CIRES

2012 Annual Report

Executive Summary

COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES

University of Colorado Boulder UCB 216
Boulder, CO 80309-0216

Phone: 303-492-1143
Fax: 303-492-1149
email: info@cires.colorado.edu
http://cires.colorado.edu

CIRES Interim Director
William M. Lewis, Jr.

Annual Report Staff
CIRES Associate Director for Science
Kristen Averyt

Kristin Bjornsen, Editor

Robin L. Strelow, Design

Agreement No. NA10OAR4320142

To access our ePub version of the Executive Summary, please visit http://cires.colorado.edu/about/ePubs/

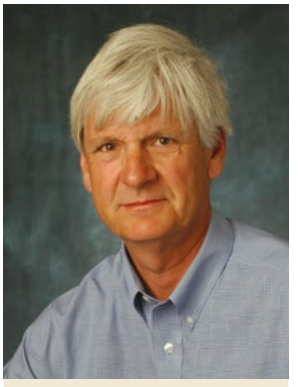
Cover image: Ice crystals forming on a window during a cold January morning
Photo by Christopher McNeave, Associate Scientist III, CIRES/NSIDC

Table of Contents

Freeze, Flow, Vaporize related

From the Director

Over the last eight years, under the leadership of Director Konrad Steffen, CIRES has enjoyed steadily increasing research support matched by rising productivity and growth in scientific staff. In July 2012, Director Steffen left CIRES to meet a strong challenge from the Swiss University ETH, which incorporates a number of large research units comparable to CIRES. Dr. Steffen, who is Swiss, will lead the ETH Institute for Forest, Snow and Landscape Research. CIRES feels a great loss but will have continuing research ties with Dr. Steffen.



Dr. William M. Lewis, Jr.

CIRES now enters a new era in which the Fellows choose a new Director to be reviewed for approval by the University of Colorado. The new Director's appointment will be a natural time for CIRES to consider current issues, including an increasingly difficult funding environment for science. A happy coincidence is that CIRES received in August 2012 from the NOAA Cooperative Institute Program approval for a new cooperative agreement with a five-year term and a scope of work matching that of CIRES in recent years. Under this stimulus, the collaboration between CIRES and NOAA scientists in Boulder will continue to thrive.

Achievements of CIRES scientists for FY2012 (July 2011–June 2012) extended over the broad CIRES environmental research agenda, which includes physical, chemical, and biological aspects of environment as well as the human dimension of environmental analysis. Studies of atmospheric chemistry, a special strength of CIRES and its NOAA partner, produced advances in understanding of atmospheric soot, fossil fuel combustion, and bacteria suspended in the air. CIRES and NOAA collaborators continued their intensive collaboration on the study of the effects of the 2010 Gulf of Mexico Deepwater Horizon oil spill on air quality. While the immediate concern of the spill was environmental damage to the aquatic environment, these scientists showed that the strategy of burning oil to remove it from the water surface produced more than 1 million pounds of black carbon in the form of soot. Data produced by these scientists will guide oil spill management in the future as air pollution joins other concerns that determine the response to spills.

CIRES scientists participated in a landmark study of fossil fuel combustion showing, contrary to expectation, that gasoline is less desirable than diesel fuel as a producer of some types of air pollution that are of environmental concern. In addition, CIRES scientists documented the presence of surprisingly high abundances of bacteria derived from dog feces in the urban atmosphere, suggesting the existence of unresolved air pollution problems associated with pets.

Global climate with a focus on ice sheets continued to be a major interest of several working groups within CIRES. CIRES scientists contributed to the conclusion that Arctic sea ice reached its lowest minimum recorded extent in 2012. Long-term detailed studies of the Greenland ice sheet by CIRES scientists showed that movement of the ice sheet toward the Greenland coast may accelerate when increased meltwater reaches the bottom of the ice sheet; water lubricates the movement of ice over rock.

The National Snow and Ice Data Center (NSIDC), which holds a global archive of information on ice and climate related to cold regions, was honored during the past year with Presidential and State awards for its successful commitment to drastic diminution of energy use in support of the massive, power-hungry computing equipment that is necessary for maintenance of global records on ice and climate. A renovation plan that was surprisingly simple in design reduced power use for the NSIDC data center by more than 90 percent.

CIRES scientists presented evidence at the national and state level in a controversy over nutrient (phosphorus, nitrogen) regulation to protect quality of inland waters nationwide. Some scientists have concluded that regulation of nitrogen is not necessary if phosphorus is regulated. Others see evidence, particularly of recent derivation, that nitrogen regulation is critical as well. Individual states have taken varied positions on this regulatory issue. Colorado during 2012, partly in response to evidence presented by CIRES scientists, ruled through its Water Quality Control Commission to proceed with dual regulatory control of nitrogen and phosphorus pollution of waters.

The active Solid Earth Sciences Division of CIRES in 2012 released information on measurements of Earth's crustal movement along the Rio Grande Rift, which extends from Colorado's Rocky Mountains to Mexico. A specialized GPS system that measures crustal movements as small as 1 millimeter over a distance of 1,000 kilometers showed widespread crustal movement around the rift but no indication of strong localized movement, as might be associated with large earthquakes. Small earthquakes will happen, but disasters are unlikely.

CIRES sees well-supported opportunities to advance environmental science in the coming year.

William M. Lewis, Jr.

William M. Lewis, Jr.,
Interim Director of CIRES

Photo by Christopher McNeave

Freeze...Flow...Vaporize... And Repeat.

From solid to liquid to gas, water is the only natural substance that exists in all three physical states at temperatures normally found on Earth. Its deceptively humble structure—one oxygen and two hydrogen atoms—endows it with unique properties: It expands when frozen, so ice floats instead of sinks; it absorbs large amounts of heat before getting hot, buffering temperatures; its surface tension allows water to move through plant roots and blood through capillaries; and as the "universal solvent," water dissolves more substances than any other liquid. Cycling continuously among its many forms—snow, ice, freshwater, saline, vapor—water sculpts the landscape, moderates the climate, and makes life on Earth possible, while also driving our curiosity about life on planets beyond our own.

Although water covers most of Earth, less than 3 percent is freshwater. Worldwide, changes are occurring that strain the supply and demand structure of this vital resource. The global population now exceeds 7 billion people, 1.1 billion of which lack access to safe drinking water. As our numbers increase, we will need more water for drinking, as well as to grow food and provide sanitation. At the same time, warming temperatures are altering the hydrologic cycle and changing the amount, timing, and quality of freshwater resources.

Understanding freshwater resources is an interdisciplinary problem requiring an interdisciplinary approach. Observing and understanding the processes affecting freshwater systems in the past and in the present; identifying and projecting future stressors; and evaluating the capacity of human and ecological systems to adapt, are all necessary to meet the challenge of sustaining freshwater resources.

CIRES has emerged as an international leader in water research. The FY2012 CIRES Annual Report highlights cutting-edge research by CIRES scientists that focuses on the 21st-century challenge of water.

As has been the practice at CIRES, each Annual Report highlights how CIRES brings interdisciplinary expertise to bear on a specific environmental issue. This Annual Report showcases CIRES research related to sustainability of freshwater resources. Throughout the document, high-impact research is specifically called out. The work and accomplishments profiled are not comprehensive in terms of all the water-related work at the Institute, just the tip of the iceberg, so to speak, but they exemplify the breadth of expertise within CIRES. Watch for the above water-molecule icon, indicating a Water Box, throughout the report.

CIRES: World-Class World Science

Since its inception in 1967, the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado Boulder has emerged as an international leader in research that addresses the pressing challenges facing our planet. The scope of scientific accomplishments over fiscal year 2012 (FY2012, July 1, 2011, through June 30, 2012) illustrates the continuation of this tradition, and how CIRES continues to help NOAA support and meet its strategic goals. In support of the NOAA paradigm of Science in Service to Society, CIRES continues to coordinate and communicate relevant research to decision makers and the public.

Vision and Mission

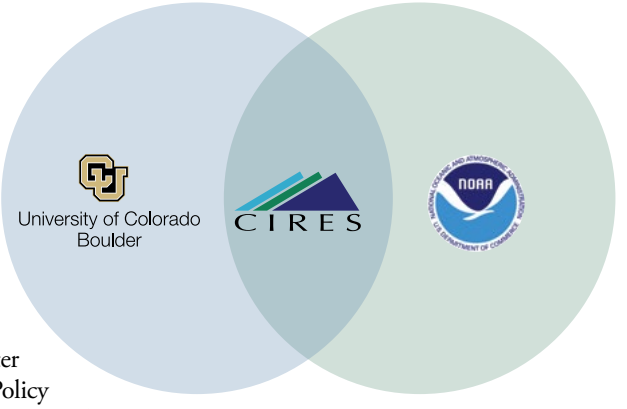
As a world leader in environmental sciences, CIRES is committed to identifying and pursuing innovative research in Earth system science and fostering public awareness of these processes to ensure a sustainable future environment. CIRES is dedicated to fundamental and interdisciplinary research targeted at all aspects of Earth system science, and to communicating these findings to the global scientific community, to decision makers, and to the public.

Photo by CIRES

A Guide to the CIRES Annual Report FY2012 Executive Summary

The scope of research and accomplishments outlined in the CIRES FY12 Annual Report transcends many departments at the University of Colorado, divisions within the NOAA Earth System Research Laboratory, and traditional academic sectors. The Annual Report is an accounting of the collaborative research goals, including those described in the CIRES-NOAA workplan, year two. This Executive Summary outlines details about the CIRES organization in the context of FY2012 research highlights and accomplishments.

This Is CIRES



The Cooperative Institute for Research in Environmental Sciences (CIRES) was established in 1967 to facilitate collaboration between the University of Colorado Boulder and the National Oceanic and Atmospheric Administration (NOAA). CIRES's original and continuing purpose is to support NOAA goals by facilitating interdisciplinary studies that crosscut traditional scientific fields and transcend the many facets of environmental research. CIRES fosters interdisciplinary science through five centers—the National Snow and Ice Data Center, the Center for Limnology, the Center for Science and Technology Policy Research, the Climate Diagnostics Center, and the Earth Science and Observation Center. Such interdisciplinary combinations provide unique opportunities for discovery and for application of knowledge to meet societal needs. The work of the CIRES enterprise strengthens the scientific foundation upon which NOAA's many services depend, and allows coordinated studies on a scale that could not be addressed by university research units or by NOAA alone.

University of Colorado Boulder

Aerospace Engineering Sciences

Atmospheric and Oceanic Sciences

Chemistry and Biochemistry

Civil, Environmental, and Architectural Engineering

Ecology and Evolutionary Biology

Electrical and Computer Engineering

Geography

Geological Sciences

Molecular, Cellular, and Developmental Biology

Physics

Environmental Studies

CIRES Divisions

Cryospheric and Polar Processes

Ecosystem Science

Environmental Chemistry

Environmental Observations, Modeling, and Forecasting

Solid Earth Sciences

Weather and Climate Dynamics

Interdisciplinary Research Centers

Climate Diagnostics Center

Center for Limnology

Center for Science and Technology Policy Research

National Snow and Ice Data Center

Earth Science and Observation Center

Programs

Education & Outreach

Western Water Assessment

NOAA at Boulder Earth System Research Laboratory (ESRL)

Chemical Sciences Division

Global Monitoring Division

Global Systems Division

Physical Sciences Division

NOAA Centers

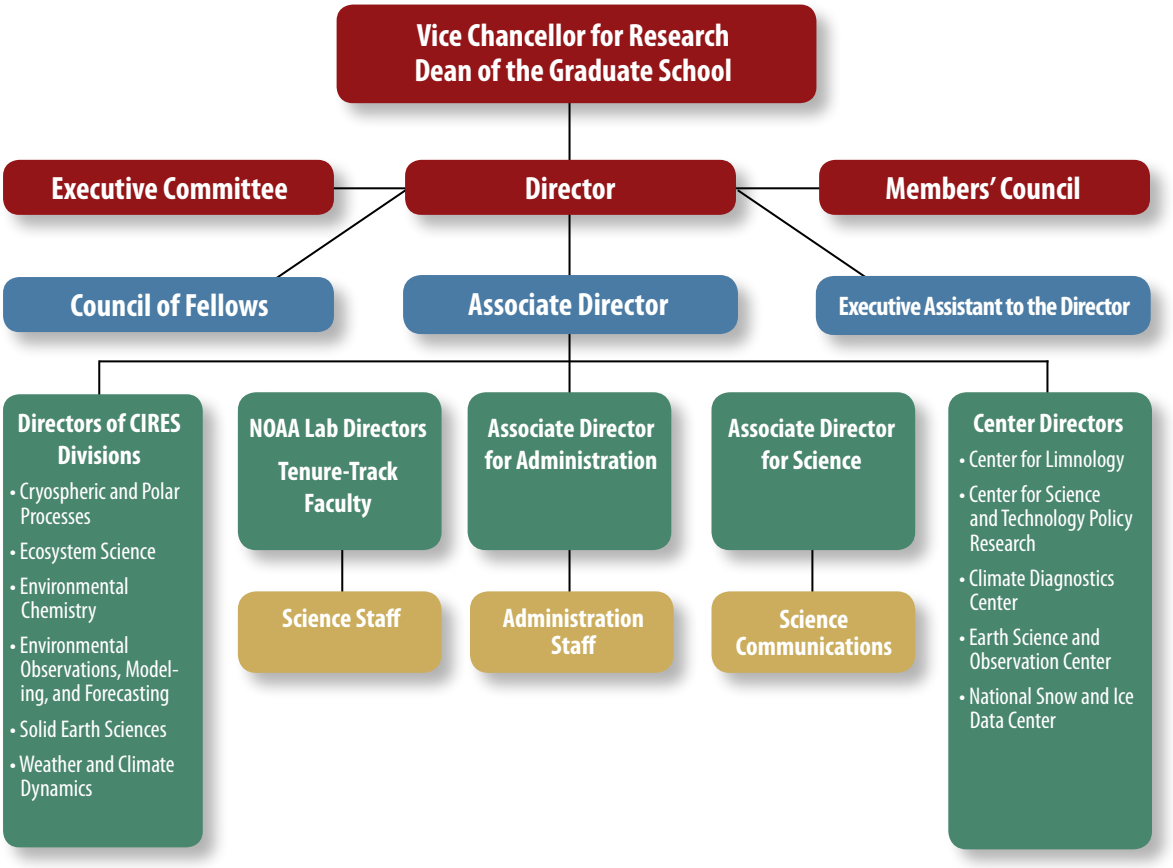
National Geophysical Data Center

Space Weather Prediction Center

Governance, Management, and Organization

The governance and management of CIRES is provided through its Council of Fellows, an advisory Executive Committee, and the CIRES Members' Council. The CIRES Centers (Climate Diagnostics Center, Center for Limnology, Center for Science and Technology Policy Research, National Snow and Ice Data Center, and Earth Science and Observation Center) link NOAA to 11 different university departments. Coordination among all these entities is facilitated through the Communications group.

CIRES Organizational Structure



Council of Fellows

The Council of Fellows constitutes the "Board of Directors" and chief governing body of CIRES. It is comprised of individuals with an outstanding record of achievement and ability in diverse areas of environmental sciences. They are university faculty, senior research scientists, or government scientists who form the core leadership of the Institute. Their responsibilities are to 1) provide leadership at all levels in environmental science, 2) maintain an active scientific research and education program, 3) support the CIRES infrastructure through indirect cost recovery and in-kind contributions, 4) participate in CIRES management, and 5) contribute interdisciplinary expertise and participate in collaborative work. As a group, they personify the spirit of collaboration that is the founding principle of the NOAA Cooperative Institutes Program. Ex-officio individuals include representatives of the Members' Council and CIRES administration. Fellows meetings are held monthly during the academic year. The Council of Fellows met seven times during FY12: Sept. 15, Oct. 20, and Dec. 15 of 2011; and Jan. 19, Feb. 9, March 22, and April 26 of 2012.

Executive Committee

The Executive Committee assists and advises the Director in matters regarding day-to-day management of the Institute. Members of the Executive Committee include the Associate Directors of CIRES's six divisions, two Fellows elected at-large for two-year terms (renewable for one term), and two Members' Council members. The Associate Director for Administration, Associate Director for Science, and the Director's Executive Assistant are ex-officio members.

The CIRES Team

	FY2011	FY2012
Faculty Lines	22	20
CIRES Fellows	47	47
Research Scientists	193	187
Associate Scientists	228	237
Visiting Scientists	29	32
Postdoctoral Researchers	28	26
Administrative Staff	32	38
Graduate Students	96	101
Undergraduate Students	86	76

Career Track Committee

This committee is charged with consideration of all nominations for promotion within the CIRES career tracks of Research Scientist, Associate Scientist, and Administrative Associate. Nominations are made once yearly, and the committee's recommendations are forwarded to the Director for consideration and action.

Fellows Appointment Committee

Fellows of CIRES are selected by two-thirds vote of the Council of Fellows and are appointed or reappointed by the Director of CIRES with the concurrence of the Vice Chancellor for Research and the Dean of the Graduate School. New Fellow nominations are considered by the Council of Fellows once yearly, drawing from the community of scientists at the University of Colorado Boulder and NOAA. Theme leaders present cases for appointment of new Fellows to the Council of Fellows. The initial appointment of any new CIRES Fellow is for two years, and continuing-term reappointments are for five years. Qualifications for reappointment are the same as for the initial appointment, except that the established record of the appointee must show evidence of commitment to the affairs of CIRES.

Diversity Committee

Recent studies highlight that fewer underrepresented minorities are pursuing careers in science, especially in higher education. To increase diversity is a major challenge scientists and educators face, and CIRES has made it a priority to extend its knowledge and community to include more diverse ethnic groups and improve gender balance. Toward that end, the Diversity Committee was created in 2010 and is working to achieve this goal. The Committee works with CIRES Education and Outreach, the Communications group, and scientists and staff to identify opportunities for CIRES to make a difference in this vital work to enrich our science and enhance our mission.

Members' Council

The CIRES Members' Council was created in 1997 to act as an information and policy conduit between CIRES leadership and Institute members. To provide uniform representation, the CIRES membership is divided geographically into eight groups that comprise various divisions and centers across the Institute, with representation reflecting the size of each group. From the council, two delegates to the CIRES Council of Fellows and Executive Committee are elected to serve as the liaison between these governing bodies and the Members' Council. The Members' Council, which meets monthly, then serves as a direct line of communication to the Member population at large. At these meetings, the council hears members' inquiries and concerns, discusses and develops potential solutions to any outstanding issues, and works directly with CIRES leadership to implement these solutions. Additionally, the Members' Council performs regular service to the Institute by, for example, sponsoring the annual Rendezvous Symposium, the Awards Committee for CIRES Outstanding Performance Awards, and the CIRES Bike Share Program.

Special Committees

Additional special committees are appointed as needed by the Director. These include Faculty Search committees, the University Academic Review and Planning Advisory Committee, Award Committee, Faculty Promotion committees, and others. They are created as the need arises, exist to accomplish a specific task, and are then disbanded.

Other CIRES Committees:

Visiting Fellows Committee
Distinguished Lecture Committee
Graduate Student Research Fellowship Committee
Innovative Research Program Committee

Council of Fellows (July 1, 2011–June 30, 2012)

Waleed Abdalati Associate Professor of Geography; Director of the Earth Science and Observation Center

Richard Armstrong CIRES Senior Research Scientist in the National Snow and Ice Data Center (NSIDC); Associate Director of the Cryospheric and Polar Processes Division

Benjamin Balsley Research Professor and CIRES Senior Research Scientist

Stan Benjamin Chief of Assimilation and Modeling Branch, ESRL Global Systems Division

Roger Bilham Professor of Geological Sciences

Maxwell Boykoff Assistant Professor of Environmental Studies

John Cassano Associate Professor of Atmospheric and Oceanic Sciences

Thomas Chase Associate Professor of Civil, Environmental, and Architectural Engineering

Xinzhao Chu Associate Professor of Aerospace Engineering

Shelley Copley Professor of Molecular, Cellular, and Developmental Biology

Joost de Gouw CIRES Senior Research Scientist, ESRL Chemical Sciences Division (CSD)

Lisa Dilling Assistant Professor of Environmental Studies

Randall Dole Deputy Director for Research, ESRL Physical Sciences Division (PSD); Associate Director of the Weather and Climate Dynamics Division

David Fahey Research Physicist and Program Lead, Atmospheric Composition and Chemical Processes, ESRL CSD

Christopher Fairall Chief, Weather and Climate Physics Branch, ESRL PSD

Lang Farmer Professor and Department Chair of Geological Sciences

Fred Fehsenfeld CIRES Senior Research Scientist, ESRL CSD; Co-Associate Director of the Environmental Chemistry Division

Graham Feingold Research Scientist, ESRL CSD

Noah Fierer Associate Professor of Ecology and Evolutionary Biology

Baylor Fox-Kemper Assistant Professor of Atmospheric and Oceanic Sciences

Timothy Fuller-Rowell CIRES Senior Research Scientist, NOAA Space Weather Prediction Center

Vijay Gupta Professor of Civil, Environmental, and Architectural Engineering

Michael Hardesty Senior Scientist and Program Lead, Atmospheric Remote Sensing, ESRL CSD; Associate Director of the Environmental Observations, Modeling, and Forecasting Division

José-Luis Jiménez Associate Professor of Chemistry and Biochemistry

Craig Jones Associate Professor of Geological Sciences

William M. Lewis, Jr. Professor of Ecology and Evolutionary Biology; Director of the Center for Limnology; Interim Director of CIRES

Peter Molnar Professor of Geological Sciences

Steve Montzka Research Chemist, ESRL Global Monitoring Division

William Neff Senior Scientist and Director, ESRL PSD

Steven Nerem Professor of Aerospace Engineering

David Noone Associate Professor of Atmospheric and Oceanic Sciences

Judith Perlwitz CIRES Research Scientist III, ESRL PSD

Roger Pielke, Jr. Professor of Environmental Studies

Balaji Rajagopalan Associate Professor of Civil, Environmental, and Architectural Engineering

Prashant Sardeshmukh CIRES Senior Research Scientist, ESRL PSD; Director of the Climate Diagnostics Center

Mark Serreze Professor of Geography; Director of the National Snow and Ice Data Center

Anne Sheehan Professor of Geological Sciences; Associate Director of the Solid Earth Sciences Division

Robert Sievers Professor of Chemistry and Biochemistry; Director of the CU-Boulder Environmental Program

Konrad Steffen Professor of Geography; Director of CIRES

Margaret Tolbert Distinguished Professor of Chemistry and Biochemistry; Co-Associate Director of the Environmental Chemistry Division

William Travis Associate Professor of Geography; Director of the Center for Science and Technology Policy Research

Greg Tucker Associate Professor of Geological Sciences

Veronica Vaida Professor of Chemistry and Biochemistry

Rainer Volkamer Assistant Professor of Chemistry and Biochemistry

Carol Wessman Professor of Ecology and Evolutionary Biology; Associate Director of the Ecosystem Science Division

Tingjun Zhang CIRES Senior Research Scientist, NSIDC

Emeritus Fellows

Susan Avery Former CIRES Director; Former Professor of Electrical and Computer Engineering

Roger Barry Distinguished Professor of Geography; Director of the World Data Center for Glaciology

John Birks Professor of Chemistry and Biochemistry

George Reid Senior Scientist, ESRL CSD (deceased)

Doug Robertson Retired NOAA National Ocean Service, National Geodetic Survey

Hartmut Spetzler Professor Emeritus of Geological Sciences

CIRES Centers

The Centers within the CIRES enterprise provide the functional link between NOAA and 11 different departments at the University of Colorado Boulder. The goal is that the Centers provide an environment to develop collaboration and facilitate partnerships between federal and academic entities.

Climate Diagnostics Center

The mission of the Climate Diagnostics Center (CDC) is to improve our understanding of global climate interactions to improve regional climate predictions, and to train the next generation of climate scientists in advanced climate system diagnosis and prediction. Research disciplines include but are not limited to the atmospheric sciences, oceanography, stochastic dynamics and physics, remote sensing, numerical computational methods, computer sciences, data management, and complex dynamical systems analysis. An integration of these disciplines is required to transfer improvements in the understanding of climate processes to improvements in the models and methods used for climate predictions.

CDC Research Highlight

The Twentieth Century Reanalysis (20CR) project was a major international effort led by CDC and NOAA to produce a comprehensive global atmospheric circulation data set spanning the period 1871 to the present. The data set has already proven to be a valuable resource to the climate research community for climate model validations and diagnostic studies. The journal article describing its development and main features has already been cited more than 70 times in the first year since publication, and the data acquired was deemed one of the "Great Long-Term Datasets in all of Science" by *Wired* magazine.

Center for Science and Technology Policy Research

The Center for Science and Technology Policy Research (CSTPR) was established within CIRES in 2001 to conduct research, education, and outreach at the interface of science, technology, and the needs of decision makers in public and private settings. The Center focuses on the intersection of the environment and society, applying the social and policy sciences to problems of environmental change, management, and sustainability. Much of the work at CSTPR poses questions about how people and institutions make decisions under uncertainty; how perception and technical information influence choices; and how, over time, those choices affect the co-evolution of science, technology, and policy.

CSTPR Research Highlight

CSTPR researchers completed a five-year NSF "SPARC" (Science Policy Assessment and Research on Climate) project, which resulted in more than 11 master's theses and dissertations, as well as 200 mostly peer-reviewed publications. Numerous workshops were conducted that directly engaged science policy practitioners from around the world, advancing SPARC's goal of a highly integrated research and outreach agenda. A handbook on usable science was also written for practitioners. The book summarized SPARC research findings and was widely distributed across the community.

Center for Limnology

The Center for Limnology makes ecologically oriented studies of inland waters: lakes, streams, and wetlands. The goals of the center are to provide visibility and continuity and technical support for interdisciplinary studies involving inland aquatic ecosystems, to maintain undergraduate training programs and individualized undergraduate instruction in the science of aquatic ecosystems, to attract and use research funds for the collection and analysis of data on aquatic ecosystems, to publish and disseminate research findings in the open literature, to participate at the national and international level in the study of important questions relating to aquatic ecosystems, and to help resolve important problems related to either the basic science or applied science of inland waters.

Clearing the Waters

The overgrowth of aquatic plants and algae can strangle a lake or stream—producing toxic algal blooms, depriving fish of oxygen, and tainting the water's smell, taste, and appearance. While phosphorus has received the most attention for fueling that growth, research is shedding light on another equally important nutrient, nitrogen. **William M. Lewis, Jr.**, director of the CIRES Center for Limnology, explains.

Why has phosphorus consistently received higher priority than nitrogen in regulatory efforts?

Early studies of the statistical relationships between nutrients and abundance of algae in inland waters showed that phosphorus is more tightly correlated with algal abundance than nitrogen. Recent studies have shown that the strength of such correlations is not an accurate indicator of nutrient control. A warning that all scientists are taught as they learn statistics was proven in this case: Correlation does not necessarily correspond to causation.

Why has nitrogen's role in lake eutrophication been so murky (no pun intended)?

A large portion of the total nitrogen in water is unavailable for uptake by algae. This is a contrast with phosphorus, for which the unavailable fraction is very small. Therefore, interpretation of nitrogen concentrations in relation to growth of algae has been confusing, but now is becoming clearer (no pun intended).

What are the main sources of nitrogen discharge into lakes, streams, and wetlands?

All lakes, streams, and wetlands have natural nitrogen sources that support the growth of algae and other aquatic plants even in the absence of pollution. Three categories of pollution are associated with nitrogen enrichment of water: (1) Point sources, which consist of all wastewater flows that enter inland waters by pipes or canals; (2) nonpoint sources, which contribute nitrogen through widely distributed underground or overland flows, as in the case of nitrogen applied to land as fertilizer for plants; and (3) atmospheric deposition (wet precipitation and dryfall), which in industrialized areas may carry large amounts of nitrogen capable of stimulating the growth of algae and other aquatic plants.

Earth Science and Observation Center

The Earth Science and Observation Center (ESOC) provides a focus for the development and application of modern remote-sensing techniques used in the research of all aspects of Earth sciences at CU-Boulder. The aim is to work on all scales of problems, from technique development in small test sites to understanding pattern and process on regional and global scales. A long-term goal of ESOC research is to investigate problems in global geosciences—questions of global change, in particular—through remote-sensing observations. ESOC had seven faculty associates during FY12, 20 graduate students, eight postdocs, and four visiting fellows.

Photo courtesy of Xinzhao Chu

ESOC Research Highlight

The polar middle and upper atmosphere provides a unique natural laboratory for studying the complex physical, chemical, and dynamical processes in Earth's atmosphere and space environment. However, very little is known in the altitude range of 100 to 200 kilometers because observations are extremely difficult to make. The first lidar discovery of neutral iron (Fe) layers with gravity wave signatures in the thermosphere up to 155 kilometers made by the Chu Research Group at McMurdo, Antarctica, is a breakthrough in the upper atmosphere research. Not only is this the first time for a single instrument to trace gravity waves from 30 to 155 kilometers, but also it enables the first direct measurements of neutral temperatures deep into the E-region, revealing the neutral-ion coupling and aurora-enhanced Joule heating. The new observations of Fe, neutral temperatures, and gravity waves up to 155 kilometers have opened the door to exploring the neutral polar thermosphere with ground-based instruments.

National Snow and Ice Data Center

The mission of the National Snow and Ice Data Center (NSIDC) is to advance understanding of Earth's frozen realms: the floating sea ice cover, lake ice, glaciers, ice sheets, snow cover, and frozen ground, collectively known as the cryosphere. Major areas of research at NSIDC include processes driving the downward trend in Arctic sea ice extent; environmental impacts of this sea ice loss both within and beyond the Arctic; the behavior of the Greenland and Antarctic ice sheets; Himalayan glaciers and their contributions to sea level rise; links among snowfall, temperature and streamflow; and the implications of changes in Earth's permafrost. Informatics research includes developing alternative database structures to search vast data volumes to answer science questions; developing technologies to make NSIDC data more visible to more researchers; and enhancing data discovery through semantic interoperability. NSIDC also has a broad scope of education and outreach efforts.

Is Earth Losing Its Cool?

Many people know that Arctic sea ice is melting, but what they don't realize is that this has present-day ramifications far beyond the Arctic, says **Mark Serreze**, director of CIRES's National Snow and Ice Data Center (NSIDC).

How much has sea ice declined?

Since 1979, Arctic sea ice extent has declined by more than 30 percent in summer months. It hit a record low in 2005, and then broke that record by 23 percent only two years later, in 2007. We now set a new record low in sea ice in August this year.

How has this affected Arctic dwellers?

Without protective ice cover, shorelines are eroding, forcing entire towns to move. This has disrupted longstanding patterns of travel and hunting and made them more dangerous. Ice loss is also affecting the ocean food chain from the level of phytoplankton all the way up to polar bears and walruses.

What are the ramifications for lower latitudes?

The Arctic sea ice acts as an air conditioner for the northern hemisphere. The white ice reflects more sunlight than the darker oceans, so it keeps the underlying water and surrounding land masses cooler. As the sea ice melts, the sun's rays heat up more of the exposed water, causing ripple effects throughout the northern seas. Researchers also have found links between declining sea ice cover and extreme weather events in North America. Recent studies suggest that having less ice in the fall, for example, could contribute to cold air outbreaks in other parts of the northern hemisphere. This is because the ice loss helps to warm the Arctic, which in turn influences the jet stream patterns in the atmosphere. So what we are realizing is that the change in Arctic sea ice is not just a problem for the Arctic but for all of us.

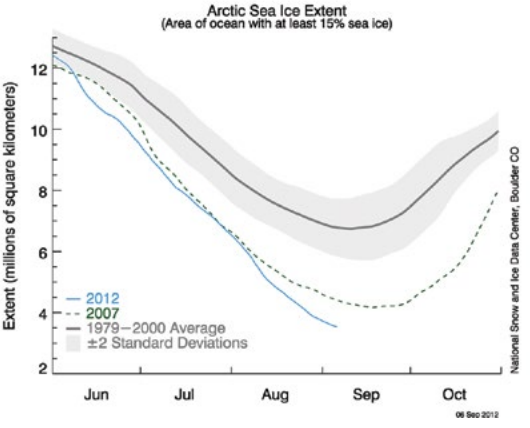


Table courtesy of the National Snow and Ice Data Center

Interdisciplinary Programs

A vibrant research environment is fostered through a number of programs and initiatives designed to stimulate interdisciplinary collaborations among CIRES, NOAA, and university departments.

Western Water Assessment

The Western Water Assessment (WWA) is CIRES's signature integrating activity, relying on multidisciplinary teams of experts in climate, hydrology, ecology, law, and policy to work with decision makers across the Intermountain West to produce policy-relevant information about climate variability and change. WWA is one of 11 NOAA-funded Regional Integrated Sciences and Assessments (RISA) programs across the country. By building relationships with networks of decision makers, WWA is able to develop practical research programs and useful information products. WWA's mission is to identify and characterize regional vulnerabilities to—and impacts of—climate variability and change, and to develop information, products, and processes to assist decision makers throughout the Intermountain West. WWA addresses NOAA's mission, strategic goals, and cross-cutting priorities, as well as other Congressional NOAA mandates, including the U.S. Global Change Research Act and the U.S. Climate Change Science Program.

iStock photo

CIRES programs, such as the Western Water Assessment, serve society with timely science. Above: Horseshoe Bend of the Colorado River near Page, Ariz.

Dust on Snow

White snow, brown snow, deep snow, no snow. CIRES research has revealed that dust-covered snowpacks melt about three weeks sooner than normal. This deprives the Colorado River—the lifeblood of the American Southwest—of 5 percent of its average annual runoff. The findings serve as both a warning—and an opportunity—for the West, says CIRES scientist **Jeff Deems**.

Where does the dust come from?

From deserts and drylands to the west and southwest of the Rocky Mountains. Gusty spring storms deposit the dust on the mountain snowpack, turning it red or brown.

Photo by Chris Landry

And this accelerates snow melting?

Yes, dark, dust-covered snow absorbs more sunlight and melts faster than white snow. The effect is readily observed: If you were to scrape a dusty patch of snow free of dust, then come back in the afternoon, you'd see an elevated patch of snow because the dusty snow around it melted faster [similar to the effect seen in the above photo].

How does the early melt reduce the Colorado River flow?

Earlier snowmelt leads to a longer snow-free season, and snow-free ground and vegetation lose more water to the atmosphere through evaporation and transpiration than does snow. Our study showed this extra evaporation decreases the annual flow in the Colorado River by more than 250 billion gallons on average.

Is that significant?

Yes. That's twice Las Vegas's annual usage and would provide 18 months of water for Los Angeles. Colorado River flow is also being reduced by growing demand, drought, and climate warming.

Is there a silver lining to your findings?

This could be an opportunity to help ease stresses on the Colorado River. If we can reduce the amount of dust on snow through restoration and improved land management practices in the dust source regions, this could put billions of gallons back into the river.

Do your results apply elsewhere?

Yes. We've seen both anecdotally and in observations that dust production from drylands is on the rise worldwide, and we're seeing dust deposited on mountain snow cover and glaciers in regions such as the Tien Shan in China, the Zagros Mountains, the Himalaya, and the Antarctic Peninsula. So while the numbers we produced in our current work may not be directly applicable to other regions, the physical processes and science certainly are.

Visiting Fellows

CIRES annually conducts a competitive Visiting Fellows program that promotes collaborative research at the forefront of scientific knowledge. Visiting Fellows conduct interdisciplinary research in areas spanning the scope of the CIRES research portfolio. Fellowships of up to one year are awarded to Ph.D. scholars (postdoctoral fellowships) and faculty planning sabbatical leave (sabbatical fellowships). A committee comprised of CIRES Fellows is responsible for the review of all applications for CIRES Visiting Fellowships. The committee chooses those best qualified for a sabbatical or postdoctoral fellowship and submits that slate to the Fellows Council for final discussion and selection. Selections for the Visiting Fellows program are based in part on the likelihood of interactions between the Visiting Fellows and CIRES scientists and the degree to which both parties will benefit from the exchange of new ideas. To further this goal, priority is given to candidates with research experience at institutions outside the Boulder scientific community. Since 1967, CIRES has awarded more than 280 Visiting Fellowships. Recipients have included previous CIRES Directors Susan Avery and Konrad Steffen.

cires.colorado.edu/collaboration/fellowships

2012 CIRES Visiting Fellows

Fellow	Sponsor
Jeffrey Amato	L. Farmer
Franco Biondi	T. Chase
Stuart Bradley	W. Neff, M. Hardesty
Lindsay Chapman	W. Lewis, J. McCutchan
Jean-Francois Doussin	V. Vaida
Brian Ebel	G. Tucker
Steven Hansen	A. Sheehan
Mark Hemer	B. Fox-Kemper
Shao-Meng Li	J. De Gouw
Bjorn-Ola Linner	R. Pielke, Jr.
Ben Livneh	C. Wessman
Xian Lu	X. Chu
Ralph Milliff	B. Fox-Kemper
Kyung-Eun Min	F. Fehsenfeld
Arnaud Temme	G. Tucker
Dan Yakir	D. Noone, S. Montzka

Innovative Research Programs

The purpose of the CIRES-wide competitive Innovative Research Program (IRP) is to stimulate a creative research environment within CIRES and to encourage synergy among disciplines and research colleagues. The program encourages novel, unconventional, and/or fundamental research that may quickly provide concept viability or rule out further consideration. Activities are not tightly restricted and can range from instrument development, lab testing, and field observations to model advancement. Funded projects are inventive, often opportunistic, and do not necessarily have an immediate practical application or guarantee of success. Each year, an interdisciplinary committee of CIRES Fellows selects the award recipients. The committee reviews all the research proposals and recommends to the CIRES Director for funding those that are the most inventive and bridge boundaries between traditional disciplines. The results of IRP research are presented the following year at a poster reception. For the 14th annual Innovative Research Program, three additional IRP awards were made to support CIRES's Energy and Environment Initiative. This initiative is focused on the environmental effects of the production and use of present and future energy sources. More details on the Energy and Environment Initiative can be found at http://cires.colorado.edu/science/initiatives/ee/.

cires.colorado.edu/science/pro/irp

2012 Innovative Research Program Awards

Project	CIRES and NOAA Investigators
Cropland, soil moisture, and recent heat waves	T Chase, EC Gill, K Wolter, and RJ Pielke Sr.
MiniCam 600-680 nm sensor for the PolarCube Satellite	D Gallaher, T Scambos, and W Meier
Developing an ensemble prediction system for operational space weather forecasting	CA de Koning and G Millward
Testing a silver bullet: Evaluation of mechanisms that link COS and ^{18}O in CO_2 to gross ecosystem uptake of CO_2	D Noone, M Berkelhammer, J Miller, C Sweeney, and D Yakir
Chemopreventive aerosols to reduce dysplasia	RE Sievers and SP Cape
Validating and enhancing airborne lidar snow depth mapping with ground-based lidar	JS Deems
Nighttime aerosol optical depth measurements in the Arctic: Development of a lunar photometer for use in Barrow, Alaska	RS Stone, EG Dutton, J Wendell, and D Longenecker
Emissions of hydrogen sulfide and other air toxics associated with natural gas production using hydraulic fracturing	C Warneke and M Graus
A new approach to NOx: Applications to diesel engines, biofuels, and oil and gas emissions	EJ Williams, WP Dube, PM Edwards, and SS Brown

Making a Splash: FY2012 in Review

Contributions to NOAA's Vision

CIRES's fundamental research priority—to enhance the understanding and prediction of Earth's environment—complements NOAA's priorities. CIRES research supports the four Mission Goals identified in the NOAA Strategic Plan: Ecosystems, Climate, Weather and Water, and Commerce and Transportation.

Ecosystem Mission Goal: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management

CIRES contributes to NOAA's ecosystem mission goal by implementing new approaches to monitoring biotic and abiotic conditions in remote ocean and coastal areas; by improving forecasts for extreme weather events that impact coastal areas; and by developing and archiving new data sets and other information products that can help assess coastal hazards and support seafloor research.

A prime example of CIRES contributions to ecosystem services in FY12 was the novel development, testing, and evaluation of software that automatically identifies ice seals and derives fractal ice characteristics. The software has been successfully applied to more than 50,000 images collected by unmanned aircraft systems over the Arctic. The data can be used to characterize seal habitat and to evaluate changes in populations. Both the executable and source codes for this software are freely available.

Climate Mission Goal: Understand climate variability and change to enhance society's ability to plan and respond

CIRES is a world leader in climate science research relevant to NOAA's climate mission goal. During FY12, CIRES researchers contributed significantly to all three categories of NOAA's climate-related programs: climate observations and monitoring, climate research and modeling, and climate service development.

CIRES researchers were fundamental to the success of data collected during the CalNex 2010 campaign, as well as subsequent analyses. Measurements from the CalNex campaign provided critical insight into the evolution of aerosol optical properties impacting climate and visibility in Southern California. The results will be used by the California Air Resources Board (CARB) in its efforts to reduce air-quality degradation across the state.

Instruments developed for the CalNex 2010 campaign have also supported a number of additional studies. The instruments were deployed to Barbados to study the optical properties of transported Saharan dust. In addition, they were used by CIRES researchers at the NOAA ESRL site to collect optical property measurements of biomass burning aerosol sampled during the Four-Mile Fire near Boulder, Colo. This data set advances our understanding of the climate impacts of biomass burning emissions.

CIRES researchers are also making headway improving forecasts of aerosol within air-quality models, in direct support of NOAA's goal of having an operational national particulate matter (PM2.5) aerosol forecasting system by 2015. Using measurements made during the 2006 Texas Air Quality Study field mission of aerosols and their precursors, in conjunction with a state-of-the-art air-quality forecast model, researchers were able to assess recent developments in the treatment of secondary organic aerosol formation and its impact on particulate matter aerosol forecasts.

In winter 2012, acidic trace gases in the Uintah Basin in Utah were measured by CIRES collaborators as part of a larger study that focused on the atmospheric emissions associated with natural gas production and the role these emissions play in atmospheric chemistry. Among the trace gases

iStock photo

quantified, measurements of nitrous acid (HONO) were particularly important as HONO can provide a source of free radicals that can potentially initiate ozone chemistry.

Through the NSIDC, CIRES continues to collect and maintain important cryospheric data sets for use by the research community. Ongoing monitoring and analysis of long-term data sets, continue to provide NOAA with valuable information about the nature of short- and long-term change in polar regions.

CIRES research has also provided insights into the drivers of drought, with the ultimate goal of improving predictability. To enhance understanding of the sensitivity of North American drought to tropical sea surface temperature (SST), CIRES researchers evaluated the sensitivity of monsoon regions around the world to tropical SST changes, with particular emphasis on the northeast Asian summer monsoon region. Observations indicate increasing trends of summer precipitation amount, intensity, and frequency of extremes over northeast Asia since the 1960s.

CIRES scientists are also directly engaging in research to support the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5). A specific example is support of the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP). Analyses by CIRES and NOAA partners determined the effects of different Representative Concentration Pathways on the distribution of chemical species and on their deposition at the surface. This will enable improved understanding and modeling of the effect of atmospheric chemical composition on climate.

CIRES's broad research portfolio has also brought the social sciences to bear on NOAA goals, particularly in decision science. CIRES research conducted in FY12 investigated the conditions under which local decision makers in the West decide to adapt to increased climate-related risks and hazards. The results provide insights as to how to best communicate climate information to the public.

Weather and Water Mission Goal: Serve society's needs for weather and water information

CIRES researchers support NOAA's mission to provide essential information on weather and water by advancing numerical weather model forecasting through model improvements and assimilation of data collected in observational field campaigns, ongoing monitoring, and from satellite missions.

Weather

From space to the sky, to the oceans and rivers, CIRES continued its legacy of supporting NOAA's forecasting abilities from pure research through transition to operations.

CIRES researchers continued to engage in the fundamental research necessary to provide weather information to support the energy industry. Using a data set of a motion-compensated, high-resolution Doppler lidar offshore wind measurements, CIRES researchers were able to better understand the range of atmospheric conditions—and their spatial and temporal variability—encountered by offshore wind turbines above the surface at the level of the rotor blades. This type of information is critical for determining optimal siting of wind farms, as well as for short-term projections of wind regimes and, thus, energy production.

CIRES also continued its support of Space Weather Prediction Center (SPWC) efforts to improve the prediction of traveling solar disturbances that impact the geospace environment. Such disturbances, which are associated with both coronal holes and coronal mass ejections (CME) from the sun, can cause substantial geomagnetic effects leading to the crippling of satellites, disruption of radio communications, and damage to electric power grids. During FY12, CIRES scientists made significant advances in understanding subsurface velocity flows that affect flare production.

In August 2011, the Hurricane-Weather Research and Forecasting model (HWRF v3.4a), which contains the

The Past Reveals the Future

Climate variability and change may impact more than just the water supply—it may also impact water quality. CIRES Fellow **Balaji Rajagopalan,** in collaboration with former student and current NCAR research scientist Erin Towler, is working to forecast water quality, in part, by looking at the distant past. By studying how extreme events, such as drought and flooding, thousands of years ago influenced water quality, researchers can get a glimpse of future scenarios.

How can climate variability affect water quality?

Climate variability affects water quality in two ways: streamflow variability and temperature variability. Reduced streamflow, for example, can lead to higher salinity concentrations that can increase the treatment cost to water utilities and reduce the lifespan of water-using appliances for customers. On the other hand, peak streamflows from high-intensity precipitation events can bring increased sediment loads, or turbidity, which can cause water-quality violations and require changes in plant operations. Temperature variability impacts stream temperature, which is related to the amount of dissolved oxygen available in the stream. As such, it has a direct bearing on aquatic health and is related to events such as algal blooms, which affect treatment decisions.

How could this impact people in the future?

Climate change may exacerbate water-quality issues in areas where climate variability is already stressing the system. As such, to ensure efficient management, it's important to consider current and future climate risk to not just water quantity, but water quality as well. As supplies become more limited and water-quality regulations are heightened, the extension of forecasting efforts to water quality is critical.

Are people more receptive to information on past extreme events than forecasts of future ones?

Especially in the context of paleo-reconstructed streamflow, it is easier to make a case for better preparedness using past variability than with the same information under climate change. In this regard, policy makers are more receptive.

What's one of the most surprising findings you've made?

How modest changes in the probabilities of extreme climate and water-quality events have a disproportionately larger impact on the water-supply system, both for the utilities and the public.

capabilities of the 2011 operational implementation, was released by CIRES and NOAA to the research community. Contributions from the community were incorporated in the revised HWRF operational model implemented in May 2012.

CIRES researchers continued to coordinate worldwide development of the Weather Research and Forecast–Chemistry model (WRF–Chem) as an air-quality prediction tool. In May 2012, real-time forecasts using the WRF/Chem model were used to track wildfire smoke from the Whitewater-Baldy fires in New Mexico as they moved north into Colorado.

Water

CIRES researchers are actively engaged in water resource issues across the Western U.S. and beyond.

During FY12, CIRES researchers began examining the impacts of high dust loads (observed in 2009 and 2010) and climate warming on flow in the Colorado River. Initial modeling results show that even under the strongest warming, timing of runoff is strongly sensitive to radiative forcing by dust. Under scenarios of extreme warming, however, volume of runoff becomes less sensitive to dust deposition. This research is being directly coordinated with the NOAA NWS Colorado River Basin Forecast Center.

iStock photo

The statistical and dynamical down-scaled climate projections for the Colorado River Basin, including data from the North American Regional Climate Change Assessment Program (NARCCAP), particularly as it relates to hydroclimatic processes and variability, were evaluated by a team of CIRES scientists. From this analysis, researchers determined that soil moisture feedbacks were important at high elevations in amplifying warming in summer, and a novel mechanism was proposed for enhanced wintertime warming that involves soil moisture, atmospheric humidity, and snow.

Researchers also continued important work related to extreme events and impacts on water resources. Through the persistent drought of last year, CIRES researchers, in conjunction with the National Integrated Drought Information Service (NIDIS), briefed decision makers in both the Colorado River Basin region and in the Apalachicola-Chattahoochee-Flint Basin about drought and linkages to La Niña.

CIRES also engaged in activities related to flood events. As an example, real-time monitoring of water vapor flux is critical for assessing extreme precipitation events along the West Coast of the United States. In support of the NOAA near-real-time water vapor flux tool, CIRES scientists and colleagues automated software operations for nine different NOAA and cooperative agency sites along the U.S West Coast. In FY12 developments were made to allow users to view Integrated Water Vapor, Total Flux, and Upslope Flux data spatially on Google Maps in near real-time.

Commerce and Transportation Mission Goal: **Support the nation's commerce with information for safe, efficient, and environmentally sound transportation**

In FY12, CIRES contributed to a streamlined, more fully automated, accessible, and Web-based management and stewardship process for marine geophysical data in support of seafloor research. Since July 2011, 175 multibeam swath sonar surveys (631,896 nautical miles) and 44 trackline (single-beam bathymetry, magnetics, gravity, subbottom, and seismic reflection) surveys (287,000 nautical miles), throughout all of the world's oceans, have been added to the National Geophysical Data Center's (NGDC) global marine geophysical archives by NGDC and CIRES staff. Both national and international organizations contribute to and retrieve marine geophysical data from the interactive databases. Marine geophysical data archived at and delivered by NGDC are currently supporting two specific, ongoing U.S. mapping efforts: the Extended Continental Shelf (ECS) project and the Integrated Ocean and Coastal Mapping (IOCM) program.

CIRES and collaborators also improved public access to a variety of regional and global coastline data sets through development of an interactive map service, including the addition of a new high-resolution community coastline data set developed at NGDC. Such information is mission critical to support maritime navigation.

In December 2011, CIRES researchers completed a formal assessment addressing differences between Rapid Update Cycle (RUC)–derived and Rapid Refresh (RAP)–derived Forecast Icing Potential (FIP) and Current Icing Potential (CIP) icing products for improved aviation safety. An important conclusion of this study is that the new model is more efficient at identifying areas of potential in-flight icing throughout the atmosphere.

CIRES Communications

It has long been a part of CIRES's mission to communicate world-class research in ways that help inform decision makers and the public about how we can best ensure a sustainable future environment. Our communications work is coordinated by the Science Communications Group and involves close collaborations with NOAA, CU–Boulder, our centers, and international colleagues in academic and government institutions. Through a coordinated multimedia approach, the Communications Group uses both traditional and innovative methods to convey the outcomes of key research endeavors to the public. The success of the CIRES communications strategy is exemplified by widespread coverage of our scientific work in, for example: *USA Today*, *Time*, *The New York Times*, *Scientific American*, CBS, *Discovery*, *Discovery News*, *National Geographic*, Nature News BBC, *Business Week*, MSNBC, Fox News, *Science NOW*, *Science News*, *Nature News*, and the *Los Angeles Times*.

Press Releases & Videos

2011

• **Press release**
▷ **Video**

July

• New study details glacier ice loss following ice shelf collapse.

August

• Increase in particles high in Earth's atmosphere has offset some recent climate warming.

• Slowing climate change by targeting gases other than carbon dioxide

• Scientists explore link between predator-prey relationships and rainfall patterns.

• Bacteria from dog feces pervade winter air of urbanized areas.

• CIRES expert available to talk about Colorado/Washington, D.C., earthquakes.

September

• Air pollution caused by ships plummets when vessels shift to cleaner, low-sulfur fuels.

• Arctic sea ice reaches minimum 2011 extent, the second lowest in the satellite record.

• Increased crevasse extent in Greenland may dampen ice sheet sliding.

• Gulf spill fires released more than 1 million pounds of sooty black carbon into the atmosphere.

• CIRES scientist available to discuss Antarctic ozone hole recovery paper.

@theCIREStwire | **youtube.com/user/CIRESvideos** | **Facebook/CIRESnews**

CIRES Research Highlights

Air Quality Research

Achievements of CIRES scientists for FY12 extended over the broad CIRES environmental research agenda, which includes physical, chemical, and biological aspects of environment as well as the human dimension of environmental analysis. Studies of atmospheric chemistry, a special strength of CIRES and its NOAA partner, produced advances in understanding of atmospheric soot, fossil fuel combustion, and bacteria suspended in the air.

MEDIA:

• Bacteria from dog feces pervades winter air of urbanized areas.
• Gasoline worse than diesel when it comes to some types of air pollution.
• Smoking out an air pollutant's hot spots

Polar Research: Arctic to Antarctic

Global climate with a focus on ice sheets continued to be a major interest of several working groups within CIRES. CIRES scientists contributed to the conclusion that Arctic sea ice reached its second lowest minimum recorded extent in 2011. Long-term detailed studies of the Greenland ice sheet by CIRES scientists showed that movement of the ice sheet toward the Greenland coast may accelerate when increased meltwater reaches the bottom of the ice sheet; water lubricates the movement of ice over rock.

MEDIA:

• Greenland ice sheet flushing itself away?
• A sea change in the Arctic atmosphere
• Emperor penguins threatened by Antarctic sea ice loss.

Continued Insights Related to Gulf Oil Spill

CIRES and NOAA collaborators continued their intensive collaboration on the study of the effects of the Deepwater Horizon oil spill on air quality. While the immediate concern of the spill was environmental damage to the aquatic environment, these scientists showed that the strategy of burning oil to remove it from the water surface produced more than 1 million pounds of black carbon in the form of soot. Data produced by these scientists will guide oil spill management in the future as air pollution joins other concerns that determine the response to spills.

MEDIA:

• Gulf spill fires released more than 1 million pounds of sooty black carbon into the atmosphere.
• Chemical measurements confirm official estimate of Gulf oil spill rate.

Research Relevant to the Western U.S.

CIRES's world-class researchers not only bring expertise to bear on global environmental challenges, but also to the issues that hit close to home. Important findings emerging from CIRES during FY12 have implications for regional air, water, and land resources.

MEDIA:

• Colorado mountain hail may disappear in a warmer future.
• Earthquake potential in Colorado and New Mexico

October
• El Niño: Unaffected by climate change in the 21st-century, but its impacts may be more severe.

• Climate change major factor in more frequent Mediterranean droughts.

• Bright city lights affect air pollution.

November
• NSIDC receives award for Green Data Center Design.

▷David Gallaher discusses the design and construction of the Governor's Sustainability Award–winning NSIDC project.

December
• USAID, CU–Boulder, and CIRES partner to study water resources in Asia mountains.

• Gulf oil spill releases a "city's worth" of pollution into the air.

▷What Is Remote Sensing? CIRES Fellows Waleed Abdalati and Steven Nerem explain remote sensing and the need for continued satellite observations.

▷Active Ice. NSIDC Senior Research Scientist Ted Scambos discusses ice ocean interaction and the active nature of ice sheets and glaciers.

2012

January
• Colorado mountain hail may disappear in a warmer future.

• Chemical measurements confirm official estimate of Gulf oil spill rate.

• Earthquake potential in Colorado and New Mexico

• Scientists studying the remote ocean atmospheric environment

February
▷Ozone Mystery: A CIRES and NOAA effort to understand the cause of high winter ozone levels in the Uintah Basin in northwest Utah

March
• Colorado oil and gas wells emit more pollutants than expected.

• Gasoline worse than diesel when it comes to some types of air pollution.

▷Gasoline Worse Than Diesel for Some Types of Air Pollution. Former CIRES scientist Roya Bahreini explains her recent work in Los Angeles looking at fuel types and their link to secondary organic aerosol formation.

• NSIDC scientist leads Nunavut-Nepal exchange.

April
• Thawing permafrost 50 million years ago led to global warm events.

• Greenland ice sheet flushing itself away?

• New monitoring system clarifies murky atmospheric questions.

• Smoking out an air pollutant's hot spots

▷Breakthroughs in Renewable Energy. CIRES's Suzanne van Drunick and Betsy Weatherhead convened a panel of top minds in renewable energy research at the AAAS annual meeting (2/12).

▷"Putting Scientific Breakthroughs to Work in Support of Renewable Energy" Panel Presentations (4/12). Featuring: Alexander MacDonald (NOAA, ESRL), Dan Arvizu (NREL), Susan Avery (WHOI), Peter Hauge Madsen (Technical University of Denmark), and David Grimes (World Meteorological Organization)

May
• Near-term weather forecasts get powerful boost from new computer model.

• CIRES researchers discover a new type of wave.

• A sea change in the Arctic atmosphere

June
• Emperor penguins threatened by Antarctic sea ice loss.

Caught in the Act

For the first time, the often-dramatic changes of supraglacial lakes (which sit atop glaciers) have been captured on camera as they happened. After rappelling down ice cliffs on Nepal's largest glacier, CIRES graduate student **Ulyana Horodyskyj**, a recipient of a 2011–2012 CIRES Graduate Student Research Fellowship, installed solar-powered cameras on the moraine to capture time-lapse photography of three lakes' evolution over the course of four months. Her work received widespread media attention from such titles as *National Geographic*, the BBC, and *Scientific American*.

What were some of the biggest changes the cameras captured?
One lake drained at least 10 feet—overnight! It was incredible. Most likely, a crevasse below the lake opened as the glacier moved forward, forming a conduit to the glacier's base. You could just hear the water flushing.

Did any lakes get bigger?
One lake doubled in size during the month due to monsoon rains. Falling ice also raised one lake's water level a total of 28 centimeters, in only two weeks. Ice walls were collapsing almost all the time. Standing near the shore was like being in a shooting gallery. These initial results reveal that these lakes can undergo substantial changes in a very short amount of time.

Why is that important?
When people think about glaciers, they think in terms of advances and retreats, but glaciers are also shrinking vertically. Supraglacial lakes most likely act as catalysts for this vertical ice loss. Understanding how these lakes behave and affect glacier melt is critical—both for estimating the glacier's lifespan and for predicting flooding and water surges in villages down-valley.

Spheres

This popular periodic publication highlights the diversity of CIRES research in particular topics. *Spheres* science magazine is CIRES's premier outreach publication, presenting the Institute's research in its divisions and centers. With accessible and entertaining writing and vivid images donated by the scientists themselves, the magazine's mission is to convey the full breadth of research in CIRES to the lay audience.

Each edition carries stories highlighting research funded by the CIRES Innovative Research Program, visiting fellows, and CIRES graduate students. The CIRES Communication Group distributes the magazine to Congressmen, NOAA and CU officials, scientists, high-school students, and potential visiting fellows and graduate students. Staff and scientists also distribute *Spheres* at conferences and local events. *Spheres* editions published FY12 were *Air Spheres* and *Earth Spheres*.

Education and Outreach

The research conducted at CIRES provides knowledge that helps society to build a sustainable future. The CIRES Education and Outreach (EO) group builds bridges between CIRES research and educators, communicators, students, and scientists. Its work emphasizes scientific inquiry, access to current research, and foundational concepts in geosciences education. CIRES scientists often partner with CIRES Education and Outreach as part of their research projects, contribute to education projects as presenters, reviewers, and learning-resource providers, and star in scientific video clips. This involvement by scientists helps teachers to have confidence that the resources provided by CIRES EO are scientifically sound and up-to-date.

cires.colorado.edu/education/outreach

Education and Outreach Web Resources:

▷**COSEE (Centers for Ocean Sciences Education Excellence) Teacher Professional Development Lecture Videos.** Covering science topics focusing on the Ocean and Climate. Featuring: J. Barsugli, T. Chapman, N. Doesken, B. Ebel, B. Glancy, B. Raynolds, S. Stevenson, M. Squillace, and D. Noone.

▷**ICEE (Inspiring Climate Education Excellence) Teacher Professional Development Lecture Videos.** Designed to give teachers the tools to teach the complicated topics within Earth and energy science. Featuring: W. Abdalati, J. Barsugli, L. Dilling, B. Fox-Kemper, C. Manning, M. McCaffrey, W. Meier, S. Nerem, S. Strife, P. Tans, A. Wagner, and J. White.

▷**Water Spotters.** D. Noone explains "Water Spotters," a network of middle-school students who observe rain, snow, and weather along Colorado's northern Front Range.

▷**Polar Visions.** An educational film produced by Ryan Vachon explores the causes and effects of climate change in the polar regions of the planet.
cires.colorado.edu/education/outreach/polarvisions/

• **ICEE Community Forum:** A forum for educators to discuss Climate Literacy best practices and current science.
http://iceeonline.org/forum/

▷**Extreme Ultra Violet Variability Experiment (EVE).**

All About EVE	**http://vimeo.com/4480035**
LASP Tour	**http://vimeo.com/4433858**
Space Science Careers	**http://vimeo.com/4401638**

EO Research Highlight

To provide students with accurate information about climate and energy science, educators require scientifically and pedagogically robust teaching materials. To address this need, the Climate Literacy & Energy Awareness Network (CLEAN) has developed a peer-reviewed digital collection as part of the National Science Digital Library (NSDL). The CLEAN collection is a featured educational resource collection on the NOAA climate.gov portal. The CLEAN Pathways project features teaching materials centered on climate and energy science for grades 6 through 16. Each teaching resource has undergone a rigorous review process and provides expert teaching tips on how to implement the resource in the classroom. All materials are aligned with the Benchmarks for Science Literacy, the Essential Principles of Climate Science, and key energy concepts. CLEAN is funded by grants from the National Science Foundation.

cleannet.org

Rain Catchers

David Noone has more than 200 talented research assistants—they just happen to be in middle school. Through the CIRES Education & Outreach Program, Noone has partnered up with students in the St. Vrain Valley School District to collect rainwater from school rooftops and data from weather stations as part of his research into the water cycle. By looking at the samples' chemistry, he can learn where the water came from (for example, the Gulf of Mexico or the Pacific) and where it's going. And he couldn't do this work without the help of his scientists-in-training.

What can we gain from this research?

Understanding how water moves around in the air—the water cycle—will help us know how to use water more effectively for agriculture, environmental sustainability, and recreation. One of the greatest challenges in adapting to climate change is anticipating changes to water availability. Our research seeks to improve the ability to understand and predict changes in how water on the landscape and in the atmosphere varies.

Where do the kids come in?

For our work in Colorado, we need information from the region. Some of our detailed measurements are only made at a single point, in Erie, but we need the wider network to understand the context. Obtaining the data to provide this context is not really possible without making use of citizen science—in this case, the help of students. We gain extensive data and a network perspective on the precipitation patterns in the region.

The students, in turn, get valuable learning opportunities both in regard to learning about their local and global environments and in the types of research being done in the science community. One aim of our work is to encourage students to think about science and technology as an important part of their future careers. We help the students, and the students help us. It's a win-win.

How have the students responded?

Good question! At the moment we're still in the spin-up phase. Mostly we've been working with teachers. We're rolling out curriculum packages shortly.

Events

CIRES hosts diverse events throughout the year. The CIRES Rendezvous and the Distinguished Lecture Series are among the highlights of the CIRES event portfolio.

Director Konrad Steffen speaking at the Rendezvous 2012

Rendezvous

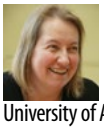
More than 400 people attended the seventh annual Rendezvous research symposium of the CIRES Members' Council on April 24, 2012. This half-day, institute-wide symposium featured more than 130 posters showcasing the depth, breadth, and quality of science being conducted by CIRES scientists, and provided a venue for them to share research with each other and NOAA colleagues. Director Konrad Steffen delivered the "State of the Institute" address and presented awards for years in service, the CIRES Outstanding Performance Awards, and awards for other professional achievements.

Distinguished Lecture Series

This lecture series brings in outstanding scientists and innovative thinkers who have given thoughtful consideration to environmental and Earth system science issues. A committee of CIRES Fellows determines invitees.

September 9, 2011
Brian Toon
Laboratory for Atmospheric and Space Physics, University of Colorado; **The Anti-Greenhouse Effect Along the Spiral of Geologic Time**

November 4, 2011
Peter Webster
School of Earth and Atmospheric Sciences, Georgia Institute of Technology; **Probability, Prediction, and Decisions: A Pathway to the Alleviation of Poverty in the Developing World**



March 16, 2012
Diana Liverman
Co-Director of the Institute of the Environment and Regents Professor in the School of Geography and Development, The University of Arizona; **Responding to the Challenges of Global Environmental Change: Carbon offsets, climate adaptation, and science for sustainable development**

April 6, 2012
Isaac Held
Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration; **Global Simulations of Tropical Cyclone Statistics: Interannual variability and the response to global warming**

April 13, 2012
A Tribute to Dr. George Reid
Presented by Susan Solomon; **From the Mesosphere to the Tropical Tropopause**

Achievements & Awards

The breadth and number of achievements by CIRES researchers and staff speak to the quality of research emerging from the Institute. From recognitions of lifetime achievements to acknowledgements of emerging junior talent, CIRES scientists are among the best of the best at what they do. Among the premier awards received by CIRES scientists during FY2012 were the 2011 AGU Ocean Sciences Early Career Medal (Baylor Fox-Kemper) and an NSF CAREER Award (Rainer Volkamer).

CIRES Awards

The CIRES Awards Committee, comprising CIRES Members' Council representatives and members at large, annually reviews nominations and makes recommendations for outstanding professional achievement in the categories of "Science and Engineering" and "Service." This year, CIRES recognized six awards of $2,000 each.

Science and Engineering

Cecelia DeLuca for being the driving force behind the important and novel software development efforts at NOAA's Environmental Software Infrastructure and Interoperability Group (NESII). She guides the group with diverse expertise in high-performance computing, software project management, and Earth sciences, and a vision to bring their efforts to fruition.

Anna Karion, Tim Newberger, and **Colm Sweeney** for developing a new atmospheric sampling instrument, the AirCore, which can profile altitude gradients of greenhouse gases. The low-cost, lightweight tool also can be used to validate satellite profiles and may yield new discoveries in stratospheric composition and circulation trends.

Dan Lack for his work putting black carbon emissions inventories for shipping on a sound scientific basis, which has had a major impact on policy decisions for regulation of international shipping.

Troy Thornberry, Andrew Rollins, and **Laurel Watts** for designing and demonstrating an airborne chemical ionization mass spectrometer (CIMS) for ultra-low water vapor measurements in the lower stratosphere. Their effort led to unique measurements that will advance our understanding of water vapor in the climate system.

Service

Ken Aiken for his essential work mastering, maintaining, and teaching all things digital. The research of NOAA's Chemical Sciences Division requires multifaceted data collection, manipulation, and presentation, at which Aiken is an unparalleled expert.

Dave Gallaher and **Ron Weaver** for their leadership in data center design and operation with the NSIDC Green Data Center project. The innovative data center redesign slashed energy consumption for data center cooling by more than 90 percent, demonstrating how other data centers and the technology industry can save energy and reduce carbon emissions.

Director's Award for Diversity

Edward Aruajo-Pradere for demonstrating that a distinguished scientific career and regular diversity outreach can be combined to the benefit of both.

Director's Award

Jon Eischeid for his essential work authoring the hydro-climate report "Understanding and Explaining Hydro-Climate Variations at Devils Lake." This key assessment of the climate conditions relevant to the recent rise of Devils Lake elevation supports the Interagency Initiative to Address Flooding Issues at Devils Lake, North Dakota.

Detecting Groundwater from Space

In 2012, geophysicist **John Wahr**, then a CIRES Fellow, was elected a member of the prestigious National Academy of Sciences. Wahr was honored, in part, for his groundbreaking work in the use of GRACE (Gravity Recovery And Climate Experiment)—twin satellites that measure changes in Earth's gravity and, hence, mass at any region on the planet—to monitor the planet's glaciers, sea levels, crustal deformation, and even groundwater depletion.

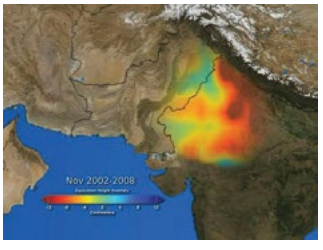


Image courtesy of NASA/Trent Schindler

Where has GRACE recorded the biggest mass changes?

Since 2002, the biggest mass changes recorded have been ice melt in Greenland, Antarctica, and Alaska. But another dramatic, long-term mass change we've seen is in northern India, Pakistan, and Bangladesh. It's a huge mass loss, and it's due to farmers pumping water from the ground for their fields. It's a serious problem. In India, the wells are drying up, and some people are having trouble getting enough to drink.

How has India responded to the data?

Our results have been discussed even on the floor of the Indian parliament, but people who try to manage groundwater sources using traditional methods are skeptical of satellite-based measurements. It is a radical idea to think you can measure changes in groundwater from space—that somehow the satellites up there can see water beneath the soil. Even though I've been involved with GRACE from the beginning, it's still staggering to think about what you can accomplish. But once you understand how GRACE works, you understand how fantastic the methodology is.

How accurately can it detect groundwater changes?

GRACE can measure changes in total water to about 1-centimeter accuracy over the scale of the Mississippi River Basin. No other method for monitoring groundwater gives such an accurate, big-picture view for a whole region.

Finance

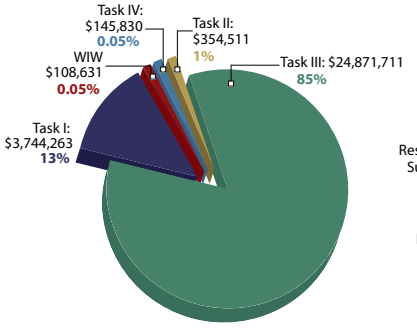
The trend for growth at CIRES continued during the 2011 to 2012 fiscal year. The largest portion of CIRES's expenditures in the past has been through our NOAA Cooperative Agreement (CA) (44 percent). However, during this reporting period, NOAA issued an external award renewing the Western Water Assessment project, so our individual award expenses (50 percent) are now greater than our CA expenses. CIRES researchers continue to have great success in obtaining external research awards. The University's monetary contribution to CIRES primarily covers faculty salaries, and it fluctuates from year to year due to our affiliated University faculty appointments.

Agreement expenditures by task for FY12 are shown in bottom-left pie chart. Task I expenditures include CIRES administration and internal scientific programs, such as the Visiting Fellows and Graduate Student Fellowship programs. Task II provides partial support for data analysis at the National Snow and Ice Data Center, the largest of CIRES's five interdisciplinary scientific centers. Task III funds CIRES's collaboration with NOAA's Earth System Research Laboratory, the National Geophysical Data Center, and the Space Weather Prediction Center, all within Boulder, Colo. Task IV was created to serve as an efficient mechanism for the administration of NOAA research grants and awards, which would otherwise be stand-alone projects outside the Agreement, to CIRES researchers in fields aligned with CIRES's mission. Two Task IV projects have been awarded through our NOAA "shadow" award, NA08OAR4320914.

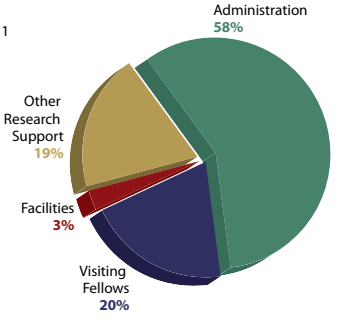
The largest share (58 percent) of Task I base funds support CIRES administration, primarily salaries and benefits for the administrative staff (middle pie chart below). The Visiting Fellows program receives the second-largest share (20 percent) of Task I base fund support and is subsidized by other Institute funding as well. Task I also provides partial support of CIRES's Education and Outreach program, other research support, and the physical plant facilities.

Our NOAA Task I base funding is augmented by CIRES's portion of the University's indirect cost recovery (ICR), which is distributed annually to University units as a proportion of indirect costs collected from institutional research grants and awards (pie chart at right).

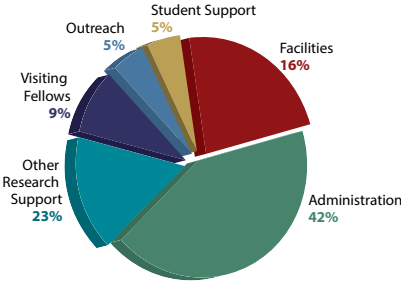
Cooperative Agreement expenditures by task 2011–12



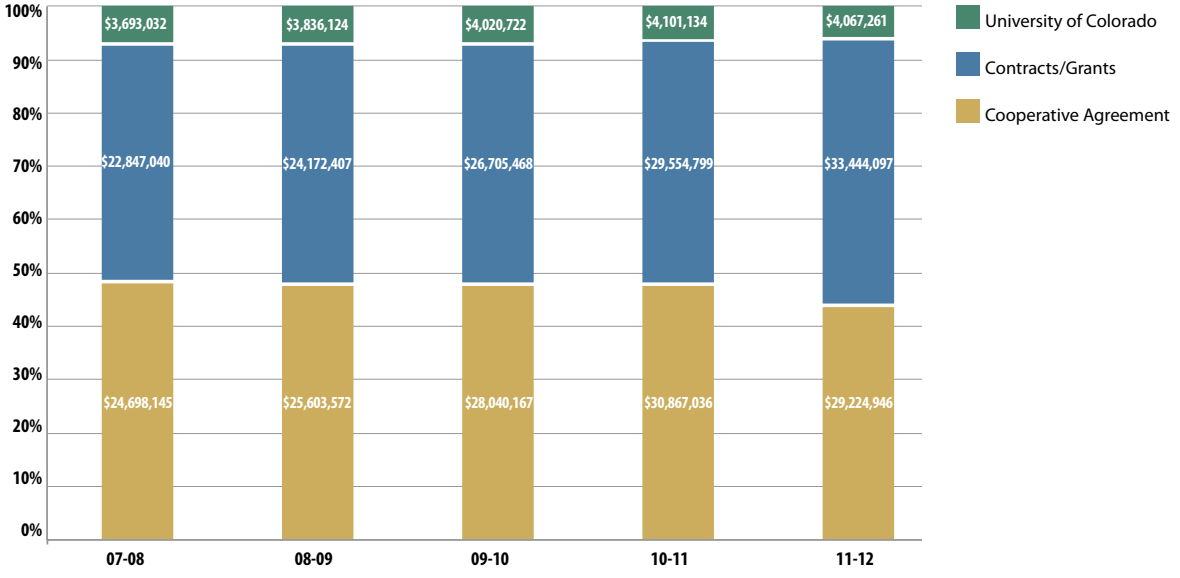
CIRES Task I base fund expenses 2011–12



CIRES Task I base and ICR-supported expenses 2011–12



Expenditures by NOAA Cooperative Agreement, individual awards, and CU funds



COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES

University of Colorado Boulder UCB 216
Boulder, CO 80309-0216