The Impacts of Glacier Change in Alaska

Testimony of

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Chairwoman Johnson, Ranking Member Lucas, and members of the House Committee on Science, Space, and Technology, thank you for the opportunity to testify on the critical issue of glacier and ice sheet melt. As a citizen of this country I am grateful that you consider this issue relevant and important, and as a scientist I am honored to be in a position to provide evidence-based testimony to the committee to aid your decision making process. I am a Research Scientist and Manager of the Climate and Cryosphere Hazards Program at the Alaska Division of Geological & Geophysical Surveys and a Research Assistant Professor in the International Arctic Research Center at the University of Alaska Fairbanks. I provide testimony today as an expert in glacier science. My comments represent my views as a scientist and private citizen, and not those of the State of Alaska or the University of Alaska Fairbanks.

Key Points

- Glaciers in Alaska are in steep decline, and are among the fastest-melting glaciers on Earth.
- The rapid melting of glaciers in Alaska is a result of rising air temperatures associated with global climate change.
- Glaciers in Alaska are projected to continue to melt and contribute to global sea level rise.
- Hazards associated with rapid glacier retreat are impacting infrastructure, and threatening public safety and resource security.
- Narrowing the range in mass loss estimates requires a comprehensive and coordinated multi-agency collaboration, and a sustained long-term funding structure.

Glaciers and Ice Sheets

A glacier is a large mound of ice, snow, water, rock and sediment that forms on land and flows outward or down slope under its own weight. A glacier forms when snow that has accumulated doesn't melt and is buried by subsequent years of snow with the same fate. As more snow is added to the mound over many years, the snow near the bottom gets compressed and forms ice. In Alaska, glaciers form in high-mountain areas where they are constrained by topography, and flow down to lower elevation.

Glaciers gain mass by snow accumulation and lose mass by surface melt and runoff, and by iceberg separation and submarine melting at the glacier-water interface. During periods of net accumulation, glaciers gain mass and advance, whereas during periods of net loss, glaciers melt and retreat. Similar to an accountant who balances the credits and debits from a bank account, we monitor mass gains and losses of a glacier over time by computing mass balance.

Ice sheets, located in Antarctica and Greenland are massive expanses of glacier ice and snow that span entire continents. These masses of ice subsume the terrain and flow outward from a high point. At their margins ice sheets becomes thinner, and interact with the terrain.

The Role and Significance of Glaciers and Ice Sheets

Glaciers and ice sheets are important components of the cryosphere, or the parts of earth where water is in its solid form. Glaciers and ice sheets cover about 10% of Earth's land area and represent the majority of perennial land ice. Land ice is distributed as glaciers across high-mountain regions all over the world, but the majority of this ice is concentrated near Earth's poles. There glaciers and ice sheets play a vital role as regulators of global weather and climate, reflecting radiation to cool the planet and providing long-term stability for atmospheric and oceanic currents.

Glaciers and ice sheets are also an integral part of the hydrologic cycle. Together with other forms of perennial land ice, they hold about 69% of the freshwater available on the planet. They temporarily store freshwater at high altitudes and latitudes, serving as frozen water reservoirs that help to maintain a relatively stable sea level and providing consistent water resources. Runoff from glaciers provides critical baseline flow during warm and dry periods when other water sources are unavailable. This runoff is crucial to billions of people around the world, particularly those in arid regions who rely on glacier-sourced streams for drinking water and irrigation for agriculture. Runoff from glaciers also regulates stream temperature and provides nutrients for plants, insects, fish, and other animals. Glacier runoff is also important for hydropower production in many parts of the world.

Observed Glacier Change

As ice melt outpaces snow accumulation worldwide, glacier change has become one of the most important and widely recognized indicators of climate change. Historically unprecedented mountain glacier recession has proceeded on a global scale for the last thirty years (Zemp *et al.,* 2015). In the Arctic, glaciers and ice caps have been experiencing increasingly negative cumulative mass balances since the early 1990s (Wolken *et al.,* 2017), and are a leading contributor to global sea level change despite their relatively small size compared to ice sheets in Antarctica and Greenland (Gardner *et al.,* 2011, 2013; Jacob *et al.,* 2012).

Over the last several decades, Alaska has warmed twice as fast as the rest of the United States. Glaciers in Alaska (including northwest Canada) represent about 22% of the Arctic land ice area and currently have one of the highest glacier melt rates in the world (Gardner *et al.,* 2013; Pfeffer *et al.,* 2014), with annual thinning rates that reach several meters (tens of feet) per year for some glaciers terminating near sea level (VanLooy *et al.,* 2006; Larsen *et al.,* 2007; Larsen *et al.,* 2015). This rapid and sustained melting and retreat of glaciers in Alaska is expected to continue as a consequence of climate warming, as predicted unequivocally by all current climate models (IPCC AR5, 2013; Huss and Hock, 2018).

Impacts of Glacier and Cryosphere Change

The rapid and sustained melting of glaciers in Alaska has led to a disproportionately large contribution to global sea level rise. This trend is projected to continue with inevitable consequences including lowland flooding and the displacement of communities, increased coastal erosion, degradation of water quality and agricultural soils, and loss of ecological habitats among other effects already impacting communities in the United States and elsewhere around the world.

As high glacier mass loss rates continue, the storage capacity of snow and ice will diminish, which is projected to have significant impacts on future water resource availability, even in basins with low glacier coverage (Huss and Hock, 2018). As a result, river discharge volume and timing in seasonal river runoff will change, and the ability of glaciers to sustain this flow during warm and dry periods will be reduced or lost. In Alaska, this will continue to produce clear and profound impacts on marine and terrestrial ecosystems at multiple levels, negatively influencing key species, including salmon, as well as the billion dollar fishing industry on which people depend. These changes will also heavily impact hydropower production, tourism, socio-economics, and the livelihoods and lifestyles of many people.

Rapid changes in climate can have a major effect on the cryosphere system and cause an increase in hazards. This is because changes in climate can modify natural physical processes and increase the magnitude and frequency of certain cryosphere hazards (e.g., avalanches, floods, erosion, slope instability, glacier collapses, and glacier lake outburst floods), which if not properly addressed, may have a damaging effect on Alaska's communities and infrastructure, as well as on the security and livelihoods of Alaskans. Rapid glacier retreat in recent decades has caused new ice-dammed lakes to form in valleys that were formerly occupied by glaciers. These new lakes are inherently unstable, with many resulting in glacial lake outburst floods that threaten communities and damage infrastructure (as in Juneau and Valdez). Rising air temperature and an increase in melt for Alaska's glaciers has also caused slopes surrounding glaciers to become unstable, which has led to an increase in the magnitude and frequency of landslides, and placed Southeast Alaska at the epicenter of these catastrophic events (Coe et al., 2016).

Improving our Understanding of Future Glacier Melt

Fifty-three years ago, a small team of U.S. Geological Survey scientists ventured onto two glaciers in Alaska to collect data to help understand snowpack variations in high-mountain settings. Those measurements on the Gulkana and Wolverine glaciers became the first data entries into Alaska's Benchmark Glacier program, which has provided some of the longest continuous data for evaluating the health of glaciers in Alaska. Although many advances in glacier monitoring have been made since the beginning of the Alaska Benchmark Glacier program, the observational data from this program are still used every year and represent one of the three important tools that support modern glacier science.

Modern glacier science relies on observations, remote sensing, and modeling to measure glacier melt and simulate future changes. In Alaska, the observational record is long, but there are only three long-term, continuous records of glacier mass balance for the entire state, which currently hosts many thousands of glaciers. Because of the lack of ground-based observational data, remote sensing and computer modeling are used to broaden the scope and extend estimates of glacier melt into the future based on a range of emission scenarios. But the current range in glacier ice loss projections can be narrowed. This can happen by increasing the number and distribution of long-term, ground-based observational data, increasing the quality and coverage of remote sensing products, and improving melt models and climate data products so that they more accurately represent the variables and processes involved in glacier melt and runoff in climatically diverse and topographically complex areas of the state. To achieve this, a comprehensive and coordinated multi-agency collaboration and a sustained long-term funding structure are required.

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