

Pine

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Core Curriculum

In examining 2,000 years of sediment in the Arctic, Dr. Darrell Kaufman pinpoints the subtle intricacies of the science behind climate change



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At the Climate's Core

*Climate change research requires an interdisciplinary perspective and the highest standards of scientific rigor. Follow **Darrell Kaufman, PhD**, from his NAU lecture hall to remote Arctic lakescapes where he analyzes the causes and effects of climatic trends*

By Anne Walden

Photograph by Mark Peterman



The Lake

August 2009, Allison Lake, near Valdez, Alaska

A 15-foot-long core tube descends through depths of frigid water to the lake floor 150 feet below. From the floating platform on the surface, a life-jacketed Dr. Darrell Kaufman and his students brace themselves to control a roped weight and tap the tube into the mud, inch by inch. Retrieving a core sample can be tricky, but today the sediment gods are kind: The tube penetrates its full length into the lake bottom, an

From left: Kaufman and his students travel to far-flung locations like Cascade Lake in Alaska to conduct their research. To access core samples, they use ropes attached to a weight that taps a tube into the sediment at the bottom of Alaska's Allison Lake.



air-tight piston at the top holds in mud like a thumb over a straw, and the team hoists the encased mass back up onto the dripping, chilly platform. In the annals of field work, the day is now officially a good day. (Watch a video on page 11.)

The Research

Benign extraction — with a gingerly touch and plenty of patience — is a recurring theme in Dr. Kaufman's life. His specialty, paleolimnology (the study of ancient and existing lakes) has entailed 15 years of consistent, disciplined research in both the field and laboratory. This painstaking acquisition and impartial dissemination of information penetrates every aspect of his vocation at Northern Arizona University, as a researcher and educator of the science behind climate change.

The impartiality of Kaufman's Arctic lake data has also served as a stalwart anchor for his initiation into



THE FULL REPORT

Go to [Pine online exclusives](#) to download a copy of the Kaufman team's study in the journal *Science*.



public scrutiny. When his research team reported in the journal *Science* last fall that thousands of years of natural Arctic cooling had been reversed by recent warming, the findings received broad media coverage and galvanized even further debate worldwide about the causes of climate change. But as Kaufman points out, the conclusions of the study stood firm, even against ideologically biased attacks.

"The data," he says, "speak for themselves."



The Students

January 2010, NAU Geology Annex

Kaufman is keen about helping others understand his work from a layperson's perspective, without oversimplifying or sacrificing nuance. Uniformed in plaid shirt and cords — and without a hint of condescension or self-importance — he presents the same persona in or out of the classroom, the conference hall or the Alaskan wilderness.

Kaufman never sees a student as just one more paper to grade, especially when today's freshman with an undeclared major could be tomorrow's co-author.



TEST YOUR KNOWLEDGE ABOUT CLIMATE CHANGE

Take the Climate Change Class Pre-Assessment quiz at [Pine online exclusives](#).

"Students drive my research program," he says. "All science is based on data; they're the fundamental currency scientists use to write papers and fuel proposals. The students are really the 'workhorses' generating the data.

"But it's a partnership," Dr. Kaufman says. "The students need guidance to understand how their data fit into the

bigger picture, and that's where experience comes in."

Later, as his 70-some students walk into the lecture hall during the second week of his class Climate Change (ENV/GLG 115), Kaufman greets them each by name.

"There's no student anonymity in my class," he tells me, grinning. "Knowing their names encourages attendance."

As does the topic itself. Students are already flocking to the new offering from the School of Earth Sciences and Environmental Sustainability, eager to resolve the contradictory media reports about global warming.



From left: Kristi Wallace, '03 MS, of the U.S. Geological Survey's Alaska Volcano Observatory is working with Kaufman's group to reconstruct the eruptive history of Alaskan volcanoes by studying ash layers deposited in lakes. NAU MS student Megan Arnold and research specialist Caleb Schiff, '07 MS, recover sediment traps. The traps remain in the lake year-round to study limnological conditions in relation to changing weather and climate.



The Human Factor

Discussing the project's conclusions, Kaufman is straightforward, earnest and non-alarmist: "My research team reconstructed Arctic temperatures at decadal scale going back 2,000 years.

Our data clearly showed that the warming which had taken place over the last half-century is beyond the variability that we expect for natural climate change."

What do these findings mean for humans in the 21st century? "We understand

how much climate tends to change on its own without human impacts," Kaufman says. "And we understand what causes those changes. It's not random. The Arctic's natural cooling trend, which should be continuing today, was reversed rapidly and dramatically at a time that coincides with the buildup of greenhouse gases."

Science's ability to improve future predictions about Earth's changing climate is good news for humankind.

It's also a validation of the meticulous scientific method.

Research, Revisited

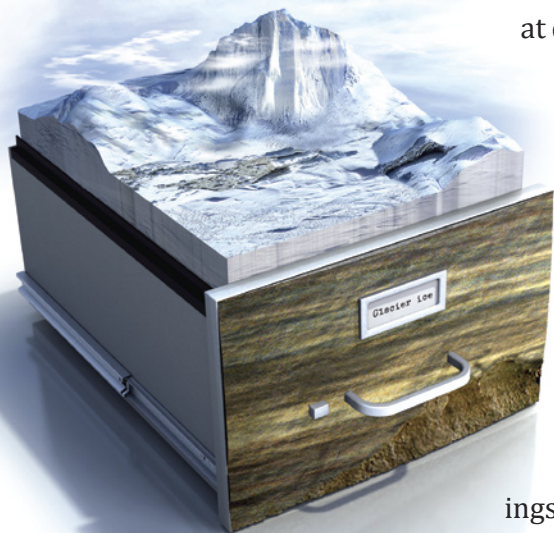
The scope of Kaufman's work is actually supervisory as well; he aligns and manages the synergies of the entire multidisciplinary team. "The *Science* article represents the culmination of a five-year project involving dozens of paleoclimate researchers working on lakes, glaciers, and trees from across the Arctic," he says.

The research project is largely sponsored by the National Science Foundation's (NSF) program in Arctic System science. NSF's overarching goal is "to understand how the physical, biological, and chemical processes within the atmospheric, oceanic and terrestrial components of the Arctic — what might be considered the entire climate system — interact and evolve through time."

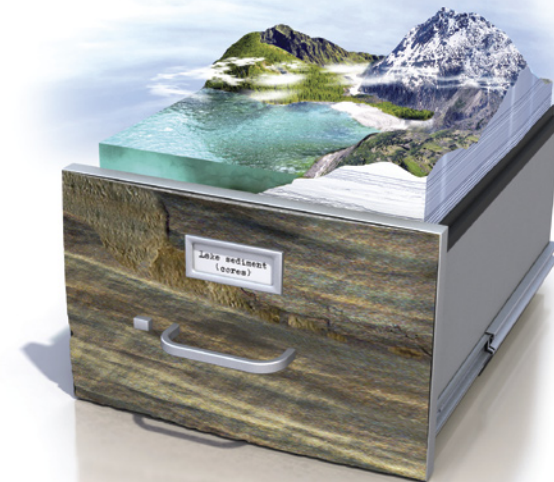
Funded in 2005, the initial four-year grant was \$2 million. Its \$2.5 million continuation extends the study through 2014.

"The first phase focused on the last 2,000 years of climate change in the Arctic. We will now expand our records and network of study to the last 8,000 years, focusing on the more dramatic natural climate changes."

Daunting, perhaps, but Kaufman is accustomed to thinking in terms of geologic time — that is, eons and epochs. Perhaps to him 8,000 years is just another few meters of mud? "True," he agrees, "but that mud will take a lot more painstaking analysis."



The Earth's sedimentary layers contain minutely detailed indicators about climate change. Kaufman is able to read samples from each of these layers to determine the climate during a specific era.



ILLUSTRATIONS BY RYAN ETTER



CLIMATE CHANGE AND YOU

Go to [Pine online exclusives](#) and let us know if and how this environmental phenomenon affects your life.



The Lake, Revisited

“Grinding, mosquito-plagued field work” is how *The New York Times* refers to Kaufman’s 25 consecutive summers in Alaska. “Sure,” he agrees, “the bugs are bad, or we work ourselves to exhaustion because we know that soon the weather’s going to be terrible. Or the weather *is* terrible and we’re trapped in our tents, and we’re frustrated because we can’t accomplish our goals.”

Here it turns out the students are a key source of inspiration: “They keep the field seasons energized. Still excited about the new discoveries, they’ve

gotten into geo/environmental sciences because they want to understand more about how the Earth works. They renew my excitement each year.”

It also can be tremendously gratifying when a “eureka” moment happens in the field. “We pull up a tube of mud, we slice it open, and we discover that the lake changed *fundamentally*, right here in the core. Suddenly, a glacier expanded to overtop the drainage divide and began to discharge meltwater in the lake. And we can see that; the sediment changes from brown organic mud at the bottom to bluish inorganic clay near the top.”

Securing that glorious mud is just the beginning. “Last year we shipped over 600 pounds of mud to [NAU’s Sedimentary Records of Environmental Change Lab](#) to analyze at millimeter scale.”

The samples are also sent out to other collaborators to study vegetation changes indicated by pollen, insect remains, organic compounds like alkenones, or isotopes. And there’s the physical sediment itself — the types of minerals, their grain sizes, and the rate at which they’re deposited in the lake are all “proxies,” indicators of past climate that speak volumes to the specialists.



A DELAYED ICE AGE?

[*The New York Times*](#)

examines Kaufman’s research into global warming and the long-term effects on the Earth’s climate.

The Language of Lakebeds

A core sample can reveal hidden information about how the Earth’s climate has changed over several millennia. Kaufman decodes this sample from Lake Allison.

DEPTH: 70–60 cm
APPROX. DATE: 1000-1200 A.D.
SEDIMENT: Organic matter and algae content reach peak values
INTERPRETATION: Warm temperatures drive an increase in biological productivity

DEPTH: 50–34 cm
APPROX. DATE: 1250 A.D.
SEDIMENT: Volcanic ash
INTERPRETATION: The thickest layer of volcanic ash of the 9,500 years falls at the site

The photograph was taken of a backup core that was not extensively analyzed (no samples removed). These ages and interpretations are approximate only, based on comparison with another core from the lake.

DEPTH: 17–0 cm
APPROX. DATE: 1660 A.D.
SEDIMENT: Clay rich in organic mud
INTERPRETATION: Meltwater from an advancing glacier spills rock flour into the lake for the first time in 9,500 years; it then retreats around 1900 A.D. (sediment not preserved)



**The Human Factor, Revisited**

Kaufman's study got a lot of media play. "Ten times as much as all 90 of my previous publications combined," he says. And though he hasn't yet had to escape through his office window like Indiana Jones, he has coped with harsh and sometimes subjective responses.

"I was amazed by the amount of feedback," Kaufman says. "Some of it was very polarized; some was a genuine attempt to understand the science."

And the naysayers? "A large number of people feel they have a mission to discredit climate science. They were all over the *Science* paper, picking apart every detail and making false accusations."

But Kaufman didn't have to mount an empirical defense. "All the criticisms

leveled against the study were minor or exaggerated. The data were available publicly along with the publication; people could analyze the data in different ways using different approaches than I chose, and yet the conclusions remain robust."

He also has received plenty of acclaim to balance the criticism, "though there's

lots of other world-class research at NAU that's equally deserving of recognition."

Has his study raised the research bar? "Because climate change research is in the international limelight, above all it's important that it's scientifically, absolutely of the highest quality."

No pressure.

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"Because climate change research is in the international limelight, above all it's important that it's scientifically, absolutely of the highest quality."



PHOTOGRAPH BY MARK PETERMAN



The Students, Revisited

January 2010,

NAU Physical Science Lecture Hall

To evoke a broader cosmic perspective, Kaufman's class watched a [YouTube video](#) on "the Earth's thin blue line," a lyrical space-eye-view appreciation of the gaseous envelope that collects and contains natural and human-made greenhouse molecules. The class participation is academic and lively, and no wonder — as sentient beings, we cannot distance ourselves from the implications of our ecosystemic impact. We're learning about the planet's behavior and the why, which is exquisitely impartial. Kaufman's class made me, a child of the 1960s, want to go back to school and even endure kamikaze mosquitoes for the sake of stewarding the Earth.

There is an essential symbiosis between Kaufman's research and teaching. "I would be at a serious disadvantage teaching my classes if I weren't active in the field," he says. "The knowledge about the Earth's climate is exploding. The research is key to both cutting-edge science and undergraduate/graduate study."



Watch the above video of Darrell Kaufman's experience in the field.

The resulting synergy creates a new generation grounded in the objective understanding of climate change cause and effect — new advocates, educated to the core. 🌱

Unedited field footage. No grant money was spent on postproduction, and no glaciers were harmed in the making of these videos.



**ON
LOCATION**

Kaufman's team taps a core tube, à la YouTube.
Watch other videos on our YouTube site.