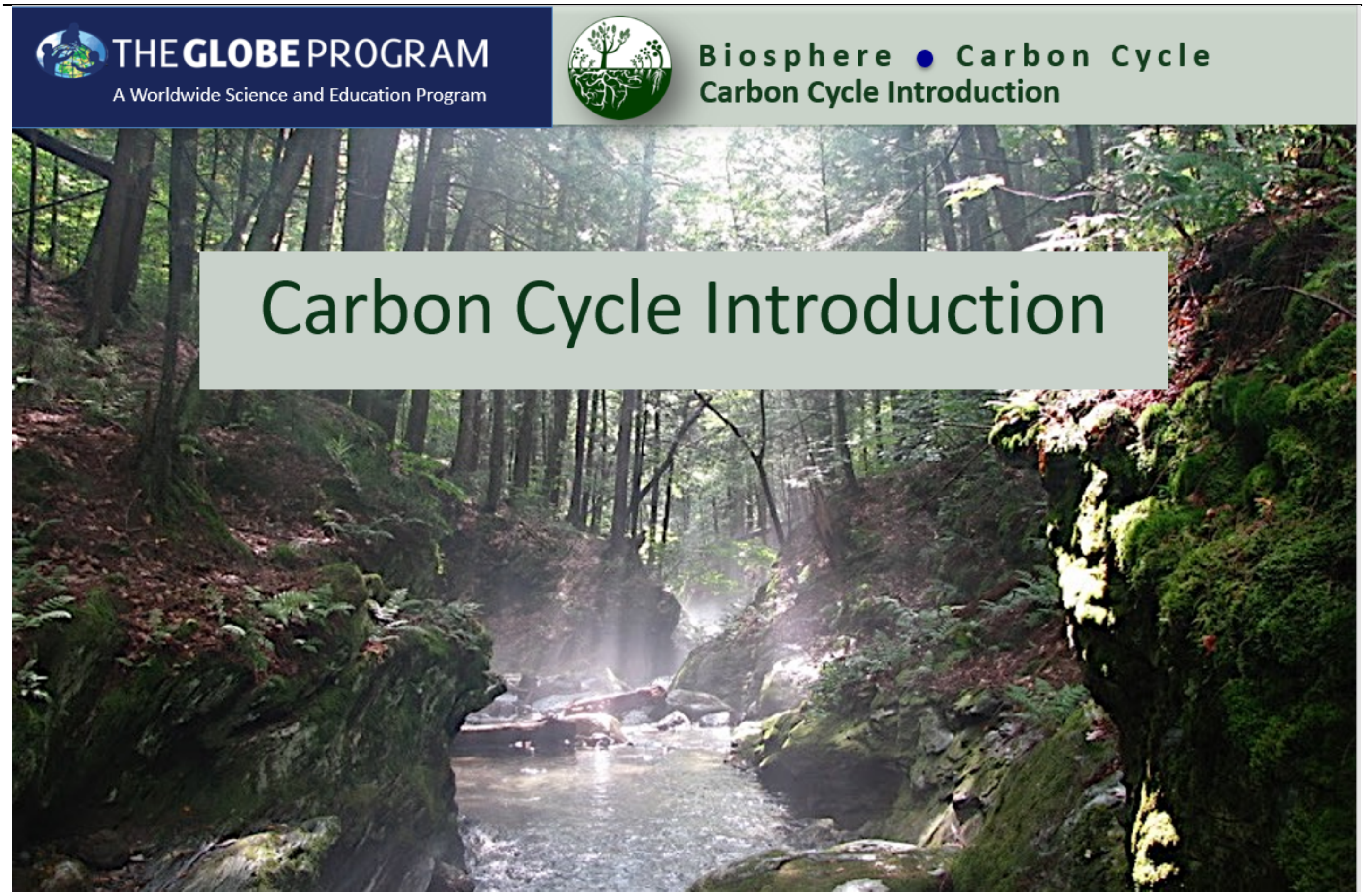
My NASA Data - GLOBE Connections

GLOBE Connections: Flow of Energy and Matter



GLOBE protocols and learning activities that complement exploration of the Flow of Energy and Matter are outlined below.

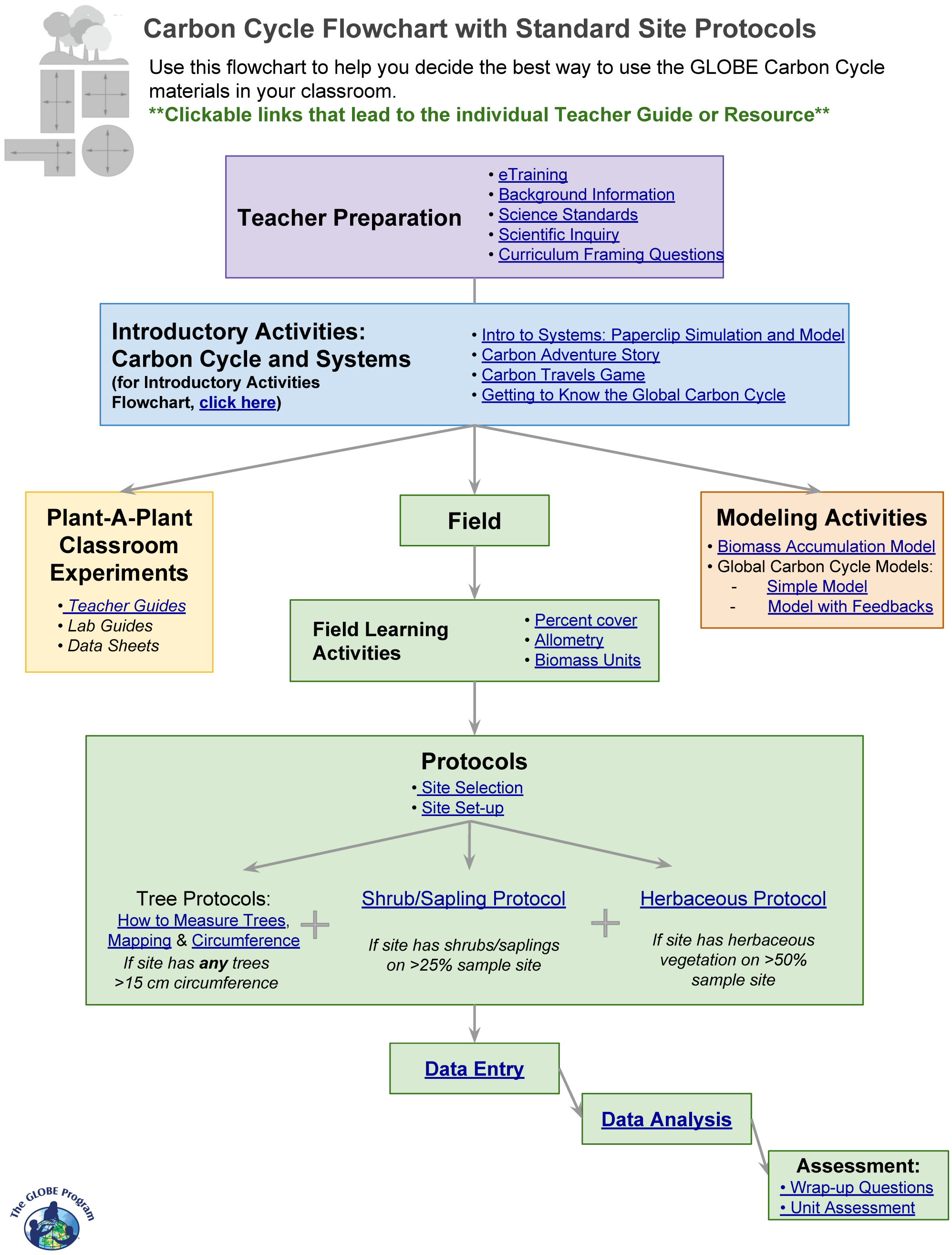
Flow of Energy and Matter

The flow of energy and matter is evident in many phenomena. These GLOBE protocols are a few examples of those that illustrate these flows. For more information on the flow of energy and matter, visit the *My NASA Data page* dedicated to this cross-cutting concept.

Protocols

GLOBE protocols can be used to collect many types of data. Students can use the protocols to collect data and share their data with other GLOBE students around the world.

Carbon Cycle The Globe Carbon Cycle project is one of four Earth System Science Projects (ESSPs) funded by NASA and NSF to develop hands-on, intermediate and secondary school-based science activities for the GLOBE (Global Learning and Observations to Benefit the Environment) Program.



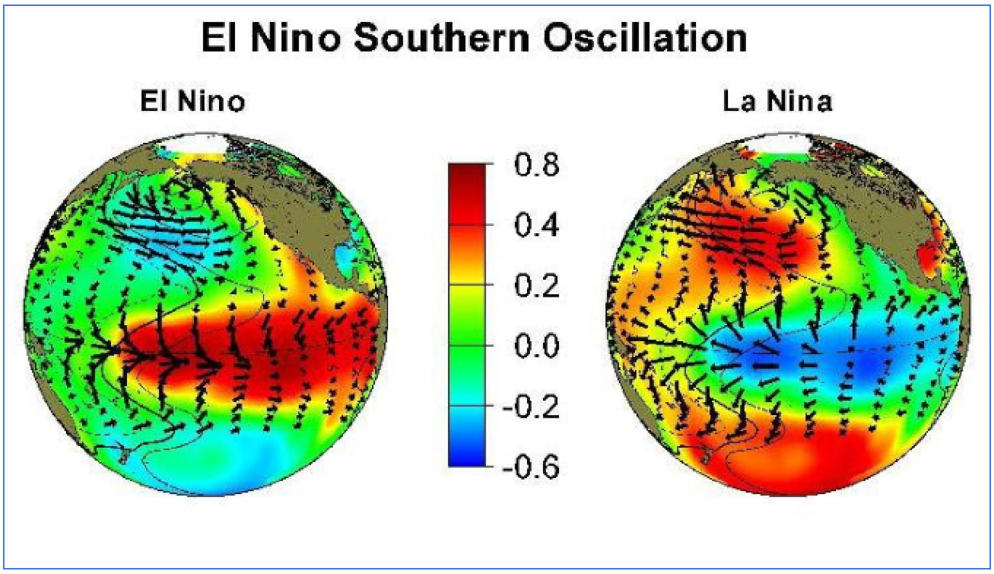
Source: GLOBE Carbon Cycle

GLOBE Carbon Cycle focuses on bringing the most cutting-edge research and research techniques in the field of terrestrial ecosystem carbon cycling into the classroom. It uses a systems-thinking approach to gain a foundation in the carbon cycle and its relation to climate and energy. The materials incorporate a diverse set of activities geared toward upper-middle and high school students. The protocols can be found in the GLOBE Teacher's Guide.

Protocol Bundles

GLOBE has developed protocol bundles that are designed to incorporate measurement protocols from different spheres to study different topics including ENSO and the water cycle. They can all be found here.

ENSO protocol bundle:

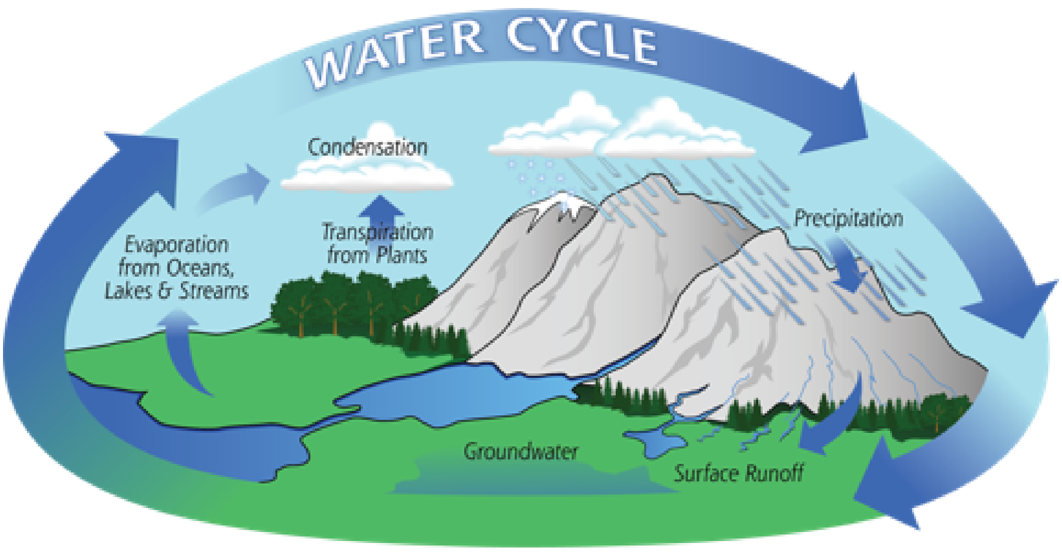


Colors indicated anomaly in sea surface temperature, arrows indicate wind direction. Source: NOAA

El Niño and La Niña are important climatic phenomena that can have impacts on the climate globally causing flooding and droughts as well as changes in seasonal weather. These interactions around the world are called teleconnections. Considering the importance of this issue, a GLOBE ENSO (El Niño Southern Oscillation) Campaign has been formulated to engage students in determining where and how much El Niño affects local places and to put students in contact with the resulting patterns in their local environment. There are several protocols that are part of this bundle.

Water Cycle protocol bundle:

Water—the main reason for life on Earth—continuously circulates through one of Earth's most powerful systems: the water cycle. Water flows endlessly between the ocean, atmosphere, and land. Earth's water is a finite, fixed amount, meaning that the amount of water in, on, and above our planet does not increase or decrease.



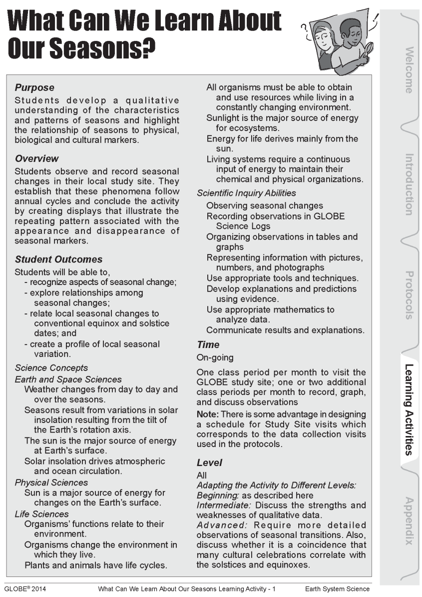
NASA studies water in a variety of ways, using satellites, airborne campaigns, and ground-based measurements to collect data. These data are used for many real-world applications to answer vital questions that are essential to our survival on this amazing "water planet". The data that GLOBE scientists, teachers, and students collect are also vital and help us to become better informed and engaged stewards for the water in our environment. There are several protocols that are part of this bundle.

Learning Activities

The measurements of The GLOBE Program provide students with the means to begin exploring Earth as a System for themselves. The processes comprising the global environment are interconnected. Many of the major environmental issues of our time have driven scientists to study how these connections operate on a global basis – to understand Earth as a system. Using GLOBE Earth System Learning Activities can guide students in the development of their own personal connections with the different components of the Earth system and how these interact with each other, including the flow of energy and matter between the components. These flows are highlighted in activities related to seasonal changes and the Carbon Cycle.

There are many learning activities for Earth as a System. You can filter the learning activities by grade band on the GLOBE Learning Activities Search Page. Select the desired grade band and click the filter button.

Selected learning activities are highlighted on this page.



What Can We Learn About Our Seasons?

Purpose

Students develop a qualitative understanding of the characteristics and patterns of seasons and highlight the relationship of seasons to physical, biological and cultural markers.

Overview

Students observe and record seasonal changes in their local study site. They establish that these phenomena follow annual cycles and conclude the activity by creating displays that illustrate the repeating pattern associated with the appearance and disappearance of seasonal markers.

Student Outcomes

Students will be able to,
- recognize aspects of seasonal change;
- explore relationships among seasonal changes;
- relate local seasonal changes to conventional equinox and solstice dates; and
- create a profile of local seasonal variation.

Science Concepts

Earth and Space Sciences
Weather changes from day to day and over the seasons.
Seasons result from variations in solar insolation resulting from the tilt of the Earth's rotation axis.
The sun is the major source of energy at Earth's surface.
Solar insolation drives atmospheric and ocean circulation.

Physical Sciences
Sun is a major source of energy for changes on the Earth's surface.

Life Sciences
Organisms' functions relate to their environment.
Organisms change the environment in which they live.
Plants and animals have life cycles.
All organisms must be able to obtain and use resources while living in a constantly changing environment.
Sunlight is the major source of energy for ecosystems.
Energy for life derives mainly from the sun.
Living systems require a continuous input of energy to maintain their chemical and physical organizations.

Scientific Inquiry Abilities
Observing seasonal changes
Recording observations in GLOBE Science Logs
Organizing observations in tables and graphs
Representing information with pictures, numbers, and photographs
Use appropriate tools and techniques.
Develop explanations and predictions using evidence.
Use appropriate mathematics to analyze data.
Communicate results and explanations.

Time

On-going

One class period per month to visit the GLOBE study site; one or two additional class periods per month to record, graph, and discuss observations

Note: There is some advantage in designing a schedule for Study Site visits which corresponds to the data collection visits used in the protocols.

Level

All

Adapting the Activity to Different Levels:
Beginning: as described here
Intermediate: Discuss the strengths and weaknesses of qualitative data.
Advanced: Require more detailed observations of seasonal transitions. Also, discuss whether it is a coincidence that many cultural celebrations correlate with the solstices and equinoxes.

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GLOBE® 2014 What Can We Learn About Our Seasons Learning Activity - 1 Earth System Science

What Can We Learn About Our Seasons?

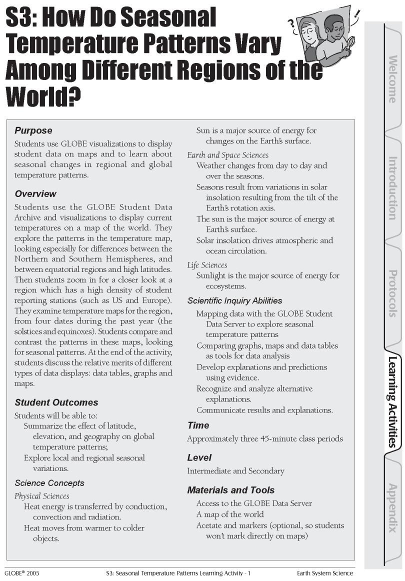
Overview: Students observe and record seasonal changes in their local study site. They establish that these phenomena follow annual cycles and conclude the activity by creating displays that illustrate the repeating pattern associated with the appearance and disappearance of seasonal markers.

Student Outcomes:

- recognize aspects of seasonal change
- explore relationships among seasonal changes
- relate local seasonal changes to conventional equinox and solstice dates

- create a profile of local seasonal variation

[How Do Seasonal Temperature Patterns Vary Among Different Regions of the World?]


S3: How Do Seasonal Temperature Patterns Vary Among Different Regions of the World?

Purpose
Students use GLOBE visualizations to display student data on maps and to learn about seasonal changes in regional and global temperature patterns.

Overview
Students use the GLOBE Student Data Archive and visualizations to display current temperatures on a map of the world. They explore the patterns in the temperature map, looking especially for differences between the Northern and Southern Hemispheres, and between equatorial regions and high latitudes. Then students zoom in for a closer look at a region which has a high density of student reporting stations (such as US and Europe). They examine temperature maps for the region, from four dates during the past year (the solstices and equinoxes). Students compare and contrast the patterns in these maps, looking for seasonal patterns. At the end of the activity, students discuss the relative merits of different types of data displays: data tables, graphs and maps.

Student Outcomes
Students will be able to:
Summarize the effect of latitude, elevation, and geography on global temperature patterns;
Explore local and regional seasonal variations.

Science Concepts
Physical Sciences
Heat energy is transferred by conduction, convection and radiation.
Heat moves from warmer to colder objects.
Sun is a major source of energy for changes on the Earth's surface.
Earth and Space Sciences
Weather changes from day to day and over the seasons.
Seasons result from variations in solar insolation resulting from the tilt of the Earth's rotation axis.
The sun is the major source of energy at Earth's surface.
Solar insolation drives atmospheric and ocean circulation.
Life Sciences
Sunlight is the major source of energy for ecosystems.

Scientific Inquiry Abilities
Mapping data with the GLOBE Student Data Server to explore seasonal temperature patterns
Comparing graphs, maps and data tables as tools for data analysis
Develop explanations and predictions using evidence.
Recognize and analyze alternative explanations.
Communicate results and explanations.

Time
Approximately three 45-minute class periods

Level
Intermediate and Secondary

Materials and Tools
Access to the GLOBE Data Server
A map of the world
Acetate and markers (optional, so students won't mark directly on maps)

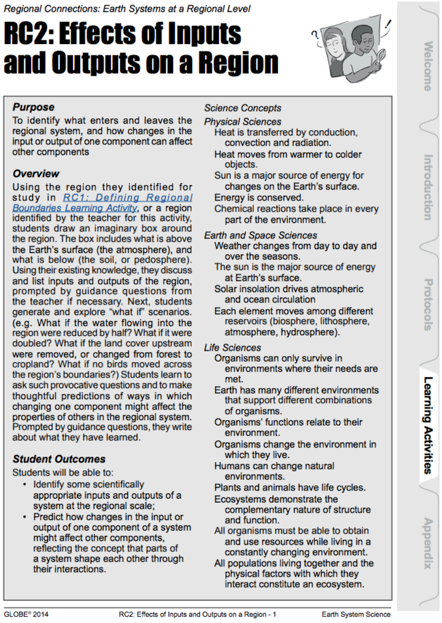
GLOBE® 2005 S3: Seasonal Temperature Patterns Learning Activity - 1 Earth System Science

Overview: Students use the GLOBE Student Data Archive and visualizations to display current temperatures on a map of the world. They explore the patterns in the temperature map, looking especially for differences between the Northern and Southern Hemispheres, and between equatorial regions and high latitudes. Then students zoom in for a closer look at a region that has a high density of student reporting stations (such as the US and Europe). They examine temperature maps for the region, from four dates during the past year (the solstices and equinoxes). Students compare and contrast the patterns in these maps, looking for seasonal patterns. At the end of the activity, students discuss the relative merits of different types of data displays: data tables, graphs, and maps.

Student Outcomes:

- Summarize the effect of latitude, elevation, and geography on global temperature patterns
- Explore local and regional seasonal variations
- Heat energy is transferred by conduction, convection, and radiation
- Heat moves from warmer to colder objects
- Sun is a major source of energy for changes on the Earth's surface
- Weather changes from day to day and over the seasons
- Seasons result from variations in solar insolation resulting from the tilt of the Earth's rotation axis
- The sun is the major source of energy at Earth's surface
- Solar insolation drives atmospheric and ocean circulation
- Sunlight is the major source of energy for ecosystems
- Mapping data with the GLOBE Student Data Server to explore seasonal temperature patterns
- Comparing graphs, maps and data tables as tools for data analysis
- Develop explanations and predictions using evidence
- Recognize and analyze alternative explanations
- Communicate results and explanations

[Regional Connections-Effects of Inputs and Outputs on a Region]:



Regional Connections: Earth Systems at a Regional Level

RC2: Effects of Inputs and Outputs on a Region

Purpose
To identify what enters and leaves the regional system, and how changes in the input or output of one component can affect other components

Overview
Using the region they identified for study in *RC1: Defining Regional Boundaries Learning Activity*, or a region identified by the teacher for this activity, students draw an imaginary box around the region. The box includes what is above the Earth's surface (the atmosphere), and what is below (the soil, or pedosphere). Using their existing knowledge, they discuss and list inputs and outputs of the region, prompted by guidance questions from the teacher if necessary. Next, students generate and explore "what if" scenarios. (e.g. What if the water flowing into the region were reduced by half? What if it were doubled? What if the land cover upstream were removed, or changed from forest to cropland? What if no birds moved across the region's boundaries?) Students learn to ask such provocative questions and to make thoughtful predictions of ways in which changing one component might affect the properties of others in the regional system. Prompted by guidance questions, they write about what they have learned.

Student Outcomes
Students will be able to:
- Identify some scientifically appropriate inputs and outputs of a system at the regional scale;
- Predict how changes in the input or output of one component of a system might affect other components, reflecting the concept that parts of a system shape each other through their interactions.

Science Concepts
Physical Sciences
Heat is transferred by conduction, convection and radiation.
Heat moves from warmer to colder objects.
Sun is a major source of energy for changes on the Earth's surface.
Energy is conserved.
Chemical reactions take place in every part of the environment.

Earth and Space Sciences
Weather changes from day to day and over the seasons.
The sun is the major source of energy at Earth's surface.
Solar insolation drives atmospheric and ocean circulation
Each element moves among different reservoirs (biosphere, lithosphere, atmosphere, hydrosphere).

Life Sciences
Organisms can only survive in environments where their needs are met.
Earth has many different environments that support different combinations of organisms.
Organisms' functions relate to their environment.
Organisms change the environment in which they live.
Humans can change natural environments.
Plants and animals have life cycles.
Ecosystems demonstrate the complementary nature of structure and function.
All organisms must be able to obtain and use resources while living in a constantly changing environment.
All populations living together and the physical factors with which they interact constitute an ecosystem.

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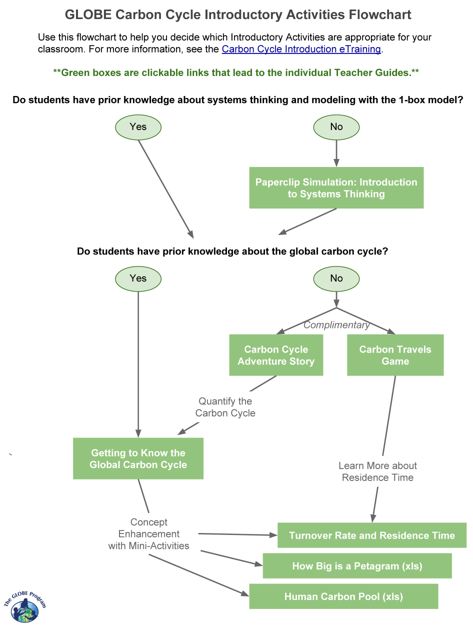
GLOBE® 2014 RC2: Effects of Inputs and Outputs on a Region - 1 Earth System Science

Overview: Using the region they identified for study in RC1: Defining Regional Boundaries Learning Activity, or a region identified by the teacher for this activity, students draw an imaginary box around the region. The box includes what is above the Earth's surface (the atmosphere), and what is below (the soil, or pedosphere). Using their existing knowledge, they discuss and list the inputs and outputs of the region, prompted by guidance questions from the teacher if necessary. Next, students generate and explore "what if" scenarios. (e.g. What if the water flowing into the region was reduced by half? What if it were doubled? What if the land cover upstream were removed, or changed from forest to cropland? What if no birds moved across the region's boundaries?) Students learn to ask such provocative questions and to make thoughtful predictions of ways in which changing one component might affect the properties of others in the regional system. Prompted by guidance questions, they write about what they have learned.

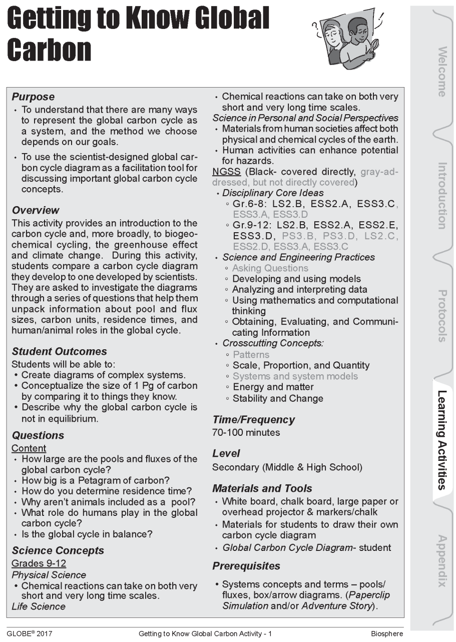
Student Outcomes:

- Identify some scientifically appropriate inputs and outputs of a system at the regional scale;
- Predict how changes in the input or output of one component of a system might affect other components, reflecting the concept that parts of a system shape each other through their interactions.

There are also learning activities associated with the **GLOBE Carbon Cycle Project**.



The **[GLOBE Carbon Cycle Introductory Activities Flowchart]** is a useful guide to selecting Carbon Cycle learning activities. Here are a few of the projects.



Getting to Know Global Carbon

Purpose
- To understand that there are many ways to represent the global carbon cycle as a system, and the method we choose depends on our goals.
- To use the scientist-designed global carbon cycle diagram as a facilitation tool for discussing important global carbon cycle concepts.

Overview
This activity provides an introduction to the carbon cycle and, more broadly, to biogeochemical cycling, the greenhouse effect and climate change. During this activity, students compare a carbon cycle diagram they develop to one developed by scientists. They are asked to investigate the diagrams through a series of questions that help them unpack information about pool and flux sizes, carbon units, residence times, and human/animal roles in the global cycle.

Student Outcomes
Students will be able to:
- Create diagrams of complex systems.
- Conceptualize the size of 1 Pg of carbon by comparing it to things they know.
- Describe why the global carbon cycle is not in equilibrium.

Questions
Content
- How large are the pools and fluxes of the global carbon cycle?
- How big is a Petagram of carbon?
- How do you determine residence time?
- Why aren't animals included as a pool?
- What role do humans play in the global carbon cycle?
- Is the global cycle in balance?

Science Concepts
Grades 9-12
Physical Science
- Chemical reactions can take on both very short and very long time scales.

Life Science
- Chemical reactions can take on both very short and very long time scales.

Science in Personal and Social Perspectives
- Materials from human societies affect both physical and chemical cycles of the earth.
- Human activities can enhance potential for hazards.

NGSS (Black- covered directly, gray-addressed, but not directly covered)
- *Disciplinary Core Ideas*
  - Gr.6-8: LS2.B, ESS2.A, ESS3.C, ESS3.A, ESS3.D
  - Gr.9-12: LS2.B, ESS2.A, ESS2.E, ESS3.D, PS3.B, PS3.D, LS2.C, ESS2.D, ESS3.A, ESS3.C
- *Science and Engineering Practices*
  - Asking Questions
  - Developing and using models
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Obtaining, Evaluating, and Communicating Information
- *Crosscutting Concepts:*
  - Patterns
  - Scale, Proportion, and Quantity
  - Systems and system models
  - Energy and matter
  - Stability and Change

Time/Frequency
70-100 minutes

Level
Secondary (Middle & High School)

Materials and Tools
- White board, chalk board, large paper or overhead projector & markers/chalk
- Materials for students to draw their own carbon cycle diagram
- *Global Carbon Cycle Diagram*- student

Prerequisites
- Systems concepts and terms – pools/fluxes, box/arrow diagrams. (*Paperclip Simulation* and/or *Adventure Story*).

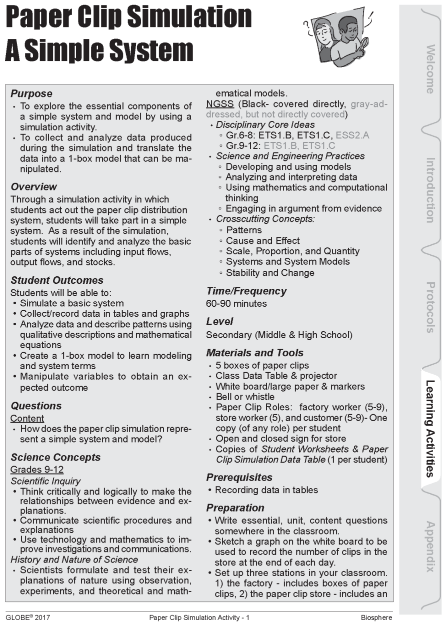
GLOBE® 2017 Getting to Know Global Carbon Activity - 1 Biosphere

Getting to Know Global Carbon

Overview: This activity provides an introduction to the carbon cycle and, more broadly, to biogeochemical cycling, the greenhouse effect and climate change. During this activity, students compare a carbon cycle diagram they develop to one developed by scientists. They are asked to investigate the diagrams through a series of questions that help them unpack information about pool and flux sizes, carbon units, residence times, and human/animal roles in the global cycle.

Student Outcomes:

- Create diagrams of complex systems
- Conceptualize the size of 1 Pg of carbon by comparing it to things they know
- Describe why the global carbon cycle is not in equilibrium



Paper Clip Simulation
A Simple System

Purpose
- To explore the essential components of a simple system and model by using a simulation activity.
- To collect and analyze data produced during the simulation and translate the data into a 1-box model that can be manipulated.

Overview
Through a simulation activity in which students act out the paper clip distribution system, students will take part in a simple system. As a result of the simulation, students will identify and analyze the basic parts of systems including input flows, output flows, and stocks.

Student Outcomes
Students will be able to:
- Simulate a basic system
- Collect/record data in tables and graphs
- Analyze data and describe patterns using qualitative descriptions and mathematical equations
- Create a 1-box model to learn modeling and system terms
- Manipulate variables to obtain an expected outcome

Questions
Content
- How does the paper clip simulation represent a simple system and model?

Science Concepts
Grades 9-12
Scientific Inquiry
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations
- Use technology and mathematics to improve investigations and communications.

History and Nature of Science
- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

NGSS (Black- covered directly, gray-addressed, but not directly covered)
- *Disciplinary Core Ideas*
  - Gr.6-8: ETS1.B, ETS1.C, ESS2.A
  - Gr.9-12: ETS1.B, ETS1.C
- *Science and Engineering Practices*
  - Developing and using models
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Engaging in argument from evidence
- *Crosscutting Concepts:*
  - Patterns
  - Cause and Effect
  - Scale, Proportion, and Quantity
  - Systems and System Models
  - Stability and Change

Time/Frequency
60-90 minutes

Level
Secondary (Middle & High School)

Materials and Tools
- 5 boxes of paper clips
- Class Data Table & projector
- White board/large paper & markers
- Bell or whistle
- Paper Clip Roles: factory worker (5-9), store worker (5), and customer (5-9)- One copy (of any role) per student
- Open and closed sign for store
- Copies of *Student Worksheets & Paper Clip Simulation Data Table* (1 per student)

Prerequisites
- Recording data in tables

Preparation
- Write essential, unit, content questions somewhere in the classroom.
- Sketch a graph on the white board to be used to record the number of clips in the store at the end of each day.
- Set up three stations in your classroom. 1) the factory - includes boxes of paper clips, 2) the paper clip store - includes an

GLOBE® 2017 Paper Clip Simulation Activity - 1 Biosphere

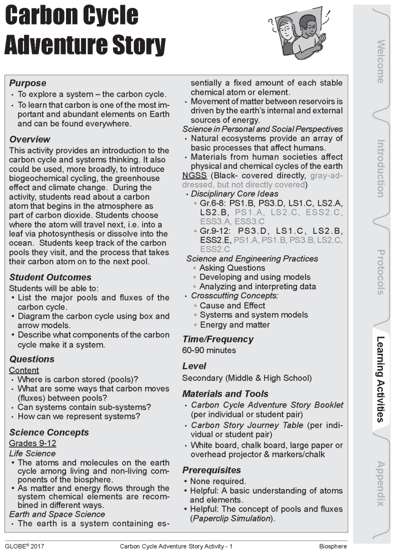
[**Paper Clip Simulation A Simple System**]

Overview: Through a simulation activity in which students act out the paper clip distribution system, students will take part in a simple system. As a result of the simulation, students will identify and analyze the basic parts of systems including input flows, output flows, and stocks.

Student Outcomes:

- Simulate a basic system
- Collect/record data in tables and graphs
- Analyze data and describe patterns using qualitative descriptions and mathematical equations
- Create a 1-box model to learn modeling and system terms
- Manipulate variables to obtain an expected outcome

[Carbon Cycle Adventure Story](#)



Carbon Cycle Adventure Story

Purpose
- To explore a system – the carbon cycle.
- To learn that carbon is one of the most important and abundant elements on Earth and can be found everywhere.

Overview
This activity provides an introduction to the carbon cycle and systems thinking. It also could be used, more broadly, to introduce biogeochemical cycling, the greenhouse effect and climate change. During the activity, students read about a carbon atom that begins in the atmosphere as part of carbon dioxide. Students choose where the atom will travel next, i.e. into a leaf via photosynthesis or dissolve into the ocean. Students keep track of the carbon pools they visit, and the process that takes their carbon atom on to the next pool.

Student Outcomes
Students will be able to:
- List the major pools and fluxes of the carbon cycle.
- Diagram the carbon cycle using box and arrow models.
- Describe what components of the carbon cycle make it a system.

Questions
Content
- Where is carbon stored (pools)?
- What are some ways that carbon moves (fluxes) between pools?
- Can systems contain sub-systems?
- How can we represent systems?

Science Concepts
Grades 9-12
Life Science
- The atoms and molecules on the earth cycle among living and non-living components of the biosphere.
- As matter and energy flows through the system chemical elements are recombined in different ways.

Earth and Space Science
- The earth is a system containing essentially a fixed amount of each stable chemical atom or element.
- Movement of matter between reservoirs is driven by the earth's internal and external sources of energy.

Science in Personal and Social Perspectives
- Natural ecosystems provide an array of basic processes that affect humans.
- Materials from human societies affect physical and chemical cycles of the earth

NGSS (Black- covered directly, gray-addressed, but not directly covered)
- *Disciplinary Core Ideas*
  - Gr.6-8: PS1.B, PS3.D, LS1.C, LS2.A, LS2.B, PS1.A, LS2.C, ESS2.C, ESS3.A, ESS3.C
  - Gr.9-12: PS3.D, LS1.C, LS2.B, ESS2.E, PS1.A, PS1.B, PS3.B, LS2.C, ESS2.C
- *Science and Engineering Practices*
  - Asking Questions
  - Developing and using models
  - Analyzing and interpreting data
- *Crosscutting Concepts:*
  - Cause and Effect
  - Systems and system models
  - Energy and matter

Time/Frequency
60-90 minutes

Level
Secondary (Middle & High School)

Materials and Tools
- *Carbon Cycle Adventure Story Booklet* (per individual or student pair)
- *Carbon Story Journey Table* (per individual or student pair)
- White board, chalk board, large paper or overhead projector & markers/chalk

Prerequisites
- None required.
- Helpful: A basic understanding of atoms and elements.
- Helpful: The concept of pools and fluxes (*Paperclip Simulation*).

Welcome Introduction Protocols Learning Activities Appendix

GLOBE® 2017 Carbon Cycle Adventure Story Activity - 1 Biosphere

Overview: This activity provides an introduction to the carbon cycle and systems thinking. It also could be used, more broadly, to introduce biogeochemical cycling, the greenhouse effect, and climate change. During the activity, students read about a carbon atom that begins in the atmosphere as part of carbon dioxide. Students choose where the atom will travel next, i.e. into a leaf via photosynthesis or dissolve into the ocean. Students keep track of the carbon pools they visit, and the process that takes their carbon atom on to the next pool.

Student Outcomes:

- List the major pools and fluxes of the carbon cycle
- Diagram the carbon cycle using box and arrow models
- Describe what components of the carbon cycle make it a system