S2: What Are Some Factors That Affect Seasonal Patterns?

Purpose

Students use GLOBE data and graphing tools to compare the influence of latitude, elevation, and geography on seasonal patterns.

Overview

Students analyze the graph of the past year's maximum and minimum temperatures at their site. They compare this graph to similar graphs for two other sites - one nearby and one distant. They list factors that might cause the patterns to be different, and select one to investigate in depth. They repeat this process with other parameters. Students summarize their investigations by describing how latitude, geography and elevation influence seasonal patterns.

Student Outcomes

Students will be able to:

- Interpret a graph of annual temperature data;
- Identify factors that account for temperature pattern differences;
- Compare temperature patterns on a regional basis.

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 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.
- 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

- Graphing GLOBE data to show seasonal patterns
- Comparing graphs and analyzing data to determine the effects of latitude, elevation and geographical features
- Drawing conclusions about which factors can influence seasonal patterns
- Generating questions and developing hypotheses
- Designing and conducting an investigation
- Develop explanations and predictions using evidence.
- Recognize and analyze alternative explanations.
- Communicating conclusions to others

Time

(assuming 45 minute classes)

Day 1	Steps 1-3
Day 2	Steps 4 and 5
Day 3	Steps 6-9
Days 4 and 5	Steps 10 and 12
Extension	Step 11

Level

Intermediate and Advanced

Materials and Tools

- Wall map of the world
- If computers are unavailable or limited in number, print outs of the graphs in Steps 1, 4 and 6
- Computer and access to the GLOBE Web site
- GLOBE Science Logs

Preparation

Post a wall map of the world.

Assemble necessary data for students to plot.

Prerequisites

Students should understand that insolation levels vary with latitude, and that latitude has a powerful influence in determining seasonal conditions and the annual patterns of environmental and climatic parameters such as precipitation and temperature. For a more complete discussion, read The Seasonal Picture: Why Are There Seasons? in the Introduction to Earth As a System Investigation.

Crosswalks to Other GLOBE Learning Activities

See *Earth as a System Investigation: Using Graphs to Show Connections* for another good graphing exercise in which students construct graphs of air, soil, and water temperatures. Student graphs are then interpreted and interconnections explored.

Procedure

Step 1. Using the GLOBE graphing tool, have students plot the past year's maximum and minimum temperatures for their site on a single graph. See Figure EA-S2-1.

Step 2. To highlight the general temperature trends, have students use one of the following ways to draw a line through the middle of the plot of the maximum and minimum temperature measurements.

a. have each student draw the lines directly on a copy of the graph.

b. have students lay a clear sheet of acetate over a copy of the graph and draw the lines onto the acetate with overhead markers.

Note: Because temperatures can fluctuate dramatically from day to day, a plot of daily temperatures can look very jagged. Furthermore, since the GLOBE graphing tool connects each data point with a line, the resulting graph has a great deal of "noise", marks that add little real information. In most cases, however, it is the long-term trends that enable students to make the most meaningful comparisons. By drawing a line approximately through the center of each plot, students can determine a rough average for each set of measurements and highlight the long-term trends. See Figure EA-S2-2.

Once students draw an "average line," they can superimpose it on other "average lines." For example, students can superimpose an "average line" of the minimum temperatures at their site onto the plot of their site's maximum temperatures to see if both temperatures rise and fall in the same way. Also, students can examine temperature patterns from different years by superimposing the "average lines" of the maximum and minimum temperatures from one year on a similar graph from another year. Students can also see how trends at different sites compare by superimposing the "average lines" from one site onto the plot of the temperatures at another site.

Step 3. Have students analyze the graph of these data by considering questions such as:

- What is the general shape of the average line?

Figure EA-S2-1: The plot of a GLOBE site's maximum and minimum temperature data generated by the graphing tool

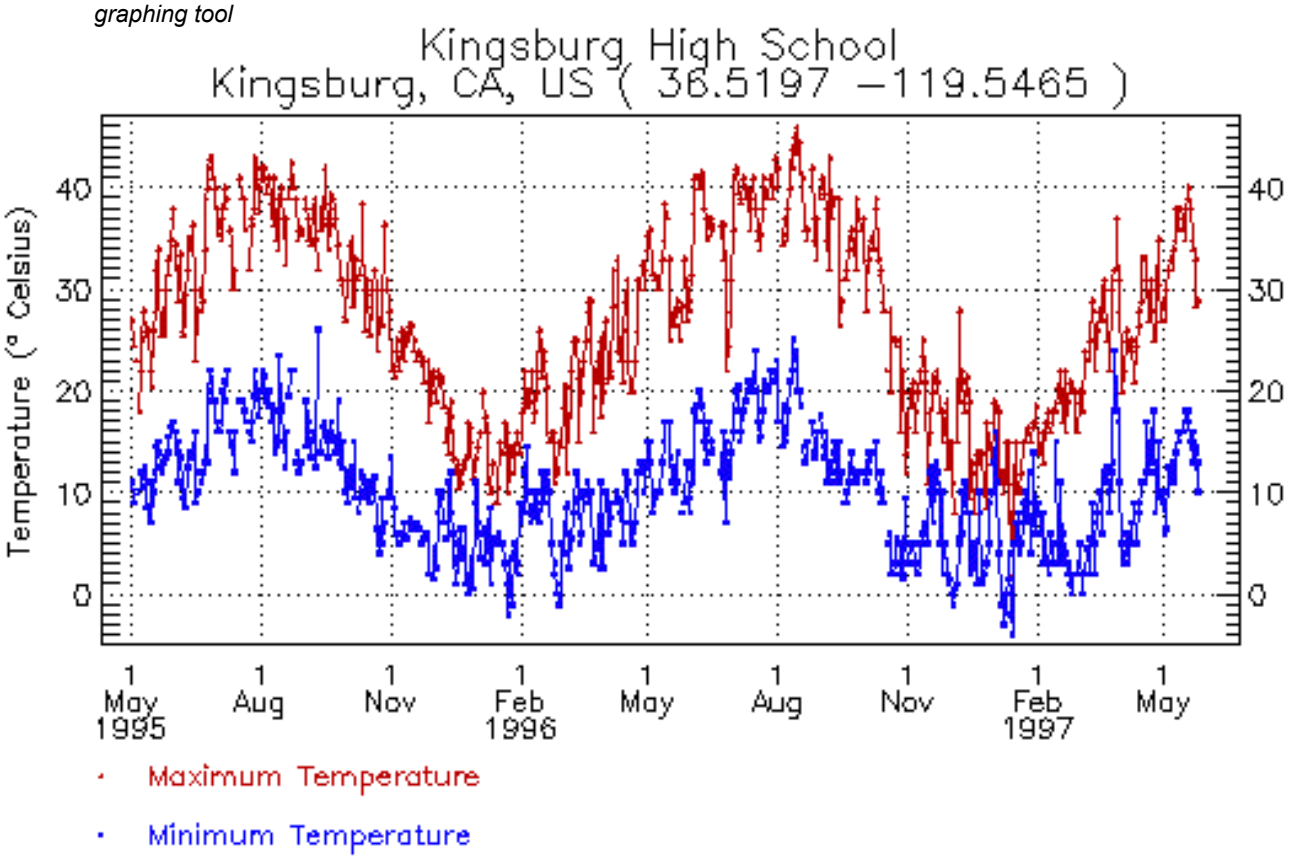


Figure EA-S2-2: Two "average lines" drawn through a plot of a GLOBE site's maximum and minimum measurements.

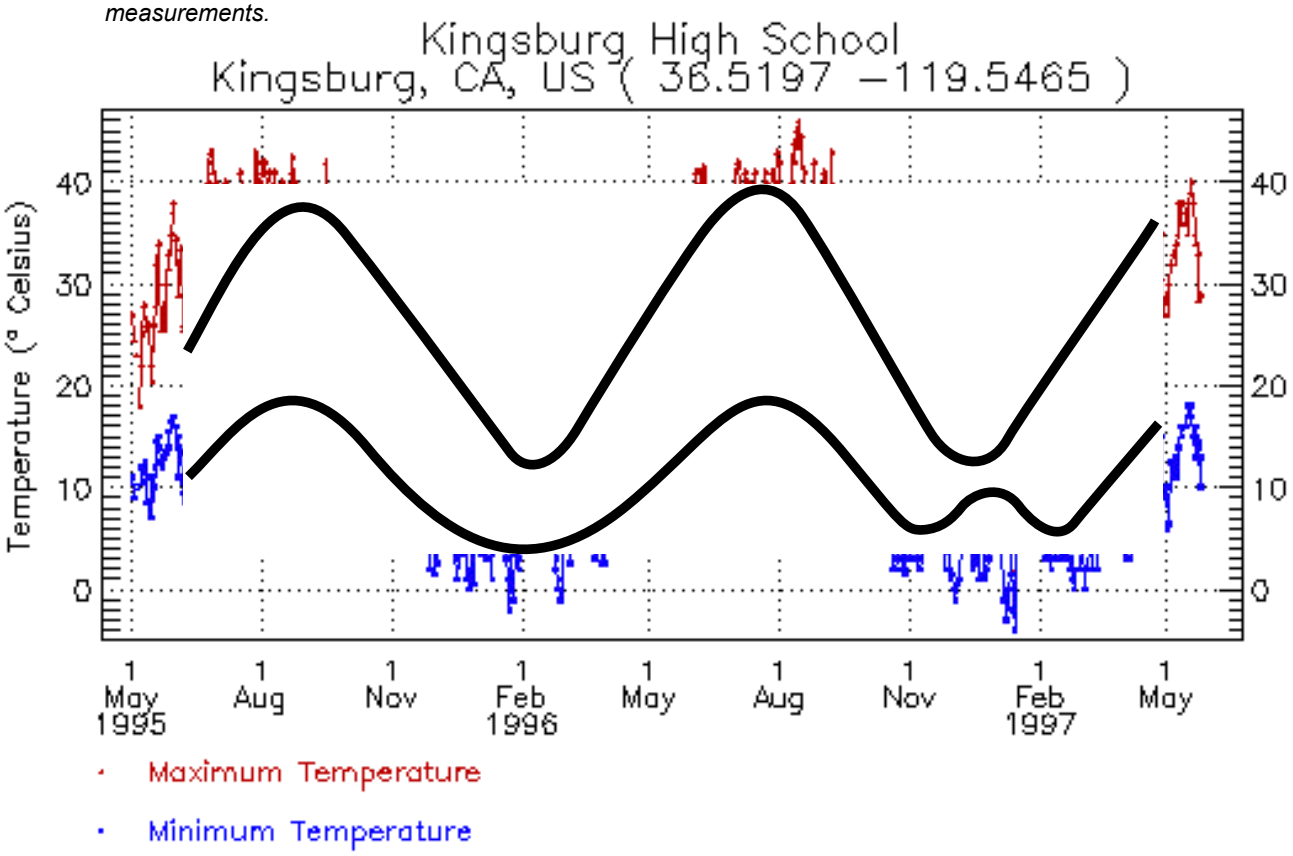
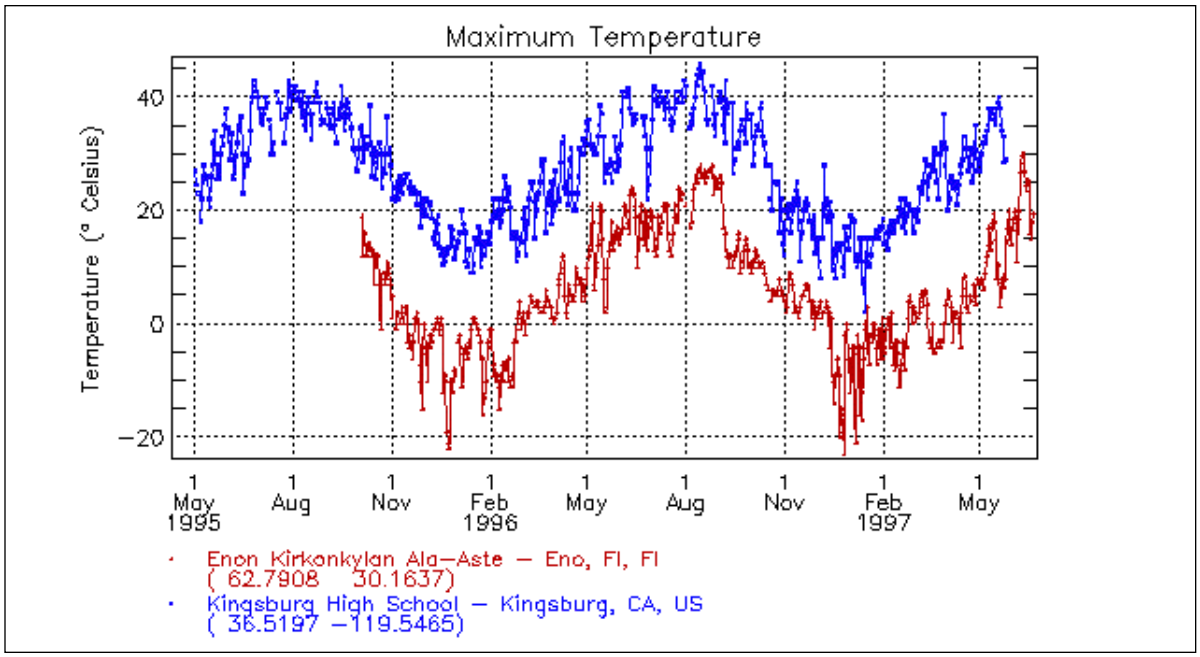


Figure EA-S2-3: The maximum temperature plot from GLOBE sites in Finland and California generated by the graphing tool. Note that the California site has reported data over a longer time period.



- What does the shape of the average line enable us to say about our site?
- What is the approximate difference between the daily maximum and minimum temperatures throughout the year? How does this difference vary over the year?

Note: This analysis can be conducted as a class discussion. If the graph is printed for each student, it can also be done in small groups or assigned as homework. Have students copy or paste the graph into their GLOBE Science Logs and record their analysis and any questions that arise.

Step 4. Have students find another GLOBE school about 100 km away and repeat Steps 1-3 for this school.

Note: This step asks students to find a school at approximately the same latitude as theirs (100 km north or south is roughly equivalent to 1˚ of latitude). Climatic changes happen gradually unless there is some dramatic elevation or geographic change over a short distance. As a result, by analyzing the data from a nearby school, students are likely to see similar temperature patterns. When there are differences, their knowledge of the local geography should help them pinpoint reasons for the differences, such as one site is coastal and the other is inland, one site is at a higher elevation than the other, or one site is behind a mountain range.

This step builds students' graph-analysis skills by having them compare graphs with only a few significant differences. Also, because they are familiar with the local geography, this step increases the likelihood that students will identify key factors that influence temperature patterns. By pre-selecting a nearby site with sufficient data, you can greatly expedite this step.

Step 5. Have students describe how the temperature patterns at the nearby site are similar to and different from theirs. For each difference they observe, have students suggest reasons that might explain such variations. After students work together in small groups, conduct a class discussion that summarizes the comparison. Possible points of comparison include:

- How does the timing of the year's maximum and minimum temperatures compare?
- How does the spread between daily maximum and minimum temperatures compare?
- How do the general shapes of the graph lines on the two graphs compare?
- What conclusions about seasons can be drawn based on the temperature patterns at these two sites?
- Do the temperature levels change similarly after the solstices and equinoxes?

Note: To facilitate comparisons, the graphing tool can be used to plot one parameter such as maximum temperature for two sites. See Figure EA-S2-3. If graphs are printed for each student, this step could be done in small groups or assigned as homework. Have students sketch or attach print outs of the two graphs and record their analysis and any questions that arise in their GLOBE Science Logs.

Step 6. Have students choose another GLOBE site at least 1000 km away that is likely to be climatically different. Have them repeat Steps 1-5

Note: The intention of this step is to find a GLOBE site with an annual temperature pattern quite different from the two already considered. The analysis could be assigned as homework.

Step 7. Have students list factors that might cause the patterns to be different.

Note: Use a wall map of the world or the maps found under GLOBE Visualization to focus attention on differences in latitude and elevation, and in proximity to oceans and other significant geographic features. Have students record the factors and any questions that arise in their GLOBE Science Notebooks.

Step 8. Since every site has a combination of factors, conduct a class discussion based on the Venn diagram shown in Figure EA-S2-4. In their GLOBE Science Logs, have students write a general statement about how latitude, elevation and geography influence their local temperature patterns.

Note: Students should understand that it is important to know a site's latitude, elevation and geography before drawing conclusions about its temperature patterns.

Step 9. Ask each group to select one of the factors that might account for temperature pattern differences between the distant site and theirs. Have group members write a plan for investigating this factor, including how to use GLOBE data to test their hypotheses. For example:

Elevation: Compare the annual temperature patterns of sites at different elevations.

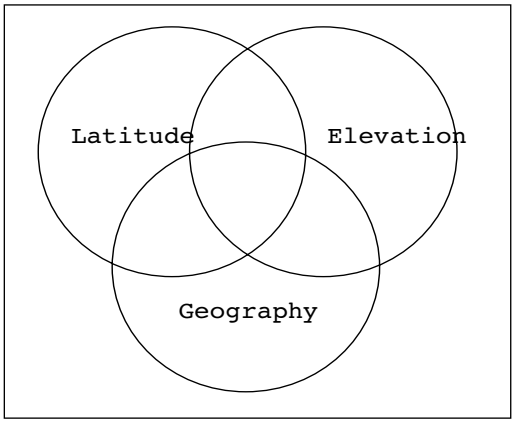
Latitude: Compare the annual temperature patterns of sites at different latitudes.

Coastal versus Inland: Compare the annual temperature patterns of sites at different distances from oceans — where do the effects of a marine climate end? They might also compare the marine effect along different coasts.

Note: Different coasts can have different marine effects. For example, the Atlantic and Pacific coasts of the U.S. have different current patterns and prevailing winds that result in different kinds of marine climates. However, both these marine climates moderate temperature extremes and provide considerable moisture to the air.

Additional Factors: Many parts of the world have factors that pertain only to a local region. For example, students could compare sites near to and far from the Gulf Stream, the Santa Anna winds, the Sahara Desert, the Amazon basin, coastal mountain chains, rain shadows, and prairies. Also, they could investigate what kind of influence the size of a continent and the direction of the prevailing winds can have.

Figure EA-S2-4: Every site has a combination of factors that influences the annual patterns of its parameters



Note: To confirm the influence of one factor, students will have to keep all other factors constant. For example, to see if elevation has an effect, students must find sites that differ in elevation but have similar coastal-continental locations, latitudes, and proximity to significant geographical features. If the only difference in the sites is elevation, then any differences in temperature patterns can be ascribed to elevation. To bolster confidence in any pattern they find, students will also need to use data from several sites and from a significant time period (e.g., a year). An effect seen by comparing data from only two sites or from a single day is vulnerable to errors and short-term changes and is very unreliable. Have students record their hypotheses and procedure in their GLOBE Science Logs.

Step 10. Have students follow their plan and summarize any effects they discover.

Note: Have students record their data, analysis and conclusions in their GLOBE Science Logs. They can share their investigation, conclusions and further questions with another school (such as the ones selected for comparison) using GLOBEMail.

Step 11. To further investigate how these factors influence seasonal patterns, have students repeat Steps 1-10 using precipitation and any other parameters they deem important in characterizing a season.

Note: For a mini-investigation in how to

determine whether one parameter such as temperature influences another such as precipitation, see How Can One Tell Whether Two Parameters Are Interrelated? in the Appendix.

Step 12. In their GLOBE Science Logs, have students write statements about:

a. how latitude, elevation and geography influence the seasonal patterns of the parameters measured in the GLOBE program; and
b. how the annual patterns of the parameters measured in GLOBE are interrelated.

Assessment

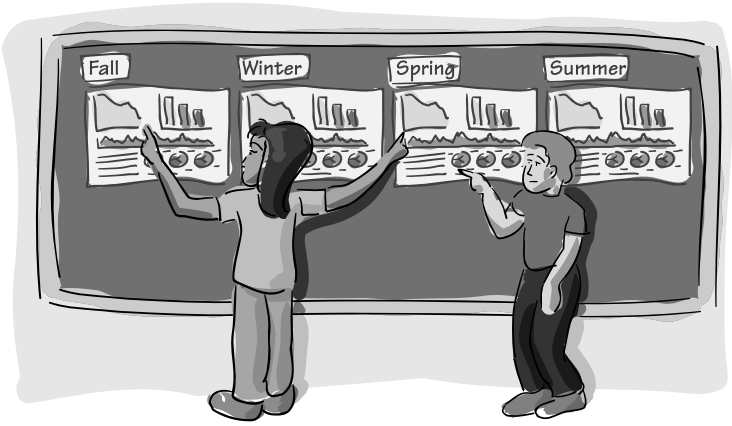
By the end of this activity, students should be able to use graphs and data to support the claim that seasonal patterns are influenced by a combination of latitude, elevation and geography.

All Levels

Poster reports, papers, and multi-media and oral presentations require that students organize and prioritize their thoughts and present their understanding coherently. Consequently, they are effective techniques for assessing students' mastery of concepts, skills and processes. The quality of the information recorded in their GLOBE Science Logs is also an important component in assessing students' ability to communicate their science. Examine their log entries, and have them use their GLOBE Science Logs to develop their reports and presentations.

Have students demonstrate their understanding of how latitude, elevation and geography influence seasonal patterns by having them respond to questions such as:

- Why are patterns at our site so similar to those at the site 100 km away?
- Why are there such differences between our site and the one 1000 km away?
- What factor(s) did you investigate, how did you do it and what did you conclude?



- Discuss how latitude, elevation and geography influence each parameter measured in GLOBE.
- What are some geographical features that influence seasonal patterns in our area? Describe how they influence the patterns and use data to support your claim.
- How can there be distant sites that experience patterns similar to ours while at the same time there are other distant sites that experience patterns different from ours?
- When considering latitude, elevation and geography, does one seem to be more important than the others in determining local seasonal patterns?
- What would you want to know about a site before commenting on its seasonal patterns? Explain why such information is important.
- Why is temperature alone a poor indicator of a season?

  Note: Temperature is variable over the short term and is influenced by other variables such as latitude, elevation and geography. For example, summer at the poles can still be cold and spring at the base of a mountain is different from spring at its summit. One needs to know a location's latitude, elevation and geography to understand the seasonal patterns.

Advanced

- How would the graphs of a site change were it moved to a different latitude, elevation or geographical setting?
- Provide students a graph of an annual pattern that is inconsistent with that pattern at their site. Students should be able to identify specific ways the "mystery" pattern is different from theirs.

  Note: You could draw a hypothetical pattern or use one from another site.
- How do seasonal fluctuations relate to the timing of the solstices? Equinoxes? How soon after the solstices do changes begin to occur? Is the lag time the same for each season? For each solstice?

  Note: Temperature levels are influenced by the energy available from the sun. Because the solstices are the dates that correspond with insolation extremes in the temperate and polar zones, the solstices represent points in a temperature's annual cycle in these zones. However, it takes time for the atmospheric temperatures to respond to these insolation extremes, so there is a lag time of several weeks before the new levels of insolation have a significant affect on temperature. In this activity, students will discover lag times as they check whether temperature levels in the temperate and tropical zones change on the date of the solstices. Because sites have different latitudes, elevations and geographical settings, different sites will have different lag times. Note that on the equinoxes, the sun is directly over the equator. Consequently, the equinoxes represent the insolation extremes in the tropical zone.