Introduction

Summary of Learning Activities

In the *Seasons* learning activities, students investigate the causes of seasons and their impact on the Earth system. During these explorations, students practice basic science process skills such as quantitative and qualitative observation, inference, measurement, prediction, classification, data collection, analysis, and interpretation, and designing and carrying out an investigation. The concepts presented in *Seasons* are reinforced through the use of visualization techniques that are important tools for four of the learning activities.

Seasons

There are five learning activities that focus on developing student understanding of seasons. These learning activities are located in two different investigations (*Earth as a System* and *Atmosphere*). In *What Can We Learn About Our Seasons?* (located in the Earth as a System Investigation) students develop a qualitative understanding of the characteristics and patterns of seasons and highlight the relationship of seasons to physical, biological, and cultural markers. Two activities (located in the Atmosphere Investigation) focus on atmospheric data: 1) *What Are Some Factors That Affect Seasonal Patterns?* guides students to use GLOBE data and graphing tools to compare the influence of latitude, elevation, and geography on seasonal patterns; and 2) *How Do Seasonal Temperature Patterns Vary Among Different Regions of the World?* guides students to use GLOBE visualizations to display student data on maps and to learn about seasonal changes in regional and global temperature patterns.

The last two seasons learning activities (also located in the Earth as a System Investigation) use visualizations to enhance student understanding. One of the most important causes of seasonal changes across the globe is the orientation and orbit of Earth in relation to the sun. The spatial model that scientists have designed to explain their observations involves Earth's tilt and the way sunlight spreads across a sphere. Understanding how Earth's relationship to the sun gives us seasons requires an understanding of complex spatial relationships that change over time. In *Modeling the Reasons for Seasonal Change*, students explore these relationships with a 3-D model of Earth that they construct from paper. Aided by depictions of Earth's placement at the equinox and solstice seasonal events, and by simple modeling tools that represent the sun and sunlight as it spreads over a spherical surface, students are guided to an understanding of how the astronomical relationship affects the temperatures and length of day experienced by plants and animals. A color visualization of incoming solar energy offers another source of visual data; in this activity, multiple representations are used to promote coherent student understanding.

As various activities demonstrate, the physical relationship between Earth and the sun is not the only factor that affects seasonal change. In *Seasonal Change on Land and Water*, students use color visualizations and graphs to understand how, at a global level, the presence of large bodies of water (in Earth's Southern Hemisphere) or large land masses (in Earth's Northern Hemisphere) affects the seasons in those regions. By analyzing color visualizations of incoming solar energy and surface temperature, students see that temperature ranges are not entirely consistent with the seasonal pattern of incoming solar energy in the two hemispheres, a result of the difference in heat capacity of large bodies of water and large land masses. Through this activity, students can connect their own local experience of heat capacity and thermal inertia with seasonal differences at a global scale.

Implementation Considerations

Design of Visualization Learning Activities

The seasons learning activities that utilize visualizations have the same basic organization. First, the teacher provides background for students in a class discussion. Teachers often use this discussion period to elicit initial student ideas, linking the activity to students' experiences. Teachers may also decide to demonstrate the more difficult parts of the small group activity. Next, students

break into small groups to further investigate the concepts, guided by a Work Sheet. During small group time, teachers move from group to group, facilitating the activity and checking for understanding.

Materials used in both the class discussion and small groups include the familiar diagrams, tables, graphs, and paper models. Perhaps less familiar to teachers are the use of color visualizations of global data. Against the background of an outline map projection, Earth systems data such as incoming solar energy, temperature, and vegetation vigor are represented as colors. These color visualizations are used to detect patterns in the data and to suggest questions that students can explore. The GLOBE *Earth System* posters have good examples of the type of color visualizations used in these activities.

After students have worked in small groups, the class comes together again to deliver their group results. Student assessment can be conducted through several means. One is the Student Work Sheet, for which rubrics are given. Another is the teacher observation of student work during small group time. Finally, students may demonstrate their understanding of the activity during their group presentation.

Alignment to Other GLOBE Learning Activities

Alignments for Seasons Learning Activities

The learning activities listed below reinforce the concepts presented in the seasons learning activities.

GLOBE Earth System Poster Activity Guide

These posters provide excellent layout for allowing solar energy visualizations to be compared with visualizations of other environmental variables. The *Activity Guide* will help students understand what they are observing.

Atmosphere Investigation: *Making a Sundial*

Students construct a sundial and use it to observe the movement of the sun through the sky over the course of a day by marking changes in the position of the shadow once each hour. Students determine the approximate time of solar noon at their school as indicated by the time of the shortest shadow. Students revisit the site on a subsequent day to estimate the time of day using their sundial.

Alignment for Use of Seasons Learning Activities that Utilize Visualizations

Two of the GLOBE *Seasons Learning Activities* have students use color visualizations and other data to reason about causes, ask questions, and solve problems. Students will be taking a primarily global view of seasonal phenomena. It is important that students understand how to relate the global and local. Therefore, a sample unit of instruction which can be found in the *Teachers Implementation Guide — Earth as a System: First Impressions Describing Earth*, will be useful activities in helping students connect the global phenomena they encounter with their experiences on the ground.

The seasons learning activities that use visualizations also rely on students' understanding how to interpret color visualizations. Several additional activities in the Atmosphere Investigation that focus on learning how to use visualizations in solving problems are recommended. One is *Draw Your Own Visualization*, which teaches the basic components of a visualization; its purpose, the chosen color scheme, the data and units, and the underlying geography and scale. A second helpful learning activity is *Learning to Use Visualizations: An Example with Elevation and Temperature*, which employs color visualizations in problem solving. Students learn to identify important patterns in a color visualization. They also explore the relationship between two variables using color visualizations.

Student Learning Goals and Alignment with National Science Education Standards.

Student Learning Goals

The learning activities in the seasons section target aspects of science learning: content knowledge (particularly in the areas of seasonal change) and the skills of scientific inquiry.

In the seasons learning activities, students investigate regional temperature patterns and then look at the causes of seasonal change, considering issues such as Earth's tilt, its rotation around the sun, and resulting patterns in the incoming solar radiation as experienced in the different hemispheres.

Throughout the activities, students build skills in the use of the tools and processes of scientific inquiry. Many of the activities, for example, use *visualizations* as tools to support description and analysis of complex scientific data. Frequently, students are asked to investigate patterns using data from multiple sources or in multiple representations (ranging from color visualizations to graphs to physical models) and to draw conclusions based on their analysis. Students also develop skills in evidence-based reasoning and in presenting scientific arguments to their classmates.

Alignment with National Science Education Standards addressed by each of the Seasons and Phenology Learning Activities:

National Science Education Standards (NSES) offers valuable guidelines to teachers across the country. Such standards furnish teachers with what the science community currently believes are the important ideas in science, hopefully encouraging the exploration of connections and key concepts rather than the memorization of facts.

The following table indicates the particular National Science Education Standards addressed by each of the *Seasons Learning Activities*.

Student Learning Assessment

Assessment rubrics are included at the end of many of the seasons and phenology learning activities. These can be used by the teacher to determine the extent to which students have understood the concepts and mastered the skills that were examined or used in the activity and to identify where there is still confusion. The assessments can also be used by students to help them reinforce what they have learned and to identify areas of weakness.

Coverage for Seasons

National Science Education Standards	Learning Activity				
	What can we learn about our seasons?	What are some factors that affect seasonal patterns? *(Atmosphere Investigation)*	How do seasonal temperature patterns vary among different regions of the world? *(Atmosphere Investigation)*	Modeling the reasons for seasonal change	Seasonal change on land and water
Earth And Space Sciences					
Changes in Earth and Sky (K-4)					
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	■	■	■	■	■
Energy in the Earth System (9-12)					
The sun is the major source of energy at Earth's surface	■	■	■	■	■
Solar insolation drives atmospheric and ocean circulation	■	■	■	■	■
Earth in the Solar System (5-8)					
Sun is major source of energy for phenomena on Earth's surface				■	■
Physical Sciences					
Energy: Transfer and Conservation (5-8)					
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	■	■	■	■	■
Energy is conserved					■

National Science Education Standards	Learning Activity				
	What can we learn about our seasons?	What are some factors that affect seasonal patterns? *(Atmosphere Investigation)*	How do seasonal temperature patterns vary among different regions of the world? *(Atmosphere Investigation)*	Modeling the reasons for seasonal change	Seasonal change on land and water
Life Sciences					
The Characteristics of Organisms (K-4)					
Organisms and their Environments (K-4)					
Organisms' functions relate to their environment	■				
Organisms change the environment in which they live	■	■			
Life Cycles of Organisms (K-4)					
Plants and animals have life cycles	■				
Regulation and Behavior (5-9 & 9-12)					
All organisms must be able to obtain and use resources while living in a constantly changing environment	■				
Populations and Ecosystems (5-8)					
All populations living together and the physical factors with which they interact constitute an ecosystem					■
Populations of organisms can be categorized by the functionthey serve in the ecosystem					
Sunlight is the major source of energy for ecosystems	■	■	■	■	■
The number of animals, plants and microorganisms an ecosystem can support depends on the available resources					■
Matter, Energy, and Organization in Living Systems (9-12)					
Energy for life derives mainly from the sun	■	■		■	■
Living systems require a continuous input of energy to maintain their chemical and physical organizations	■	■		■	■
The Behavior of Organisms (9-12)					
The interaction of organisms in an ecosystem have evolved together over time					