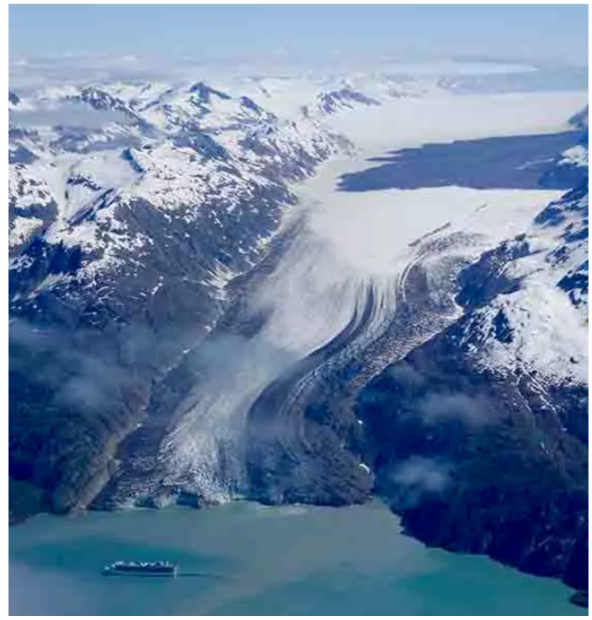
Landslide and Tsunami Hazard Assessment NPS & USGS

- *Where are unstable slopes?*
- *Which slopes are susceptible to landslides?*
- *What type of impact will a landslide have if it reaches the ocean and generates a wave?*
- *Where are people exposed to landslide generated tsunamis?*
- *What research are we doing to understand these hazards?*



The 6/23/2016 landslide on Lamplugh Glacier. There was a similar release on 9/17/2022. Neither landslide delivered rocks to the water. Photo courtesy of Paul Swanstrom, Mountain Flying Service.

Principal Researchers:
U.S. Geological Survey Landslide Hazards Program; Sean Eagan, NPS; Sarah Venator, NPS. Chad Hultz initiated this research.

Dates: The 2025 fieldwork will occur in late summer. The USGS will begin landslide modeling in the fall. Tsunami modeling is the third step.

Did You Know?

Thawing permafrost, increasing rain, and retreating glaciers are increasing the frequency and size of landslides in Glacier Bay and across coastal Alaska.

Using remote-sensing imagery from planes and satellites, we have mapped over 70 areas with landslide features throughout the park. And we have detected motion on many of the slopes.

Introduction

The Glacier Bay area has a history of large earthquake and climate-induced rockslides and rock avalanches. When these landslides rapidly enter the water, they can generate tsunamis with extraordinary destructive power. This was demonstrated by both the 1958 Lituya Bay earthquake-triggered rockslide and tsunami and the 2015 rock avalanche and tsunami in Taan Fiord in Wrangell-St. Elias National Park and Preserve. More recently, a landslide-generated tsunami occurred in Kenai Fjords National Park during the summer of 2024. Glacier Bay contains active faults at the boundary of the North American and Pacific tectonic plates, and large earthquakes have triggered landslides in the past. However, after analysis of landslides in high-altitude areas in the park between 1984 and 2016, all 24 of the landslides detected were caused by climatic factors, not earthquakes. The susceptibility of slope failures in the park is increasing due to these climate factors: 1) Deglaciation is rapidly increasing and the withdraw of glaciers removes support from steep slopes (i.e., debuttressing), increasing the susceptibility to failure; 2) The mean average temperature is rising, high-altitude permafrost is thawing; and 3) Precipitation is falling more frequently as rain than as snow and rain-on-snow events are increasing. All three factors are projected to increase in future climate models, so the susceptibility to slope failures will increase.

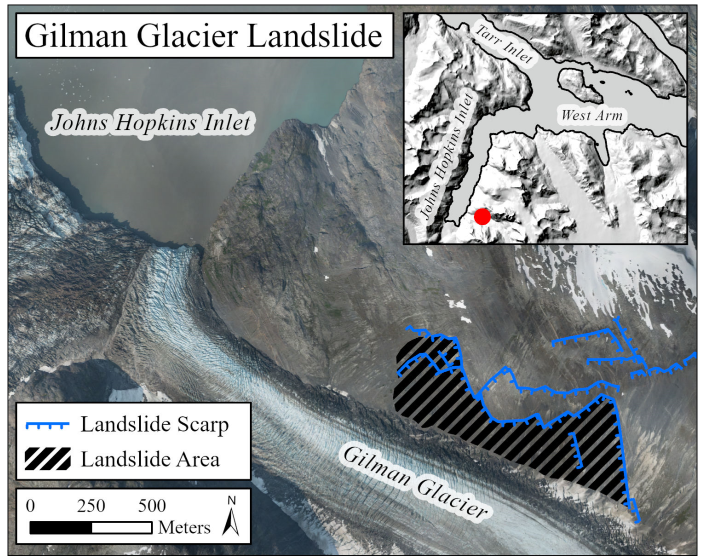
Methods

We are using satellite, airborne, and ground-based remote sensing datasets in addition to in-situ measurements to characterize landslide features and detect landslide motion. We plan to measure high-resolution digital elevation models (DEMs) using terrestrial LiDAR scanning (TLS) to document detailed ground deformation of known and suspected landslides. We will also collect data on the bedrock structure and measure the quality and strength of rocks to help characterize landslide materials and assess potential failure characteristics. The primary focus areas for fieldwork during 2025 include: Tidal Inlet, Johns Hopkins Inlet, and Sandy Cove-Mount Wright. These areas contain steep slopes and reveal landslide features, including fractures and scarps.

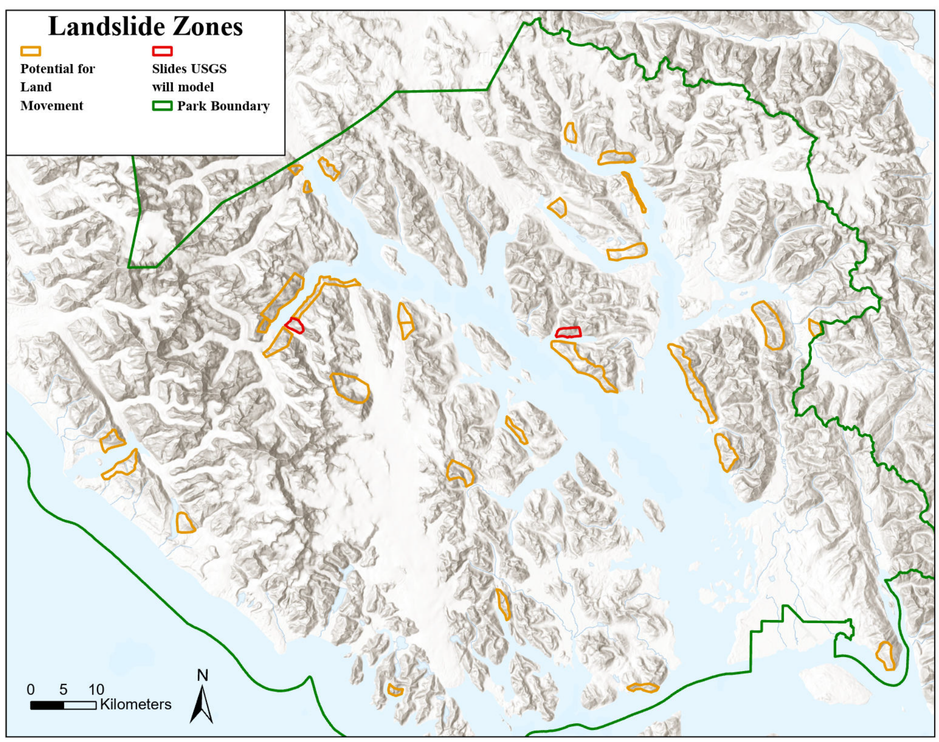
Field assessments will aid in characterize the landslide processes at each of these locations, including the type of failure, style of movement, and the types of materials involved. By capturing these deformation and structural measurements, we will gain a clearer understanding of the deformation processes of these unstable slopes to model potential failure modes. This information is critical for future modeling efforts that will be used to assess how far landslides will travel, and whether they could generate tsunamis. We will model how potential tsunamis propagate out of an inlet and into the larger arms and bays. With this information, we will be equipped to identify hazard zones and develop plans for mitigating potential risks.

Preliminary Results

Parts of a landslide above the Gilman Glacier moved downslope from 0.8 to several meters between 2019 and 2023. The amount of displacement varied greatly across the slide. This information was gained by differencing structure-from-motion (SfM) photos captured in 2023 from digital elevation models (DEM) constructed from LiDAR imaging in 2019. One of our 2025 goals is to determine if the Gilman landslide is accelerating or slowing down based on IfSAR data taken in the snow free months of 2023 through 2025.



Orange polygon areas contain fractures and scarps and have potential for land movement. In some remote areas movement was detected from repeat satellite imagery. In other locations, NPS staff on boats can see recently moved material. The USGS Hazards program will model landslide and tsunamis that could originate in the two red polygon zones and a third area which will be selected during 2025 summer field work.



Contact

Contact: Sean Eagan, NPS-Glacier Bay, sean_eagan@nps.gov
To learn more about geohazards in Alaska National Parks, see the special issue of Alaska Park Science: https://www.nps.gov/articles/aps-18-1-1.htm