



Arctic Answers

Science briefs from the Study of Environmental Arctic Change
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How is land ice changing in the Arctic, and what is the influence on sea level?

THE ISSUE. Changes in Arctic land ice area and volume directly influence sea level rise locally, regionally, and globally. Understanding where land ice is being lost and how quickly it is disappearing is key to projecting the rates of sea level rise around the globe.

WHY IT MATTERS. Globally, land ice is shrinking due to a rapidly warming climate and ocean. This lost land ice is a major contributor to global sea level rise. The pace of future land ice loss is projected to increase as warming increases, causing an acceleration in the rate of sea level rise. Glaciers, with the potential to raise sea level almost 50 cm, will retreat faster in ever-warmer temperatures. But as more and more mountain glaciers disappear, their contribution will begin to diminish because less ice is left to melt. The Greenland Ice Sheet, which contains a much larger volume of ice (see Figure 1), will continue to contribute an increasing amount of water to sea level rise. The Antarctic Ice Sheet's role remains the least certain, but Antarctica has the greatest potential impact on future rates of sea level change because it contains the largest volume of ice on Earth.

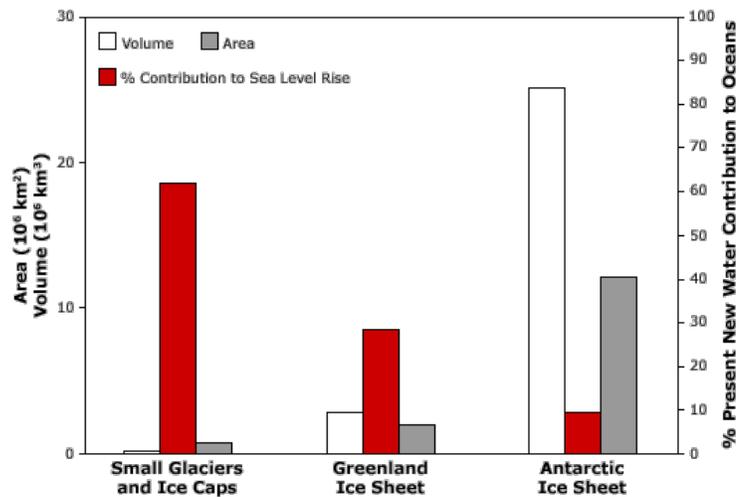


Figure 1. The recent contribution rate of glaciers and ice caps and the Greenland and Antarctic Ice Sheet to sea level rise (red). This is in contrast to the ice area and volume contained in each [Meier et al., 2007].

STATE OF KNOWLEDGE. Land ice in the Arctic consists of mountain glacier regions (example: southeastern Alaska), small ice caps (example: Devon Ice Cap), and large ice sheets such as the Greenland Ice Sheet. Arctic glaciers and land ice caps are sometimes subdivided according to the environment where the ice ends: on land, or in a lake, or the ocean. These differences have an influence on how the glaciers or ice sheet respond to changes in air and water (e.g., ocean) temperatures.

The Arctic has warmed far faster than the global mean rate, and this will continue. As a result, ice in the Arctic is also melting rapidly, leading to a disproportionate contribution to increased sea level. Examples of the changes that scientists have observed include:

- Abnormally widespread retreat of glaciers across the Arctic, including across Alaska (see Figure 2), Canada, and Greenland. Some glaciers have disappeared entirely.
- Increases in surface melt on Arctic glaciers and ice caps and the Greenland Ice Sheet. Surface melting on Arctic land ice leads to meltwater runoff via streams, rivers, or directly into the ocean. In Greenland increased warming is also exposing older (dirtier) ice further, which absorbs heat more

easily and accelerates meltwater production. In addition to this melt, the water often penetrates to the bottom of the glacier and in some instances can increase the speed of ice flow and further enhance ice loss.

- Faster ice motion in many glaciers across the Arctic. Speed up and glacier retreat are especially dramatic for glaciers that end in the ocean and that act as primary conveyor belts to move ice from higher regions to the ocean.

Based on observations and continuing study, scientists understand the basic causes and mechanisms of land ice loss. This research informs computer simulations that are used to project future changes in land ice. These computer simulation efforts indicate that land ice loss will continue and likely accelerate.

WHERE THE SCIENCE IS HEADED. The science is clear that land ice loss will continue. However, estimates of sea level rise from land ice loss have larger uncertainties than other sources of sea level rise. Scientists are working to reduce these uncertainties by conducting focused research about glacier and ice sheet processes, particularly involving ice interaction with ocean and atmosphere. A primary goal is to use these observational studies to improve computer simulations and further constrain the range of sea level rise expected over the next centuries.

KEY REFERENCES

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3. Shepherd, A. et al. (2012), A Reconciled Estimate of Ice-Sheet Mass Balance, *Science*, 338(6111), 1183–1189, doi:10.1126/science.1228102.

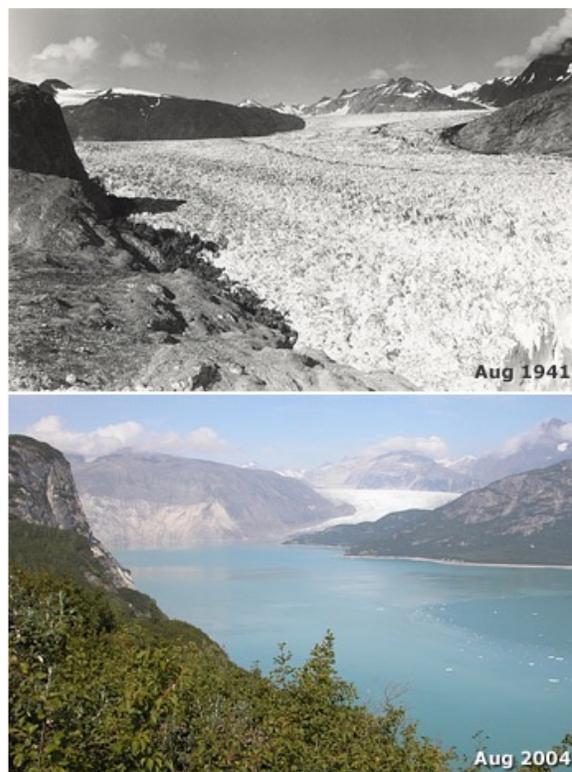


Figure 2. Dramatic retreat between 1941 and 2004 of the Muir Glacier in Glacier Bay National Park and Preserve, Alaska. This pattern of glacier retreat has now been observed across the world [NSIDC Photo Archive].

SEARCH: *Advancing knowledge for action in a rapidly changing Arctic*

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