An Alaskan Spring Mystery: A GLOBE Data Exploration

Purpose

Students learn about the timing of spring budburst, develop multiple working hypotheses about why timing differs year-to-year, and test hypotheses using environmental data collected by GLOBE students in Alaska to come to a conclusion about the factors that influence timing of budburst in paper birch trees.

Overview

Students analyze data about the timing of budburst for a tree species over three years in the same location. They investigate two different hypotheses for why timing differs by analyzing weather data from the same time period.

Student Outcomes

Students will be able to:

- Analyze different types of data (phenology, temperature, rainfall)
- Form hypotheses based on their analysis of a dataset
- Test hypotheses with environmental data
- Come to a conclusion about the impacts of environmental factors on budburst and explain their reasoning

Science Concepts

- *Earth Systems Science*
- *Weather and Climate*
- *Seasons*
- *Weather can be described with quantitative measurements*
- *Weather changes day to day and over seasons.*

Science Practices

- *Asking questions*
- *Analyzing and interpreting data*
- *Using mathematical and computational thinking*
- *Constructing explanations*
- *Obtaining, evaluating, and communicating information*

Time

One class period (50 minutes)

Level

Middle and high school (grades 6-12)

Materials and Tools

For the computer-based activity:

- Computers with access to Microsoft Excel or Google Sheets
- The data file linked with this activity
- *Reading: Seasons and Trees*
- *Student Activity Sheets A* and *B*

For the pencil and paper activity:

- *Reading: Seasons and Trees*
- *Student Activity Sheets C, D,* and *E*

Preparation

- For the computer-based activity, save a version of the spreadsheet that has only the tab labeled "Data #1" (budburst data) for students to use in Step 2 and a version with the tabs labeled "Data #2" (temperature) and "Data #3" (precipitation) for students to use in Step 5.
- Copy the reading and appropriate activity sheets for each student

Prerequisites

Students with some knowledge of spreadsheet software will be able to accomplish the computer-based version of this activity with greater ease than students that are not familiar with the software. If your students are not familiar with the software, you might choose to allow two class periods to do this activity and guide the experience for students, or do the pencil and paper version of the activity.

Students should also have some background with forming hypotheses. If they do not have

experience with this, provide more coaching during the steps that involve hypothesis development.

Background

The study of how living things change through their life cycle is called phenology. In plants, life cycle changes are often associated with seasonal patterns - such as when buds burst in the spring and when leaves fall in the autumn. Animals have seasonal life cycle events too such as hibernation, molting, and mating.

The timing of seasonal life cycle events can be useful for understanding patterns of weather and climate. Conversely, knowing weather and climate patterns can help predict when plants and animals will experience change, which can be useful information for people. For example, knowing when apples will form and ripen on trees is useful information for farmers, knowing when pollen will be released into the air is helpful to people with allergies, and predicting the timing of peak fall foliage is helpful for tourist destinations that rely on autumn visitors.

In this activity students explore data about the timing of budburst in the spring, temperature, and precipitation to learn the factor that is responsible for differences in timing of budburst in paper birch trees from year to year.

The timing of budburst (and other seasonal changes) is affected by four main factors.

- **Genetics:** Different species can have different timing of events. Budburst can happen at different times for different species of trees, for example.
- **Latitude:** In lower latitude locations, where warm temperatures arrive earlier in the spring, budburst generally happens earlier than at higher latitude, cooler locations.
- **Temperature:** In most tree species, warming temperatures in the spring, especially after a cold winter, triggers budburst.
- **Moisture:** The amount of moisture available in the environment can impact the timing of budburst in the spring depending on the species of plant.

Paper birch (*Betula papyrifera*) are deciduous trees with light-colored, papery bark that grow in moist, sunny, cold locations in Canada, Alaska, and the northern part of the contiguous United States. Buds burst to reveal small green leaves in the spring. The leaves then unfold and grow larger. Students report the timing of budburst as a part of the GLOBE Program Green-Up Protocol. For more information about paper birch trees, visit the USDA Plant Profile (http://plants.usda.gov/core/profile?symbol=BEPA).

About the data: The phenology data used in this activity comes from the Innoko River School in Shageluk, Alaska, USA, between 2005 and 2007. Students reported the timing of budburst for several paper birch trees in two locations in the village. Note that what makes this a particularly interesting dataset to explore is that multiple trees of the same species were monitored. This helps us have a general impression of when budburst happens for this tree species in this location. The air temperature data was also collected by students at the Innoko River School in Shageluk, Alaska. Precipitation data is from the U.S. National Weather Service.

What To Do and How To Do It

Step 1. Orient students to phenology and the seasonal cycles of deciduous trees.

- Write the following on the board and explain that these are different phases of development for deciduous trees: *buds form on branches, buds burst, leaves grow, leaves turn colors, leaves fall, branches are bare.*
- Post signs for the four seasons in the four corners of the classroom. Have students move to the corner that represents their favorite season. When there, have students explain to each other what they think is happening with deciduous trees during that season (choosing from the phases listed on the board). Have one student report out what the group decides.
- Hand out the *Seasons and Trees Reading* to each student as they return to their

seats. Have students complete the reading. As a class, survey student understanding of phenology, seasonal cycles of deciduous trees such as the paper birch, and what controls the timing of phenological events.

Step 2. Analyze Alaska budburst data.

- Hand out *Student Activity Sheet A* to each student (for the computer-based activity) or *Student Activity Sheet C* (for the pencil and paper version of the activity).
- Students doing the compute-based version of the activity will need to open the spreadsheet of budburst data (Data#1). (Note: If you would like student work to be preserved, have each student pair select "Save as" from the "File" menu and save the file with a different name.)
- Explain that GLOBE students at a school in Alaska collected these data. Over three years the students reported the date when birch tree buds first burst in the spring.
- Instruct students to follow the instructions as they analyze the data and to answer the questions within *Student Activity Sheet A* or *C.*

Step 3. Share multiple working hypotheses.

- Ask students to name the four factors that influence the timing of burst, according to the reading (*latitude, plant species, temperature, precipitation*).
- Ask students which of these factors cannot be responsible for the difference in timing of budburst between years. (*Students should recognize that the latitude and species of the trees are the same between years so could not be the cause of the different timing*.)
- Have students share their hypotheses about what could be the cause of the difference in timing. Students should have two different hypotheses: (1) that the difference in budburst timing is due to differences in spring temperatures and (2) that the difference in budburst timing is due to different amounts of moisture available to the trees.
- Explain that both hypotheses are valid. Scientists often develop several possible explanations for natural phenomena, called multiple working hypotheses, and then investigate each to identify which one (or more than one) is likely and whether some can be found to be false.

Step 4. Generate more specific hypotheses.

- As a class or in groups, have students brainstorm how they would explore the temperature hypothesis – what they would want to know to explore the hypothesis. (Students should suggest looking at what 2005-2007 spring temperatures were like in the location.) Ask students to make a more specific hypothesis based on high and low daily temperatures from the location. (*Hypothesis: Warm temperatures arrived earlier in May in 2005 and 2007 and later in 2006*.)
- As a class or in groups, have students brainstorm how they would explore the moisture hypothesis. (Students may need a reminder that it is not the precipitation on a particular day that impacts timing of budburst but rather the amount of moisture over the preceding months.) Ask students to make a more specific hypothesis based on precipitation data from a nearby location over the winter. (*Hypothesis: More moisture in 2005 and 2007 caused buds to burst earlier in those years than in 2006*.)
- Note: If you wish to add more structure, guide students to make two "if/then" hypotheses by filling in the blanks of the following:

  If spring temperatures are __warmer/cooler__ then the budburst will be __earlier/later__.

  If the amount of moisture in has been __high/low__ then budburst will be __earlier/later__.

Step 5. Test hypotheses using temperature and precipitation data.

- Hand out *Student Activity Sheet B* to each student (for the computer-based activity) or *Student Activity Sheet D* and *E* (for the pencil and paper activity).

- Instruct students to write their specific hypotheses for temperature and moisture.
- For the computer-based activity, have students open the Excel file with the temperature and precipitation data. Orient students to the temperature and precipitation data and then instruct students to analyze data with the pointers provided in the *Student Activity Sheet B*.
- Instruct students doing the pencil and paper activity to interpret the graph of temperature data on *Student Activity Sheet D* and then interpret the precipitation data on *Student Activity Sheet E.*

Step 6. Summary class discussion

- Ask students what they think of the temperature hypothesis. (*Students should identify that the temperature hypothesis is supported by the data. The temperature data shows that warmer temperatures occurred earlier in 2005 and 2007 than in 2006.*)
- Ask students what they think of the moisture hypothesis. (*Students should notice that the data do not support the moisture hypothesis. There was more precipitation in 2005 than 2006, but less precipitation in 2007 than 2006.*)
- Ask students what else they would like to know about moisture. (*Students may notice that more specific information about soil moisture in the area with the trees would be a helpful refinement to explore this hypothesis.*)
- Remind students that a hypothesis cannot be found to be true; it can be supported by the data for those particular conditions. A hypothesis can be rejected, but not proven correct. Ask student whether their testing of these hypotheses helps them come to a conclusion about the timing of budburst.

Assessment

Student answers to the questions on the activity sheets will illustrate whether they understand the science concepts (phenology and environmental science) and whether they are using scientific ways of understanding to generate hypotheses and form conclusions.

Extensions: Delve Deeper into GLOBE Data

- Have students use the GLOBE Visualization Tool (viz.globe.gov) to find data about when leaf drop occurs in the autumn and form hypotheses about what influences the timing of leaf drop.
- Have students explore the timing of budburst in their location following the GLOBE Green Up Protocol. Consider monitoring several trees of the same species as the students from Shageluk, Alaska, did to get a sense of the amount of variability in timing of budburst. Consider also monitoring soil moisture in the same location following the GLOBE Soil Protocol to be able to more accurately address the moisture hypothesis. Have students monitor other phenophases so that they can assess whether the timing of those is tied more to moisture or temperature.
- Find birch tree phenology data from different latitudes using the GLOBE Visualization Tool and explore how latitude impacts the timing of budburst.
- If there are orchards in your region, have students ask farmers what the timing of budburst means for their harvests.

Credits

This activity is part of *GLOBE Data Explorations*, a collection of activities developed by the UCAR Center for Science Education (scied.ucar.edu), a GLOBE partner. Activities were reviewed by science educators and staff at GIO and field tested by teachers.

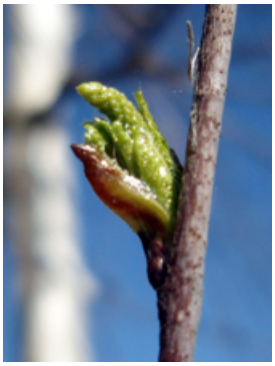
Investigating an Alaskan Spring Mystery
Reading: Seasons and Trees

The study of how living things change through their life cycle is called phenology. In plants, life cycle changes are often associated with seasonal patterns - such as when buds open in spring and when leaves fall in autumn. Animals have seasonal life cycle events too, such as hibernation, molting, and mating.

In this activity you will explore data about the timing of budburst in paper birch trees from year-to-year. GLOBE students at the Innoko River School in Shageluk, Alaska, US, collected the data over three years (2005-2007).

Budburst is the time in the spring when the buds on trees first open to expose the small leaves within. The timing of seasonal changes in living things are affected by four main factors.

- **Genetics:** Different species can have different timing of events – budburst can happen at different times for different species of trees, for example.
- **Latitude:** In lower latitude locations, where warm temperatures arrive earlier in the spring, budburst generally happens earlier than at higher latitude, cooler locations.
- **Temperature:** Seaasonal changes can be triggered by warming temperatures in the spring.
- **Moisture:** The amount of moisture available in the environment can impact the timing of seasonal changes.


A bud bursting on a paper birch tree.

If you have a record of when events happened to plants and animals from year to year, then you have indirect evidence of what the weather was like each year. This can be helpful when figuring out what the climate of an area was like at a time in the past for which we have no weather record.

If you have weather and climate records, you can predict when plants and animals are likely to experience change. These predictions can be useful, for example, to farmers who wish to know when apples will form and ripen on their trees and to people with allergies who wish to know when pollen will be released into the air.

Paper birch (*Betula papyrifera*) are deciduous trees with light-colored, papery bark. These trees grow in moist, sunny, cold locations in Canada, Alaska, and the northern part of the contiguous United States.

Buds burst to reveal small green leaves in the spring. The leaves then unfold and increase in size. In the autumn, the leaves turn color and fall.

Catkins, flower clusters that have no petals, also form in the spring. Paper birch trees have both male and female catkins.

Investigating an Alaskan Spring Mystery
Student Activity Sheet A

Name _____

Date _____

In this part of the activity, you will analyze the budburst data according to the following instructions and then make observations about the data answering the questions on the bottom of this page. GLOBE students at a school in Alaska collected these data between 2005 and 2007. They monitored five paper birch trees in their village each year and reported seasonal changes including when each tree's buds first burst in spring.

Day	Bud Burst (% of trees studied)		
	2005	2006	2007
1-May	0%	0%	40%
2-May	0%	0%	0%
3-May	0%	0%	0%
4-May	0%	0%	40%
5-May	0%	0%	0%
6-May	0%	0%	0%
7-May	40%	0%	20%
8-May	60%	0%	0%
9-May	0%	0%	0%
10-May	0%	0%	0%
11-May	0%	0%	0%
12-May	0%	0%	0%
13-May	0%	0%	0%
14-May	0%	0%	0%
15-May	0%	0%	0%
16-May	0%	0%	0%
17-May	0%	0%	0%
18-May	0%	0%	0%
19-May	0%	0%	0%
20-May	0%	0%	0%
21-May	0%	100%	0%
22-May	0%	0%	0%
23-May	0%	0%	0%
24-May	0%	0%	0%
25-May	0%	0%	0%
26-May	0%	0%	0%
27-May	0%	0%	0%
28-May	0%	0%	0%
29-May	0%	0%	0%
30-May	0%	0%	0%
31-May	0%	0%	0%

Instructions for investigating:

1. Open the spreadsheet of budburst data.
   Notice that the columns indicate what percentage of the five trees had buds burst in each day in May for each of three years.
2. Make a bar chart to examine these data visually.
   a) Select the area with the percentage of budburst data for 2005, 2006, and 2007 and the dates (including the three year headers). See example at the right.
   b) Select "Charts" from the top of the window (Insert > Chart in Google). Choose a "column" or "bar chart" for the chart type.
   c) If you had the three years selected, then bars with different years should appear in different colors. Take a look at the color key to identify which year is which color in the bars.

What did you find?

Write a sentence that describes what you notice about the timing of budburst according to these data.

If you were going to choose a week when the buds of paper birch trees usually start to burst in this location, which week would you choose? Why? Is it an easy choice?

Write a question that you have about when budburst happens.

Review factors that affect the timing of budburst in the reading. Which factors do you think might affect timing of budburst for the paper birch trees in Shageluk, Alaska?

Investigating an Alaskan Spring Mystery
Student Activity Sheet B

Name _____

Date _____

TEMPERATURE
My hypothesis about the impact of temperature on budburst is:

Instructions for investigating:
1. Open the spreadsheet of temperature data reported by the GLOBE students in Shageluk, Alaska.
2. Select the measured at date, the minimum and maximum temperatures, and create a line graph with date on the x-axis and degrees on the y-axis. (Choose "line" as your chart type.)
3. Locate the dates when budburst occured in the graph. Does temperature correlate with timing of budburst?

What did you find?
- ☐ The data support the hypothesis, so this is evidence in support of the hypothesis.
- ☐ The data do not support the hypothesis, so I can reject this hypothesis.

PRECIPITATION
My hypothesis about the impact of moisture on budburst is:

Instructions for investigating:
1. Open the spreadsheet of precipitation data reported by the National Weather Service in nearby McGrath, AK.
2. Add the amount of precipitation in the four months before budburst for each year. For example, to add up the precipitation for 2005, type in the cell below the 2005 data **=sum(C5:C8)**
3. Does the amount of moisture correlate with timing of budburst?

What did you find?
- ☐ The data support the hypothesis, so this is evidence in support of the hypothesis.
- ☐ The data do not support the hypothesis, so I can reject this hypothesis.

CONCLUSION
Based on this evidence, what do you think has a larger impact on the timing of budburst in paper birch trees, temperature or moisture? Write your conclusion as a complete sentence.

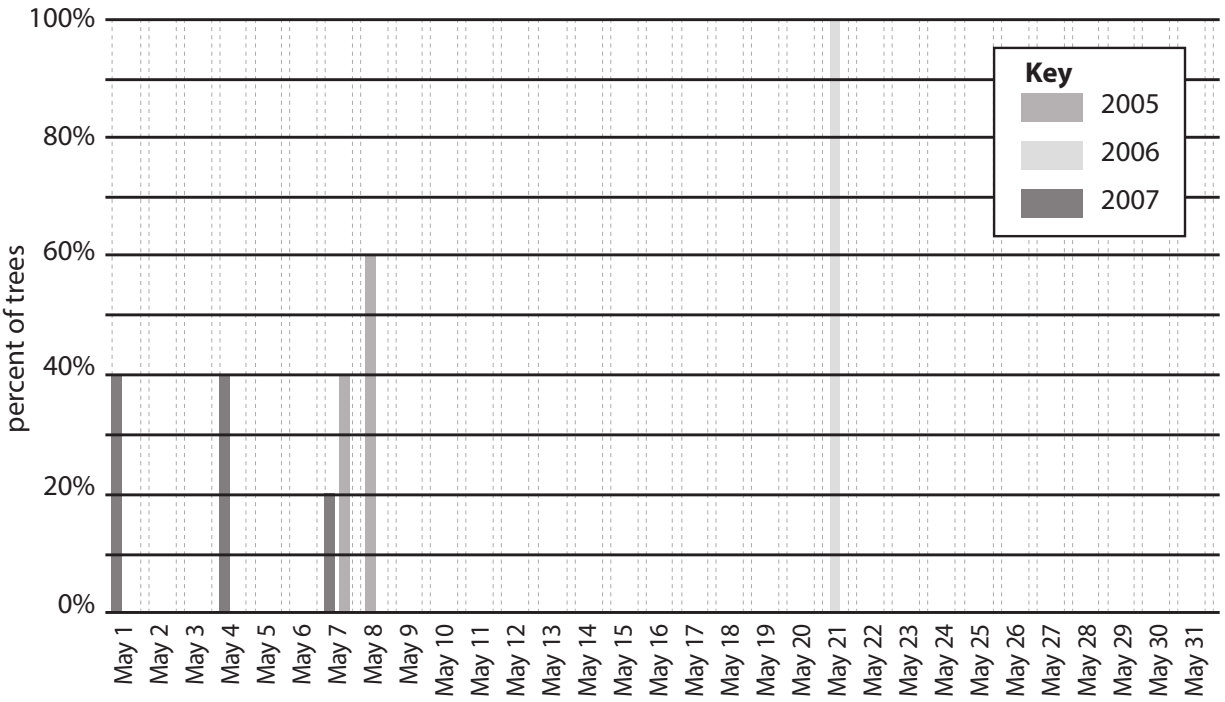
Investigating an Alaskan Spring Mystery
Student Activity Sheet C

Name _____

Date _____

In this part of the activity, you will analyze the budburst data and answer the questions on the bottom of this page. GLOBE students at a school in Alaska collected these data between 2005 and 2007. They monitored five paper birch trees in their village each year and reported seasonal changes including when each tree's buds first burst in spring.

Date of Budburst: Paper Birch Trees, Shaguluk, Alaska, US



Write a sentence that describes what you notice about the timing of budburst according to these data.

If you were going to choose a week when the buds of paper birch trees usually start to burst in this location, which week would you choose? Why? Is it an easy choice?

Write a question that you have about when budburst happens.

Review factors that affect the timing of budburst in the reading. Which factors do you think affect timing of budburst for these trees?

Investigating an Alaskan Spring Mystery
Student Activity Sheet D

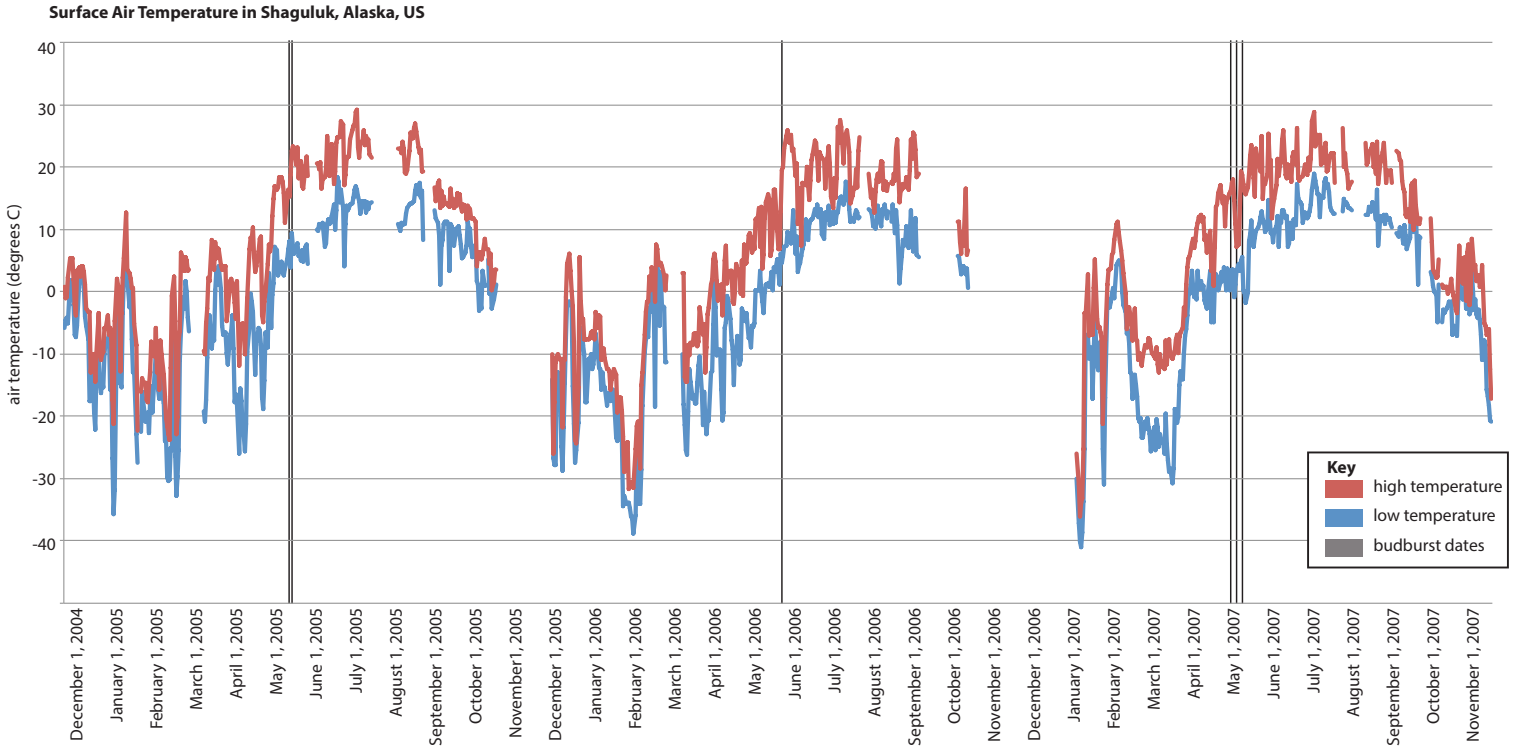
Name _____

Date _____

TEMPERATURE

My hypothesis about the impact of temperature on budburst is:

Locate the dates when budburst occured in the graph of air temperature below.



What did you find?

Does temperature correlate with timing of budburst?

☐ The data support the hypothesis, so this is evidence in support of the hypothesis.
☐ The data do not support the hypothesis, so I can reject this hypothesis.

Name _____

Date _____

PRECIPITATION
My hypothesis about the impact of moisture on budburst is:

Instructions for investigating:
The precipitation data below was reported by the National Weather Service in nearby McGrath, Alaska.
Add the amount of precipitation in the four months before budburst for each year to get a sense of the amount of moisture available to the trees.

	2005	**2006**	**2007**
January	2.01 inches	0.13 inches	1.29 inches
February	0.71 inches	0.87 inches	0.05 inches
March	0.89 inches	0.79 inches	0.01 inches
April	0.20 inches	0.66 inches	0.10 inches
TOTALS:			

What did you find?
Does the amount of moisture correlate with timing of budburst?

☐ The data support the hypothesis, so this is evidence in support of the hypothesis.
☐ The data do not support the hypothesis, so I can reject this hypothesis.

CONCLUSION
Based on this evidence, what do you think has a larger impact on the timing of budburst in paper birch trees, temperature or moisture? Write your conclusion as a complete sentence.