
“Borders? I have never seen one, but I heard they exist in the minds of most people.”
— Thor Heyerdahl (1914–2002) Distinguished Research Associate of the Climate Change Institute

The CLIMATE CHANGE INSTITUTE fosters learning and discovery through excellence in graduate academic programs, addresses local and global needs through basic and applied research, and contributes research-based knowledge to make a difference in people’s lives. It is dedicated to improving the quality of life for people in Maine and around the world, and promoting responsible stewardship of human, natural and financial resources, now and in the future.
From the Director

CLIMATE CHANGE INSTITUTE SCIENTISTS conduct climate change research around the globe — from the deserts and highlands of Peru throughout the Andes, throughout the glaciers of the Arctic onto the summit of Greenland, throughout the Himalayas and the Tibetan Plateau, across the vast Antarctic continent, to the rocky shores of Maine.

CCI’s work has led to important discoveries with far-reaching implications, such as the phenomena of **abrupt climate change** that revolutionized the field of climate science in the early 1990s; the contribution of **marine-based ice sheets** to past and future sea-level rise; documented **retreat of glaciers** in Antarctica, Greenland, South America, Asia and New Zealand over the last few decades with implications for sea-level rise, water resources and ocean circulation; a **framework for assessing climate change**; demonstration of the **unprecedented rise in human source pollutants** over the last century; and the impact of **climate change on humans and ecosystems**.

CCI researchers have extensive field experience and expertise to tackle critical, complex issues related to climate change and human adaptations to changing climates. These issues are extremely challenging, but they are particularly well suited to the character of the Climate Change Institute. Physical, chemical and biological climate change issues are deeply embedded in the fabric of local to global-scale concerns about economy, health and overall quality of life. Change in the physical and chemical characteristics of the climate system is compelling, and understanding the state of current and future levels of human source pollutants, including greenhouse gases, acids, toxic metals and radioactivity, will define our reality and opportunities in the future.

OUR MISSION continues to evolve as CCI researchers probe further into the complexities and implications of Earth’s changing climate, and as we strive to provide unique scientific products:

- **Long-term Perspective** in the form of records of past climate (ice cores, lake sediment cores, glacial deposits, human adaptation) from around the world.
- **Climate Prediction and Planning** from local to global, long-term to abrupt scales through highly detailed and innovative analysis of climate records within climate modeling perspectives. Positive Policy Implications, such as environmental and renewable founded on sound science.
- **Technological Advances** in environmental monitoring, processing and analyses of archives containing physical and chemical climate information, and cyberinfrastructure needed to interpret climate data.
“In a matter of decades we will likely see changes in Antarctica thought in the past as taking hundreds of thousands of years.”

— Paul Andrew Mayewski, Director, Climate Change Institute

Paul Andrew Mayewski has led nearly 50 expeditions to Antarctica, the Arctic, Tibet, the Himalayas, Greenland and Tierra del Fuego. He has pioneered the use of ice core records to reconstruct past atmospheric conditions, documented changes in atmospheric chemistry produced naturally and by humans, and correlated associations between climate change and disruptions to civilization.

It’s the current implications of human-induced climate change, particularly in the last 20 years, that have high-profile scientists like Mayewski stepping up research and speaking out. “Since the 1980s, the warming rate has been large enough to potentially push us into the realm of abrupt climate change,” says Mayewski, director of the Climate Change Institute. “Until recent decades, climate change occurred by natural processes. Today, we’re overpowering the natural system with greenhouse gas increases at a rate 100 times faster than nature. With other stresses — from sulfate aerosols and toxic substances in the atmosphere to freshwater injection into the oceans — the climate system cannot be expected to respond in a linear fashion.”

Cold Time Capsules

Ice cores retrieved from polar regions are like buried meteorological stations, revealing evidence of past temperature, precipitation, atmospheric and ocean circulation, sea ice extent, biological productivity and volcanic activity as far back as hundreds of thousands of years. Upwards of 100 properties can be measured in a small sample taken from an ice core. At the Climate Change Institute, ice cores are one of the many tools researchers use to add to our understanding of climate. CCI scientists have retrieved ice cores from every continent and every major mountain range.
Every summer for the past decade, paleoecologist Jasmine Saros has trekked across snowfields and horsebacked up bouldered mountain passes to reach remote, high-altitude lakes. She arrives in the pristine wilderness just after ice off to study changes in the algal community, looking for evidence of climate change and airborne pollution.

IN LAKE SEDIMENTS, the remains of the silica cell walls of ancient diatoms testify to their centuries of existence. By combining paleolimnology with ecological field observations and bioassays of diatoms now living in the water column, CCI paleoecologist Jasmine Saros uses the fossil records to reconstruct environmental change and to better understand the mechanisms — from rising water temperatures to decreasing numbers of zooplankton grazers — driving past and present change.

Sediment cores reveal that over the past 6,000 years, the abundance of various Cyclotella, one of the most common diatom groups, has fluctuated in lakes in the central and northern Rockies. However, in the 20th century, the diatoms’ numbers have increased not only in the Rockies, but also worldwide in alpine and temperate lakes, as well as in the Arctic.

“What’s most disturbing is that this is a wilderness area, yet it’s undergone such rapid change because of human activity.”

— Jasmine Saros, CCI Associate Professor of Paleoecology

IN ALPINE LAKES in the Pacific Northwest and the Rockies, in salt lakes in the northern Great Plains and in the “Great Ponds” of Maine, Jasmine Saros and her graduate student researchers are working to interpret the data preserved in fossil records by gaining a better understanding of the relationships between environmental variables, and the growth and distribution of diatoms. Two of the critical variables are nitrogen and phosphorus — essential nutrients for algae in the right quantities; in excess, the cause of poor water quality.
Polar and alpine regions are responding dramatically to increasing atmospheric temperatures. Ultimately, these changes will affect all of us.”

— Karl Kreutz, CCI Associate Professor of Glaciology and Geochemistry

EVERY SPRING, mountain climbers from across the globe gather at a base camp on the Kahiltna Glacier, preparing to scale North America’s highest peak. In 2008, while more than 1,000 alpine adventurers had their sights set on 5,800-meter Mt. McKinley, seven scientists from the University of Maine, University of New Hampshire and Dartmouth College searched for the best location to drill and extract an ice core from Kahiltna and nearby Upper Yetna Glacier.

“Ice cores recovered from the Denali region will provide several centuries of atmospheric and glaciological history, giving us a context for understanding recent changes,” says Karl Kreutz, CCI associate professor.

Kreutz studies the atmospheric and hydrologic dynamics of high-latitude and high-elevation regions on seasonal to millennial timescales. His current projects include high-resolution climate reconstructions in the Arctic, Antarctic and Asia.

The Denali cores retrieved in May 2008 were 20 meters long. UMaine maintains two ice core freezers containing more than 1,500 meters of ice drilled from around the world.
“Our results showed that things are happening in Greenland a lot faster than anyone thought. Now the rush is on to find out why it’s happening and if it’s going to continue.”

— Gordon Hamilton, CCI Associate Research Professor of Glaciology

CCI RESEARCHERS Leigh Stearns and Gordon Hamilton explore the jagged spires of ice and yawning crevasses of Greenland, tracking glacier speed and movement in an effort to understand how ice sheets contribute to sea level.

They conduct their research using high-resolution data from GPS receivers installed on glaciers and from the latest in satellite imagery provided by NASA.

Stearns and Hamilton, along with Ph.D. candidate Bill Sneed, have opened a new chapter in glacier research using ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) — state-of-the-art sensor technology found on NASA’s Terra satellite.

From 440 miles above, ASTER captures unique, stereoscopic images of Earth’s glaciers, supplying the researchers with an unprecedented tool for measuring the size and tracking the movements of the planet’s frozen water reserves. To date, some of the most significant discoveries have come from satellite images of Greenland.

By analyzing hundreds of ASTER images and comparing a complex array of data points, Leigh Stearns showed that three of Greenland’s largest glaciers had accelerated as much as 200 percent between 2003 and 2005, racing to the ocean at an incredible 14 kilometers annually — three times faster than what had been previously considered fast for a glacier. Dumping hundreds of cubic kilometers of meltwater into the Atlantic, the accelerating glaciers could cause a significant rise in sea level and dramatic changes to ocean currents and salinity.
The importance of Brenda Hall’s research is evident in her selection as a distinguished young scientist by the National Academy of Sciences.

The im portance of Brenda Hall’s research is evident in her selection as a distinguished young scientist by the National Academy of Sciences.  

“This is important to understanding past climate, because there must have been a change in climate for the seals to have lived there.”  
— Brenda Hall, CCI Associate Professor of Glacial Geology

SOUTHERN ELEPHANT SEALS that grow up to 20 feet long and weigh as much as 3 tons weren’t really what CCI and Department of Earth Sciences associate professor Brenda Hall expected to find in Antarctica.

In 1994, Hall and her scientific team were comparing ancient beaches created by the slow retreat of glaciers throughout thousands of years in Antarctica. In particular, they were compiling information about sea level and glacier movement along the Ross Sea.

But in addition to glacial data, they found remains of elephant seals as much as 7,000 years old — evidence of less sea ice in the region, which they believe occurred between 2,300 and 1,100 years ago. A change in climate had to have occurred for the seals to have lived that far south, says Hall.

Today, sea-ice conditions in the Ross Sea relegate the southern elephant seals to subantarctic locales farther north.

Hall’s findings shed new light on the past conditions of the huge southern Antarctic ice shelves, according to CCI Libra Professor George Denton, an internationally recognized authority in Antarctic research.

Elephants in Antarctica

WHILE IT MAY seem a bit unusual for a geologist to be using seals to tell a story about climate change, stranger still is the fact that penguins seem to be backing it up. Brenda Hall is working closely with Carlo Baroni, a researcher from the University of Pisa in Italy and an expert on the status of past and present populations of Adelie penguins. Together, they are working to determine how data on ancient populations of southern elephant seals and penguins in the Ross Sea can be combined to create a more accurate picture of climate conditions in the region.
We can’t only think about life within our political borders. We need to start thinking about humanity as highly interconnected, both spatially and historically. Climate change doesn’t know these boundaries.”
— Gregory Zaro, CCI Assistant Professor of Anthropology

BETWEEN THE TAMBO and Ilo rivers in southern Peru, the soil is a crumbly, faded brown. Tree stumps jut from the hillsides like half-exhumed skeletons. But it hasn’t always been this way. The remains of stone-faced terraces and ditchlike irrigation canals are evidence of the area’s agricultural past. Today, however, a few lonely farms remain. Desertification as a process often includes both human and nonhuman drivers,” says Gregory Zaro, an assistant professor of anthropology and climate change. “What I can do is use desertification as a measuring stick to gauge how the landscape has changed and what role we have in that change.” Looking at climate change from an archaeological perspective allows Zaro to better understand the way human activities have shaped the environment — and, equally important, how they have not. What’s important to understand, he says, is that the local and regional impact humans have on landscapes ultimately affects climate.

Peru’s southern coast features steep, barren terrain, often shrouded in dense fog. Up until 600 years ago, the coastal hills and nearby canyon, Quebrada Chololo, were agricultural sites. It would be easy to blame local smelter plants for the subsequent desertification, says CCI anthropologist Gregory Zaro. But the reality is that such a process usually has human and non-human causes.

IN GREGORY ZARO’S research, anthropology, geology, soil chemistry, paleoethnobotany and zooarchaeology combine to provide a historical view of land use on the southern coast of Peru. “We’re beginning to understand how humans have had an impact on the environment deep into the past,” he says. “The research really questions what benchmarks we set for ‘natural’ environments. What we’re inheriting today are environments people have manipulated for thousands of years.”

Agents of Change

UN DERS TAN D ING inquiry

UNDERSTANDING
“The Climate Change Institute offers students the opportunity to conduct fieldwork in some of the most remote regions on Earth and access to state-of-the-art laboratory facilities, promoting cutting-edge research.”

— Bjorn Grigholm, CCI Graduate Student

AN UNDERSTANDING of climate change and its implications are absolutely critical to the future of society, ecosystems, the economy and governance. Consequently, the Climate Change Institute will continue to pursue an ever-broadening agenda for interaction with other disciplines, University of Maine research and academic units, and national and international partners.

It also will be faced with rapidly emerging opportunities for the application of its findings to critical issues, including: climate change-induced hazards (e.g., flood, coastal erosion, drought, heat); adverse health (e.g., heat, moisture, disease, dust, species in jeopardy); poverty (local to global); sustainability challenges (e.g., energy, urbanization, agriculture); and individual, private and governmental decision making.

To meet these challenges and opportunities, the Climate Change Institute has successfully competed for federal funds. It also requires resource flexibility not typically available through federal agency programs. The combination allows the Institute to continue to grow.

Unique Perspective

CCI has an internationally renowned reputation because it offers a unique perspective that contributes substantially to the understanding of past, present, and future physical and chemical climate change and associated climate/society/ecosystem interactions.
A $1.6 MILLION GRANT from the W. M. Keck Foundation to the Climate Change Institute, in concert with scientists in UMaine’s Laboratory for Surface Science and Technology, will develop new ice core measuring capabilities, including chemical sensors embedded in ice core drills. Based in Los Angeles, the W.M. Keck Foundation was established in 1954 by the late William Keck, founder of Superior Oil Co. The foundation’s grantmaking is focused primarily on pioneering efforts in the areas of medical research, science and engineering.

DOWN EAST MAINE’S ice Age trail is now mapped in detail in a travelers’ guide, newly published by the University of Maine. The trail stretches from Mount Desert Island north along the state’s rugged coast, where, 16,000 years ago, the last great North American continental ice sheet sculpted the mountains of Acadia National Park and left the spectacular sand barrens where Maine’s wild blueberry crop grows. Maine’s Ice Age Trail: Down East provides directions and information about more than 46 geological features visible or accessible along roads and highways in the state. Development of the map and guide, spearheaded by CCI glacial geologist and Institute founder Harold Borns and cartographer Michael Hermann, was funded by a grant from the National Science Foundation.

THE CLIMATE CHANGE INSTITUTE is the founder and leader of the 21-nation International Trans Antarctic Scientific Expedition (ITASE)—a multidisciplinary project that has traversed many thousands of kilometers over Antarctica collecting records of past climate change covering the last 200–1000 years in an effort to understand the role of Antarctica in global climate change.

AN ANALYSIS of the state’s future in the context of changing climate in the 21st century is the focus of a recently released, 70-page report, Maine’s Climate Future: An Initial Assessment. Requested by Gov. John Baldacci in 2007, the analysis was led by the Climate Change Institute, with support from Maine Sea Grant and several UMaine research departments. It considers past climate change, recent evidence of accelerated rates of change, and the implications of continued change in Maine as a result of greenhouse gas emissions and associated pollutants. The report stresses the need for Maine to have a plan for adaptation, it also highlights opportunities for the state to benefit from a changing climate, and identifies gaps in the information needed for a positive transition.
PAN EL D ISCU SSIO NS led by world-class scientists talking about their climate change research highlighted a two-day conference in October 2008 at the University of Maine, organized by the Climate Change Institute.

AN ICE CORE from Mt. Everest shows evidence that the South Asian monsoon, the largest seasonal reversal of wind patterns and precipitation on Earth, has weakened in the past 1,300 years in the northern high-elevation regions of monsoon influence, according to researchers at CCI and the Joint Key Laboratory of Cryosphere and Environment in China.

BU RIED AND ENGRAVED along Maine’s coast are valuable pieces of the region’s past. CCI Researchers are collaborating with members of the Passamaquoddy Tribe in an effort to learn, preserve and share as much as they can. CCI anthropologist Brian Robinson leads a summer field school to provide students with hands-on experience excavating endangered shell midden sites while working with the modern Native communities.

SCIEN TIFIC  C O N TR IB U TIO NS to the understanding of climate science

• Natural climate variability
• Major transitions in climate
• Recent change in Antarctica and Greenland
• Abrupt climate change and the collapse of past civilizations
• Implications of abrupt climate change to climate prediction

• Modern glacier retreat
• Abrupt climate change
• Volcanic forcing of climate
• Solar forcing of climate
• Role of marine ice sheets and ice streams in rapid deglaciation and sea-level rise

• Abrupt clim ate change and the collapse of past civilizations
• A framework for assessing the role of human activity in climate change
• Role of marine ice sheets and ice streams in rapid deglaciation and sea-level rise

In complying with the letter and spirit of applicable laws and in pursuing its own goals of diversity, the University of Maine System shall not discriminate on the grounds of race, color, religion, sex, sexual orientation, national origin or citizenship status, age, disability, or veteran status in employment, education, and all other areas of the university. The university provides reasonable accommodations to qualified individuals with disabilities upon request. Queries and complaints about discrimination in any area of the university should be directed to the Office of Equal Opportunity, University of Maine, Room 101, 5754 North Owens Hall, Orono, ME 04469-5754, telephone (207) 581-1226 (voice and TDD).

A member of the University of Maine System.
If you are interested in contributing to our activities, please visit us at:

climatechange.umaine.edu
Tel: (207) 581-2190