science, geography, mathematics, and technology.

Understanding ISS EarthKAM Photography

More information about how the images are taken is available on the ISS EarthKAM Camera lithograph. Many more images, as well as education support materials and information describing how to participate in the ISS EarthKAM program, are available on the Web at http://www.earthkam.ucsd.edu

Familiarizing Yourself with ISS EarthKAM Lithographs

We recommend that you spend time examining the lithographs—identifying features, locating them on maps, asking questions, and so on—before introducing them to your class. The Earth Features Seen from Space lithograph and the student sheets are helpful guides. Visit the Educators section of the ISS EarthKAM Web site (www.earthkam.ucsd.edu) for additional support in exploring the images, including answers to the questions posed on the back of each lithograph.

Introducing ISS EarthKAM Lithographs to Students

When presenting the lithographs to students, explain that they are visible-light photographs taken from the ISS or the Space Shuttle. Emphasize that the photographs were taken by students just like themselves who have participated in the ISS EarthKAM program.

Explore a Photograph

Have students explore a lithograph in detail. The Exploring Earth from Space worksheet, located at the end of this guide, offers a series of questions that will help students discover information from the image. To foster an open-ended, inquiry-style experience, tell students not to read the back of the lithographs until you direct them. This approach fosters student creativity and improves critical observation skills. Encourage students to use atlases and other reference materials to enhance their exploration of the photograph.

Brainstorm Questions

As students work with the lithographs, prompt them to write down questions and ideas generated as a result of their exploration. Working with Earth photographs involves asking questions about a) what is there, b) why it is there, c) how did it get there, d) what effects it has, and e) what this suggests about an area or topic. These questions often serve as the basis for further study of other images. This brainstorming is most successful if done as a class or group discussion.
Integrating ISS EarthKAM Lithographs into Your Curriculum

Earth photographs can spark student interest, be sources of questions and information, serve as starting points for inquiry-based studies of Earth, and be used in student assessment. Many topics for study are possible with these lithographs, as well as with the thousands of images available through the ISS EarthKAM Web site located at http://www.earthkam.ucsd.edu. Outlined below are ideas for using ISS EarthKAM imagery to enhance your curriculum.

Map Skills and Geographic Analysis

Students can use the latitude and longitude coordinates provided with each image to determine the image's location on a world atlas. They can match the features in the photographs to the same features in atlases. Students can create a classroom bulletin board by mounting the lithographs around a world map and then using string to connect each lithograph to the corresponding location(s) on the map. What parts of the world are shown in the photographs? What human and physical characteristics can be identified from maps of the photographed regions? What types of information do images of Earth provide that maps do not?

Land Use and Agriculture

Images of Earth from space show how agriculture shapes Earth's surface. Rio Salado, Creative Agriculture, Buenos Aires, Northeast Coast of Australia, and Nile River Delta show different types and patterns of agriculture. Students can consider both the importance and the impact of agriculture. They can look at the relationships among agricultural lands, natural vegetation, water sources, and cities. Where does agriculture occur? Why is it located in some areas, but not others? What are the patterns and shapes of agriculture? What factors cause these observed patterns and shapes? How does agricultural development affect natural ecosystems?

Land Use and Conservation

Human use of the environment, as well as efforts to protect and conserve environments from human influence, can be seen in the lithographs. Gazankulu Homeland, Ganges River Delta, and Andalusia, Spain all show side-by-side areas of settlement and conservation. This type of visual information gives students a context for studying conservation issues and human geography. How do the protected lands appear different from the unprotected lands? What are the borders between them like? What types of land are protected? Why are these lands protected? For what are the nonprotected lands used?

Cultures

Earth photographs can be used as an entry point into the study of regional culture and history. Gazankulu Homeland shows a visual contrast between rural settlements and a national park. What were the social and political factors that led to this settlement pattern? How are these factors different today? Urban areas are a reflection of the cultures that build them. Close study of Buenos Aires shows a city with docks, streets, airports, parks, and racetracks. What do the people of Buenos Aires do for work and for recreation?
Rivers
Rivers, vital parts of the water cycle and major shapers of Earth’s surface, are particularly visible when viewed from space. Students can observe variations in river form, how rivers are a cause and a reflection of a given area’s landscape, and how humans use and affect rivers; they can also compare different types of drainage systems. They can compare the deltas in Ganges River Delta, Buenos Aires, and Nile River Delta. Prominent rivers are visible in Río Salado, Creative Agriculture, Andalusia, Spain, and Colorado River. What do rivers look like and why? What colors are rivers in the lithographs and why are there differences? Why do some rivers meander, while others follow a more direct path?

Geologic Features and Processes
Many types of geologic features and processes can be observed from the perspective of space. The San Andreas Fault slices a straight line across the San Jose lithograph. What do fault lines look like? Volcanism, folding, and differential erosion are visible in Colorado River. Students can sometimes identify sedimentary and igneous rock formations in the lithographs. They can compare sedimentary landforms in Colorado River to igneous or metamorphic landforms in Northeast Coast of Australia or San Jose. How do sedimentary rocks appear to erode compared to igneous rocks? How are volcanic mountains shaped compared to other types of mountains?

Atmospheric Processes
One factor influencing weather is the difference in the heat-holding capacities of land and water. Students can observe the location of clouds in relation to land masses and water in Cloud Patterns, and they can develop explanations for their observations. Students can also download current images of clouds from weather sites on the Web to expand their study of weather patterns and phenomena.

Change over Time and Space
Photographs of Earth taken from space offer compelling visual information that can be used to study changes over time. By comparing photographs of the same area taken at different times, students can analyze such things as seasonal and human-caused changes. Tibetan Plateau shows images taken 10 months apart. What has changed between these two images? Are these changes surprising? What features have changed? Students can use Web resources to find additional images of the areas shown in these lithographs to observe change over longer periods of time. How do rivers change on a seasonal basis? How much have cities or agricultural regions grown or shrunk over time?

Mathematics
The ISS EarthKAM lithographs offer practical, real-life opportunities for students to learn many math skills, including measurement, proportionality, scale, and graphing. Students can use the dimensions of the photographs to create a scale bar and measure the size of objects. How long is the dam and how large are the agricultural fields in the Río Salado lithograph? What is the area of the Nile River Delta? What is the average population density of Buenos Aires? The back of the Buenos Aires lithograph states that the city is home to about 13 million people, and students can estimate the size of the city from the photograph. What is the scale of the photograph? How does this scale compare to the scale of an atlas? How large are various features? What is the relative size of different features?
Supplemental Resources

ISS EarthKAM images are only one of many available types of Earth imagery. This guide and the Exploring Earth from Space Worksheet can be used with images and remotely sensed data of Earth taken from space by other instruments. These sources of information can help you find additional images and resources for use in your classroom. Also check your local library, the Web, and your NASA Educator Resource Center.

Books


Looking at Earth: Topographical portrait of Earth, organized by region, including stunning visual photographs collected by spacecraft and remote-sensing equipment. Priscilla Strain and Frederick Engle, National Air and Space Museum Smithsonian Institution and Turner Pub. ISBN 1878685163. (Out of print.)


Seeing Earth from Space: This book begins with photographs of Earth taken from the Moon and then moves on to photographs taken by astronauts orbiting the planet. Patricia Lauber, Orchard Books, 1990. ISBN 0531059022.


Web Sites

EarthRISE: Photographs of Earth taken by Shuttle astronauts. They can be searched by key word (Form) and by map (Political and Topographical). http://earthrise.space.com/

Johnson Space Center Earth from Space: Many of the best astronaut-acquired photographs of Earth. Photographs can be searched easily by areas of interest: cities, weather, features, technical, and others. http://earth.jsc.nasa.gov

ISS EarthKAM: ISS EarthKAM photographs, including those in this lithograph set, as well as educator guides, activities, and other classroom materials are available at this Web site. Go to the Datasystem to search the photographs. http://www.earthkam.ucsd.edu

Mission Geography: Curriculum materials that link the content, skills, and perspectives of Geography for Life: The National Geography Standards with the missions, research, and science of NASA. http://missiongeography.org/

NASA Education Home Page: Gateway to information regarding educational programs and services offered by NASA for educators and students across the United States. http://education.nasa.gov/


NASA Office of Space Flight: Information on the Space Shuttle, International Space Station, Mir Space Station, rocket launches, and other programs that are exploring, using, and enabling the development of space. http://www.hq.nasa.gov/osf/

NASA Spacelink: Specifically for the educational community, Spacelink provides links to virtually every one of NASA’s Web sites and resources, including programs, educator materials and opportunities, and current events. http://spacelink.nasa.gov

Terraserver: Terraserver has a collection of very high-resolution aerial photographs and satellite images. You can order prints of individual images. Search by name, map, or latitude and longitude coordinates. http://www.terraserver.com
Exploring Earth from Space

Student Information Sheet

Students who participated in NASA’s ISS EarthKAM (International Space Station Earth Knowledge Acquired by Middle School Students) program have taken thousands of photographs of Earth from space. Using the tools of modern technology—including the Internet and a digital camera mounted on the International Space Station—EarthKAM students are able to take stunning, high-quality photographs of our planet.

You will be closely studying ISS EarthKAM photographs that were taken from either the International Space Station or the Space Shuttle. Before beginning your exploration of these photographs, you need to learn a few facts about photographs from space so that you can better understand what you see.

Earth Features

You can identify human and physical features by examining their appearance in the photographs and comparing them to maps of the same area. In addition, many features are identified in the labeled image located on the back of each lithograph. The Earth Features Seen from Space lithograph identifies features like those shown below. Use it as an identification guide as you study other photographs of Earth from space.

![Images of agriculture, beaches, urban areas, delta]

Colors

The photographs you will be exploring are all visible-light images—they show what your eyes can naturally see. However, the processing and printing of the photographs has changed the colors slightly; they appear somewhat redder than they should.

Colors on the Photograph: Can Indicate:
blues water
black, dark blue, or dark green vegetation
white clouds, snow, or human impacts
red, orange, peach, or brown ground, soil, or sediment
**Image Identification Number**

Each ISS EarthKAM photograph has its own image identification number. These numbers contain information about how and when the photograph was taken. The identification system for images taken from the International Space Station differs from the identification system for images taken from the Space Shuttle. Each part of the ID number is described below.

**International Space Station**

<table>
<thead>
<tr>
<th>ISS 004 . ESC 2 . 066 10 36 26</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mission and Camera Identification</strong></td>
</tr>
<tr>
<td>ISS International Space Station</td>
</tr>
<tr>
<td>004 Crew Number</td>
</tr>
<tr>
<td>ESC Electronic Still Camera</td>
</tr>
<tr>
<td>2 ISS EarthKAM mission number for this ISS crew</td>
</tr>
<tr>
<td><strong>Time of image in Greenwich Mean Time (GMT)</strong></td>
</tr>
<tr>
<td>066 Day of the year image was taken</td>
</tr>
<tr>
<td>10 Hours (GMT)</td>
</tr>
<tr>
<td>36 Minutes (GMT)</td>
</tr>
<tr>
<td>26 Seconds (GMT)</td>
</tr>
</tbody>
</table>

**Space Shuttle**

<table>
<thead>
<tr>
<th>STS 089 . ESC . 07 15 41 37</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mission and Camera Identification</strong></td>
</tr>
<tr>
<td>STS Space Shuttle</td>
</tr>
<tr>
<td>089 Mission Number</td>
</tr>
<tr>
<td>ESC Electronic Still Camera</td>
</tr>
<tr>
<td><strong>Time of image after launch of Space Shuttle</strong></td>
</tr>
<tr>
<td>07 Days</td>
</tr>
<tr>
<td>15 Hours</td>
</tr>
<tr>
<td>41 Minutes</td>
</tr>
<tr>
<td>37 Seconds</td>
</tr>
</tbody>
</table>

Image ID numbers should be recorded for any photograph studied.

**Location**

Latitude and longitude are provided on the back of each lithograph. These coordinates pinpoint the center of the photograph and locate the area on Earth. Latitude and longitude can also be used to find locations on maps. Small maps also appear on the back of each lithograph to help find the image’s general location. By comparing the photograph and maps, you can identify the features and learn about the area within as well as surrounding the photograph.

**Scale**

The scale of an ISS EarthKAM photograph depends on the camera and lens used and the altitude of the ISS or Space Shuttle when the photograph was taken. The back of the lithographs provide the exact dimensions for each image.

**North**

The top of the page on the colored side of the lithograph is NOT necessarily north. The back side of most lithographs shows the photograph rotated to put north at the top. Knowing which way is north helps to align the photographs with maps and to identify features on the image.
Exploring Earth from Space Worksheet

Name _________________________

Directions: Answer these questions as you examine an ISS EarthKAM lithograph provided by your teacher.
1. Lithograph title: _____________________________________________________________

2. Describe the image:
   a. What shapes, colors, and patterns do you see?
   b. What features, such as rivers, mountains, or cities, can you identify?
   c. What questions do you have about what you see?

Directions: Record the following data using information provided on the back side of the lithograph.
1. Image ID #: ___________________________________________________________________________

2. Center latitude: _________________________ Center longitude: _____________________________

3. Examine the annotated photograph and read the description. What facts, features, or aspects interest you the most? Why?

Directions: Use the information recorded above and resources such as atlases to answer the following questions.
1. Describe the location of the photograph so that someone else could find it on Earth:
   a. What country/ countries does it show?
   b. What specific features can be identified?
   c. What does the surrounding area look like; what does it contain; and how is it used?

2. What questions do you now have about this photograph?
To achieve America’s goals in Educational Excellence, it is NASA’s mission to develop supplementary instructional materials and curricula in science, mathematics, and technology. NASA seeks to involve the educational community in the development and improvement of these materials. Your evaluation and suggestions are vital to continually improving NASA educational materials.

1. With what grades did you use the lithograph set?
   - K–4
   - 5–8
   - 9–12
   - Community College
   - College/University - Undergraduate
   - College/University - Graduate

2. a. What is your home 5- or 9-digit ZIP code? __ __ __ __ __ — __ __ __ __
    b. What is your school 5- or 9-digit ZIP code? __ __ __ __ __ — __ __ __ __

3. This is a valuable lithograph set.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

4. I expect to apply what I learned in this lithograph set.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

5. What kind of recommendation would you make to someone who asks about this lithograph set?
   - Excellent
   - Good
   - Average
   - Poor
   - Very Poor

6. How did you use this lithograph set?
   - Team Activities
   - Demonstration
   - Group Discussions
   - Hands-On Activities
   - Integration into Existing Curriculum
   - Critical Thinking Tasks
   - Science and Mathematics
   - Interdisciplinary Activity
   - Student Projects

7. Where did you learn about this lithograph set?
   - NASA Educator Resource Center
   - NASA Central Operations for Resources for Educators (CORE)
   - NASA Education Resource Center
   - Fellow Educator
   - Workshop/Conference
   - Institutional/Office System

8. What features of this lithograph set did you find particularly helpful?

9. How can we make this lithograph set more effective for your?

10. Additional comments:

   Fold along line and tape closed.

You will then be asked to enter your data at the appropriate prompt.

http://worldplace.nasa.gov/edcats/lithograph_set

Please take a moment to respond to the statements and questions below. You can submit your response through the Internet or by mail. Send your reply to the following Internet address:

http://ehb2.gsfc.nasa.gov/edcats/lithograph_set

You will then be asked to enter your data at the appropriate prompt.

To today’s date:

Please return the reply card by mail. Thank you.
These images of Lake Manasarowar (a) on the Tibetan Plateau illustrate how images from space can show changes in weather. Taken on different Shuttle flights and cropped to show the same area, the pair of images reveals the impact of weather on the region.

Tibet has a cold, dry climate, making it one of the harshest places to live. The average annual temperature is 1 °C (34 °F), and temperatures in the mountains and plateaus are especially cold. Most of the rainfall occurs between June and September, when temperatures are slightly warmer. Strong winds are common year-round.

The March 1996 image shows large amounts of snow that fell during unusually strong blizzards in the previous months. The January 1997 image shows a more typical dry and cold winter.

At an altitude of 4,727 m (15,510 ft), Lake Manasarowar is one of the highest freshwater lakes in the world. Lake Manasarowar’s water supply comes from glaciers on the Himalayan peak Gurla Mandhata (c) and the Kailash Range. Both images capture interesting white patterns (b) in the lake. These cracked patterns form when slabs of ice, pushed by wind, collide with one another. Drifting snow can then accumulate at the junctions.

Additional information:
ISS EarthKAM images and lessons:
http://www.earthkam.ucsd.edu
NASA Spacelink:
http://spacelink.nasa.gov
San Jose, California

San Jose (a), California, is the 11th largest city in the United States with a population of 894,943 (2000). San Jose’s economic development began a century ago with processing the agricultural products of the fertile Santa Clara Valley (b). However, in the last 25 years, high-tech computer-related industries have concentrated in the San Jose region, earning it the nickname Silicon Valley. Today, more and more areas of the Santa Clara Valley are being used for urban purposes.

The metamorphic and sedimentary rocks of the Santa Cruz Mountains (c) have washed down as sediments carried by rivers and streams, including Coyote River (d), to produce the rich soils of the Santa Clara Valley. This is a geologically active, earthquake-prone region. It is criss-crossed by a series of active fault lines, including the San Andreas Fault (e).

Water is very important to San Jose for agriculture, industry, and municipal purposes. The Anderson Reservoir (f), built in 1949, serves as one of a linked system of water storage lakes used to recharge groundwater and to provide the growing urban population with drinking water.

Additional information:
ISS EarthKAM images and lessons: http://www.earthkam.ucsd.edu
NASA Spacelink: http://spacelink.nasa.gov

LG-2002-12-554-HQ
Rio Salado, Argentina
Cultivated fields create the main visual pattern for this image, which is located in northern Argentina at the foothills of the Andes Mountains (a). This is one of the new regions of rapid development in Argentina. The pattern of yellow-tan rectangles—large agricultural fields (b)—suggests that the fields are corporate agriculture, not small independent farms. The agriculture extends north of the Rió Salado (c) and follows the main road north to Bolivia.

There is a finer structure on the larger fields—possibly smaller plots planted in the same crop. The fields decrease in size and change shape toward the river. The pattern of long, skinny plots radiating from the river (d) indicates that water access and river front property are high priorities, and that water control is an important regional issue. The Rió Salado also has a reservoir (e) near one corner of the image. Several smaller rivers (f) cut across the image. The dark region to the west and northwest is mostly forested, undeveloped land (g).

Additional information:
EarthKAM images and lessons:
http://www.earthkam.ucsd.edu
JSC Earth From Space image database:
http://earth.jsc.nasa.gov
NASA Spacelink:
http://spacelink.nasa.gov
This part of northeastern Australia along the coast of Queensland (a) shows variable topography and landcover. The elevation in the image drops from between 2500 and 3500 feet in the Connors Range (b) to sea level at the Pacific Ocean (c). Because this region receives some of the highest rainfall in Australia, the mountains are heavily eroded and gullied and covered in forest. The afternoon sunlight highlights the shape of the mountains and river drainage network through them. The rainfall is seasonal, however, and this image was taken during the dry season. Tell-tale rectangular land-use patterns along the coastal plain indicate extensive agriculture (d), primarily sugar and cotton. The gray region at the northern end of the coastline is the small city of Mackay (e). In the southern part of the image, the irregular coastline is fringed with dark vegetation, probably mangroves (f), and light regions, possibly hypersaline areas (g) in the upper reaches of the coastal tidal flats. Sediment suspended in the coastal waters trace the tidal and nearshore currents and create patterns offshore around the small islands (h).
Nile River Delta
What factors influence the location of agriculture?

The Nile River (a) is the longest river in the world. From its major source, Lake Victoria, the river extends 5,589 kilometers (3,437 miles) before emptying into the Mediterranean Sea (b). Just north of Egypt's capital city, Cairo (c), the Nile River divides into two main branches, the Rosetta Branch (d) and the Damietta Branch (e). These two branches spread apart to form the triangular Nile Delta. The Nile Delta is predominantly agricultural; half its occupants are farmers who depend upon the waters of the Nile to irrigate their crops. Average farm size is about 8,000 square meters. The dark color of the irrigated delta farmland contrasts starkly with the arid yellow of the surrounding desert.

Gray patches seen throughout the delta are densely populated settlements. The even distribution of the settlements shows the human tendency to organize spatially in regular patterns. Alexandria (f), founded in 332 B.C. by Alexander the Great, is Egypt's largest seaport. More than 80 percent of Egypt's imports and exports pass through Alexandria. The Suez Canal (g) is an artificial waterway connecting the Mediterranean Sea with the Gulf of Suez. The canal is 195 kilometers (121 miles) in length and has a minimum channel width of 60 meters (200 feet).

Additional information:
ISS EarthKAM images and lessons: http://www.earthkam.ucsd.edu
NASA Spacelink: http://spacelink.nasa.gov
International Space Station

The International Space Station (ISS) is the result of an unprecedented international collaboration. Fifteen countries are partners in the design, development, operation, and use of the Station. Today, ISS is the largest laboratory ever built in space. The Station and its crew draw from the resources and scientific knowledge of multiple countries to perform state-of-the-art research in a space environment.

On May 6, 2001, the ISS EarthKAM Electronic Still Camera (ESC) was set up on the ISS. The next few weeks were used for intensive testing of the camera and flight software’s interaction with its new home on the ISS. During the first year of operation, ISS EarthKAM captured over 2,000 images.

Within the ISS, EarthKAM is housed in the U.S. Destiny Laboratory. The aluminum lab, 28 feet long by 14 feet wide, is composed of three cylindrical sections and two end-cones used to connect the lab to the other station components. The ISS EarthKAM camera points out the nadir window, a 50.9-centimeter-diameter optical-quality glass window that points directly toward Earth’s surface. After its installation, ISS EarthKAM will be one of the first payloads mounted on the Window Observational Research Facility (WORF), a special rack for mounting sensors to the nadir window.

ISS EarthKAM’s permanent home on the Space Station has innumerable effects on the study of Earth science. Images taken by ISS EarthKAM on the more recent flights show drastic changes when compared to those taken just a few years earlier. With ISS EarthKAM permanently on the Station, students will be better equipped to track the changes on Earth. Since Earth is constantly changing, there will never be two identical images.

ISS EarthKAM Photography

ISS EarthKAM is a NASA-sponsored education program that enables students to take electronic photographs of Earth using a camera mounted on the International Space Station. During an ISS EarthKAM operational period, students use interactive Web pages to target and request images of Earth. They then use the images to study Earth from the unique perspective of space.

The ISS EarthKAM camera is a digital camera with a light-sensitive detector instead of film. This detector produces an image that can be transmitted directly to a computer. Like most cameras, the ISS EarthKAM camera takes pictures using visible light. As a result, students can only photograph Earth during the 45 minutes of each orbit when the Station flies over Earth’s sunlit side.

For the program’s first five years, the ISS EarthKAM camera operated from the Space Shuttle. In May 2001, operations switched to the ISS.

Operations on the Space Shuttle are very similar to operations on ISS. During a Shuttle mission, an astronaut mounts the camera in the Shuttle’s overhead window as soon as the Shuttle reaches orbit. While in orbit, the Shuttle flies “upside down” (with the overhead window facing Earth), so the camera points straight toward the ground. For ISS operations, the ISS EarthKAM camera is mounted in the Destiny Lab.

After mounting the camera, astronauts connect it to the ISS EarthKAM computer, which communicates with a computer in NASA’s Mission Control. Middle school students study Earth science, geography, weather, current events, and more in order to determine photographic targets. Students track the spacecraft to find the time it flies over a location of interest.

Using the Internet, middle school students transmit the time and target information to the University of California, San Diego, where the requests are compiled into a list and sent to NASA’s Mission Control Center. From there, the list is sent to the ISS EarthKAM computer in orbit. At each listed time, the computer commands the camera to take a picture. Within a few hours, the images are added to the ISS EarthKAM Datasystem on the World Wide Web, where students and the general public can access them for viewing and study.

About the Images on the Front of the Lithograph

International Space Station

The entire International Space Station as photographed by the STS-110 crew in April 2002. The Destiny module is at the very bottom of the image. Look closely to spot the nadir window.

ISS EarthKAM Photography

Astronaut Carl Walz confirms that the ISS EarthKAM camera is set up properly during February 2002 operations. Problems with a power cable forced the camera to be set up in the service module instead of the U.S. lab.

Nadir Window

Astronaut Steven Frick admires the view from the nadir window of the U.S. lab during his visit to the ISS on Shuttle mission STS-110.

Additional information:
ISS EarthKAM images and lessons: http://www.earthkam.ucsd.edu
NASA Spacelink: http://spacelink.nasa.gov
This image, of the northeast corner of South Africa (a) where it meets Mozambique (b), highlights distinctive land-use patterns. The central part of the scene is South Africa’s Kruger National Park (c), a famous wildlife reserve scarred by recent burning (d). Different land-use practices on either side of the Kruger National Park outline the Park borders.

The Gazankulu Homeland (e), one of the several black African homelands, contains dozens of small white patches marking “rural ghettos” (f), population centers where hundreds of thousands of black Africans were forced to set up their homes during the height of the apartheid regime of the past South African government. The patches are evidence of denudation of the natural vegetation due to overpopulation and overgrazing by herd animals. Shuttle imagery shows not a single patch in this area in 1983, indicating the scale and speed of the population removals which resulted in the ghettos.

The most prominent feature in Mozambique is the dry bed of the Limpopo River (g), a major river which, further north, acts as the border between the states of South Africa and Zimbabwe.

Additional information:
EarthKAM images and lessons:
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http://earth.jsc.nasa.gov
NASA Spacelink:
http://spacelink.nasa.gov
This image shows the Sundarbans, the central part of the large delta of the Ganges River in western Bangladesh. The Ganges River, one of the world's longer rivers, carries a tremendous load of sediment eroded from the Himalayan region. When the river enters the Bay of Bengal (a) at the India-Bangladesh border, sediment is deposited to form the delta at the coastline. The suspended sediment gives the water a very muddy color.

At the end of the delta, the combined action of river and tidal flow creates a complex network of water channels, forming many islands. The dark-colored land in the delta is mangrove forest (b) in a coastal preserve and is one of the last habitats for Bengal Tigers. The lighter, reddish-colored land has been completely deforested of mangrove forests and supports a very large human population. The very light colored land just north of the mangrove preserve marks the border (c) of Bangladesh (d) with India (e).

Additional information:
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NASA Spacelink:
http://spacelink.nasa.gov
One of the first well-publicized impacts of the 1997-1998 El Niño was out-of-control burning and a large smoke pall over the Indonesia region from August through October, 1997. El Niño delayed the monsoon rains, allowing the fires (many of which were probably deliberately set to clear the land) to race out of control.

This view is a photomosaic of 2 images taken in sequence over the southern tip of the island of Sumatra. Together, the images provide a sense of the regional scale of the fires and smoke.

The number of fires, the small, arrow-like plumes (a), and the thickness of the smoke pall increase from south to north. The dark regions along the coast are the forested slopes of the coastal mountains (b). The smoke drapes around the mountains and becomes thick and dense enough that it forms waves (c).

Additional images are available in the same series cutting completely across Sumatra. EarthKAM images STS086.ESC.00215637 and STS086.ESC.00215701.

Additional information:
EarthKAM images and lessons: http://www.earthkam.ucsd.edu
JSC Earth From Space image database: http://earth.jsc.nasa.gov
NASA Spacelink: http://spacelink.nasa.gov
Earth Features Seen From Space

- Sediment
- Volcanoes and Ash
- Forests
- Forestry
- Roads and Railways
- Snow
- Mountains and Hills
- Coastlines
- Pivot Irrigation
- Lakes and Dams
- Clouds
- Islands
- Rivers
- Agriculture
- Urban Areas
- Smoke
- Deltas
- Beaches
- Ports and Docks
- Airports
# Earth Features Seen From Space

This litho shows twenty features and patterns that are commonly found in images of Earth’s surface. The thumbnails and descriptions will help you identify these features in this set of images, *Exploring Earth From Space*, and in other images you can find in NASA’s extensive archives.

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<tr>
<th>Sediment</th>
<th>Volcanoes and Ash</th>
<th>Forests</th>
<th>Forestry</th>
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<tbody>
<tr>
<td>Rivers and streams carry suspended material into lakes and seas where it is deposited; look for sediment plumes near deltas, along coasts, around islands. Curving shapes show the effect of currents and eddies sweeping material along.</td>
<td>Volcanoes often have characteristic round or cone-like shapes; look for dark-colored billowing eruption clouds (coming from a point source) showing wind direction, with ash falls beneath.</td>
<td>Forests–areas of dense vegetation–show up as regions of consistent color (dark green, dark blue, black) with a subtle motting texture (from light and shadow on tree tops), with rivers and roads cutting through them.</td>
<td>Forestry areas result from lumbering (clearing and replanting); look for light and dark color variations (between clearing and trees), shapes (e.g., sharp edges, grid-like lines), patches of settlement or roads.</td>
<td>Roads and railways are difficult to differentiate; look for extended straight or gently curving lines, which are often light-colored, typically radiate from urban areas, and cut through forests or agricultural areas. Sharp curves or bends suggest roads.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Snow</th>
<th>Mountains and Hills</th>
<th>Coaslines</th>
<th>Pivot Irrigation</th>
<th>Lakes and Dams</th>
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<tbody>
<tr>
<td>Snow, clouds, and smoke are difficult to distinguish; for snow, consider high elevations and/or high latitudes, season (date when image was taken), and patterns (shadows cast by terrain, shapes of underlying terrain).</td>
<td>Mountains and hills are higher-elevation terrain; look for indications of elevation (shadows, tree cover, tree cover thinning out), patterns of ridges and valleys (“wrinkles” with light and shade). Use a map to identify mountains and hills.</td>
<td>Coaslines show up easily because of striking land-sea color and shape differences; look for beaches, headlands, river mouths, on-shore settlement and development. Use the shapes of coastlines to align images and maps.</td>
<td>In pivot irrigation, water is sprayed in a circle from a field’s center; look for circular shapes, for dark areas of vegetation against a lighter background, and for regular patterns of circles in grids.</td>
<td>Lakes come in all sizes and shapes; look for light blue-, green-, or even white-colored areas with rounded, sometimes irregular edges and beaches. Dams are nearly straight features across rivers, behind which lakes form.</td>
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</tbody>
</table>

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<th>Clouds</th>
<th>Islands</th>
<th>Rivers</th>
<th>Agriculture</th>
<th>Urban Areas</th>
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<tr>
<td>Clouds, smoke, and snow are difficult to distinguish; for clouds, look for dark shadows on the ground, relation to ground surface (over land or water), color (white or gray), effects of wind (streaks), and patterns (puffy balls, lines, blankets).</td>
<td>Color and shape differences between land and water are the best indicators of islands; look also for beaches and surf lines, currents and sediments eddying around islands, clouds forming just over islands or just over water around islands.</td>
<td>Rivers are sinuous “breaks” in human and physical patterns; look for meandering shapes (with branches and tributaries), color (light or dark depending on riverbed composition and suspended material), development (e.g., roads, fields, buildings).</td>
<td>Agriculture creates patchworks of fields of different shapes and colors; look for rectangular patterns possibly organized along rivers or roads, with patches of varying color (usually light through dark blue-greens or browns).</td>
<td>Cities and towns vary in size and shape; look for areas of light colors (white, gray, pale blue, beige), geometric shapes (radial or grid patterns), with features such as parks, stadiums, and airports intermingled.</td>
</tr>
</tbody>
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<th>Smoke</th>
<th>Deltas</th>
<th>Beaches</th>
<th>Ports and Docks</th>
<th>Airports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke, clouds, and snow are difficult to distinguish; for smoke, look for a source (point, small area), nature of source (forest fire, chimney, volcano), color (white, gray, brown), pattern (billowing with shadows or thin, wispy), and wind direction.</td>
<td>Deltas form where rivers meet the sea; look for meandering shapes with many small and large channels, sediment plumes (shaped by currents and eddies), and color differences (in water and on land, e.g., sand build-up or vegetation).</td>
<td>The land-water edge is marked by deposits of sediment; look for very light colors, off-shore color variations (indicating water depth), sediment plumes from currents and eddies, and serrated shapes (from jetties and breakwaters).</td>
<td>Ports and docks link urban areas and coastlines. Look for “tooth-shaped,” light-colored, rectangular projections into the water, often with roads and railways lines running inland away from the coast.</td>
<td>Airports, with long straight runways intersecting in cross-shaped patterns, are usually found on the edge of urban areas. Look for light-colored lines, intersecting at 90 or 45 degrees, with dark areas between runways.</td>
</tr>
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Additional information and images:
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NASA Spacelink: [http://spacelink.nasa.gov](http://spacelink.nasa.gov)

Image database: [http://earth.jsc.nasa.gov](http://earth.jsc.nasa.gov)

Exploring Earth From Space, JSC Earth From Space image database: [http://earth.jsc.nasa.gov](http://earth.jsc.nasa.gov)
Creative Agriculture in Response to Limited Water
Creative Agriculture in Response to Limited Water

In desert areas where water is scarce, many ingenious ways of finding and using water have been developed to support agriculture. This composite shows several different methods.

The mosaic of two images shows patterns of agriculture in an arid valley of Saudi Arabia where aquifers have been tapped for water. The image centered on the Menindee Lakes along the Darling River (a) is in a desert region of New South Wales, Australia. A dam (not seen in the image) allows the river water to rise and flow into the lakes through a series of canals (b). The water in the lakes is used for local agriculture, such as in the rectangular fields in the old bed of Lake Tandou (c). The image of the Nile River (d) and the Faiyum depression (e) in Egypt shows one of the first regions in the world to be cultivated using irrigation. The Faiyum depression, where Nile water is diverted to support agriculture, is a naturally occurring low spot that was formerly a lake until it was drained and cultivated by Ptolemy II more than 2,000 years ago.

Additional information:
ISS EarthKAM images and lessons: http://www.earthkam.ucsd.edu
NASA Spacelink: http://spacelink.nasa.gov

Location: Saudi Arabia
Latitude: 24° N  Longitude: 45° E
Image Dimensions: 39.4 x 94.4 km
Date: March 29, 1996
Image ID #: STS076.ESC.06214832 and STS076.ESC.06214838

Location: Darling River, Australia
Latitude: 32.44°S  Longitude: 142.34°E
Image Dimensions: 84.2 x 126.0 km
Date: January 30, 1998
Image ID #: STS089.ESC.07182155

Location: Nile River, Egypt
Latitude: 29.60° N  Longitude: 30.33° E
Image Dimensions: 138.9 x 207.8 km
Date: January 14, 1997
Image ID #: STS081.ESC.02002611

What evidence do you see of the arid conditions in these areas?

- Mountains
- Sand dunes
- Ephemeral streams
- Center pivot irrigation fields

Which regions look like they’ve been cultivated recently? Which look older?

- Darling River
- Canals
- Lake Menindee
- Normal flood plain of the Darling River
- Lake Qarun (darker region)
- Faiyum depression
Colorado River
The Colorado River (a) is the largest river in the southwestern United States. As it flows through southern Utah, the river continuously erodes the sedimentary rock layers forming a deep, narrow canyon. Within this image, two tributary rivers, the San Juan (b) and the Escalante (c), flow into the Colorado. The region that gathers rainfall into a river is called a drainage basin. The entire drainage basin of the Escalante River is visible. Tree-covered, high-elevation mountains around the head of the Escalante River basin appear dark compared to the sparsely vegetated, orange-colored sedimentary rocks found at lower elevations.

Navajo Mountain (d) marks the gathering of the San Juan and Colorado Rivers. This isolated dome volcano pushed through the sedimentary rock layers of the Colorado Plateau and is situated near the Utah-Arizona border. Nearby Monument Valley (e), a Navajo Nation Tribal Park, has been characterized by red sandstone buttes and mesas that rise up to 300 meters above the surrounding landscape.

The Glen Canyon Dam (f) is visible at the far western edge of the image. Built between 1960 and 1963, the dam provides the area with water, electricity, and recreation. However, the introduction of the dam permanently changed the local ecosystem, which led to a controversy that is often cited as contributing to the birth of the modern environmental movement.

Additional information:
ISS EarthKAM images and lessons: http://www.earthkam.ucsd.edu
NASA Spacelink: http://spacelink.nasa.gov
The Earth’s surface plays an important role in the formation of clouds—collections of water and ice droplets. As shown in this composite, clouds often form just over the land or just over the water, and can be indicators of surface features or near-surface processes.

The top left image is a high oblique view of clouds over water. The Earth limb (a) shows the thickness of atmosphere. The top right image is of clouds over Trinidad (b). Clouds have formed only over the land through the combined actions of transpiration (the release of moisture through leaves) from the trees and the uplift of air over the islands. The bottom left image is of clouds along the Amazon River (c). Transpiration from the heavy vegetation growth in the Amazon basin provides the trigger for cloud formation over the land but not over the river. Regions that have been cleared of forest generally have fewer clouds. Finally, the bottom right image is of coastal fog along Namibia (d). Where the cool waters off the southwest coast of Africa meet the warm land, low stratus clouds form. Occasionally this fog drapes inland a small distance, providing the only moisture to this desert region.

Additional information:
EarthKAM images and lessons: http://www.earthkam.ucsd.edu
JSC Earth From Space image database: http://earth.jsc.nasa.gov
NASA Spacelink: http://spacelink.nasa.gov
Buenos Aires, Argentina

Latitude: 34.52° S  Longitude: 58.49° W
Date: January 30, 1998
Type of Image: EarthKAM
Image ID #: STS089.ESC.07154137

Argentina’s capital city of Buenos Aires (a), is home to about 13 million people, more than 1/3 of the country’s population. This image provides an excellent example of an urban landscape. Recognizable features include road patterns, especially major highways into and out of the city, a large airport (b), and port facilities on the coast (c). The darker regions within the city are parks and other areas with vegetation. The rectangular patterns, outside of the city, suggest that the countryside is heavily farmed.

Buenos Aires was built on the coast of the Río de la Plata (d), the large, muddy estuary which forms part of the border between Argentina (e) and Uruguay (f). At the head of the estuary is the large delta of the Río Paraná (g). The muddy pattern in the water, called the water turbidity, is formed by the heavy sediment load (sands and mud) carried by the Paraná and the Uruguay River. The turbidity shows the circulation pattern of the surface water in the estuary (h).

Argentina’s capital city of Buenos Aires is located here? Why is Buenos Aires located here?

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This coastal region of Andalusia, Spain, contains one of the most important untouched environments in all southwestern Europe. The Las Marismas (a) wetlands and the dunes of Doñana (b) are protected by a 50,000-hectare (124,000-acre) national park. The region illustrates the ways landforms change over time and area. Originally, Las Marismas was a bay on the Atlantic Ocean. Erosion from the sandy hills to the northwest formed a sand spit, which then evolved into the dunes of Doñana. This spit nearly closed off the bay, leaving only a small opening for the mouth of the Guadalquivir River (c). Though protected as both a national park and a UNESCO World Heritage Site, the wetlands are threatened by tourism, urbanization, and the use of the water for drinking and irrigation.

The Guadalquivir River is also diverted for agricultural irrigation. Due to the long growing season, local farmers grow mainly fruits. At the mouth of the Guadalquivir River sits Sanlúcar de Barrameda (d), the port from which Magellan and Columbus sailed. Its major industries are fishing and sherry.

The smaller port cities of Rota (e) and El Puerto de Santa María (f) boast fine beaches. Both cities also have harbors that can be seen to extend into the Gulf of Cádiz (g).

Additional information:
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NASA Spacelink: http://spacelink.nasa.gov