# Forward or Reverse?

**Subjects**
Science
Math

**Skills**
Graphing
Inferring
Writing
Interpreting

**Materials**
Graph paper
*Paradise Snowfall and Nisqually Glacier Records**

**Vocabulary**
Terminus
Glacial advance
Glacial retreat
Equilibrium line
Ablation

## Learner Outcome

Students will graph and make correlations between snowfall and glacial advance and retreat.

## Background

The Nisqually Glacier has been studied for many years. In 1857, August V. Kautz was the first European to visit the glacier. S.F. Emmons described it in a scientific paper in 1871 and John Muir measured the flow rate of the glacier in 1888. Since 1887 the terminus of the Nisqually Glacier has been measured on a regular basis. In 1931 Tacoma City Light began mapping the glacier terminus every five years because they became concerned about the retreat of the glacier, the source of their water supply being collected in the newly constructed Alder Lake Reservoir.

What determines whether a glacier advances or retreats? If accumulation of snow exceeds ablation over a number of years, the glacier terminus advances. If ablation exceeds accumulation over a number of years, the glacier terminus retreats. Even when its terminus is retreating up valley, the main body of the glacier continues to flow down valley unless the ice is stagnant.

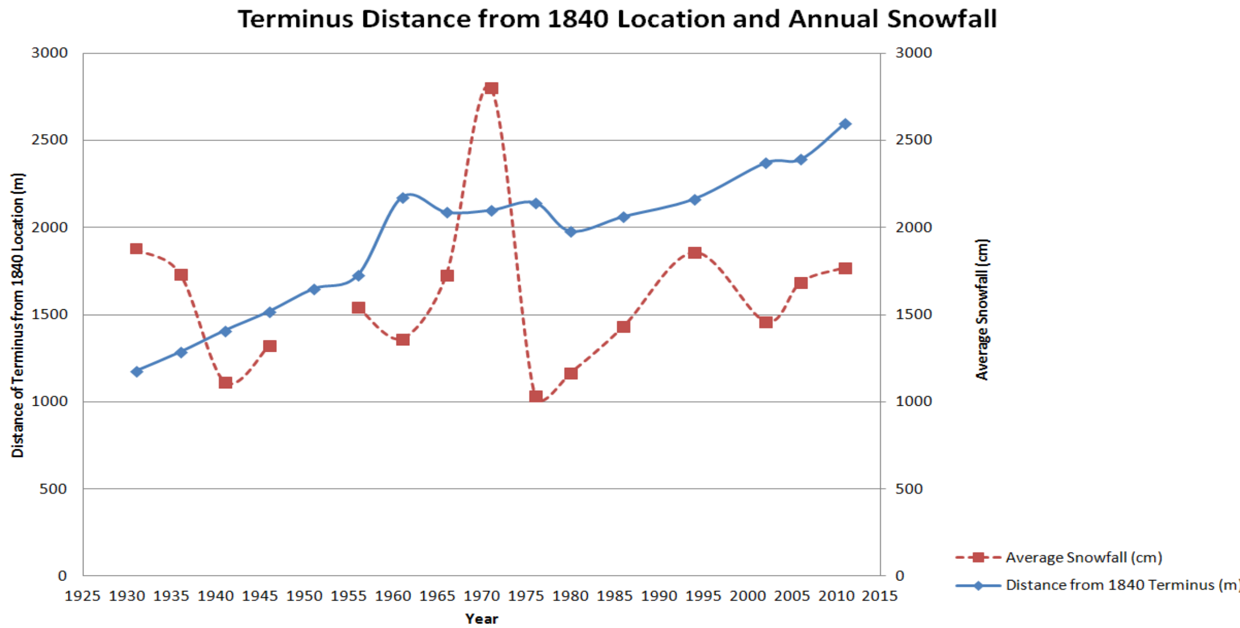
There is a delicate balance between accumulation and melting, known as an equilibrium line. The equilibrium line (also called the firnline) marks the limit on a mountain above which snow persists from one winter to the next. The equilibrium line on most of Mount Rainier's glaciers is about 1950 meters (6,500 feet). Accumulation of ice and snow exceeds accumulation in the zone of ablation at the lower part of the glacier.

Glaciers react to climatic changes, and very small changes in air temperatures can have a major effect on the advance and retreat of a glacier. At Mount Rainier there is about a ten year average lag time between climatic stimulus and glacier response at the terminus (Note: the lag times are hypothetical). Each glacier's response is unique due to the glacier's length, shape, slope, elevation and aspect on the mountain.

**Procedure**

1.) Using the data, students will prepare a graph for the years 1931-2011 at five year intervals (intervals will vary slightly after 1976 because measurement years vary). See example below.

Graph
Horizontal Axis= Years
Right Vertical Axis= Snowfall in centimeters
Left Vertical Axis= Distance of Nisqually Glacier Terminus from 1840 Terminus in meters




2.) Have the students study the graph to note any correlations which might explain what makes a glacier advance or retreat and write a paragraph summarizing these observations. (Note: These are somewhat simplified, hypothetical examples and not often used in actual glacier-climate research work).

Example Paragraph:

Between 1960 and 1965 there was a decrease in the average snowfall and a dramatic retreat of the glacier during that same time period. Because the size of glaciers are sensitive to climatic changes, having less snowfall during this period reduced the Nisqually Glacier's snowpack, leading to a reduction in size, causing a retreat. You can also see about a 10 year lag between the decreased snowfall around 2002 and the increased retreat in 2012.

## Paradise Weather Station Annual Snowfall Records 1931-2011

| Years | Snowfall (in centime-ters) |
|---|---|
| 1931-32 | 1878 |
| 1936-37 | 1733 |
| 1946-47 | 1323 |
| 1951-52 | Data not available |
| 1956-57 | 1548 |
| 1961-62 | 1363 |
| 1966-67 | 1730 |
| 1971-72 | 2805 |
| 1976-77 | 1035 |
| 1981-82 | 1948 |
| 1986-87 | 1435 |
| 1991-92 | 1248 |
| 1996-97 | 2383 |
| 2001-02 | 2126 |
| 2006-2007 | 1689 |
| 2011-12 | 1773 |

## Distance of Nisqually Glacier Terminus From 1840 Location

| Year | Distance from 1840 Terminus (in meters) |
|---|---|
| 1931 | 1144 |
| 1936 | 1286 |
| 1941 | 1409 |
| 1946 | 1518 |
| 1951 | 1648 |
| 1956 | 1725 |
| 1961 | 2173 |
| 1966 | 2087 |
| 1971 | 2098 |
| 1976 | 2142 |
| 1980 | 1978 |
| 1986 | 2062 |
| 1994 | 2164 |
| 2002 | 2370 |
| 2006 | 2391 |
| 2011 | 2598 |

| | | |
|---|---|---|
| | **Nisqually River Education Project**<br>and Next Generation Science Standards | |
| **PERFORMANCE EXPECTATIONS** | **Summary** | **Forward or Reverse** |
| **5-PS-1** | **Matter and Its Interactions** | |
| 5-PS2-1. | Support an argument that the gravitational force exerted by Earth on objects is directed down. | X |
| **5-ESS2** | **Earth's Systems** | |
| 5-ESS2-1. | Develop a model using an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact. | X |
| **Science and Engineering Practices** | | |
| Developing and Using Models | Develop/use a model to describe phenomena | X |
| Planning and Carrying Out Investigations | Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. | X |
| Engaging in Argument from Evidence | Support an argument with evidence, data, or a model. | X |
| Using Mathematics and Computational Thinking | Measure/Describe and graph quantities such as weight, area, etc. to address scientific and engineering questions and problems. | X |
| Analyzing and Interpreting Data | Represent data in graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. | X |
| Obtaining, Evaluating, and Communicating Information | Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. | X |
| | **Summary** | |
| **Disciplinary Core Ideas** | | |
| **ESS2.A:** Earth Materials and Systems | Earth's major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere. These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. | X |
| **ESS2.C:** The Roles of Water in Earth's Surface Processes | Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands and the atmosphere. | X |

| | Summary | Forward or Reverse |
|---|---|---|
| **Cross Cutting Concepts** | | |
| Cause and Effect: | Cause and effect relationships are routinely identified, tested, and used to explain change. | X |
| | Standard units are used to measure and describe physical quantities such as weight time, temperature, and volume | X |
| Energy and Matter | Matter is transported into, out of, and within systems. | X |
| Systems and System Models | A system can be described in terms of its components and their interactions. | X |
| Patterns | Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena. | X |
| **Connections to Nature of Science** | | |
| Scientific Knowledge Assumes an Order and Consistency in Natural Systems. | Science assumes consistent patterns in natural systems | X |
| Science Models, Laws, Mechanisms and Theories Explain Natural Phenomenon | Science explanations describe the mechanisms for natural events. | X |
| Science Addresses Questions About the Natural and Material World | Science findings are limited to questions that can be answered with empirical evidence. | X |
| | **Total number:** | **18** |
| | **Percentage coverage:** | 33.96% |