

Alaska and Canada glacier melt significant to world sea level rise

Every summer, Alaska's glaciers melt and send vast quantities of water gushing through silty gray rivers, past towns and villages and finally into the sea. Some glaciers calve directly into the ocean, instantly losing car-sized chunks of ice and wowing boats full of tourists.

The world's melting glaciers are boosting ocean levels by 0.71 millimeters a year, accounting for roughly one-third of total sea level rise, according to a 2013 study published in *Science* magazine.

"That's the equivalent of draining the Great Lakes once a month each year," says Regine Hock. She and colleague Anthony Arendt, both glaciologists at the University of Alaska Fairbanks Geophysical Institute, contributed to the *Science* article.

Alaska and Canada glacier melt comprise nearly half of that—purging 100 gigatons of mass annually from frozen storage into the ocean.

The mass loss, which scientists call wastage, is so big that

it changes Earth's gravity field and alters ocean currents around Alaska. It is so heavy that parts of the earth can bounce up several centimeters in response.

Hock and Arendt worked with an international team to calculate the ice loss of glaciers around the world from 2003–2009 using satellite data and ground measurements.

"When many people think about sea level rise, they only think about the big ice sheets in Greenland and Antarctica," said Hock. "They don't

(continued next page)

FIELDWORK—Graduate student Joanna Young drills a hole into the Susitna Glacier for a weather station and a melt stake. In the background is a look at the upper reaches of Susitna Glacier in the Alaska Range. Photos by Regine Hock.



(continued from cover)

think these smaller ones can contribute anything.”

The other two-thirds of total sea level rise comes from equal parts melting ice sheets and the warming and expansion of oceans. Overall, oceans have risen 2.5 millimeters a year since 2003.

“In 10 years, that’s an inch. That’s quite a lot,” said Hock.

It trickles in from the state’s favorite glaciers – Gulkana in the Alaska Range, Exit in Seward, Portage on the Kenai Peninsula, Mendenhall in Juneau, Columbia on Prince William Sound, and all throughout the Wrangell Mountains.

Where does it go?

“Most of the meltwater ends up in streams and eventually makes its way to the oceans,” Hock said.

This affects not just the ocean but Earth’s hydrology.

Communities in the Andes, for example, rely on glacial runoff for water in the summer dry season. The more ice that’s lost, the smaller their water source.

Glacier water is cold and fresh, which affects the temperature and chemistry of rivers and oceans – and can impact fisheries and ecosystems.

“Salmon and other species are really sensitive to stream composition,” said Arendt. “If the temperature changes just a few degrees, that might affect whether salmon can spawn.”

Glacier mass changes have traditionally been estimated by field measurements of individual glaciers.

“It’s really old school,” Arendt said.

Scientists dig a snow pit in the winter and measure the snow accumulation, calculate its density, and then convert

it to water equivalent. This tells them the annual growth of the glacier.

To calculate melting, they drill a stake into the ice at the beginning of summer and measure the height sticking above the surface. An end-of-summer measurement reveals how much was lost. This depth is converted to water equivalent and extrapolated to the whole basin.

The melt has greatly outpaced the snowfall, according to these observations.

But because of logistics, there are only a handful of such field sites over Alaska’s vast ice-covered region.

To capture broader changes, the new study combined conventional field measurements with satellite data.

What does this mean for the world and Alaska?

Some coastlines will be hit harder than others, depending on which glacier regions melt the most.

Sea levels will actually drop in Alaska, as the weight of glaciers is lifted and the earth rises relative to the water.

“As the glaciers disappear, and you take off that load, it allows Earth’s crust to rebound in response,” Hock said.

Smaller glaciers, like those in the Brooks Range, will disappear faster than bigger, high-elevation glaciers like those on St. Elias. As glaciers shrink, so could tourism.

Understanding glacier wastage can help predict flooding in river communities and plan energy projects.

“With hydropower coming online, these companies need to know how much water will be transported into these watersheds and how that will change in the future,” said Hock.



Exit Glacier photo courtesy of wikimedia | Dubhe

Curiosity and risk-taking grabs National Geographic Society attention



© Mark Thiessen/National Geographic

The National Geographic Society named Erin Pettit, assistant professor of geophysics, as one of their Emerging Explorers for 2013.

She was featured in the June 2013 issue of *National Geographic* magazine for her unique approach to researching glaciers and for her outreach program that engages teenage girls in science. She received a \$10,000 award as well.

Pettit teaches and conducts research through the University of Alaska Fairbanks College of Natural Science and Mathematics and the Geophysical Institute.

Cheryl Zook, director of Explorer Programs for National Geographic, said Pettit grabbed the National Geographic Society's attention because she developed a new way to explore glaciers by listening to them.

"Some people say the Earth has already been explored, but there are new ways to explore our planet and beyond through innovative technological approaches," said Zook.

Pettit uses underwater instruments called hydrophones to listen to glaciers in Alaska and Antarctica. Whenever ice greets seawater, a noisy conversation follows as ice calves and falls into the water to form icebergs. Freshwater also rushes out from underneath the glacier and bubbles rise, all adding to the glacier's ramblings.

Pettit listens to the sounds and deciphers what they have to say about sea level rise, climate change and how these changes will affect the ocean's natural processes.

"Curiosity and risk-taking drive many of the best scientific breakthroughs," Pettit told National Geographic. "You may feel scared, be questioned, or get cold before you learn how to keep warm, but the more you push yourself, the more discoveries you will make throughout life."

Pettit also shares her love of exploration with others. She created a free wilderness science program, Girls on Ice, which brings high school girls on glacier trips to learn research techniques, survival skills and how to use challenge as a tool for discovery about themselves and the world.

The NatGeo Emerging Explorers program does not take

applications or unsolicited nominations. Zook said the program learns of candidates through research and a network of nominators. Paul Layer, CNSM dean, said Pettit's research and outreach is well known, appearing in major news publications like *The New York Times*.

"It's no wonder Erin came to National Geographic's attention," said Layer. "Erin is a true explorer. She challenges herself to think outside the box and inspires her students to do the same. This is what makes her a great researcher and a great teacher."

Two GI scientists earn 2013 Emil Usibelli awards

Two Geophysical Institute scientists won the 2013 Emil Usibelli Research, and Public Service Awards, respectively.

Jeffrey Freymueller, professor of geophysics, received the research award. Catherine Cahill, professor of chemistry, received the service award.

Freymueller joined the GI in 1995 after serving four years as a postdoctoral researcher at Stanford University.

His work since then has focused on measuring how Earth deforms as the result of geologic processes. He is widely regarded as one of the pioneers of GPS field monitoring in the state.

“Jeff built this program in Alaska from the ground up, literally, beginning with the installation of GPS networks where none existed,” said Michael West, a GI research associate professor who nominated Freymueller for the award. “He has developed a processing system, research group and funding to apply these data to questions with global impact.”

“Through countless collaborations, research projects, papers and professional meetings he has brought international attention to the University of Alaska Fairbanks and helped secure UAF as an indispensable collaborator for any researcher pursuing questions of North Pacific plate tectonics.”

Freymueller’s work frequently crosses multiple disciplines, as he studies how Earth’s surface reacts to a wide variety of factors, including volcanic and tectonic forces, as well as ice and hydrologic loads.

“Because of his research, the largest scale plate motions have been defined and refined,” said Bob McCoy, GI director.

“Freymueller’s efforts have fundamentally changed our understanding of how tectonic deformation is exhibited both globally and particularly in Alaska.”

In addition to his core research, Freymueller is the coordinating scientist at the Alaska Volcano Observatory, which is a collaborative project between UAF and the U.S. Geological Survey. In that

role, he leads the efforts of affiliated UAF researchers of various disciplines as they help monitor volcanic activity throughout the state.

Cahill joined the faculty at UAF in 1998. She is well regarded as a teacher and researcher, in addition to a stellar record of service both inside the university and in the public realm.

She has served on at least three dozen university service and governance groups in the last 15 years, including stints as president of the UAF Faculty Senate and chair of the UAF Faculty Affairs Committee.

Cahill is known locally for her work on air quality and is a past chair of the Fairbanks North Star Borough’s Air Pollution Control Commission.

“She has particularly endeared herself to the Fairbanks public by contributing her time as an impartial expert, articulating the scientific issues relating to air pollution in town,” McCoy said. “She has worked tirelessly with the Fairbanks North Star Borough’s Air Quality Division and the Alaska Department of Environmental Conservation’s Division of Air Quality to assist the borough’s attempts to come into compliance with National Ambient Air Quality Standards.”

She frequently gives public lectures and is a reliable source of information for journalists. In local schools, she is often called on to judge science fairs and do classroom demonstrations, work that stands to inspire the next generation of researchers.

Jonathan Rosenberg, UAF professor of political science, received the 2013 Usibelli Distinguished Teaching Award.

The Emil Usibelli Distinguished Teaching, Research and Public Service Awards are considered some of the university’s most prestigious awards. They are funded annually from a \$600,000 endowment established by Usibelli Coal Mine in 1992.

Each of the winners receives a cash award of \$10,000.



SERVICE— Catherine Cahill was awarded the 2013 Emil Usibelli Public Service Award.



RESEARCH— Jeffrey Freymueller was awarded the 2013 Emil Usibelli Research Award.



Photo of Mount Martin (foreground) and Mount Mageik (background)
courtesy of Taryn Lopez

Lopez continues volcano work with prestigious postdoctoral fellowship

Taryn Lopez received a GeoPRISMS Postdoctoral Fellowship to pursue a project focused on three volcanoes on the Alaska Peninsula. Her project will use geochemical measurements of volcanic fluids and seismic data from three historically active volcanoes within the Katmai Volcanic Cluster. With this information, she hopes to determine the source and flux of volcanic gases, identify proportions of magmatic and hydrothermal fluids within the subsurface and distinguish trends in gas composition and/or flux that correlate with seismic signatures of fluid movement.

Lopez’s project will build off her doctoral research with the Geophysical Institute at the University of Alaska Fairbanks, which used repeated volcanic gas measurements throughout varying stages of volcanic unrest to understand the surface and subsurface workings of Redoubt, Bezmianny and Karymsky Volcanoes.

Lopez graduated from UAF on May 12, 2013 (see pg. 5). She earned her doctorate in environmental chemistry, working with Catherine Cahill, a professor at the GI.

GeoPRISMS is a new National Science Foundation funding initiative focused on understanding the origin and evolution of the continents through the investigation of their active margins.



D. Fee photo

POSTDOC—Taryn Lopez sits upon the caldera rim overlooking Karymsky Volcano, Kamchatka, Russia on July 23, 2012.

From river ice, to volcanoes, ocean tides and solar winds:



Peter Bieniek

Atmospheric Sciences

Dissertation: “Assessing river ice breakup date, coastal tundra vegetation and climate division in the context of Alaska climate variability.”

Abstract: Large-scale drivers of Alaska climate were investigated to advance seasonal forecasting. River ice breakup is earlier when spring temperatures are higher under clearer skies from reduced storminess. Objective methods revealed 13 climate divisions for Alaska, based on homogenous variability. Tundra vegetation responds to snow and sea ice, which impact temperatures.

Advisor: GI Associate Professor Uma Bhatt



Helena Buurman

Geophysics

Dissertation: “Volcano seismicity in Alaska. Volcanic earthquakes can show us how volcanic systems work.”

Abstract: I used volcano seismicity to track the progression of magma as it moves through the crust during eruptions. I also examined 10 years of volcano seismic data recorded at 46 different volcanoes to determine what controls volcanic activity in Alaska.

Advisor: State Seismologist and GI Research Associate Professor Michael West



Yuning Fu

Geophysics

Dissertation: “Loading deformation on various timescales using GPS and GRACE measurements.”

Abstract: The effect of using inconsistent reference frame to correct ocean tidal loading on GPS coordinate solutions was examined. Two geodetic observations, GPS and GRACE, were used to investigate the seasonal and long-term loading deformation in the Nepalese Himalaya and seasonal hydrology loading effects in southern Alaska.

Advisor: GI Professor Jeffrey Freymueller



Ronni Grapenthin

Geophysics

Dissertation: “Volcano deformation and subdaily GPS products.”

Abstract: Daily averages of GPS positions are utilized to infer characteristics of the magmatic systems of Redoubt (Alaska) and Bezymianny (Kamchatka) volcanoes. Subdaily GPS data is used to visualize and analyze the dynamics of the 2011 Tohoku earthquake (Japan) and to demonstrate the detectability of volcanic plumes in GPS data.

Advisor: GI Professor Jeffrey Freymueller

Nicole DeRoin

Geophysics

Dissertation: “Methods for forecasting volcanic hazards and eruptions using seismology and other geophysical data.”

Abstract: The relationship of seismicity and physical characteristics of eruption phenomena at three volcanoes was studied. Correlations between plume heights, rockfall sizes and rockfall run-out distances and seismicity were found. A method for detecting tremor was found by modeling duration-amplitude distributions of volcanic tremor with an exponential law.

Advisor: Former GI Research Professor Stephen McNutt

Sarah Henton

Geology

Dissertation: “Using amphiboles to test models of magma storage and preeruptive magma dynamics preceding the 2006 eruption of Augustine Volcano.”

Abstract: This study used techniques in petrology and experimental petrology to refine models of the magmatic pulling system of one of Alaska’s most active volcanoes.

Advisor: GI Research Associate Professor Jessica Larson

2013 PhDs make their mark in GI research



Elchin Jafarov

Geology and Geophysics

Dissertation: “The effects of changes in climate and other environmental factors on permafrost evolution.”

Abstract: The central objective in this study was to predict permafrost thermal dynamics during the 21st century using high resolution climate datasets. As an additional outcome of this objective, permafrost modeling was improved by using better snow parameterization methods and addressing consequences of forest fires on permafrost.

Advisor: GI Professor Vladimir Romanovsky



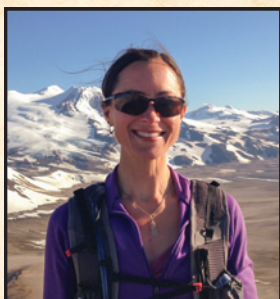
Poul Jensen

Space Physics

Dissertation: “Analysis of methods for solar wind propagation from Lagrangian Point L1 to Earth.”

Abstract: Several methods for extrapolating solar wind data from an upstream location (Lagrangian Point L1) to the magnetosphere using data from a single satellite were explored. Results may help improve accuracy of such extrapolated data, which is widely used for magnetospheric research and short-term forecasting of geomagnetic activity.

Advisor: GI Professor Bill Bistrow



Taryn Lopez

Environmental Chemistry

Dissertation: “Characterization and interpretation of volcanic activity at Redoubt, Bezymianny and Karymsky volcanoes through direct and remote measurements of volcanic emissions.”

Abstract: Volcanic emissions measurements can be used to characterize eruptive activity and infer subsurface processes at active volcanoes. This dissertation uses direct and remote volcanic emissions measurements to (1) quantify SO₂ emissions from Redoubt Volcano, (2) detect magma ascent at Bezymianny Volcano, and (3) remotely characterize diverse activity at Karymsky Volcano.

Advisor: GI Professor Catherine Cahill



Xuanye Ma

Space Physics

Dissertation: “Kelvin-Helmholtz instability and magnetic reconnection at Earth’s magnetospheric boundary.”

Abstract: Entropy can strongly increase only for small inflow plasma beta conditions. A field-aligned current can be generated by a guide magnetic field, a perpendicular shear flow, and inclusion of Hall physics. Magnetic reconnection is strongly modified by mutual interaction with Kelvin-Helmholtz modes for southward interplanetary magnetic field conditions.

Advisors: GI Professor Antonius Otto and GI Associate Professor Curt Szuberla

Jacob Mongrain

Geology

Dissertation: “Depositional systems, paleoclimate, and provenance of the late Miocene to Pliocene Beluga and Sterling formations, Cook Inlet Forearc Basin, AK.”

Abstract: Investigation of the Beluga and Sterling formations of the Cook Inlet Forearc Basin, AK revealed significant differences in depositional style. These differences are ascribed to sediment-flux changes between transverse-axial dominated (Beluga Fm.) and axial dominated (Sterling Fm.) fluvial systems attributed to exhumation in the Alaska Range ~11 Ma.

Advisor: GI Professor Paul McCarthy

Huy Nguyen Tran

Atmospheric Sciences

Dissertation: “Analysis of model and observation data for the development of a public PM_{2.5} air quality advisories tool.”

Abstract: An air-quality advisory tool that combines mobile measurements of particulate matter less than or equal to 2.5µm in diameter (PM_{2.5}) with outputs of an air-quality model was developed to interpolate PM_{2.5} measurements into unmonitored neighborhoods in Fairbanks, Alaska, and to provide a spatially differentiated public air quality advisory.

Advisor: GI Professor Nicole Mölders

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Sea ice hazards spur need for local collaboration

With climate change causing the arctic ice pack to melt, more and more northern waters are opening up to shipping each summer. Sea ice in the region is a major hazard, warns Hajo Eicken, a geophysicist and sea ice expert at the University of Alaska Fairbanks Geophysical Institute. According to Eicken, better forecasts are urgently needed and will require a new network to manage and distribute sea ice data. Eicken's ideas were published in a comment piece in *Nature*.

As the planet warms, sea ice is becoming more variable and mobile. Tracking changing ice is difficult. Surface meltwater can confuse satellites and freezing in coastal waters can take days to be recognized in low-resolution images from space. Information is supplied by academic experts, governments, industry and citizen scientists from indigenous communities, but arctic observations are not being coordinated or disseminated widely.

Eicken calls for the network of arctic stakeholders to decide which sea ice variables need to be monitored to satisfy everyone's needs, implement programs to do so and then share the data and usable products openly.

Nature is a leading international scientific weekly journal that was founded in 1869.



photo by Hajo Eicken

RESEARCH SITE — An automated sea ice research site at Barrow, Alaska measures the thickness and temperature of the sea ice, along with sea level and other data. Data is relayed by radio link to a UAF lab.