Fire AND ICE

WITH THE RISE OF GLOBAL TEMPERATURES AND UNPRECEDENTED ICE MELT IN THE EARTH'S POLAR REGIONS, THOUSANDS OF SCIENTISTS FROM 60 NATIONS — INCLUDING ST. OLAF COLLEGE FACULTY, STUDENTS AND ALUMNUS KNUT CHRISTIANSON '05 — ARE EMBARKING ON A COORDINATED CAMPAIGN OF RESEARCH THAT WILL INITIATE A NEW ERA IN POLAR SCIENCE.

By David Hawley

A graduate student at Penn State University, Knut Christianson '05 is part of a research team at the Thwaites Glacier, near the Antarctic Peninsula. He is conducting geophysical experiments and ground-penetrating radar and seismic studies to better understand the internal dynamics and subglacial processes of this glacier. The project is part of the International Polar Year.

PHOTOGRAPHED BY STEVE BOYLE / POLARIS

Two years at two different poles. "I guess you can't go to farther extremes than that," says Knut Christianson, a 2005 St. Olaf graduate and Fulbright scholar who majored in physics, mathematics and Norwegian.

Polar science is a cold subject but a hot field — especially during the current International Polar Year (IPY), which has engaged scientists and researchers from around the world in interdisciplinary studies related to global climate change.

At St. Olaf College, however, researchers have been involved in polar studies for decades. Its legacy includes a generation of graduates like Knut Christianson.

Between 2005 and 2006, Christianson's year-long Fulbright took him to the Svalbard archipelago, a cluster of frigid islands about 350 miles north of the northern-most edge of mainland Norway. There he took courses in Arctic geophysics and geology at the University Centre in Svalbard and worked with the Norwegian Polar Institute. This past November, as part of his Ph.D. studies in geophysics at Penn State University, Christianson began an eight-week IPY research project on the Thwaites Glacier in Antarctica.

The source of Christianson's fascination with ice at both poles began with what he calls "serendipitous choices" at St. Olaf. The first bit of serendipity for Pittsburgh-raised Christianson was discovering the college, which he did by accident.

The second, after arriving as a freshman in 2001, was discovering that two of his physics professors were deeply immersed in polar research, including Robert W. Jacobel, whose work in Antarctica over two decades was honored in 2003 when a massive glacier that flows into Antarctica's Sulzberger Ice Shelf was named for him.

And the third bit of fate is the recent acknowledgment of what many believe are major environmental crises in world history: global warming

STUDENT RESEARCH
Physics students who participate in the St. Olaf Center for Geophysical Studies of Ice and Climate (CEGSIC) conduct research on Storglaciären, a glacier in Arctic Sweden, to understand how the world's ice masses are responding to global climate change.

NASA.GOV

WAY DOWN SOUTH
The Amundsen-Scott South Pole Station sits at the Earth's axis atop a constantly shifting continental ice sheet several miles thick. Brian Welch (below), St. Olaf assistant professor of physics and environmental studies, conducts research at the pole.

ROBERT JACOBEL

and climate change. Suddenly, everyone is interested in ice — specifically, melting ice. When there's concern, there are opportunities for scientists. Christianson believes he's has the good fortune of pursuing the right thing at the right time.

THE INTERNATIONAL POLAR YEAR

Concern for a planet that is warming is a driving force behind a flurry of polar research going on now during the International Polar Year (IPY), a huge multinational program that began last March and continues through March 2009. Because of the distances and climate conditions involved, IPY is taking two years instead of one. Thousands of scientists and researchers from 60 nations around the world are focused on the Arctic and Antarctic. Among them are St. Olaf faculty and students involved in two major IPY-related activities at opposite ends of the earth.

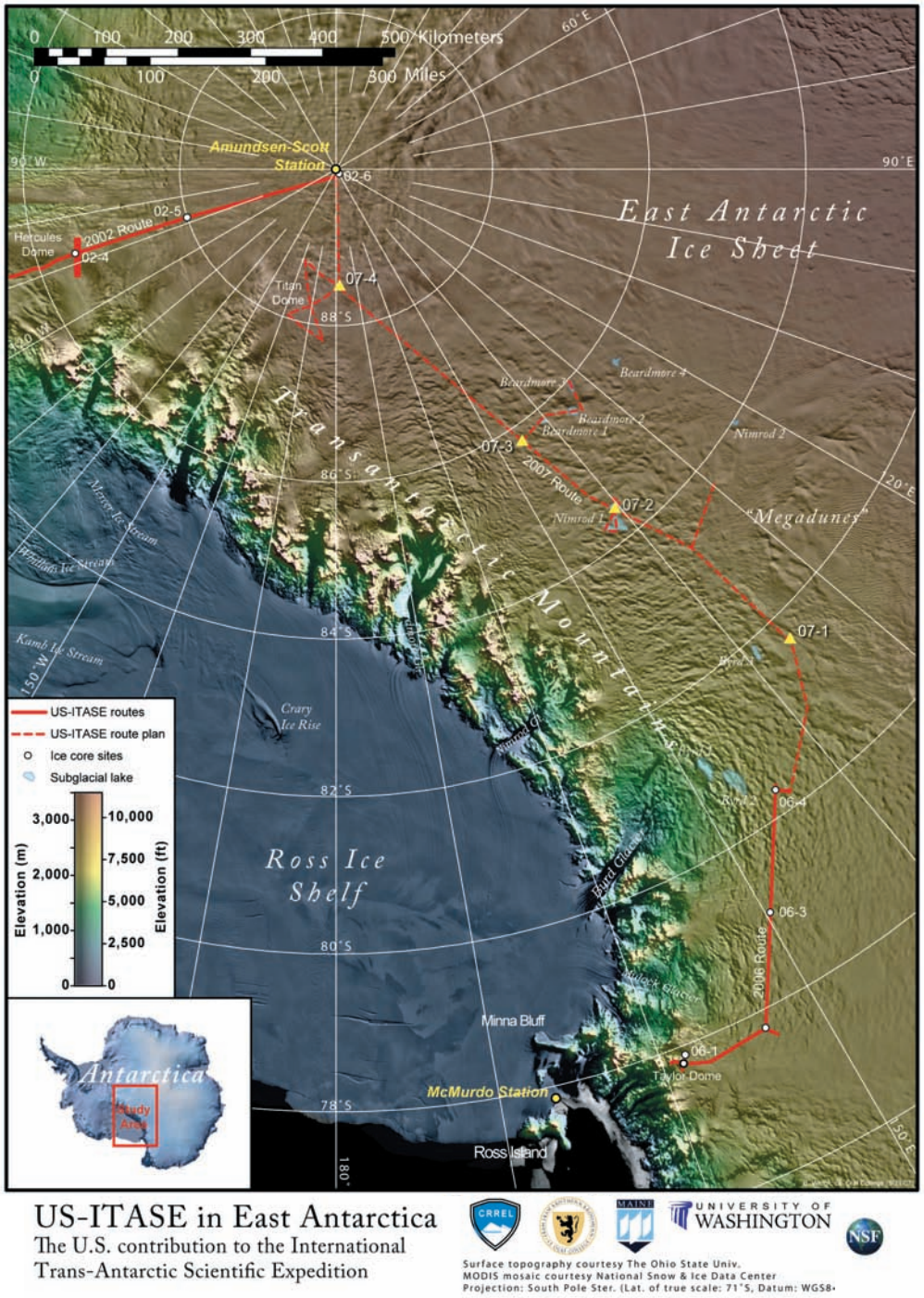
In late October, Brian Welch, assistant professor of physics and environmental studies, left for a two-month research project in Antarctica that involves using deep-penetrating radar to analyze areas inland from the Ross Ice Shelf in the western part of the continent. This final leg of a two-year mapping project culminates in a rare overland trek to the South Pole.

Also in October came word that St. Olaf will be sending students and faculty to an Arctic area in remote Siberia as part of the "Polaris Project," a three-year program organized by the Massachusetts-based Woods Hole Research Center. John Schade, assistant professor of biology and environmental studies, says St. Olaf participants will research carbon and nitrogen recycling in areas of the Siberian tundra where permafrost is melting because of climate change.

The International Polar Year now underway is actually the fourth that has been declared since 1882, when much of the research on the poles involved just getting there. Today's IPY is jointly coordinated by the International Council for Science and the World Meteorological Organization, though funding comes through a variety of sources.

"It's been 50 years since the last IPY and a lot has been discovered about the polar regions in that time," Jacobel says.

Did you know? Glaciers differ from sea ice in that they are regions of fresh water ice on land. Their retreat and loss of volume indicates climate change.



The map at left shows the routes of the U.S. component of the International Trans-Antarctic Scientific Expedition (US–ITASE), a National Science Foundation project in which researchers from several U.S. colleges and universites are collecting data in order to describe and understand the scope of environmental change in Antarctica over the last 200+ years.

US-ITASE MAP BY BRIAN WELCH

"This is the opportunity for geophysicists to collaborate with others from around the world and do things we normally couldn't get sufficient funding to do."

For the past 20 years, Jacobel, joined by Welch in 2001, has headed a group at St. Olaf called the Center for Geophysical Studies of Ice and Climate. Funded primarily by the National Science Foundation, the center's activities in polar research have involved dozens of St. Olaf students, including Christianson, whose experiences reflect the center's ripple effect in inspiring future scientists.

"When I started at St. Olaf I was more interested in meteorology than glaciology," Christianson recalls. "Besides that, I wanted to do more than science, so I wasn't looking at schools based entirely on their strengths in physics."

Indeed, not long after arriving at St. Olaf, Christianson decided to add a major in Norwegian, the language his great-grandparents spoke when they came to America. It was another "serendipitous choice," because Christianson credits Norwegian Professor Solveig Zempel with encouraging him to apply for the Fulbright that took him to his first Arctic research project in northern Norway.

Science, however, is clearly part of Christianson's heritage. The son of Owen Christianson, a nuclear engineer, and Elizabeth McPherson, a medical geneticist, Knut was a high-school junior visiting college campuses around the country when he came to Northfield with his father in 1999 to visit Carleton College, the only Minnesota school on their list.

"My dad had a map and when he looked at it, he said, 'Hey, there's another school across the river. Why don't we go and take a look,'" Christianson remembers. On that day, after a brief visit with an admissions counselor, the two decided to explore the St. Olaf campus.

"We went to look at Old Main because — well, because it was old. And then we were just wandering around the science building when a [physics] professor, Dr. Amy Kolan, bumped into us and talked for about a half-hour. She was friendly, outgoing and interested, and something just clicked," he says.

The following fall, Knut applied for early admission.

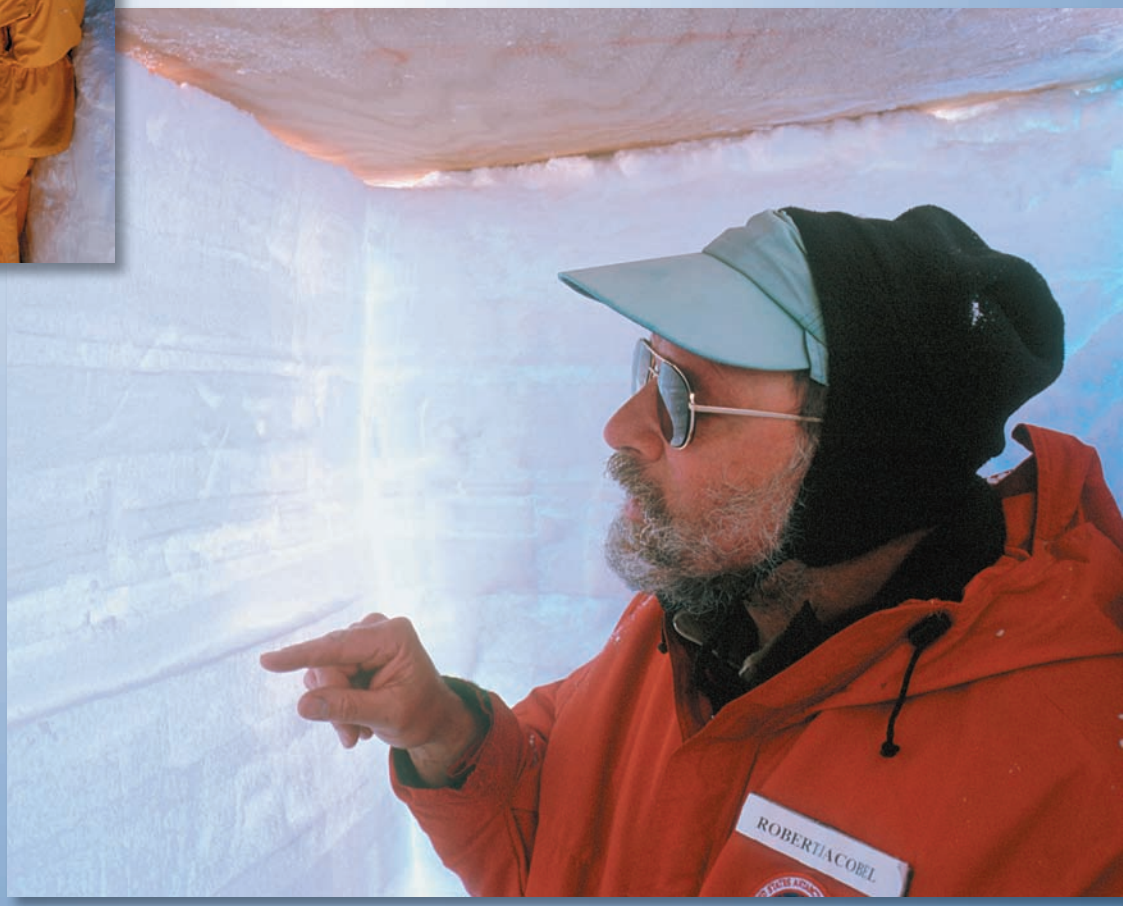
GOING POLAR

The St. Olaf Center for Geophysical Studies of Ice and Climate, under Jacobel's direction, has been engaged in an ongoing study of West Antarctica — focusing on the impact of climate change as revealed by the ice but also related to the atmosphere, ocean circulation and other factors.

"The research is entirely dependent on outside funding, primarily from the National Science Foundation, so whenever we're fortunate enough to get a grant awarded, we go," Jacobel says. "This time it's Brian Welch's turn."

A number of scientific groups are involved in studying the Antarctic ice sheet and each of them uses different methods.

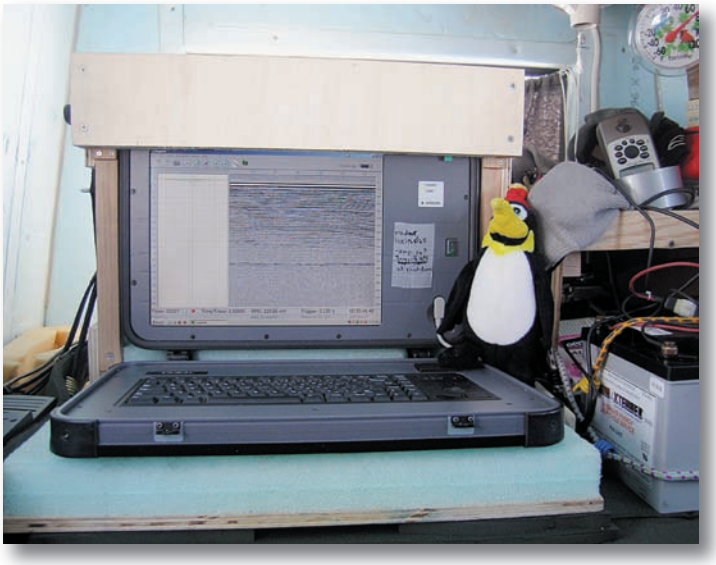
SCENES FROM THE US-ITASE TRAVERSE
(A) One of the two tractor trains that pull the ice coring equipment and the radar sled (at rear); (B) Working to free the radar shelter hung up on sastrugi (hard-crusted, wind-blown snow drifts), a common occurrence on the route to South Pole; (C) The shallow ice core drilling rig is used to recover samples of the atmosphere buried in ice down to about 100 meters.

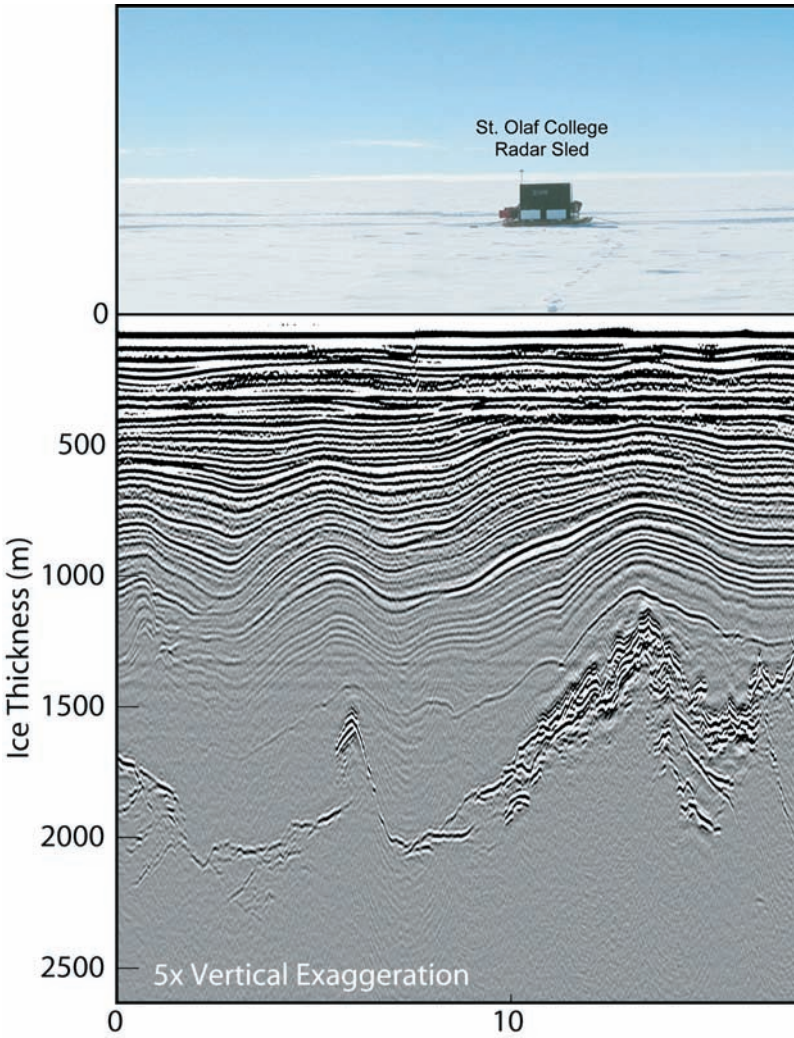


ENROUTE TO THE SOUTH POLE
Physics Professor Robert Jacobel examines snow layers in a shallow pit. Snow is removed from the outside of the left wall of the pit so that light coming through reveals details of the layering in the snow. In the uppermost layers, individual precipitation events can be distinguished as well as periods of temperature extremes and high winds. Layers become compressed at greater depths allowing only average annual values to be retrieved.

PHOTOGRAPHS BY BRIAN WELCH, COURTESY OF ROBERT JACOBEL

BRIAN WELCH





MAPPING THE ICE

On the current and former US-ITASE expeditions, St. Olaf researchers have focused primarily on mapping the Antarctic ice sheet with deep-penetrating radar that can collect data through some two miles of ice to the bedrock below.

The radar image at right reveals a range of mountains buried beneath more than 1,000 meters of ice. The layers within the ice are the result of deposits from the atmosphere buried over time and show scientists how the ice deforms.

For a number of years, the St. Olaf researchers have been mapping the ice sheet with deep-penetrating radar that can collect data through some two miles of ice to the bedrock below.

The radar equipment is pulled on a sled behind a caterpillar tractor that travels at about five to six miles per hour. The data retrieved produce a profile, a vertical slice through the flowing ice, revealing various properties of the ice and bedrock. Once it is collected and processed, the data can be combined with information from other researchers, such as chemical properties learned through deep-core ice borings.

The current project, now in its second year, involves mapping a long traverse from the edge of the Ross Ice Shelf in an area called "Taylor Dome" across a plateau on the east side of the Transantarctic Mountains and eventually reaching the South Pole.

"We can cover 500 to 1,500 kilometers in one season and amass 30 to 50 gigabytes of data," Welch says. "We bring all of that home and then students help us process and interpret it during the summer. It's a lot of data, and some students have also written the software that does the processing and runs the radar system."

That's how Knut Christianson got involved.

THE ALASKA VOLCANO

Near the end of his freshman year, Christianson was asked by Jacobel if he'd be interested in spending the summer at St. Olaf analyzing data from what was then the most recent Antarctic trip.

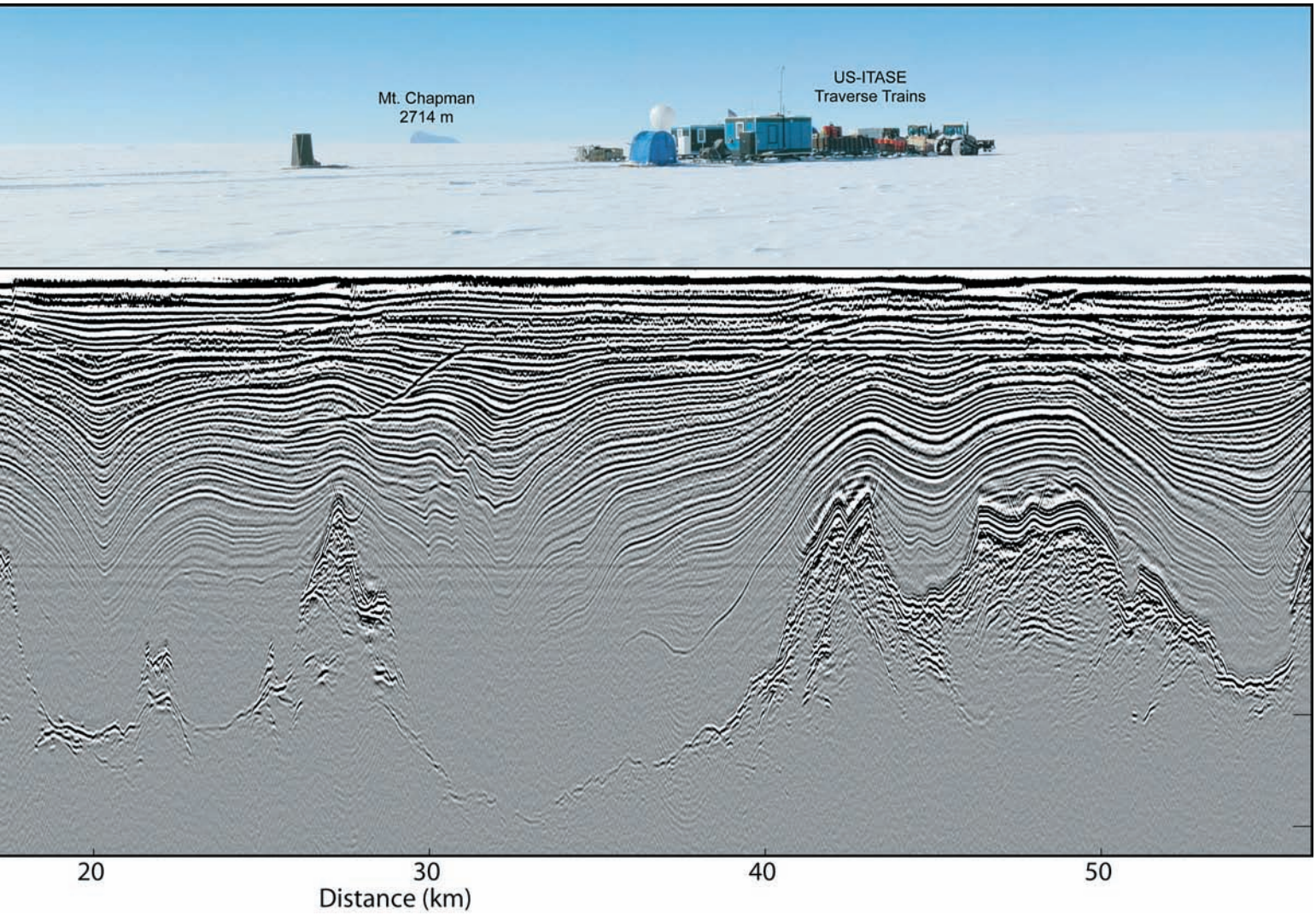
"I'd already accepted another job in Pittsburgh, working in a genetics lab. Back then I'd gotten interested in the medical side of physics, so I had to turn him down," Christianson recalls. "But then I took a class from him my sophomore year and I applied again and was accepted."

Christianson spent two summers working with Antarctic data, though the second summer was by default after a planned research trip headed by Welch to Alaska had to be scrubbed. The purpose of that trip was to use the same radar equipment from the Antarctic to analyze the glacier-filled cone of the Veniaminof volcano in the Alaskan peninsula southwest of Anchorage.

"The idea was to estimate the flow of water if the glacier melted from an eruption," Christianson says. "The concern is that mudflows from a major eruption could destroy valuable salmon fisheries, so we were funded by the U.S. Geological Survey."

Fate intervened, however. Veniaminof, a perpetually smoldering cone, suddenly became more active, and though a major eruption never occurred, the Alaska trip was postponed for safety reasons.

"It wasn't much in the way of a melt, but it was probably a good thing we didn't go up," Christianson says. "So there



was still some Antarctic data left to be analyzed and we worked on that the rest of the summer. After I graduated, Brian Welch and two St. Olaf students, Mike Helgen and Kieran Cofell-Dwyer, did make the trip."

WARNING: THIN ICE

The International Polar Year is taking place at a time when there is abundant evidence of worldwide climate changes, from the dramatic Arctic melt that opened the Northwest Passage last summer and the widespread loss of glaciers in temperate latitudes to the perceptible shrinking of glaciers and ice caps at both of earth's polar regions and in Greenland.

"There are a whole variety of ways to look at it, and we're still working on them," Welch says. "For instance, snowfall rates have changed in the past 100 years or so. From readings in the ice core, there's no doubt that chemistry comes into it. Also, if there's water beneath the ice sheet, it can slide more easily and it appears that more melt water *is* reaching the bottom of glaciers and increasing the flow."

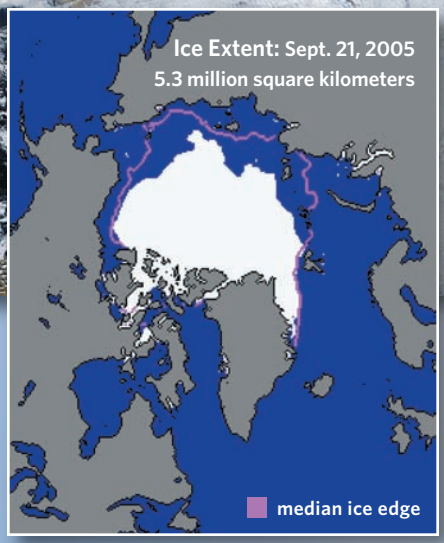
Christianson says the seismic studies he's conducting on the Thwaites Glacier with a Penn State research team led by Dr. Sridhar Anandakrishnan involves the use of sound waves from passive and active sensors to study ice-flow conditions.

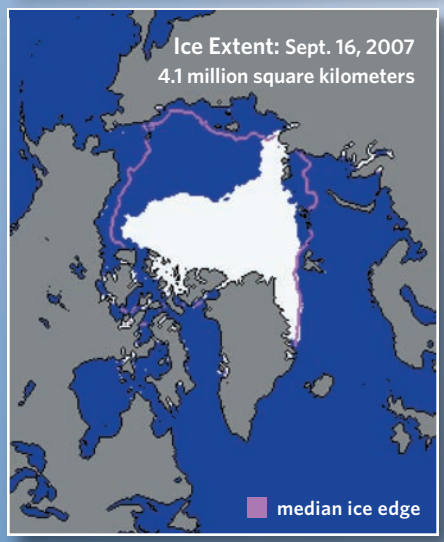
Did You Know?

Antarctica is an ice-covered continent surrounded by ocean and is generally uninhabited. By contrast, **the Arctic** encompasses a large, mostly frozen ocean surrounded by land, is home to almost four million people, and includes some or all of the territories of eight nations, including the United States.

Did you know? In September 2007, the Northwest Passage was completely ice free for the first time in human history. For better or worse, the passage could become a direct route from Europe to Asia for ships traveling through the Arctic.

PHOTO COURTESY OF NASA.GOV





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The Northwest Passage

From 1907 to 1910 the Norwegian polar explorer, Roald Amundsen, piloted the small sailing ship, *Goa,* through the Northwest Passage after nearly 60 years of failed attempts by others because of choking ice conditions.

The map at upper left shows the extent of ice in September 2005, the minimum ice area ever recorded until that point. But the passage remained blocked.

The map at lower left shows conditions in September 2007 — the extent of ice decreased by about 25 percent from 2005 and the Northwest Passage was open. The average ice extent over the past 30 years is shown by the purple line.

Melting glaciers, ice sheets and sea ice are part of a global trend identified by scientists.

"From satellite and remote sensing we think the ice is becoming thinner and flowing faster in some areas," Christianson says. "One of these is where a portion of the West Antarctic ice sheet drains through the Thwaites Glacier and then funnels into the Antarctic Ocean. It's like a large floating ice log."

Another intriguing puzzle, Christianson says, is finding a reason for the apparent thinning of the ice sheet in Antarctica's continental interior.

"Until five years ago, everyone believed it would be gaining mass due to precipitation," he says. "It's difficult to study the total mass because there just aren't enough observations. But recent studies seem to indicate that the accumulation of ice mass is probably slightly negative. Since the interior stays below freezing throughout the year, changes in ice flow patterns may be the reason for the loss."

The increased flow, Christianson adds, could also be the result of water reaching the bedrock — a major reason for radar and seismic research.

"Big changes aren't necessary," Christianson says. "Small changes can have a large effect."

Evidence that global warming is happening and that human activity through the creation of greenhouse gases is causing it — long accepted by most climate scientists — is no longer seriously debated, even by reluctant politicians, Jacobel says.

"In February 2007, the Intergovernmental Panel on Climate Change issued a now widely cited report that said the evidence is overwhelming that climate is warming and that it's us causing it," Jacobel says. "We've recently reached a tipping point in public perception. It's no longer deniable."

THE POLARIS PROJECT

Meanwhile, members of the biology and environmental studies faculty at St. Olaf were thrilled last October when the National Science Foundation approved their proposal to conduct multiyear field research projects in an Arctic region of Siberia.

"We were pretty surprised because we didn't expect to get our first proposal approved," says biology professor John Schade. "Usually, these kinds of proposals don't get approved right away. But we had worked hard and felt we had a good idea, so it was very gratifying."

The Polaris Project involves St. Olaf and a number of other universities and colleges (St. Olaf is the only one from Minnesota) that will send students and faculty to the Siberian Arctic during the next three summers. The initial destination is the Northeastern Station near the Siberian village of Cherskiy, some eight time zones from Moscow in a tundra region twice the size of Holland but with a population of just a few thousand people.

A year-round research station was established there in 1982 and is continuously manned. Nonetheless, the area is one of the remotest populated places on earth, with summers of endless daylight and winters of endless night.

"We forget there are some relatively untouched places in the world and this is one of them," Schade says. "That's why this is such a unique opportunity."

Environmental changes resulting from climate change — including melting permafrost — in the areas surrounding the Siberian research station are having an impact not only on ecological processes but also on human culture, Schade notes. An important area of scientific research is the impact of climate change on cycling of carbon and nutrients as they are carried by water flowing from the softening tundra to the Arctic Ocean. Yet another is the immediate impact of climate change on local populations.

"There are stories in the newspapers of whole villages in the Arctic that have had to consider moving because they are sinking into the melting permafrost," Schade says.

> "Evidence that global warming is happening and that human activity is causing it, long accepted by most climate scientists, is no longer seriously debated, even by reluctant politicians."

Did you know?

Polar ice reflects light from the sun. As the ice begins to melt, less sunlight gets reflected into space and instead is absorbed by the oceans and land, raising the overall temperature and fueling further melting. This results in a positive feedback loop called "ice albedo feedback," which causes the loss of the sea ice to be self-compounding. The more it disappears, the more likely it is to continue to disappear. (*NASA.gov*)

PART OF THE SOLUTION

A major goal of the Polaris Project is to introduce future scientists to the rigors and adventures of field research and climate studies. Schade says a project curriculum being developed at St. Olaf should result in course materials that will be shared with other colleges and universities involved in the project.

In addition, the project also involves grade-school and secondary-school programs, including the "GoNorth" curriculum (polarhusky.com), which is already used in

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FIRE AND ICE [CONTINUED FROM PAGE 17]

thousands of schools around the world. Polaris Project participants also will participate in a central website featuring student blogs that will enlarge the program to international proportions, Schade says.

"The number of students who go to Siberia from St. Olaf will be small, maybe 15 over the three years," Schade says. But the impact could be big.

"When it comes to climate change, people understand that something is going on [in Siberia], but not in a deep way," Schade adds. "To really get it you have to immerse yourself in it. The more people we can expose to the situation, the more likely it is that we'll have more brains working on this problem. That's a major goal."

Field support is provided to research camps by ski-equipped Hercules LC-130 transport planes flown by the New York Air National Guard.

BRIAN WELCH

THE RISING SURGE

The polar research projects and studies at St. Olaf reflect the issue of climate change, a topic that has moved to the front of the international agenda. The U.N. Intergovernmental Panel on Climate Change, which shared the Nobel Peace Prize last year with former Vice President Al Gore, was cited for two decades of scientific reports that have "created an ever-broader informed consensus about the connection between human activities and global warming." In addition, talks are set to resume on replacing the 1997 Kyoto Protocol on climate with agreements on more substantial actions to reduce greenhouse emissions.

Christianson believes polar research — the field he discovered at St. Olaf — is a frontier science.

"We're just starting to understand how these systems act and change," he says. "The next 10 to 20 years are going to be exciting in the field as we start to comprehend how changes take place and what effects we are having on them."

Jacobel agrees.

"The International Polar Year is a time to refocus, and it helps that the attention of the world seems to be turning in our direction," he says. "If you like to work on scientific problems that have widespread societal implications, it's a great place to be right now."

David Hawley is a Twin Cities-based freelance writer.

KNUT CHRISTIANSON '05

Did you know?

On February 2, 2007, the U.N. scientific panel studying climate change declared that the evidence of a warming trend is "unequivocal." Its latest report predicts that the global climate is likely to rise between 3.5 and 8 degrees Fahrenheit if the carbon dioxide concentration in the atmosphere reaches twice the level of 1750, and by 2100, sea levels are likely to rise between 7 and 23 inches.

Stay informed

International Polar Year: ***ipy.org***

U.S. Environmental Protection Agency: ***epa.gov/climatechange***

Natural Resources Defense Council: ***nrdc.org/globalwarming***

Arctic Change: ***arctic.noaa.gov/detect***

National Snow and Ice Data Center: ***nsidc.org/noaa***

NASA and the International Polar Year: ***nasa.gov/vision/earth/environment***

Intergovernment Panel on Climate Change: ***ipcc.ch***

U.S. Climate Change Science Program: ***climatescience.gov***