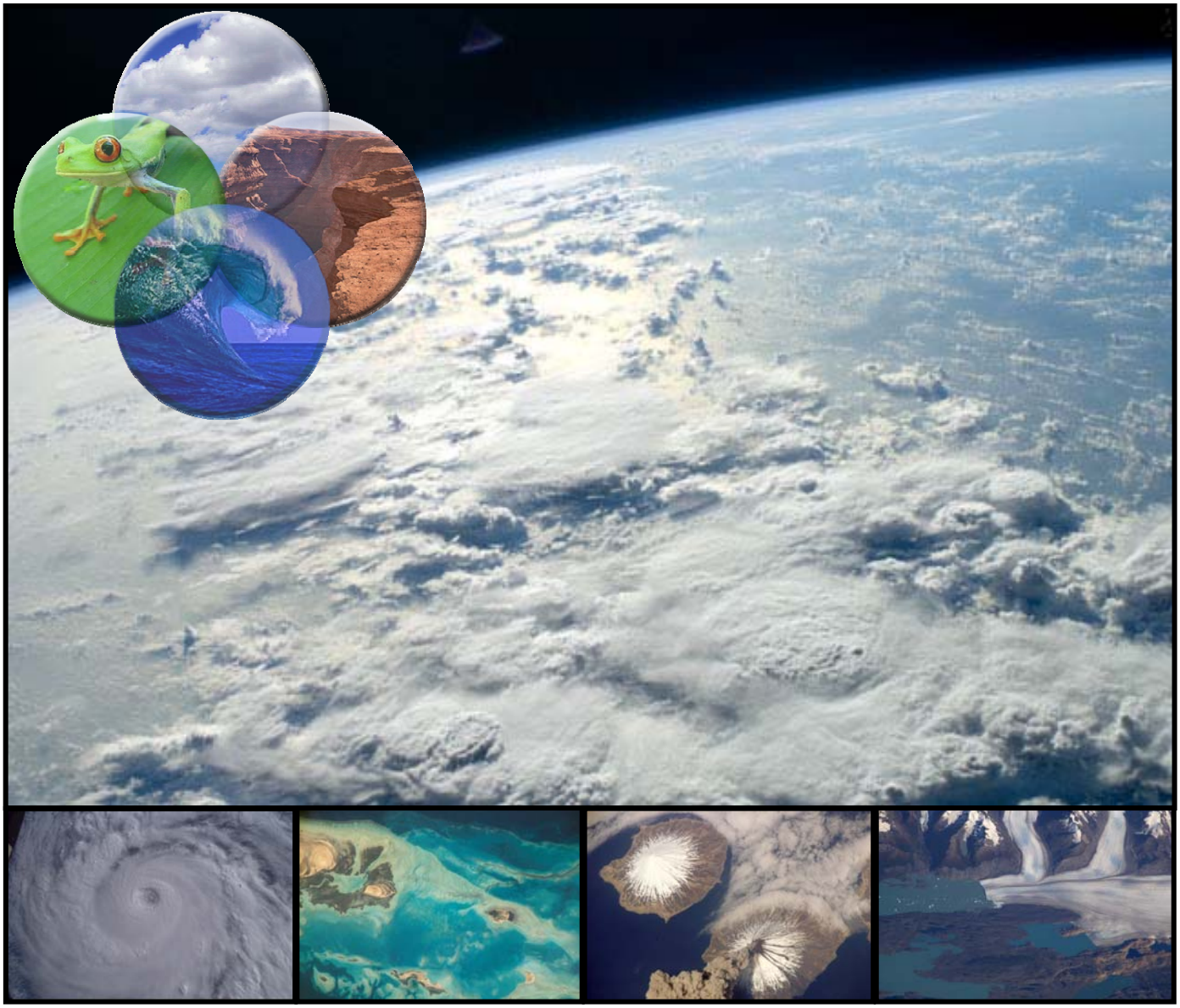
National Aeronautics and
Space Administration

SPHERES OF EARTH

An Introduction to Making Observations of Earth Using an Earth System Science Approach

TEACHER GUIDE



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Astromaterials Research & Exploration Science

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An Introduction to Making Observations of Earth Using an Earth System Science Approach

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Front cover images courtesy of the ARES Image Science and Analysis Laboratory, NASA JSC.
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5-E Activity - Teacher's Guide

Goal: This activity is designed to promote an interest in authentic investigations of Earth with a general understanding of Earth System Science. The activity uses the 5-E model of instruction which is an inquiry-based learning approach. The use of images acquired by astronauts of Earth is used as a hook for potential future student investigations.

Objectives: Students will:
1. Be introduced to, and become familiar with, the relationship among different Earth systems.
2. Identify and associate visible features on Earth with "spheres" or systems of Earth.
3. Understand remote sensing terminology associated with studying imagery from space.

Grade Level: 4 – 12+

Time Requirements: 2 – 4 class periods

Materials:
- Computer lab for students to explore Gateway to Astronaut Photography of Earth website (http://eol.jsc.nasa.gov) ***OR*** printed Spheres of Earth Image Resource Set
- *Spheres of Earth Student Guide*
- *Spheres of Earth Teacher Guide*
- *Projector (optional)*
- *Spheres of Earth Quick Reference Sheet (optional)*

***Other Use*ful Materials & Resources**
- World map, or Google Earth or NASA World Wind, if available, to increase students knowledge of the geography of the Earth
- Individual Student Sheets are provided at the end of this Teacher Guide for printing as desired

National Science Education Standards:
CONTENT STANDARD A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Communicate scientific procedures and explanations
- Think critically and logically to make the relationships between evidence and explanations

CONTENT STANDARD D: Earth and Space Science
- Develop an understanding of the structure of the Earth system
- Develop an understanding of Earth's history
- Develop an understanding of Earth in the Solar System

CONTENT STANDARD G: History and Nature of Science

- Develop an understanding of science as a human endeavor
- Develop an understanding of the nature of science
- Develop an understanding of the history of science

Useful Websites for Additional Background Knowledge:

- Gateway to Astronaut Photography of Earth: http://eol.jsc.nasa.gov
- NASA Earth Observatory: http://earthobservatory.nasa.gov

Teacher Note: The *Spheres of Earth Student Guide* is designed to include activity sheets and text to allow students to rely less on the teacher for information and instruction, and more on themselves as independent learners. You are encouraged to review information with students to ensure understanding of concepts and instructions.

Printing Alternative: As your resources permit, you can download the pdf of the *Student Guide* on your student computers and have students fill in answers to questions, save their work, and continue each day without printing anything. You can use Adobe Reader (http://get.adobe.com/reader/) or FoxIt Reader (http://www.foxitsoftware.com/pdf/reader). Both are freely available. Be sure to have students test this before completing the entire activity.

Introduction and Background

This activity is designed to be used for multiple purposes. It can be used as a stand-alone activity introducing students to an Earth System Science approach to studying Earth. It can also be used as an introductory activity to students participating in the Expedition Earth and Beyond Program. The activity allows students to explore and discover visible features in astronaut photography acquired from space. There is a database of over 900,000 images available for students to view images from space, available at the Gateway to Astronaut Photography of Earth website, http://eol.jsc.nasa.gov. This activity provides a framework in which to have students observe our Earth from the unique perspective of space and teach objectives and standards you may be required to cover. Students will have a rich authentic experience of looking at NASA images in which they will identify features associated with the different Spheres of Earth (Earth Systems). Additionally, they will gain insight into the process of science. The activity builds on students' prior knowledge about Earth and takes them through a process where they can recognize visible features of Earth, associate those features with an Earth system, and consider how changes in one system/feature may cause a change in another.

Our home planet, Earth, is the launch pad for learning and understanding other bodies in our Solar System. Our Earth System is made up of 4 major components. Those are the atmosphere, hydrosphere, biosphere and litho/geosphere. Most school textbooks likely use lithosphere as the term used for studying the "rocks" and geologic processes. Since the 1960's however, and the study of plate tectonics, the term "geosphere" has been becoming more widely used in the scientific community to refer to what has traditionally been referred to as the lithosphere. For this activity, we will use the term litho/geosphere to enable you, as teachers, to parallel concepts traditionally taught without fear that the term geosphere is not a part of your standard curriculum. We also hope to have you and your

students ahead of the curve with what current science has moved towards, that may or may not yet be reflected in your books or curriculum. Keep in mind there is no one correct way to divide up Earth's systems. For example, you may find that some scientists make reference to the cryosphere when they refer to water in the Earth's surface where water is in solid (ice) form. Others may include other spheres such as the magnetosphere, for example. For the purposes of this activity, we will divide up the components of Earth's systems as the atmosphere, hydrosphere, biosphere and litho/geosphere.

By using an Earth System Science approach, scientists, and your students, are able to understand that our Earth is made up of a set of systems that are all interrelated. It is similar to the human body system, which is referred to in Part 1 of the activity. All human body systems work together to maintain a healthy body that functions properly. In terms of Earth System Science, each of those systems allows Earth to keep itself in balance. A change in one system will affect other systems. Changes may be subtle, but with careful observation and critical thinking skills, students will be able to understand an introductory connection between the systems.

Features listed and associated with a system in this activity are not all-inclusive. Additionally, there are certain features that may be considered a feature related to more than one system. For example, clouds are listed within the atmosphere system of Earth. They could however, be listed under the hydrosphere system of Earth as clouds are small droplets of water in liquid or solid state suspended in the atmosphere. Likewise, let's think about glaciers. Thinking of glaciers as merely masses of ice and studying that ice might lead you to identify the hydrosphere as the main system related to glaciers. Looking at glaciers as a geologic feature or focusing on glacial processes and how they shape the surface would be more related to the litho/geosphere. Students can scientifically debate (argue!) their justification of a feature being most closely associated with one system versus another. As long as they can justify the association based on the explanation of the Earth system and its association to that feature, there may or may not be a wrong classification. Justification is key.

The following information, also listed in the student guide, provides a breakdown of the four major systems or spheres of Earth, and features associated with those systems that can be studied using astronaut photography. Again, this is not an all-inclusive list of features, but does provide a good list to use to help students understand the different systems and features. Key words related to each system are in bold italics to help reinforce important information.

1. **Atmosphere:** This sphere relates to meteorological features and phenomena such as weather, clouds, or aerosols (particles in the air). It includes an ever-changing ***mixture of gas and small particles located above and surrounding the Earth's surface***. Features include:

   -Clouds -Hurricanes and Cyclones -Aurora
   -Air Pollution/Aerosols -Dust and Sand Storms

2. **Biosphere:** This sphere is associated with ***living systems*** such as ***biomes*** or ***ecosystems***. This includes life on land, in the oceans and rivers, and even life we cannot see with the naked eye. Features visible in astronaut photographs include:

   -Coastal Biomes -Forests -Deserts
   -Grasslands -Urban/Agricultural Ecosystems

3. **Hydrosphere**: This sphere is associated with ***water in solid (ice) and liquid states***. Water in a gas state (water vapor) is probably best considered as a feature of the atmosphere. Features include:

   -Oceans -Lakes and Rivers -Snow
   -Ice Bergs -Glaciers

4. **Litho/Geosphere:** This sphere is associated with solid portions of the Earth. It includes rocks, sediments and soils, ***surface landforms*** and the ***processes*** that shape the surface. Features associated with this system can be broken down into a variety of different processes. These are:

   -***Fluvial and Alluvial Processes:*** Deltas, river channels/canyons, alluvial fans
   -***Aeolian Processes:*** Sand dunes, yardangs, wind streaks
   -***Tectonic Processes***: Folds, faults, mountains
   -***Volcanic Processes:*** Volcanoes, central vents, volcanic deposits
   -***Impact Processes:*** Impact craters
   -***Other Processes:*** Mass wasting processes, erosional processes

Most images will include features that can be associated with more than one Earth system. This reinforces the idea that together these systems make up our Earth today and changes to any system or feature will also have an effect on what our Earth will be like in the future.

Crew Earth Observations – Astronaut Photography

Astronauts onboard the International Space Station (ISS) are asked to take images of our Earth as part of their science activities. Scientists at the Image Science and Analysis Laboratory (ISAL) at the NASA Johnson Space Center train the astronauts to identify features from orbit and also help provide scientific context to the need for this data. While on the ISS, astronauts are sent task lists with images to acquire while on orbit. Images are acquired using hand-held digital cameras that are onboard the ISS. These off-the-shelf cameras and a variety of lenses allow astronauts to capture images of Earth from the unique perspective of space and at varying resolutions. Currently, the Nikon D2 and D3 series cameras are being used. Other cameras that have been used by astronauts (on both the shuttle and ISS) are the digital Kodak DCS760, as well as film cameras such as the Hasselblad 70mm camera, which was used early on. Images from space have been acquired by astronauts since the 1960's during the Mercury missions. The quality of the images has improved with camera technology and with the use of different focal length lenses. By changing the focal length of the lens, astronauts are able to acquire images that have a wider or narrower field of view. The higher the focal length (800mm for example) the narrower the field of view (less area will be covered). Higher focal lengths allow greater detail of the surface to be revealed but less surface area is covered. Lower focal lengths allow a larger area to be imaged, but the details of the surface will not be as crisp. The scientific need for the image drives the focal length that is requested. Sometimes astronauts take images of Earth just to reveal its beauty from space. These images allow all of us here on Earth to enjoy the wonder and beauty of our planet.

The Gateway to Astronaut Photography of Earth website (http://eol.jsc.nasa.gov) houses the database of these 900,000+ images that have been acquired by astronauts. There are many ways to search for images. This activity has students make observations of images found in the ***Weekly Top 10*** list. The images listed here can change so it is important to make sure students use the provided observation logs to record their data. These log sheets are important for students to get accustomed to, as any

science investigation or experiment requires logging data. The metadata students are asked to record will help them to sort through the variety of information that is provided for every image. As students become familiar with how to find this basic metadata, it will help them if they choose to conduct a research project using astronaut photography.

Oftentimes there are captions written for images on the website. These captions can be very useful to provide background information. It is important to have students read, or at least skim this information to help them understand the image they are observing as well as help them as they look at other images. The more they observe and read, the more they will transfer that knowledge when examining other images. There is also a link listed that states, ***"Download a Keyhole Markup Language (KML) file for use in Google Earth."*** If you have Google Earth on your computer, clicking on this link will take you to a view of the location on Earth shown in the image. This provides a greater context for the image and its location. This will assist your students in learning geography of Earth, as well as the importance of context when trying to understand what is going on in an image.

Included below are examples of two astronaut photographs and information about some of the visible features and their associated Earth System. Additionally, there is information to help relate how a change to one features/sphere could cause a change in others. The images shown here include labeled features to help you identify the features being listed. Not all images on the Gateway to Astronaut Photography of Earth website include images with labeled features.

IMAGE EXAMPLES:

This image shows a variety of features. It includes glaciers (hydrosphere), a lake (hydrosphere), mountains (litho/geosphere) and snow or ice (hydrosphere).

If there is more snow (hydrosphere) Greve Glacier will grow and eventually flow into Lake Greve. The glaciers may also carve deeper valleys into the mountains (litho/geosphere). As Greve Glacier breaks off and melts, this will cause the Greve Lake levels to rise (hydrosphere).

Image ID#: ISS003-E-6061

This image contains features such as an island/atoll (litho/geosphere), coral reefs (biosphere), sand deposits (litho/geosphere) the ocean (hydrosphere), clouds (atmosphere), and vegetation (biosphere).

If sea levels were to rise (hydrosphere) this could change the coastline (litho/geosphere) of this island. Sand deposits (litho/geosphere) would possibly end up under water and vegetation and any life forms (biosphere) that lived off that vegetation would not be able to survive.

Image ID#: ISS018-E-18129

These examples are included in the student guide. Additionally, the student guide discusses how scientists may focus on features within one system, but must consider influences from other systems.

The oil spill off the coast of Louisiana can be used an example. There were definite effects on the hydrosphere (ocean) from the spill. You could see oil in images taken from space. Students can think about how the spill affected the other spheres. First, students should think of the gases and smoke that went into the atmosphere when the explosion occurred. The biosphere (marine life and coastal ecosystems) were certainly harmed by the spill. As the oil reached land, it became mixed in and absorbed into the soils and sediment along the coast. Students do not need to understand the complex details of the effects, as they are very complicated and will probably not be fully understood for years to come. They should understand that you cannot observe these effects in a single astronaut photograph. Additionally, it is important for students to realize that scientists who may study the effects on a specific Earth system may use a variety of data sets, in addition to images, to conduct a study. Although this example illustrates the impacts on Earth systems from a human induced disaster, the main point to reinforce to students is that spheres are always interacting. The interaction of Earth's systems is continuous as systems respond to both natural or human induced changes. For example, interaction among systems and changes to features can be caused from naturally occurring events like hurricanes, volcanic eruptions, or earthquakes, or from human influences. The interactions of Earth's systems allow the planet to remain in balance.

5-E Model

The 5-E model is an inquiry based model of instruction that has 5 phases. They are: Engagement, Exploration, Explanation, Elaboration, and Evaluation. This model builds on prior knowledge students may have and helps them to expand on that knowledge while also correcting any inaccuracies. This model and activity is designed as guided discovery to maintain a structure for learning.

5-E Phase	General Description	Spheres of Earth Activity
Engagement	Teachers engage students in questions and probe for prior knowledge and conceptions.	Students use an understanding of the human body systems to relate to Earth systems and features. Students fill out information to demonstrate what they may already know.
Exploration	Students explore, make discoveries, and log observations of images helping to establish an understanding of content.	Students use the Gateway to Astronaut Photography of Earth website to log metadata and observations on data collection sheets.
Explanation	Building on students' explorations and explanations, students communicate new understandings and listen to other students' knowledge acquisition. Students use formal language and vocabulary associated with content.	Presentations by students of their data gathering activities. Students present their identification of features seen in images, their associated Earth System, and their observations. Students discuss how a change in one feature/system may cause a change in another.
Elaboration	Students apply new understandings to new problems.	Students elaborate on a scientific question that focuses on a visible feature and methods they could use to answer that question.
Evaluation	Teachers and students use formal and informal means to assess new knowledge and understandings.	Students use the same Systems table from Part 1 of the activity and fill in systems and associated system features without the aid of a word bank. Students also briefly describe an example to show how the spheres of Earth are all interconnected.

Table 1. 5-E model of instruction with general description and application to *Spheres of Earth* activity.

ACTIVITY PROCEDURE

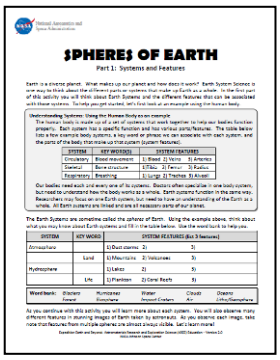
This activity procedure is provided as a suggested guide for the Spheres of Earth activity. Estimated times for each section are provided but can vary depending on your level of students and time you feel is necessary for engagement in discussion. Additionally, this procedure includes thumbnails of student pages for each section for your reference.

Part 1: Systems and Features (Engage Activity):

Estimated time for Part 1: ~15 minutes

Materials needed:

- Page 1 of the *Student Guide*


SPHERES OF EARTH
Part 1: Systems and Features

Students should be told that this part of the activity will help them judge what they may or may not know about Earth systems and features. By the end of the activity they will be able to fill out a similar to the one here.

1. Discuss with students the comparison of the human body systems to Earth's system. Have students discuss and fill out the table at the bottom of the page in groups of 2-4. This will give students a chance to think about what they may already know about Earth's systems and features.

2. Discuss answers with students. Be sure to reinforce and acknowledge what they may already know and that the activity will help them gain more knowledge.

SYSTEM	KEY WORD	SYSTEM FEATURES (list 3 features)		
Atmo*sphere*	***Air***	1) Dust storms	2) ***Clouds***	3) ***Hurricanes***
Litho/Geosphere	Land	1) Mountains	2) Volcanoes	3) ***Impact Craters***
Hydro*sphere*	***Water***	1) Lakes	2) ***Oceans***	3) ***Glaciers***
Biosphere	Life	1) Plankton	2) Coral Reefs	3) ***Forests***

3. Ask students if they know of any other features that may be associated with each Earth system. This just allows students to expand their answers from the list of words provided in the word bank. You may also ask students if they can describe or define what makes up each system.

Part 2: Data Collection (Exploration Activity):

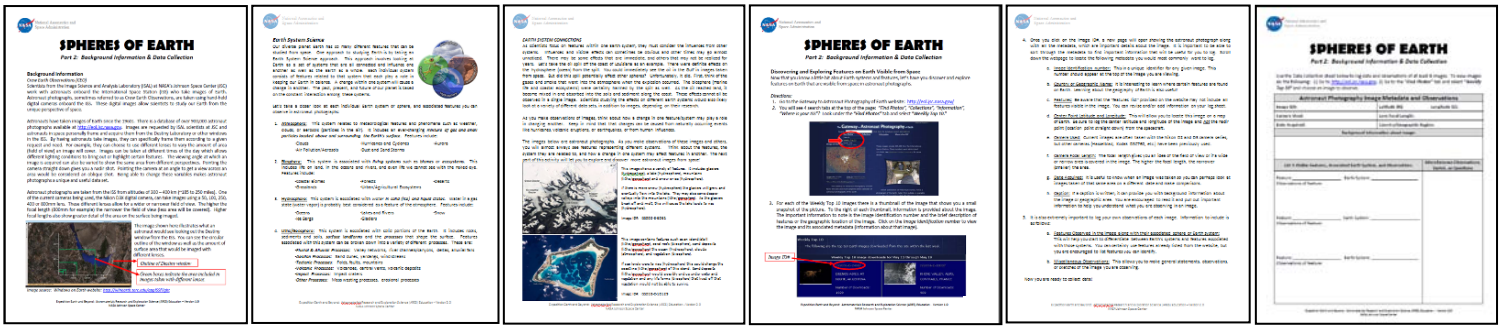
Estimated time for Part 2: ~30 minutes to discuss backgroundinformation on pp. 2-4; ~15 minutes to review collecting data information on pp.5-6; ~30-50 minutes to log data. (It is recommended to review information as a class or have students read the Background information and instructions for homework so these can be discussed in class.)

Materials needed:

- Pages 2-10 of the *Student Guide (Note: pages 2-4 are Background Information, pages 5 and 6 are instructions on how to gather the suggested data, and pages 7-10 are data collection/ observation sheets).*
- Computer lab, or projector, or printed images
- Quick Reference Sheet (optional)

For this part of the activity, consider the following choices, depending on your access to computers or a computer lab.

a. <u>If you have access to a computer lab:</u> If you have your students in groups of 4, it is recommended to separate them into 2 groups of 2 to complete this section of the activity.
b. <u>If you do not have access to a computer lab but you can project images from the front of the room:</u> You can put an image on the screen in front of the room and have students in their groups of 4 discuss and log their observations. You can also show the metadata to the class and have them log that information as well. (Note: Seeing and reading the metadata may be challenging for the students to read on a projected screen but you can log this together.)
c. <u>Hard Copy Images and Information:</u> You can print hard copies of images and information and distribute them to each group of students. An Image Resource Set is available on the curricular materials section of the Expedition Earth and Beyond Website: http://ares.jsc.nasa.gov/ares/education/eeab/curricularmaterials.cfm



Pages 2-7 of the Student Guide. Pages 7 – 10 are identical.

1. Students should read the three pages of background information (pages 2-4). You can have students read this for homework, read it together as a class, or do a jigsaw to have students gain an understanding for the information provided. The background information introduces students to:
   a. Crew Earth Observations (an overview of astronaut photography).
   b. Earth System Science (definition of each Earth system and features associated with those systems that can be viewed in astronaut photography).
   c. Earth System Connections (an example of how a change in one Earth system can cause a change in others.)

2. With an overhead projector, review instructions on how to access the images and image information with students as you feel necessary (pages 5 and 6). It may be important to go over the metadata students will be asked to log, depending on your students. This data is listed on the website in the order listed on page 6 but may be challenging for your students to sort through.

3. Once students are familiar with the instructions on how to access the information they are being asked to log, they are ready to begin logging observations of images. Have students log observations of at least 4 images. The information they are asked to log on the data collection sheets should be self-explanatory. The miscellaneous observations, sketch, or questions section is

an area where students can log any information about the images that is beyond other information they have logged. This can include a sketch of a feature or just some simple observations, thoughts, or questions they have about the image. It is not uncommon for students to leave this blank unless they are encouraged to log information here. This could be considered optional. Students can use the Quick Reference Sheet as a guide as they log information for each image.

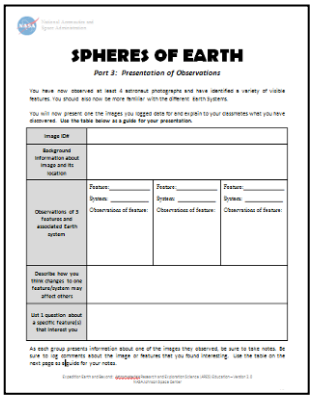
SPHERES OF EARTH
EARTH SYSTEMS AND FEATURES
Quick Reference Sheet

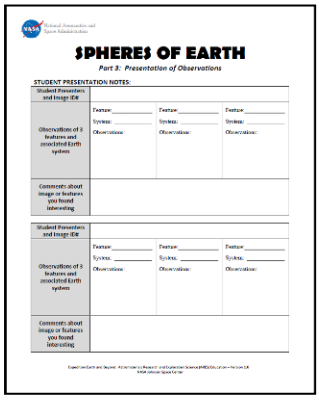
Part 3: Presentation of Observations (Explain Activity):

Estimated time for Part 3: ~30-45 minutes

Materials needed:

- Pages 11-12 of the *Student Guide*
- Computer projector to display images OR printed images show the class.


SPHERES OF EARTH
Part 3: Presentation of Observations


SPHERES OF EARTH
Part 3: Presentation of Observations
STUDENT PRESENTATION NOTES:

1. If students worked on the computers in groups of 2, they should regroup as their original group of 4 to prepare for a brief class presentation on one image of their choice. The table provided in the student guide allows students to put together their thoughts in an organized fashion to present to the class. Each student from each student group should participate in the presentation of the information to the class. Presentations should only be 2-3 minutes.

2. As students present their information to the class, students not presenting should take notes. There is a *Student Presentation Notes* table included in the Student Guide. A copy of this table is available at the end of this Teacher Guide so you can print extra copies for your students if desired. Alternatively, you can have the students recreate the table on their own notebook paper and take notes during each group presentation. Students should include any remarks or comments on the image and information presented.

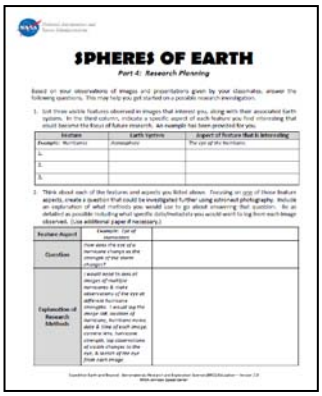
3. Discuss each image briefly after each presentation, as desired.

Part 4: Research Planning (Elaboration Activity):

Estimated time for Part 4: ~15-30 minutes

Materials needed:

- Page 13 of the *Student Guide*


SPHERES OF EARTH

Part 4: Research Planning

1. Have students fill out the table provided as a group. They should list 3 visible features, their associated Earth system and include an aspect of that feature that they think is interesting. For example, if they listed hurricanes, they should be able to identify what about hurricanes they find interesting that they can see in astronaut photography. The "aspect" of the feature becomes the basis for a research question they can formulate. An example is provided for them.

2. As students create a research question, it should focus on one of the features they have identified and should be formulated to address that **aspect** of the feature they find interesting. As part of their research methods, students should, at a minimum, include what metadata they would need to log from each image in order to answer that question. Students should base this information on the metadata/data they logged during Part 2 of the activity. Students should use additional paper as necessary.

Part 5: Systems and Features Review (Evaluate Activity):

Estimated time for Part 5: ~15 minutes

Materials needed:

- Page 14 of the *Student Guide*

SPHERES OF EARTH

Part 5: System and Feature Review

By the end of the activity, students should be able to name each of Earth's spheres and name at least 2 features associated with that sphere. The table provided is the same table students filled out in Part 1 of the activity. For this review section, they should be able to fill this table out without the aid of a word bank.

1. You can have students fill this out individually to evaluate the knowledge each student has gained throughout the activity.

Extensions:

1. Have students use this activity as a springboard to their participation in the Expedition Earth and Beyond Program. Students can discuss and debate features of interest that the class may be interested in studying as part of an authentic research project.
2. Have students investigate other planetary bodies in our solar system to discover if these other worlds have the same systems as Earth.
3. Have students explore size comparisons of features in images. All images on the Gateway to Astronaut Photography of Earth website include a KML file that opens up Google Earth to the general location of each astronaut photo. Students can use the measurement tool in Google Earth to determine the size of features in other images.
4. Have students further investigate Earth's system responses to natural or human induced changes and explore prediction capabilities.

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SPHERES OF EARTH

Part 1: Systems and Features

Earth is a diverse planet. What makes up our planet and how does it work? Earth System Science is one way to think about the different parts or systems that make up Earth as a whole. In the first part of this activity you will think about Earth systems and the different features that can be associated with those systems. To help you get started, let's first look at an example using the human body.

Understanding Systems: Using the Human Body as an example

The human body is made up of a set of systems that work together to help our bodies function properly. Each system has a specific function and has various parts/features. The table below lists a few example body systems, a key word or phrase we can associate with each system, and a few parts of the body that make up that system (system features).

SYSTEM	KEY WORD(S)	SYSTEM FEATURES
Circulatory	Blood movement	1) Blood 2) Veins 3) Arteries
Skeletal	Bone structure	1)Tibia 2) Femur 3) Radius
Respiratory	Breathing	1) Lungs 2) Trachea 3) Alveoli

Our bodies need each and every one of its systems. Doctors often specialize in one body system, but need to understand how the body works as a whole. Earth functions in the same way. All Earth systems are linked and each one is necessary to keep our Earth in balance.

The Earth Systems are sometime called the *spheres* of Earth. Using the example above, think about what you may know about Earth systems and fill in the table below. Use the word bank to help you.

SYSTEM	KEY WORD	SYSTEM FEATURES (list 3 features)
Atmo*sphere*		1) Dust storms 2) 3)
	Land	1) Mountains 2) Volcanoes 3)
Hydro*sphere*		1) Lakes 2) 3)
	Life	1) Plankton 2) Coral Reefs 3)

Word bank: *Glaciers* *Hurricanes* *Water* *Clouds* *Oceans* *Forests* *Biosphere* *Impact Craters* *Air* *Litho/Geosphere*

As you continue with this activity you will learn more about each system. You will also observe many different features in stunning images of Earth taken by astronauts. As you observe each image, take note that features from multiple spheres are almost always visible. Let's learn more!

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Part 2: Background Information & Data Collection

Use the Data Collection sheet below to log data and observations of at least 4 images. To view images do the following: 1) Go to http://eol.jsc.nasa.gov; 2) Go to the "***Find Photos***" tab and select "***Weekly Top 10***" and choose an image to observe.

Astronaut Photography Image Metadata and Observations	
Image ID#:	**Latitude (N):** **Longitude (E):**
Camera Used:	**Lens Focal Length:**
Date Acquired:	**Country/Geographic Region:**
Background information about image:	

List 3 Visible Features, Associated Earth System, and Observations	**Miscellaneous Observations, Sketch, or Questions**
Feature:_____ Earth System: _____ Observations of feature: Feature:_____ Earth System: _____ Observations of feature: Feature:_____ Earth System: _____ Observations of feature:	

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Part 3: Presentation of Observations

You have now observed at least 4 astronaut photographs and have identified a variety of visible features. You should now be more familiar with the different Earth Systems.

You will present one the images you logged data for and explain to your classmates what you have discovered. **Use the table below as a guide for your presentation.**

Image ID#			
Background information about image and its location			
Observations of 3 features and associated Earth system	Feature:_____ System: _____ Observations of feature:	Feature:_____ System: _____ Observations of feature:	Feature:_____ System: _____ Observations of feature:
Describe how you think changes to one feature/system may affect others			
List 1 question about a specific feature(s) that interest you			

As each group presents information about one of the images they observed, be sure to take notes. Use the table on the next page as a guide for your notes. Be sure to log comments about the image or features you found interesting.

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Part 3: Presentation of Observations

STUDENT PRESENTATION NOTES:

Student Presenters and Image ID#			
Observations of 3 features and associated Earth system	Feature:_____ System: _____ Observations:	Feature:_____ System: _____ Observations:	Feature:_____ System: _____ Observations:
Comments about image or features you found interesting			

Student Presenters and Image ID#			
Observations of 3 features and associated Earth system	Feature:_____ System: _____ Observations:	Feature:_____ System: _____ Observations:	Feature:_____ System: _____ Observations:
Comments about image or features you found interesting			

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Part 4: Research Planning

Based on your observations of images and presentations given by your classmates, answer the following questions. This may help you get started on a possible research investigation.

1. List three visible features observed in images that interest you, along with their associated Earth system. In the third column, indicate a specific aspect of each feature you find interesting that could become the focus of future research. An example has been provided for you.

Feature	Earth System	Aspect of feature that is interesting
Example: *Hurricanes*	*Atmosphere*	*The eye of the hurricane.*
1.		
2.		
3.		

2. Think about each of the features and aspects you listed above. Focusing on <u>one</u> of those feature aspects, create a question that could be investigated further using astronaut photography. Include an explanation of what methods you would use to go about answering that question. Be as detailed as possible including what specific data/metadata you would want to log from each image observed. (Use additional paper if necessary.)

Feature Aspect	***Example:*** *Eye of Hurricanes*	
Question	*How does the eye of a hurricane change as the strength of the storm changes?*	
Explanation of Research Methods	*I would need to look at images of multiple hurricanes & make observations of the eye at different hurricane strengths. I would log the image id#, location of hurricane, hurricane name, date & time of each image, camera lens, hurricane strength, log observations of visible changes to the eye, & sketch of the eye from each image.*	

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Part 5: System and Feature Review

You are now familiar with the four spheres of Earth and different features that can be associated with those spheres. You should also realize that although you can focus on individual features as part of an investigation, any change to one feature/system will have an effect on others. In this part of the activity, you will review what you have learned!

1. Fill in the information on the table below. Be sure to name each sphere of Earth as well as 2 features that are related to that system.

SYSTEM/SPHERE	KEY WORD	SYSTEM FEATURES (list 2 features)	
	Air	1)	2)
	Land	1)	2)
	Water	1)	2)
	Life	1)	2)

2. Describe one example of how a change in one feature/system can affect another:

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EARTH SYSTEMS AND FEATURES
Quick Reference Sheet

1. **Atmosphere:** This system relates to meteorological features and phenomena such as weather, clouds, or aerosols (particles in the air). It includes an ever-changing ***mixture of gas and small particles located above the Earth's surface***. Features associated with the atmosphere that can be studied using astronaut photography are:

   -Clouds
   -Air Pollution/Aerosols
   -Hurricanes and Cyclones
   -Dust and Sand Storms
   -Aurora

2. **Biosphere:** This system is associated with ***living systems*** such as ***biomes*** or ***ecosystems.*** This includes life on land, in the oceans and rivers, and even life we cannot see with the naked eye. Features associated with the biosphere that can be studied using astronaut photography are:

   -Coastal Biomes
   -Grasslands
   -Forests
   -Urban/Agricultural Ecosystems
   -Deserts

3. **Hydrosphere**: This system is associated with *water* ***in solid (ice) and liquid states***. Water in a gas state (water vapor) is probably best considered as a feature of the atmosphere. Features associated with this system that can be studied using astronaut photography are:

   -Oceans
   -Ice Bergs (Polar Ice Caps)
   -Lakes and Rivers
   -Glaciers
   -Snow

4. **Litho/Geosphere:** This system is associated with solid portions of the Earth. It includes rocks, sediments and soils, ***surface landforms*** and the ***processes*** that shape the surface. Features associated with this system can be broken down into a variety of different processes. These are:

   -***Fluvial and Alluvial Processes:*** Deltas, river channels/canyons, alluvial fans
   -***Aeolian Processes:*** Sand dunes, yardangs, wind streaks
   -***Tectonic Processes:*** Folds, faults, mountains
   -***Volcanic Processes:*** Volcanoes, central vents, volcanic deposits
   -***Impact Processes:*** Impact craters
   -***Other Processes:*** Mass wasting processes, erosional processes