Glaciers

This indicator examines the balance between snow accumulation and melting in glaciers, and describes how the size of glaciers around the world has changed over time.

Background

A glacier is a large mass of snow and ice that has accumulated over many years and is present year-round. In the United States, glaciers can be found in the Rocky Mountains, the Sierra Nevada, the Cascades, and throughout Alaska. A glacier naturally flows like a river, only much slower. It accumulates snow at higher elevations, which eventually becomes compressed into ice. At lower elevations, the "river" of ice naturally loses volume because of melting and ice breaking off and floating away. When melting is exactly balanced by new snow accumulation, a glacier is in equilibrium and is neither growing nor shrinking.

Glaciers are important to humans and ecosystems because their normal melting process provides a reliable source of stream flow and drinking water, particularly late in the summer when seasonal snowpack has melted away. A large portion of Earth's fresh water is found in glaciers, including the polar ice sheets. Glaciers are also important as an indicator of climate change. Physical changes in glaciers—whether they are growing or shrinking, advancing or receding—provide visible evidence of changes in temperature and precipitation. If glaciers lose mass to melting and breaking off (particularly the Greenland and Antarctic ice sheets), they ultimately add more water to the oceans, leading to a rise in sea level (see the Sea Level indicator on p. 40).

About the Indicator

This indicator is based on long-term monitoring data collected at glaciers around the world. At many glaciers, scientists collect detailed measurements to determine mass balance, which is the net gain or loss of snow and ice over the course of the year. A negative mass balance indicates that a glacier has lost ice or snow. Looking at cumulative mass balance over time will reveal long-term trends. For example, if cumulative mass balance becomes more negative over time, it means glaciers are melting faster than they can accumulate new snow.

Figure 1 shows the total change in volume of glaciers worldwide since 1960, when widespread measurement began to take place. The overall change in volume was determined by collecting all available measurements, then estimating a global trend based on the total surface area of

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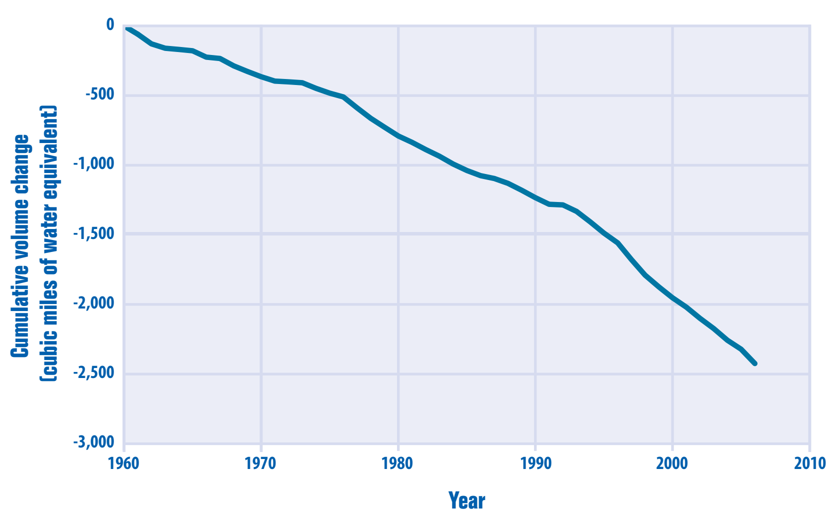
Photographs of Muir Glacier, Alaska, 1941 and 2004

Sources: Field, 1941;[5] Molnia, 2004[6]

Figure 1. Change in Volume of Glaciers Worldwide, 1960–2006

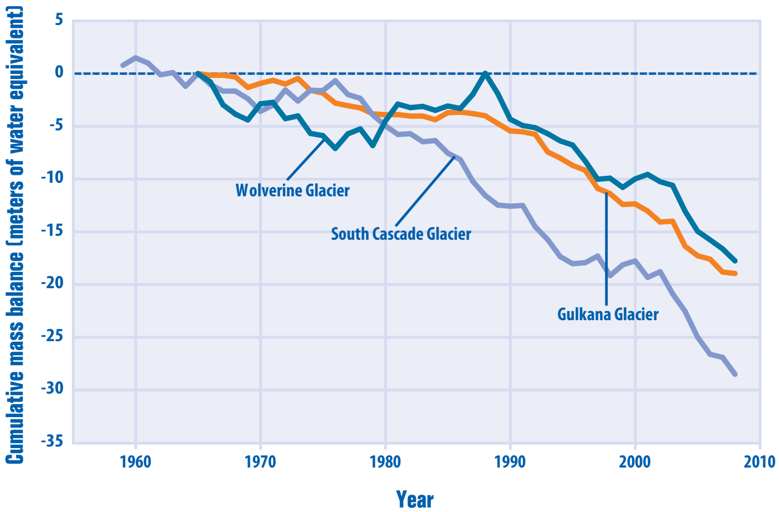
This figure shows the cumulative change in volume of glaciers worldwide beginning in 1960. Negative values in later years indicate a net loss of ice and snow compared with the base year of 1960. For consistency, measurements are in cubic miles of water equivalent, which means the total amount of ice or snow lost has been converted to the equivalent volume of liquid water.



Data source: Dyurgerov, in press[7]

Figure 2. Mass Balance of Three Typical U.S. Glaciers, 1958–2008

This figure shows the cumulative mass balance of the three U.S. Geological Survey "benchmark" glaciers since measurements began in the 1950s or 1960s. For each glacier, the mass balance is set at zero for the base year of 1965. Negative values in later years indicate a net loss of ice and snow compared with the base year. For consistency, measurements are in meters of water equivalent, which means the amount of ice or snow has been converted to the equivalent amount of liquid water.



Data source: USGS, 2009[8]

Key Points

- Since 1960, glaciers worldwide have lost more than 2,000 cubic miles of water (see Figure 1), which in turn has contributed to observed changes in sea level (see the Sea Level indicator on p. 40). The rate at which glaciers are losing volume appears to have accelerated over roughly the last decade.
- All three U.S. benchmark glaciers have shown an overall decline in mass since the 1950s and 1960s (see Figure 2). Year-to-year trends vary, with some glaciers gaining mass in certain years (for example, Wolverine Glacier between 1986 and 1988). However, most of the measurements indicate a loss of mass over time.
- Trends for the three benchmark glaciers are consistent with the retreat of glaciers observed throughout the western United States, Alaska, and other parts of the world.[9] Observations of glaciers losing mass are also consistent with warming trends in U.S. and global temperatures during this time period (see the U.S. and Global Temperature indicator on p. 22).

Glaciers Shown in Figure 2

glaciers worldwide. Figure 2 shows trends for three "benchmark" glaciers that have been extensively studied by the U.S. Geological Survey: South Cascade Glacier in Washington state, Wolverine Glacier near Alaska's southern coast, and Gulkana Glacier in Alaska's interior. These three glaciers were chosen because they are representative of other glaciers in their regions.

Indicator Limitations

The relationship between climate change and glacier mass balance is complex, and the observed changes at the three U.S. benchmark glaciers might reflect a combination of global and local climate variations. Slightly different measurement methods have been used at different glaciers, but overall trends appear to be similar.

Long-term measurements are available for only a relatively small percentage of the world's glaciers, so the total global trend in Figure 1 is also based in part on some of the best available estimates. The total in Figure 1 does not include the Greenland and Antarctic ice sheets. Other evidence suggests that these ice sheets are also experiencing a net loss in volume.[10]

Data Sources

The University of Colorado at Boulder provided the global trend in Figure 1. Its analysis is based on measurements collected from a variety of publications and databases. An older version of this analysis was published by the U.S. Global Change Research Program in 2009,[11] and the latest version is expected to be published in the scientific literature sometime in 2010.

The U.S. Geological Survey Benchmark Glacier Program provided the data for Figure 2. These data, as well as periodic reports and measurements of the benchmark glaciers, are available on the program's Web site at: http://ak.water.usgs.gov/glaciology.