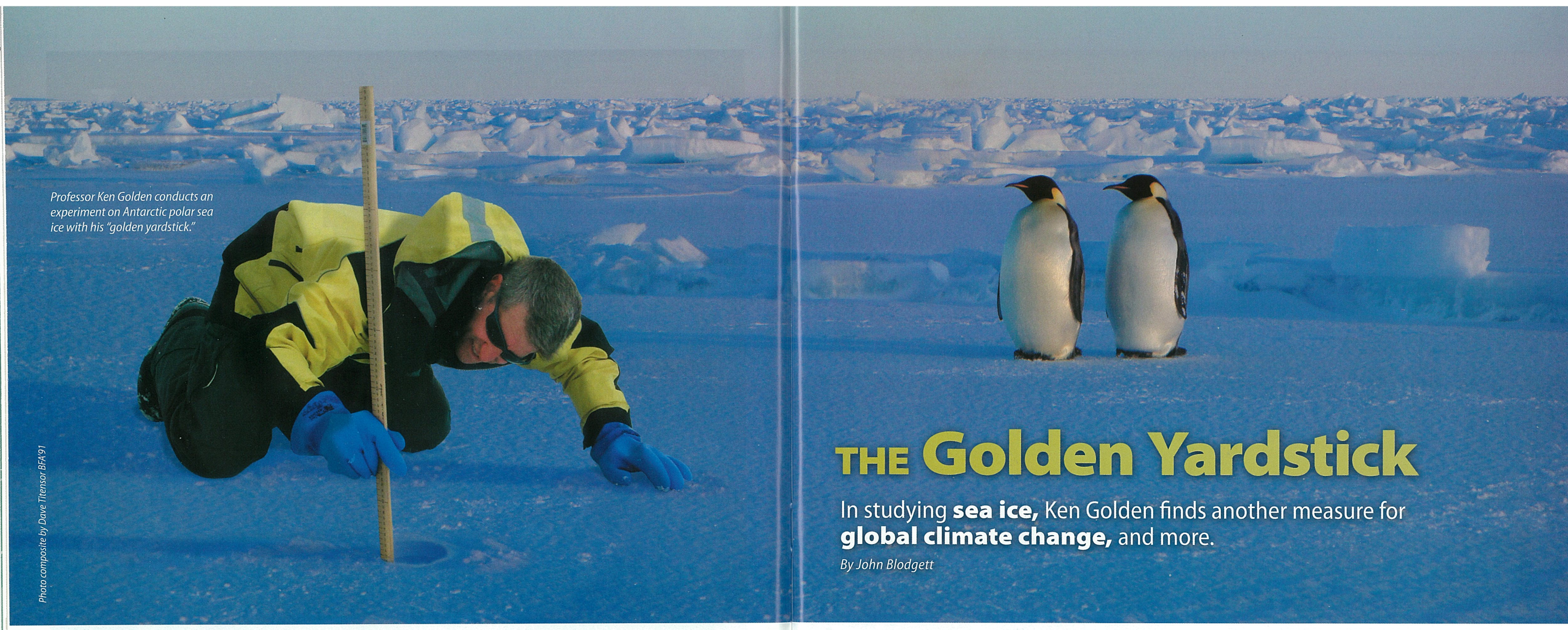


Professor Ken Golden conducts an experiment on Antarctic polar sea ice with his "golden yardstick."

Photo composite by Dave Titensor BFA'91

THE Golden Yardstick

In studying **sea ice,** Ken Golden finds another measure for **global climate change,** and more.

By John Blodgett

Professor Ken Golden conducts an experiment on Antarctic polar sea ice with his "golden yardstick."

Photo composite by Dave Titensor BFA'91

Envisioning a mathematician at the forefront of climate change research is not a stretch of the imagination. Most every presentation on global warming contains tables and charts filled with alarming numbers. What is surprising is that this particular mathematician, Ken Golden, has become a field scientist with no formal training, and his field is the polar sea ice packs.

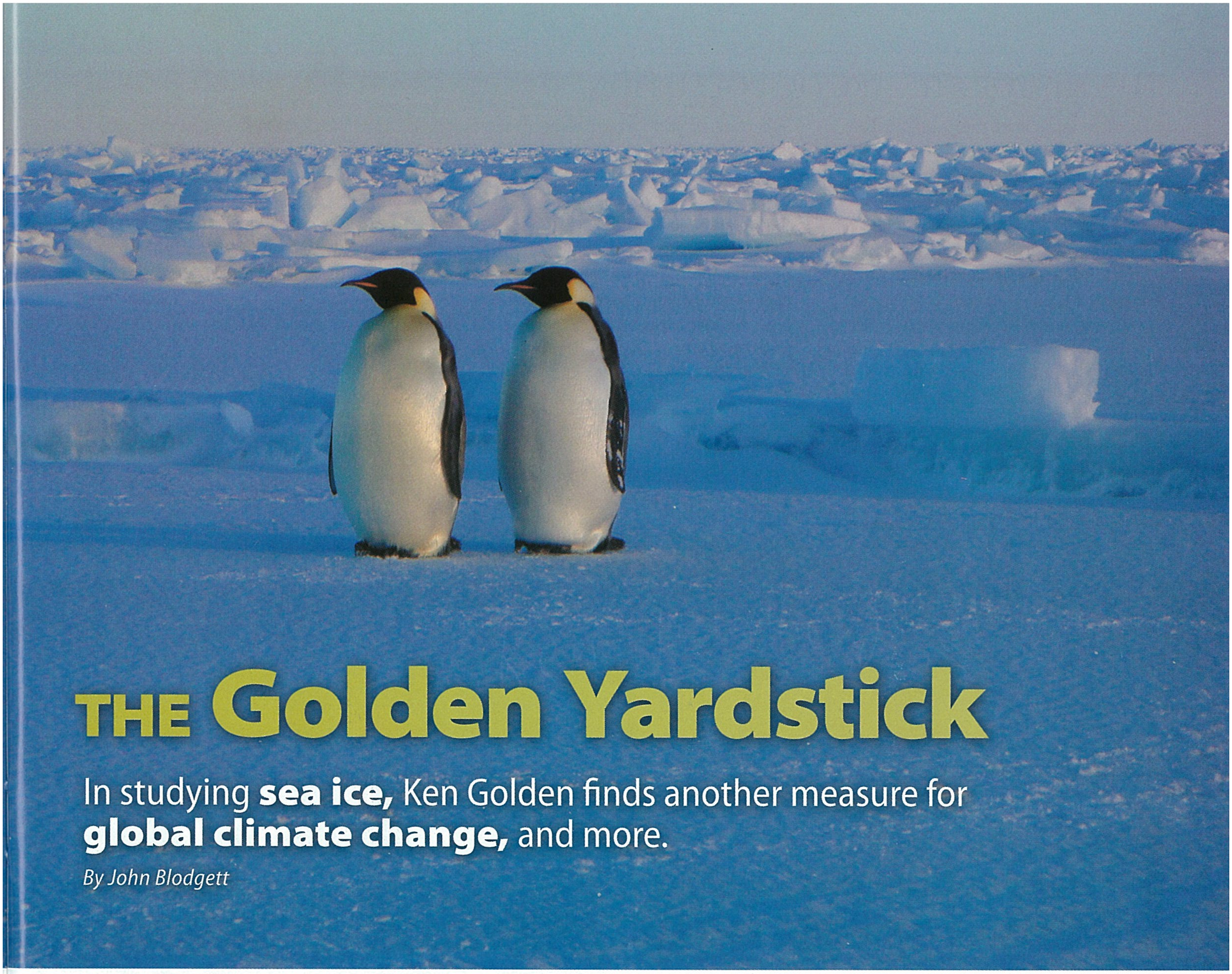
"I'm not a climate scientist," says Golden, who has taught mathematics at the U since 1991. "I'm an applied mathematician who works on effective properties of composite materials." Yet over the course of six trips to the Arctic Circle and five trips to Antarctica since 1980, Golden has formulated complex mathematical models that he is beginning to validate in the field, proving his theories amazingly prescient.

"I always knew that sea ice is an important component of the earth's climate system," says Golden. "But I did not come at this from the point of view that I want to solve global warming."

THE ROLE OF SEA ICE IN CLIMATE CHANGE

The crux of Golden's recent research is "a unified theory of the fluid permeability of sea ice and its dependence on microstructural evolution with temperature," which he developed with a handful of colleagues. *Geophysical Research Letters* published their findings in the magazine's August 2007 issue.

The albedo of polar sea ice—its ability to reflect solar radiation—is a key parameter in the regulation of global climate and a significant component of Golden's work. Put simply, bright sea ice packs protect dark polar waters from absorbing too much of the sun's rays. As these sea ice packs recede, polar oceans absorb increasing amounts of radiation. **The more the sea ice packs melt, the less likely they are to re-form, causing the polar waters to warm further in a process that might well be irreversible.** Golden's work could help determine the polar ice packs' health and predict their future. "Any reasonable global climate model has got to incorporate the earth's sea ice packs," says Golden.



THE Golden Yardstick

In studying **sea ice,** Ken Golden finds another measure for **global climate change,** and more.

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PROVING THEORY BY APPLYING HOME DEPOT SCIENCE

Accompanied by Adam Gully, one of his undergraduate research assistants, Golden journeyed to Antarctica last September to participate in the 2007 Sea Ice Physics and Ecosystem Experiment (SIPEX). The voyage, aboard the Australian icebreaker *Aurora Australis*, was Golden's fifth trip to the bottom of the world; Gully was the first student to join him. Together they would make the first direct measurements of fluid permeability and vertical electrical conductivity in the Antarctic sea ice pack, hoping to validate the mathematical models Golden had spent years perfecting.

The scientist/student pair was not alone. Teams of researchers, bundled in brightly colored jackets and snow-suits, bustled about and around the orange ship, conducting experiments and gathering data. Some got down on hands, knees, and elbows to pick at the ice and scribble notes; others crunched about the snow with electronic devices connected to laptops hanging from their necks by fabric loops. A spray of snow and ice—whipped up by the wind, a chainsaw cutting through the ice, or the helicopter flying a team out onto the ice pack—enveloped everyone. Now and then, emperor penguins stopped by, waddling upright or scooting on their bellies, surfing the snow, to take in the spectacle and pose for bemused researchers who snapped photos from a mere few feet away.

Golden and Gully extracted ice cores, from which Golden cut sections with a handsaw. He then measured the rate at which water filled the cored holes, a technique to calculate fluid permeability, by poking into each one his "million-dollar" yardstick (its ironic nickname, as it costs a fraction of the equipment many of his colleagues use). Both tools, not out of place in a garage workshop, have barcode stickers from the hardware store still firmly affixed. Golden calls it "Home Depot science," and conducts many of his experiments with items purchased at the home improvement superstore.

The pivotal moment of their SIPEX expedition likely would not have happened were it not for a basic hand drill, an almost-

THE HISTORY OF ARCTIC POLLUTION

When Tim Garrett, then a graduate student at the University of Washington, flew over the Arctic Ocean during a handful of research flights in May and June of 1998, he was astonished to see layers of pollution in the atmosphere. "We'd be flying along, and all of a sudden, all you could think of was Los Angeles," he says.

Garrett eventually learned that arctic pollution was nothing new—researchers had been studying it for decades. However, the earliest known observations were those of J. Murray Mitchell, a U.S. Air Force meteorologist, who witnessed haze at flight altitudes during missions in the 1940s and 1950s. Garrett, now an assistant professor in the Department of Meteorology at the U, thought it might be a "whimsical project" to see if earlier observations could be located.

He enlisted the assistance of Lisa Verzella BS'07 (meteorology), and after digging around the literature, some of which was translated from Norwegian and French, they discovered observations from as far back as 1883. "Some early Arctic explorers were quite puzzled by both the haze in the air and a sooty substance found in the ice in Greenland and the Arctic Ocean," says Garrett.

Most famous of these early explorers, and the first known to describe the haze, was Adolph Erik Nordenskiold, a Swedish geologist whose report appeared in the second issue of *Science* in 1883. Garrett and Verzella discovered that Nordenskiold had observed a layer of "a fine dust, gray in color, and when wet, black or dark brown" as early as 1870. Garrett suggests that the haze and dust were likely byproducts of the Industrial Revolution.

An article about their findings was published in the March 2008 issue of the *Bulletin of the American Meteorological Society*.

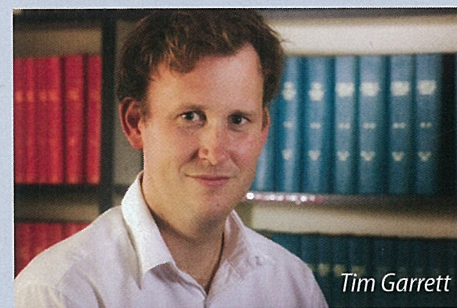


Photo by Douglas Pulsipher

Tim Garrett

"Any reasonable global climate model has got to incorporate the earth's sea ice packs," says Golden.

missing drill bit, and a circa 1960s piece of scientific equipment hastily put on board to replace a more advanced device that had been unexpectedly redirected to another expedition at the last minute.

Though a deceptively simple experiment—essentially, measuring the electrical conductivity of a core of sea ice—Golden wasn't sure they could pull it off. The old scientific apparatus, called an earth resistance tester, operated in a range that Golden feared might not provide good data. And then, although Gully did an admirable job adapting the tester on the fly, the holes Golden drilled into the ice to seat the electrodes at first were just a tad too small. He needed to drill the holes to exact specifications in order to provide the proper degree of contact between electrode and ice, but the necessary drill bit was the only one missing from Golden's set. He went back to the ship, scrounged around and finally found the right-sized bit, returned to the ice pack—and the experiment could proceed. They recorded data with crossed fingers, and then repeated the experiment as the ship moved from one ice pack to another.

Later, Golden and Gully realized with relief and excitement that they indeed had struck scientific gold. Back at the U, an undergraduate student, Christian Sampson, ran the numbers, and his calculations almost perfectly lined up with Golden's theory. It was as good as field science gets. "It was amazing to me, this ridiculous experiment that we put together on the fly with this crazy configuration and undersized holes ... and we were right on the money!" Golden recalls. The results have laid the groundwork for the next five years or so of his research.

THE VALUE OF GOLDEN'S WORK

Golden believes his work with fluid permeability links sea ice physics with the polar ecology that is highly sensitive to climate change. "What we've done is lay the groundwork for much more realistic treatment of the sea ice pack in global climate models," he says. Already, Los Alamos National Laboratory has begun to use Golden's theories in its renowned models. Others likely will follow suit, but Golden acknowledges that a few years might pass before the value of his work as an indicator and predictor of climate change is fully realized. "I know there still is some important theoretical work that needs to be done," he says.

It's tough for a scientist to predict how, when, and where his work might serve as a springboard for others' research,

but Golden has some ideas. "I'd love to see sea ice biologists and ecologists use our research to build better sea ice ecology models," he says. "Nutrient influx processes are absolutely critical to the survival and the growth or decay of [algae and bacteria] populations living in the ice"—the organisms at the very base of the dense polar food web. Oceanographers also can use his findings, he says, to study the fluid interaction between sea ice and the upper ocean. Most unexpected is the possibility that his fluid permeability models could be used to predict the presence of life in the surface ice of Europa, among the largest of Jupiter's 60 some-odd moons. Golden considers this universal, transferable aspect of mathematics one of the most rewarding parts of what he does.

WHAT NOW?

The planning for the next step and the step that follows is constant when Golden isn't tromping about an ice pack. He is applying for funding to support several upcoming Arctic and Antarctic trips, which include another voyage with the Aussies on the *Aurora Australis* and a trip to McMurdo Sound with a team from New Zealand. The latter trip will allow Golden to monitor fluid permeability in one location in real time for an extended period. In addition, he will more vigorously research the electromagnetic properties of sea ice.

A few months after returning from the SIPEX expedition, the governing board behind Math Awareness Month contacted Golden. Every year, the board chooses a topical subject—one year it was mathematics and voting, another year it was mathematics and hurricanes. In 2009, Mathematics Awareness Month will focus on mathematics and climate, and the board tapped Golden to make the national event happen. It's a surprising but rewarding assignment for a mathematician who somehow stumbled onto the ice, yet didn't slip. "It's weird where mathematics takes you," he says.

—John Blodgett is a Salt Lake City-based freelance writer.

MORE ABOUT KEN GOLDEN

As a high school student, Ken Golden wanted to be a scientist, and a passion for skiing predisposed him to the study of snow and ice. He spent the summer between his junior and senior years researching snowmelt at the University of Colorado's Institute of Arctic and Alpine Research. Two days a week during his senior year, through a program for gifted students, Golden analyzed microwave satellite imagery of Antarctic sea ice at the NASA Goddard Space Flight Center.

Golden the Dartmouth College undergraduate studied sea ice—specifically, its electromagnetic properties as a composite material of pure ice and fluid, or brine, inclusions—at the United States Army Cold Regions Research and Engineering Laboratory. He fell in love with the interplay of math and physics during his studies and graduated with a double major in the subjects in 1980.

Golden the New York University doctoral student, Rutgers University NSF Postdoctoral Fellow, and then Princeton University assistant professor in math, continued to study composite materials, but strayed from the subject of sea ice. He returned to it in 1992 when, as an associate professor at the U, he was asked to coordinate the mathematical modeling component of the five-year Office of Naval Research Accelerated Research Initiative on Sea Ice Electromagnetics.

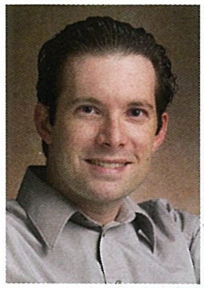
Now a professor of mathematics, Golden is also an adjunct professor of bioengineering—based solely on his experience in composites and as a self-taught field scientist, for he has no formal education in either biology or engineering.

Golden also happens to be an expert demolitionist. When helping to renovate his condominium in 2003, he joined the contractor and his team in demolishing the bathroom and, he claims, thoroughly enjoyed it. Thereafter, at Golden's request, they took him under their wing. "They now save certain jobs for me," he says.

Learn more about the 2007 Sea Ice Physics and Ecosystem Experiment (SIPEX) at *http://www.sipex.aq/*.

Thinking Big

by Jason Matthew Smith, editor



If there is a theme to this issue, it would have to be "wrestling with big ideas." Most of the stories inside touch on the concept that the people intimately connected with the University of Utah are deeply engaged in a battle to improve the human condition—in a variety of ways. Such a noble effort is at the heart of what a university is and does, and the folks featured in these pages do not shy away from tackling the most difficult problems.

For example, one morning not too long ago, *Continuum* gathered together a half-dozen health care experts to hash out some of the most daunting challenges surrounding the U.S. health care system. We asked physicians and policy makers to wrangle with the questions that plague doctors and patients every day. Realistically, no one expected the six participants to solve the health care crisis in 90 minutes—quite the opposite, for as the discussion beginning on page 24 shows, this is a monster with multiple heads, tails, and appendages. But what we hoped to accomplish was to kickstart a dialogue on the topic, and to generate a few ideas for where things ought to be headed—particularly important during this election year. What you'll probably find after reading the article is that despite the enormity of the task, fixing health care in the U.S. must occur sooner rather than later. Until then, patients and doctors are left stumbling in the dark.

Which is exactly why U of U alumna Maggi Grace found one solution to her own health care crisis when her close companion was diagnosed with a potentially fatal heart condition (page 32). She and her partner packed up and headed to India for the life-saving operation—at a fraction of what it would have cost in the U.S. Maggi relates the experience in her book, *State of the Heart*. "Medical tourism" isn't for everybody, but for those hemmed in by a dysfunctional system, it's an attractive option.

In our second feature story (page 18), writer John Blodgett presents a compelling tale about the work of Ken Golden, U of U professor of mathematics. As such, Golden had little experience with biological or environmental science. But he did have a pretty good idea about using mathematical principles to study how water flows through ice, and it turns out his brainchild has far-reaching implications for understanding the complex interactions of sea ice, water, reflected light, and—ultimately—the environmental health of polar regions (which may be the canary in the coal mine for telling us about the health of the globe). Golden—and many University researchers like him—was encouraged to venture outside of his academic comfort zone. This sort of cross-disciplinary exploration is one of the U's hallmarks. It has permitted researchers like Golden and others—such as Nobel Prize-winner Mario R. Capecchi—an invaluable opportunity to apply ideas and concepts to widely disparate fields—and often with promising results. And that's the smartest way to tackle enormously complex problems such as global climate change.

There is also a feature on the S.J. Quinney College of Law (page 12), recently ranked by *U.S. News & World Report* among the best law schools in the nation. And no discussion of the inner workings of the law school is complete without figuring Dean Hiram Chodosh as a central character. Since coming to the U a couple of years ago, Chodosh has reinvigorated the law school and clarified its purpose as an institution bent on not just educating the next generation of legal scholars, but also becoming a catalyst for positive change in the world, through a handful of innovative programs such as its efforts to train Afghan prosecutors.

Elsewhere in this issue, there are a pair of stories appropriate for the season: a look at the time-honored tradition of tailgating (page 10), and an article penned by alum Carl R. Summers on evaluating political party performance (page 36). Rounding out this issue is, appropriately, an essay from health care policy expert Robert Huefner discussing how Utah could serve as a model for finding solutions to the national crisis.

Enjoy. U

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