

Monitoring Glaciers - Visualizing Climate Change

Prince William Sound, Alaska

June 22 – 26 online

July 1 – July 12 onsite

Note: Students taking this course for college credit need to enroll through the Institute for Field Research, [here](#). Students NOT taking the course for credit need to enroll through Alaska Endeavour, [here](#).

FIELD SCHOOL DIRECTOR

Bruce Molnia, PhD, research geologist, US Geological Survey (retired); adjunct professor, Delta State University.



OVERVIEW

Glaciers shape the Earth's surface as they advance and retreat, forming fjords and valleys, modifying mountains, and leaving sedimentary deposits that form a geologic record. The processes of glaciation and deglaciation have influenced the formation of much of Alaska's landscape. Today, glaciers cover approximately 5% of Alaska's land and represent approximately 13% of the mountain and valley glaciers on Earth. However, most of Alaska's glaciers are rapidly melting, losing area and volume while contributing to global sea level rise. From 1985 to 2025, glacier-covered land in Alaska decreased by about 15%.

This program will document Alaskan glacier change and landscape evolution. The program will be led by Dr. Bruce Molnia, a glacial scientist who has studied Alaska's glaciers for over 50 years. The principal technique we will use is 'glacier repeat photography', which compares newly taken photographs with historical photographs taken from the same location, sometimes more than 140 years before. Finding the exact location where the historic photographs were taken can be a challenge, but there is no evidence of climate change more compelling than the differences that can be seen on these then-and-now photographic pairs.

The program includes one week of online preparation with Dr. Molnia and two weeks on board the research vessel *Endeavour* exploring the glaciers of the Prince William Sound, Alaska. *Endeavour* is a 72-foot US Coast Guard designated research vessel with a professional captain and crew.

Prince William Sound encompasses 3,800 miles of coastline, bounded to the east and north by the Chugach Mountains and to the west by the Kenai Peninsula. Commercially important for the fishing and oil industries, the sound is also prized for its abundance of marine and coastal life, its rain forest of Sitka spruce and western hemlock, and its glacier-studded landscape. The sound contains 150 glaciers including 17 tidewater glaciers, known for dramatically calving huge ice chunks into the sea. More than 220 species of birds, 30 species of land mammals, and at least a dozen marine mammal species are found in the region. Bald eagles are plentiful along treetops and shorelines. Among the estimated 200,000 seabirds that summer in the sound are marbled murrelets, black-legged kittiwakes, and glaucous-winged gulls.

Lecture and discussion topics will include: 1) Field safety; 2) Introduction to the Earth System; 3) Climate and weather; 4) Introduction to remote sensing; 5) Repeat photography; 6) Alaska exploration; 7) Introduction to glaciers, including the vocabulary needed to 'talk' glaciers; 8) Geography and geology of Alaska; and 9) Behavior of Alaska's glaciers since the Little Ice Age. The expedition begins in Cordova, Alaska, which is served by Alaska Airlines and ends in Seward, Alaska, which is approximately 120 miles from Anchorage International Airport.

Upon arrival in Cordova, Alaska, will board the research vessel *Endeavour* for the twelve-day hands-on, up-close look at and analysis of dozens of Alaska's glaciers, all located in some of the world's most spectacular mountains and fjords. While collecting important photographic evidence of glacial change, students will experience glaciers firsthand, and observe their importance to Alaskan environments, including today's flora and fauna. In the field, students will use historical ground photographs, aerial photographs, satellite images, topographic maps, and historical literature to 'read' landscape features, to identify locations from which photographs have previously been taken, and to identify new locations from which they can document present day glacier change and landscape evolution.

Photographic pairs that students produce will be used in a journal article that they will co-author with Dr. Molnia. Image pairs will be shared with the National Snow and Ice Data

Center where they will become publicly available documentation of Alaskan glacial change.

PREREQUISITES

None

COURSE OBJECTIVES

This program builds on millennia of indigenous traditional knowledge and nearly three centuries of European exploration and research that provide information about the dynamics of Alaska's glaciers and landscapes. The primary objective of this program is to add a new 2026 layer of information documenting ongoing behavior, especially glacier advance and retreat, with new imagery that will expand existing imagery time series.

This program plans to collect new ground photographic evidence of terminus positions changes and landscape evolution at of at least 35 glaciers we plan to visit. Every major fjord in Prince William Sound will be visited and every effort will be made to photograph the following 35 glaciers from locations where historical photographs have previously been made: Aialik Glacier, Bainbridge Glacier, Baltimore Glacier, Baker Glacier, Barry Glacier, Bryn Mawr Glacier, Cascade Glacier, Cataract Glacier, Chenega Glacier, Columbia Glacier, Contact Glacier, Cox Glacier, Childs Glacier, Dirty Glacier, Falling Glacier, Harriman Glacier, Harvard Glacier, Holyoke Glacier, Meares Glacier, Miles Glacier, Nellie Juan Glacier, Portage Glacier, Princeton Glacier, Roaring Glacier, Serpentine Glacier, Shoup Glacier, Smith Glacier, Surprise Glacier, Tebenkoff Glacier, Tiger Glacier, Toboggan Glacier, Ultramarine Glacier, Vassar Glacier, Wellesley Glacier, Worthington Glacier, and Yale Glacier.

In recent years, some glacier changes have been very dramatic. Very few glaciers are advancing, most are in retreat, especially those situated at lower elevations. The most easily and frequently measured glacier-fluctuation parameter is the geographic position of the glacier's terminus and how it has changed from previous observations. Students will learn to use satellite images, aerial photographs, topographic maps, nautical charts, and historical ground-based photographs taken as early as the 1880s, to help determine the extent of glacial change in these areas. Using these data in the field, students will relocate the sites from which the historical photographs were made and will take new photographs capturing the identical fields of view. If a glacier is no longer visible from the historical photo location, the team will establish and document a new location from which the glacier's terminus can be photographed, now and in the future. The primary data collection method is digital repeat photography.

Proxy methods, such as lichenometry, radiocarbon dating, and tree coring yield approximate dates for terminus position up to several millennia ago. Together, these methods play an important role in determining the location and changes in the position of the termini of Alaskan glaciers over time. Participants will be introduced to all of these tools.

LEARNING OUTCOMES

Students will learn to use the tools needed to understand the changing landscapes and glaciers in the areas we will visit. Tools and skills include:

- Map reading;
- Interpreting satellite imagery and aerial photography;
- Using GPS;
- Using digital photography to document landscape changes
- Understanding and using field surveys
- The application of indigenous knowledge and oral histories.

Additionally, students will learn how to read landscapes based on geological features. Through the application of material covered in lectures and readings, students will learn how to interpret the landscape, including the role of glaciers in shaping the landscapes we will encounter.

ASSESSMENT (if course taken for college credit)

Students will be evaluated on their participation in group discussions and activities, as well as performance on assignments.

Students will record observations, questions and reflections in a field journal. Students will be asked to read the landscape at each glacier we visit, using the known history of the area and applying principles and processes covered in lectures and readings to interpret the landscapes around them. Field journals will be collected periodically for evaluation.

Students will prepare a storyboard about one or more of the glaciers we visit, including photographs and illustrations of the site, its known or probable geologic history, its major and unique features and changes over time.

Finally, students will contribute to writing a journal article about the glacier changes we document. The article will be submitted to a peer-reviewed journal for publication with students as co-authors.

COURSE SCHEDULE

All IFR field schools begin with an orientation that addresses local and program protocols concerning student behavior, appropriate attire, local practices and sensibilities that may be unfamiliar, potential fauna and flora hazards, IFR harassment and discrimination policies, and the student Code of Conduct.

Online Component - During the one-week online portion of the course, (June 22-26), on a daily basis, students will be expected to complete 20-40 pages of assigned reading, attend the daily online lecture, and participate in an online discussion.

Lecture topics, discussions, and required readings will cover: field safety; introduction to the Earth System; climate and weather; Introduction to remote sensing; an introduction to

glaciers and their behavior, glacier repeat photography; Alaska exploration, and geography and geology of Alaska.

Field Research component - Students will travel to Cordova, Alaska and transfer to our research vessel, *Endeavour*. Following a half-day field trip to visit a local glacier, activities for the next 12 days will take place on or near to the ship.

Important note: As we are conducting field research, changing conditions, including weather, can dictate our exact schedule. We will follow the following schedule to the extent possible, but we must all be prepared for changes to the itinerary due to weather, unexpected findings, or other conditions.

July 1: Orientation; safety onboard the research vessel, including safety drills; shared duties and responsibilities onboard; safety in the field. Depart Cordova

July 2-11: Fieldwork in Prince William Sound Fiords - Valdez Arm, Shoup Bay, Columbia Bay, Unakwik Inlet, College Fiord, Harriman Fiord, Blackstone Bay, Port Nellie Juan, Kings Bay, Nassau Fiord, Icy Bay, Port Bainbridge, and Resurrection Bay.

Our days will typically begin early in the morning with observations and discussions on the *Endeavour*. We will use observation, field reports, GPS, maps and aerial imagery to locate use the site of past photographs and employ repeat photography to document changes in glacial coverage. We will use the *Endeavour's* shore boats to bring us to land for exploration, and/or to approach tidewater glaciers.

Students will be expected to document each day's exploration in their field journal and to take digital photographs. These photographs are important documentation of glacial change in Alaska. Students are expected to share their photography with Dr. Molnia, the National Snow and Ice Data Center (NSIDC) and the National Park Service Through the NSIDC, images and repeat photography will be freely available to anyone.

Students will participate in evening discussions on the *Endeavour*, reflecting on the day's work and relating required readings to our findings. Evening sessions will allow students to present their findings and all of us to explore how our explorations can be applied to future work. We will prepare for the following day's expeditions. Additional readings and resources will be available on the vessel to supplement your learning.

Our field work concludes with final discussions and wrap up. We will discuss our next steps for sharing our findings, including creating the outline of the jointly-authored journal article and assigning tasks related to its writing.

POST PROGRAM

Students will complete their assigned sections of the journal article. Dr. Molnia will edit and submit it for publication.

PROGRAM SPECIFIC FIELD CONDITIONS

Alaska in July brings warm weather with frequent showers. Be prepared for rain with appropriate clothing and footwear. Good footwear with grippy soles to wear on the ship is very important, as the deck of the ship can get slippery. You will need hiking boots or equivalent rugged footwear for exploring on shore. We will explore glaciers in any weather. The ship will anchor in protected areas along the coast, though some rocking of the boat is to be expected at anchor and when underway. You should make use of handrails when moving about the ship.

ACTIVITY LEVEL

Students should expect to walk and hike along the coast as we explore the glaciers, which can include uneven and slippery surfaces, crossing streams and marshes, and climbing over downed trees and rocks. There will be a moderate amount of such physical activity daily. You will move from the research vessel to shore boats to land frequently. You will also move around the ship and participate in shared duties such as food preparation, cleaning, and watch duties.

VISA REQUIREMENTS

No visa required for US citizens

TRAVEL (TO AND DURING THE PROGRAM)

Natural disasters, political changes, weather conditions and various other factors may force the cancellation or alteration of a field school. IFR recommends students only purchase airline tickets that are fully refundable and consider travel insurance in case a program or travel plans must change for any reason. General information for this program is below, but keep in mind we will discuss any updated travel information during the program orientation.

Students should fly into Cordova, Alaska, arriving no later than 2:11 pm July 1, 2026.

During our orientation call we can set up a group text that will help with travel etc. If you miss your connection or your flight is delayed, please immediately call, text or email the field school director. A local emergency mobile phone number will be provided to all enrolled students.

After we depart Cordova on July 1, students will spend 12 days onboard the ship, transferring to shore boats to explore glaciers and coastal features.

Following our arrival in Seward, Alaska on July 12, Students will take a bus to Anchorage, Alaska, arriving at 6 PM. Students should plan to fly out of Anchorage no earlier than 8 PM on July 12.

ACCOMMODATIONS

Everyone lives aboard the *Endeavor* during the field research component of the program. The ship is 72 feet long with four bunk rooms, two bunks each, and two heads, both with showers. Students will be able to shower every day and do one load of laundry during the expedition. Students are strongly encouraged to pack lightly. There is a salon and galley, and an open-air deck for observing, relaxing and group discussions. There is a small dog who shares the ship with us. You can learn more about the ship at: <https://www.alaskaendeavour.org/ship>

EQUIPMENT LIST

- Digital camera (cell phone with good camera resolution is fine).
- 15-inch-high rubber boots.
- Rain jacket and pants.

PROVIDED READINGS

PDF files of the following will be provided to enrolled students. Students are encouraged to download and/or print readings prior to traveling.

Barclay, D.J., Wiles, G.C., & Calkin, P.E., 1999, A 1119-Year Tree-Ring-Width Chronology from Western Prince William Sound, Southern Alaska, *The Holocene*, V. 9, N. 1, P. 79–84.

Calkin, P.E., Wiles, G.C., & Barclay, D.J., 2001, Holocene Coastal Glaciation of Alaska: *Quaternary Science Reviews*, V. 20 PP. 449-461.

Davidson, G., 1904, The Glaciers of Alaska that are Shown on Russian Charts or Mentioned in Older Narratives: *Transactions and Proceedings, Geographic Society of the Pacific*, 2d series, V. 3, 33 p.

Grant, U.S., Higgins, D.F. 1913, Coastal Glaciers of Prince William Sound and Kenai Peninsula, *U.S. Geological Survey Bulletin* 526, 113 p.

Molnia, B.F., 2007, Late Nineteenth to Early Twenty-First Century Behavior of Alaskan Glaciers as Indicators of Changing Regional Climate: *Global and Planetary Change*, V. 56, N. 1-2, P. 23-56.

<https://doi.org/10.1016/j.gloplacha.2006.07.011>

Molnia, B.F., 2008, Glaciers of Alaska: In: Williams RS Jr, Ferrigno JG (Eds). *Satellite Image Atlas of Glaciers of the World: U.S. Geological Survey Professional Paper* 1386-K, 525 p.

Molnia, B.F., Kantor, C.M., Dilles, S.J., & Angeli, K.M. 2022, Documenting 20th and 21st Century Glacier Change and Landscape Evolution with Maps and Land, Aerial, and Space- Based Geospatial Imagery In Alaska's Kenai Mountains: *Nova Geodesia*, V. 2, N. 1, P. 1-44.

Molnia, B.F., Karpilo, R.D. Jr, Pfeiffenberger, J., & Capra, D., 2007, Visualizing Climate Change – Using Repeat Photography to Document the Impacts of Changing Climate on Glaciers and Landscapes. *Alaska Park Science* V.6, N. 1, P. 42-47.

Solomina, O.N., Bradley, R.S., Hodgson, D.A., Ivy-Ochs, S., Jomelli, V., Mackintosh, A. N., Nesje, A., Owen, L.A., Wanner, H., Wiles, G.C., & Young, N.E., 2014, Holocene Glacier Fluctuations: *Quaternary Science Reviews*, V. 11, N.1, P. 9-34.

Wiles, G.C., Barclay, D.J., & Young, N.E., 2010, A Review of Lichenometric Dating of

Glacial Moraines in Alaska: *Geographic Annals*, V. 92 A1, PP. 101-109

OTHER READINGS

Arendt, A., Echelmeyer, K., Harrison, W., Lingle, C., Zirnheld, S., Valentine, V., Ritchie, B., & Druckenmiller M., 2006, Updated Estimates of Glacier Volume Changes in the Western Chugach Mountains, Alaska, and a Comparison of Regional Extrapolation

Methods, *Journal of Geophysical Research*, V.111, F03019, 12 P., doi:10.1029/2005JF000436.

Arendt, A., Luthcke, S., Gardner, A., O’Neel, S., Hill D., Moholdt, G., & Abdalati, W., 2017, Analysis of a GRACE Global Mascon Solution for Gulf of Alaska Glaciers. *Journal of Glaciology* V. 59, P. 913-924.

<https://doi.org/10.3189/2013JoG12J197>.

Field, W.O., 1975, *Mountain Glaciers of the Northern Hemisphere*, V. 1&2: Cold Regions Research and Engineering Laboratory, Hanover, NH.

Jorgenson, M.T., Frost, G.V., Lentz, W.E., & Bennett, A.J.. 2006. Photographic Monitoring of Landscape Change in the Southwest Alaska Network of National Parklands: Report Prepared for the U.S. National Park Service: Report No. NPS/AKRSWAN/NRTR-2006/03. ABR, Inc.– Environmental Research & Services, Fairbanks, Alaska, 214 P.

National Park Service (2021). Repeat Photography Collection in Kenai Fjords – website, URL - <https://www.nps.gov/kefj/learn/nature/glacier-repeat-photography.htm>.

National Snow and Ice Data Center (2015). Glacier Photograph Collection, Version 1. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. <https://doi.org/10.7265/N5/NSIDC-GPC-2009-12>.

Wiles, G.C., D’Arrigo, & Jacoby, G.C., 1998, Gulf of Alaska Atmosphere-Ocean Variability Over Recent Centuries Inferred from Coastal Tree-Ring Records: *Climate Change*, V. 38, PP. 289-306.

Wiles, G.C., D'Arrigo, & Jacoby, G.C., 1998, Gulf of Alaska Atmosphere-Ocean Variability Over Recent Centuries Inferred from Coastal Tree-Ring Records: *Climate Change*, V. 38, PP. 289-306