THE CENTER FOR GLOBAL & REGIONAL ENVIRONMENTAL RESEARCH

CGRER 2021 ANNUAL REPORT

WWW.CGRER.UIOWA.EDU

The names of CGRER members and those affiliated with CGRER are highlighted in boldface throughout this report.

Cover photos: Top; NASA photo by Astronaut Thomas Pesquet, Prairie flowers and powerlines by Wikipedia Commons.

CGRER is housed in the Iowa Advanced Technology Laboratories on the UI campus. Photo this page: Mary Moye-Rowley.

Right: The Ashton Prarie Restoration Project (see pages 14, 15).

THE CENTER FOR GLOBAL & REGIONAL ENVIRONMENTAL RESEARCH

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The Center for Global and Regional Environmental Research (CGRER) was established in 1990 with the intent of promoting interdisciplinary efforts that focus on global environmental change. Housed on the University of Iowa campus in the Iowa Advanced Technology Laboratories, CGRER is supported by the rate-payers and utilities of Iowa, a program begun by the State of Iowa's Energy Efficiency Act of 1990. Funds are used to support research and provide services to faculty members and students across the state who are interested in environmental change.

While environmental change is constant and natural, CGRER focuses on the human-induced acceleration of such change caused by modern technologies, lifestyles and population growth. Concerns about global change encompass multiple issues including its effects on natural ecosystems, environments and resources, and on human health, culture and social systems. Because global change promises to touch virtually every aspect of life and requires the reinterpretation of many fields of science and engineering, the humanities, health and law, an understanding of global change requires collaborative efforts among the many disciplines involved. CGRER's mission is to foster such collaborative interdisciplinary actions in three ways: by promoting dialogue among specialists and agencies, by educating students and the general public, and by fostering and supporting relevant research projects.

This annual report summarizes CGRER's activities in each of these three areas. Because CGRER's output is commensurate with that of its many members, a summary of which would require a small book, this annual report includes only a sampling of significant projects and efforts. Yet this sampling provides a vision of CGRER's multiple efforts to achieve its ultimate goal: assisting Iowa's agencies, industries and citizens in assessing and preparing for global change and its effects.

promote dialogue among specialists and agencies

educate students and the general public

foster and support relevant research projects

EXECUTIVE SUMMARY

Despite the COVID-19 pandemic, in 2021 the Center for Global and Regional Environmental Research enjoyed a productive year of scientific inquiry, education, and outreach. We took precautions by wearing masks and limiting the number of people in laboratories. We taught many classes online and met together virtually. Throughout it all, we kept in mind that CGRER's primary mission is to perform cutting edge research on environmental change, including climate change at the regional and global scales.

We believe this challenge is so important that it should be a part of every curriculum of our colleges and universities—every student should be conversant and knowledgeable regarding climate change, which will affect their world for decades to come.

This annual report documents the fruits of these labors. We are pleased with the successes of this year, but it strikes us that our most important mission is to convey research results to the public and to decision makers. Science informs good policy, and in this case the stakes are high—to stabilize the climate we must decrease greenhouse gas emissions rapidly and allow transition to a low-carbon economy.

What were the manifestations of climate change in 2021? Extreme climate events led the news. An unprecedented heat wave in the northwestern United States and western Canada shattered records. Portland, Oregon, where normally high temperatures are in the seventies, was scorched for three days by an average high temperature of 112 °F in June. Seattle, Washington set an all-time heat record of 104 °F on June 27. The next day the record was obliterated by a high temperature of 108 °F. Prior to that moment, Seattle had recorded only three days with temperatures exceeding 100 °F in over a century. Quillayute, Washington reached a high temperature of 110 °F, 45 °F greater than average, which broke the all-time high record by 11 °F. In 2021, climate records were not simply broken, they were shattered.

Canada couldn't escape the heat, either. At 116 °F, Lytton, British Columbia broke the all-time high temperature record for the entire country of Canada on June 27. That record was eclipsed the next day by 118 °F and surpassed again the following day when temperatures registered at 121 °F. Imagine fracturing the all-time high temperature record for the entire country by 8 °F! Iowa's highest state-wide temperature of at 108.8 °F dates back to July 14, 1936. That means that Lytton was more than 12 °F hotter than Iowa ever has been in recorded history, even though Lytton is more than 500 miles further north. The science of attribution analysis, which has advanced significantly in the past five years, tells us that this heat wave was virtually impossible without anthropogenic climate change—it could not have occurred without the effects of man-made greenhouse gasses in the atmosphere.

This past year, manifestations of climate change were not limited to heat waves. In the United States, on December 10 and 11, six states experienced a family of tornadoes that were by far the worst ever recorded so late in the year. Hardest hit was Kentucky, which experienced an EF-4 long-track tornado traveling over 165 miles with wind gusts up to 190 mph, which took the lives of more than 80 people.

Iowa was not spared when a rare derecho (a bow-shaped thunderstorm front with straight line winds) swept through the state on December 15. The second derecho in Iowa in 16 months and the first-ever derecho in December anywhere in the US, it spawned 92 tornadoes, 43 of which were in Iowa. That's more than seven fold the total number of tornadoes to touch-down in December in Iowa since 1950, and it is the most twisters in a single day in the state's historical record. Additionally, on that day in December, Iowa City had a high temperature of 75 °F which wiped-out the previous record of 59 °F.

Who documents climate-change science? In the fall of 2021, the United Nations Intergovernmental Panel on Climate Change released the sixth report in a series on the Physical Science Basis for climate change. Each report in this series, which has been published since 1990, is more sobering (and certain) that extreme climate events are increasing in frequency and severity as a result of human-induced warming. UN Secretary General Antonio Guterres called the report a "code red for humanity." Hundreds of leading climate scientists concluded that "it is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and (biosphere) have occurred." The report goes on to state with high confidence that "evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones (due to humans) has strengthened since the last report, 2013."

Furthermore, carbon dioxide greenhouse gas concentrations (due to humans burning fossil fuels) have never been greater in the past 2 million years; and methane and nitrous oxide greenhouse gasses in over 800,000 years. Multiple lines of scientific evidence tell us that Earth's climate is changing beyond the realm in which human civilization developed during the past 10,000 years, and we have only decades remaining to mitigate and adapt to its effects.

If science informs good policy, then who makes the policies? Decision-makers do that. This past year, between December 1 and 12, diplomats from 197 countries, including 120 heads-of-state, met in Glasgow, Scotland for the 26th Conference of the Parties of the United Nations Framework Convention on Climate Change. Decisions were made that will aid our transition to a low-carbon economy, but progress fell short of ensuring the goals: a 45% decline in human-caused greenhouse gas emissions by 2030 and net-zero emissions in 2050. Science tells us that those goals would limit global warming to about 1.5 °C (2.7 °F), but it will be almost impossible to meet that standard. While the average level of planetary warming is currently 1.1 °C (2.0 °F), it appears that we are following a scenario towards a warming of 2.7 °C (4.9 °F) in coming decades, more than twice what we have experienced so far. At that temperature, the planet would still be habitable, but it would engender more extreme storms, flooding, wildfires, heat waves, ice melt, sea level rise, and perhaps billions of climate refugees.

The stakes are very high. At CGRER, we are dedicated to providing the best scientific information that we possibly can for Iowa, the nation, and the world. In doing so, we bring together natural scientists, socio-economic and behavioral scientists, humanists, and engineers because this challenge requires all disciplines to truly understand how to transform a society from reliance on fossil fuels to renewable and low carbon energy sources while adapting to a climate never before experienced. We believe this challenge is so important that it should be a part of every curriculum of our colleges and universities—every student should be conversant and knowledgeable regarding climate change, which will affect their world for decades to come. We pledge to present faithfully our findings to decision makers, in hopes that wise policies will lead us in adapting and mitigating climate change for future generations.

Jerald L. Schnoor
Gregory R. Carmichael
CGRER Co-Directors

Photo: M. Moye-Rowley

EXECUTIVE COMMITTEE

Kelly Baker
Occupational and Environmental Health
University of Iowa

Rhawn Denniston
Geology
Cornell College

Emily Finzel
Earth and Environmental Sciences
University of Iowa

Gregory LeFevre
Civil and Environmental Engineering
University of Iowa

Louis Licht
Ecolotree, Inc.

Corey Markfort
Civil and Environmental Engineering
University of Iowa

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University of Iowa

Charles Stanier
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University of Iowa

Elizabeth Stone
Chemistry
University of Iowa

ADVISORY BOARD MESSAGE

Nine years ago, when I moved to Iowa and first became involved in addressing climate change, my motivation was simple: I wanted the world my grandchildren will grow up in to be livable.

That's when I began working with Citizens' Climate Lobby (CCL), a grassroots organization that advocates for legislation to put a price on carbon pollution. The more I learned about the issue, the more questions I had. How will we know when the rate of climate change is dire? How will we know which solutions should be pursued? How can we adapt to the changes we are unable to prevent? The answers to these questions lie in the bedrock of scientific research—peer-reviewed research that has the support and freedom to follow wherever the science leads. Without these efforts, we are wandering in the dark.

In 1988, it was James Hansen, a UI alum, who testified before Congress about the effects of human-produced greenhouse gasses on our climate. The following year, with the support of Governor Terry Branstad, a group of UI and ISU professors had the foresight to put in place a global studies center that would support interdisciplinary research on the impacts of environmental change—thus was created The Center for Global and Regional Environmental Research.

My work with CCL requires that I develop relationships with members of Congress. Iowa's Senators and Representatives now appreciate the dangers of the changing climate, though a few years ago some were climate change deniers. In its 2021 report, the Yale Program on Climate Change supports this cultural shift citing that "overall public understanding that climate change is happening, affecting the weather, and harming Americans is at all-time record highs."

These societal shifts, which are critical to an effective cultural response, are primarily the result of the work done by research scientists who, year after year, help us understand what is happening, why it is happening, and what we can do about it. These same scientists go beyond the research to communicate their findings to us, the general public.

The area of research supported by CGRER is broad, as it should be. Digital modeling of sustainability and resilience in cities, studying the unique challenges for off-shore wind turbines, using predator/prey observations to predict climate change, are a few of the endeavors supported by this Center.

We need to understand, adapt, and try to mitigate the unprecedented environmental changes we are experiencing. CGRER makes this happen by facilitating collaboration between university researchers, mentoring young environmental scientists, and helping researchers address the ever-changing array of questions presented by environmental change. CGRER-backed researchers communicate their work to the public through presentations, Iowa Environmental Focus, radio broadcasts and the yearly Iowa Climate Statement. Through CGRER, Iowa's public universities, along with collaborating universities across the state and the country, provide a responsive structure for this vital work.

It is an honor to serve on the Advisory Board for CGRER. Thanks to my association with CGRER, I have learned things I could not have learned anywhere else about environmental issues in Iowa. As we face the narrowing window of time in which we must act (now just a decade or less), we need to consider and understand all options. The work CGRER is doing to help make this happen is now more important than ever.

Peter Rolnick

Emeritus Professor of Physics, Truman State University

Iowa State Coordinator, Citizens' Climate Lobby

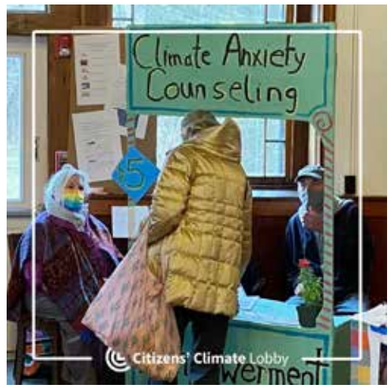


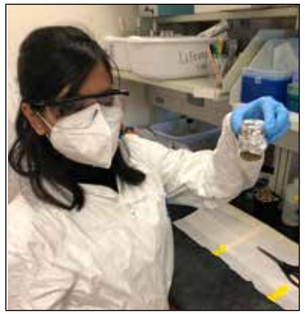
Photo: Citizens' Climate Lobby.

***Steven Hall** studies links between agricultural nitrogen inputs, air pollution, and crop damage. This Iowa crop field is shown with soil gas flux measurement chambers.*

*Kevin Cortes, a PhD student in **Eric Riddell**'s lab, records measurements on a tree swallow to understand how physiological traits influence climate vulnerability.*

The area of research supported by CGRER is broad, as it should be."

-Peter Rolnick



*Sraboni Chowdhury, a PhD student in **Greg LeFevre**'s lab, holds a beaker of newly harvested plant seeds.*

***Rhawn Denniston** uses stalagmites to reconstruct past behavior of monsoon rains in Australia and South Asia. The isotopic chemistry of this Nepalese stalagmite, which grew over the last 2000 years, records Indian summer monsoon variability, including (multi) decadal periods of drought.*

*One of two Doppler wind LiDARs installed on top of the 2.5 MW Clipper wind turbine at Kirkwood Community College in Cedar Rapids, IA. LiDAR stands for Light Detection And Ranging and is an instrument used to remotely measure wind speed up to 3 km ahead of and in the wake of wind turbines. (see page 8). Photo: **Corey Markfort**.*

*Riley Kniptash, an EES student in **Jessica Meyer**'s research group, holds a mixture of pebbles and sand recovered from lake shore drilling. These materials were deposited by the Superior Lobe of the Laurentide ice sheet and are a potential source of iron to the groundwater discharging into the lake (see page 14).*

CGRER

ADVISORY BOARD

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OUTREACH

STRENGTHENING IOWA'S ELECTRIC INFRASTRUCTURE

Climate change is here. In Iowa, we have witnessed more frequent and intense heavy precipitation, floods, droughts, and extreme heat, all of which create conditions that threaten the reliability of Iowa's electric grid. The Iowa Climate Statement 2021: *Strengthening Iowa's Electric Infrastructure* advocates for new investments in our electric systems that will make these resources more reliable and resilient to extreme weather events.

Extreme climate disasters are here to stay. Can we keep the power on?

Last year's powerful August derecho, the most destructive thunderstorm in United States history, knocked out power to more than 500,000 Iowa households for as much as two weeks. "The loss of power left people in the dark without air conditioning, refrigeration, access to food, phone chargers, and life sustaining medical equipment," said **Dave Courard-Hauri**, Chair of Environmental Science and Sustainability Program at Drake University. "This was a potentially deadly combination for many vulnerable and low-income Iowans."

"Iowa's power outages from the 2020 derecho resulted from extreme damage to transmission and distribution systems," said Jim McCalley, Anson Marston Distinguished Professor, Department of Electrical and Computer Engineering, ISU. "Looking forward, smart investments are needed to harden transmission through improved pole and tower structural strength. Hardening distribution by undergrounding can build resilience and reliability to withstand extreme wind and heavy ice loading."

McCalley believes that adding transmission capacity will support the expansion of the utility-scale wind and solar projects that are needed to address Iowa's carbon reduction efforts. Additionally, this investment will pave the way for the expected rise in electric vehicles. McCalley notes that the increase in transmission capacity enhances grid redundancy and helps avoid power generation outages.

"As the country considers infrastructure investments to rebuild our economy, resources directed to electric grid improvements and utility scale renewable energy projects will prepare us for the climate change challenges we are experiencing right now," said **Gene Takle**, Emeritus Professor of Agronomy, ISU. "These investments now will better prepare us for the coming decades when extreme weather events will become costlier, more common and more severe."

"Climate change is powerfully upon us," said **Jerald Schnoor**, CGRER co-director. "Climate action creates jobs, pristine air quality, better health, and a stable system for future generations. To prepare for future Iowa extreme weather events, we recommend that industry, policy makers and stakeholders identify ways to strengthen Iowa's electric infrastructure, protect vulnerable people, and consider enhanced risks from climate change while managing costs."

The eleventh annual Iowa Climate Statement 2021: *Strengthening Iowa's Electric Infrastructure* was endorsed by 223 Iowa science faculty and researchers from 34 Iowa colleges and universities. CGRER has coordinated the release of annual climate statements since 2012. The statements, vetted by Iowa's top experts, place pivotal climate change research into an Iowa-specific context, encourage preparedness and resilience in the face of a climate crisis.

Joe Bolkcom

Director of CGRER Outreach and Community Education

IOWA CLIMATE STATEMENT 2021

Lead authors: **David Courard-Hauri**, Chair of Environmental Science and Sustainability, Drake University; James McCalley, Anson Marston Distinguished Professor, London Chaired Professor of Power Systems Engineering, Department of Electrical and Computer Engineering, ISU; **Jerald Schnoor**, co-director, UI CGRER; and **Gene Takle**, Emeritus Professor of Agronomy, ISU.

Contributors: **Bill Gutowski**, Professor of Meteorology Department of Geological and Atmospheric Sciences, ISU; David Osterberg, Emeritus Professor, College of Public Health, UI; **Ulrike Passe**, Associate Professor of Architecture, Director Center for Building Energy Research, ISU; **Dave Swenson**, Research Scientist III, Department of Economics, ISU; **Eric Tate**, Associate Professor of Geographical and Sustainability Sciences, UI; and **Peter S. Thorne**, Professor and Head, Occupational & Environmental Health, Associate Director, Environmental Health Sciences Research Center College of Public Health, UI.

Photo: Jon Fisher.

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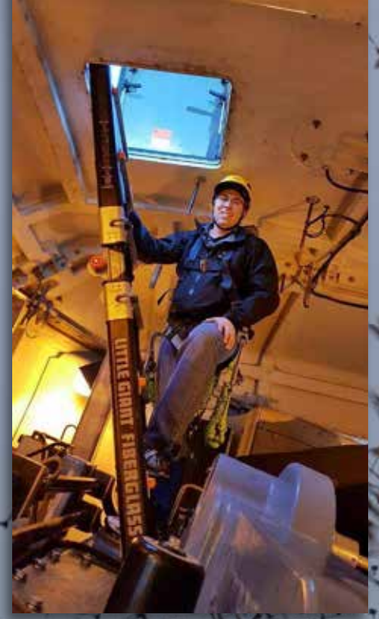
IOWA ENVIRONMENTAL FOCUS

CGRER's blog, Iowa Environmental Focus, features daily environmental news, reports on faculty research, and analysis of leading environmental issues impacting Iowa and the world. The blog is compiled and written by CGRER interns who capture stories, photos, and video pertaining to climate change and relevant environmental topics. In addition to the Iowa Environmental Focus, CGRER engages Iowans through Facebook and Twitter.

CGRER INTERNS

Eleanor Hildebrandt is in her third year at the UI where she is pursuing a BA in Journalism and Mass Communication, a BS in Global Health Studies, as well as a minor in German. Hildebrandt serves as news editor and podcast host for The Daily Iowan. She is the Public Relations Coordinator for *earthwords: the undergraduate literary review* and is Phi Beta Kappa at the UI. After graduation, Hildebrandt plans to pursue a career in journalism with a focus on health, education, and environmental reporting. She hopes to one day become a professor.

Josie Taylor is a third-year UI student working towards a BA in Journalism and Mass Communication as well as a Certificate in Writing. In addition to her responsibilities as intern for CGRER, Taylor writes for *Her Campus* and is a peer mentor for the School of Journalism and Mass Communication. After graduation, Josie hopes to work in public relations.



***Corey Markfort** inside the nacelle of the Clipper 2.5 MW wind turbine at Kirkwood Community College in Cedar Rapids, Iowa. The nacelle is located on top of the tower and contains the generator which connects to the hub of the spinning blades of the turbine.*

OPTIMIZING WIND POWER PLANTS

Alongside his research team, **Corey D. Markfort**, UI Civil and Environmental Engineering, Head of the Environmental Fluid Mechanics and Renewable Engineering Laboratory, is working to optimize the generation of electricity from wind. The results of this work will improve overall renewable energy production for onshore and offshore wind farms and will minimize risk to endangered bats. The research is funded by a CGRER seed grant.

"Our wind energy research is focused on improving descriptions of wind turbine wakes and wind farm-atmosphere interaction. It also develops wake and wind turbine array models that allow us to develop strategies for collective wind farm control to maximize power generation," Markfort said. Wakes, the low-speed wind regions located behind wind turbines, pose a major challenge for producing wind power because they reduce the power that other downwind turbines are able to produce. This causes additional fatigue loads, due to the buffeting of turbulence, that can damage wind turbine components.

"We are working to accurately predict the wakes and develop strategies to control wakes by adjusting the power each turbine generates and even stirring wakes away from downwind turbines by yawing," said Markfort. "By strategically reducing the loads of selected turbines, it may be possible for the overall wind plant to produce more electricity."

Markfort's team is also working to develop strategies for detecting endangered bats that fly near wind turbines. This detection improves turbine operations by avoiding collisions of bats with wind turbine blades. "During periods of bat migration and when wind speeds are below a defined threshold, wind turbines must be shut down to avoid killing bats, even if there are no bats around, just to be safe," Markfort said. "With the ability to accurately detect bats and birds flying near wind turbines, the turbines would only need to be shut down during periods of high risk of collision."

***Jessica Meyer** installs a piezometer in a lakebed. The piezometer is a small diameter well that will provide data to constrain the direction of water flow and the associated iron mass discharge between the lake and the underlying aquifer.*

CGRER SEED GRANTS

In 2021, CGRER awarded a total of $140,257 to five projects.

"Massive-scale discovery of new species in our own backyard: towards improved estimates of the global 'pie of life,'" **Andrew Forbes**, UI Biology, $22,270.

"Using Digital Twins to Make Cities More Sustainable and Resilient," **Joe Gomes**, UI Chemical & Biochemical Engineering; **Gregory Carmichael**, UI College of Engineering, $28,239.

"Effects of Wind-Wave Environment on Power Generation and Wake Aerodynamics for Offshore Wind Energy," **Corey Markfort**, UI IIHR—Hydroscience & Engineering, $30,000.

"Developing an approach for quantifying iron mass fluxes between aquifers and ferruginous lakes to improve constraints on biogeochemical cycling," **Jessica Meyer**, UI Earth and Environmental Sciences, $30,000.

"Linking predators and prey through physiological performance to predict the effects of climate change," **Eric Riddell**, ISU Ecology, Evolution, & Organismal Biology, $29,748.

GRANTS AWARDED TO CGRER MEMBERS

Ibrahim Demir was co-PI on the $750,000 NSF grant "Convergence Accelerator Track E: Linking the Green Economy to the Blue Economy at the Coast" (2021-2022).

Ibrahim Demir was PI on the $504,000 grant "River Morphology Data and Analysis Tools RiverMorph—A web platform for enabling river morphology research" (2020-2023).

Rhawn Denniston was PI on the NSF grant "Collaborative Research: Evaluating the Origins of Multidecadal Variability in Late Holocene Indian Summer Monsoon Rainfall in Nepal" (2021-2024). The total award, shared between Cornell College, University of New Mexico, ISU, and the Woods Hole Oceanographic Institution, was $489,950.

Steven Hall was co-PI on the $650,000 grant "Quantifying the links between agricultural nitrogen inputs, air pollution and crop damage" (2022-2025).

Gregory LeFevre was PI on the $499,950 USDA-NIFA grant "Bioaccessibility of Conjugated Plant Metabolites from Contaminants of Emerging Concern in Recycled Irrigation Water" (2021-2025).

Maurine Neiman was co-PI on a $300,000 grant "Fundação para a Ciência e a Tecnologia (Portugal): GlObal change and BioloGical Invasions: Potamopyrgus antipodarum as a case study (GOBIG)" (2021-2024).

Maurine Neiman was PI on the $25,000 grant from the Office of the Vice President for Research Diversity, Equity, and Inclusion Supplement "A parallel analysis of a snail-vectored trematode parasite" (2022-2023).

Eric Riddell was co-PI on the $976,607 NSF-DEB grant "Hidden dimensions of diversity in woodland salamanders: Investigating ecophysiological evolution in a classic non-adaptive radiation" (2021-2024).

***Greg LeFevre** studies contaminant fate in plants from recycled water increasingly used as an irrigation source in water-stressed regions.*

*Kali Gandaki river valley, central Nepal, near Siddha Baba cave where **Rhawn Denniston**'s group is evaluating the origins of multidecadal variability in late Holocene Indian Summer monsoon rainfall.*

AWARDS, ACHIEVEMENTS, AND APPOINTMENTS

Gregory LeFevre received the 2021 Royal Society of Chemistry 'HOT' article award for exceptionally high peer-review.

Craig Just was awarded $130,000 from Xylem, Inc., to install and assess five SMART Chlorinators in Honduras for drinking water purification in small rural communities.

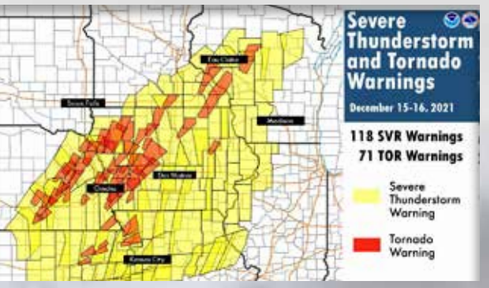
Maurine Neiman received the Iowa Center for Research for Undergraduates Distinguished Mentor Award and was a nominee for the UI's Faculty Communicating Ideas Award. Neiman established the J.J. Neiman-Brown Academic Caretaking Fund, an endowed award created in honor of Neiman's son, which is designed to support child care and other costs related to caregiving for UI tenured, tenure-track, and non-tenure-track faculty and postdoctoral researchers.

Ulrike Passe was promoted to full professor of Architecture at ISU. In October, Passe presented "Assessing a Community-Engaged Decision Framework for Increased Urban Neighborhoods Resilience in a Warming Climate" at the joint Association of Collegiate Schools of Architecture and American Institute of Architects Intersections Online Conference.

Colton Poore, an ISU graduate student studying with **Eric Riddell**, received an Honorable Mention for his Graduate Research Fellowship proposal on relating the thermal physiology of bumble bees to climate vulnerability.

SERIAL DERECHO AND TORNADO OUTBREAK

On December 15, 2021, unseasonably warm, record-setting air and dewpoint temperatures produced unstable conditions in advance of a potent Colorado low-pressure system. Temperatures across the state of Iowa were 30-40 degrees above average which created an explosive spring-like thunderstorm environment. Coupled with very strong gradient winds that produced southwesterly flow in the 40-50 mph range, a squall line developed in eastern Nebraska and propagated into Iowa during the late afternoon and evening hours.



This squall line was classified as a Quasi-Linear Convective System (QLCS) and had unique features known as Line Echo Wave Patterns. These structures are known to produce bows or divots along the length of the QLCS line and are associated with strong to severe thunderstorms. These particular bow echo features, combined with strong ambient flow, produced multiple tornadoes across the northwestern half of Iowa. Non-tornadic wind gusts associated with these thunderstorms were in excess of 80 mph, with 88 mph observed in Audubon (Audubon County). After the QLCS line passed through Iowa, strong gradient winds approaching 70 mph formed on the backside of the low pressure system. The highest non-thunderstorm wind gusts were reported at 83 mph in Decatur City (Decatur County), 81 mph in Marshalltown (Marshall County) and 80 mph in Johnston (Polk County).

As of January 2022, the preliminary tornado count for this event stands at 61, breaking Iowa's all-time highest tornado outbreak of 35 that occurred on August 31, 2014. Twenty-one of the tornadoes produced by the storm were rated EF-2 with peak winds between 111-135 mph. This multi-state tornado outbreak is the highest December outbreak in recorded history. Given the path length of the QLCS system and with wind gusts of 55 mph or greater along a majority of the system path, the December event is classified as the first serial derecho to ever occur in December.

A serial derecho typically occurs in conjunction with a strong and well-organized low pressure system. The 2021 derecho differs from the August 10, 2020, Midwest derecho—the costliest thunderstorm in United States history—which was a "progressive" derecho. Progressive derechos are dominated by self-sustaining thunderstorms that produce down- and microbursts. They generally travel along a west-to-east-oriented surface boundary with strong, unidirectional steering winds. Progressive derechos have a smaller footprint, longer pathlength and typically occur in the summer. Serial derechos have a larger footprint and smaller pathlength. Overall, the 75+ mph wind gust count from the December serial derecho outnumbers those from the August progressive derecho, however, the progressive derecho produced widespread and catastrophic damage.

Justin Glisan
State Climatologist of Iowa

Photo top left: Jared Rowe.
Photo above: Franklin County Emergency Management.
Iowa Tornado photo: Brad Goddard.

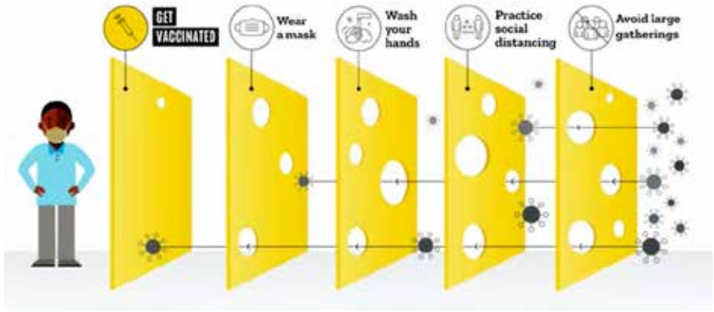
UI EQUIPS RESEARCHERS DURING COVID-19

In the face of an ongoing pandemic, the Office of the Vice President for Research (OVPR) provides support for research faculty and staff, both those who are directly researching COVID-19 and those who are managing non-COVID-related research. In the past two years, the UI has taken deliberate steps campus-wide to reduce the risk of exposure to the COVID-19 virus. They have done so by relying on guidance from the Board of Regents, the State of Iowa, the Iowa and Johnson County departments of public health, the Big Ten Conference, and the Centers for Disease Control and Prevention.

Given the greater public health-related controls and concerns on campus, OVPR has worked closely with the associate deans for research in each college to help researchers manage human-subjects research, secure funding from federal agencies, provide adequate access to shared resources like animal care, and provide opportunities for collaboration and professional growth through programs like the *Communicating Ideas Workshops* and various programs offered by the Research Development Office.

OVPR created a *Responding to COVID-19* website at the start of the pandemic and has continued to update the site to better answer questions and provide resources to research and faculty staff as the public health situation has evolved. "OVPR's work has changed over the past two years as we have learned more about the virus and its variants," said Stephen Pradarelli, OVPR Director of Strategic Communications."We have shifted more confidently to virtual-based forms of engagement such as meetings, trainings, and hosting guest speakers. Researchers themselves have adapted to the 'new normal.' But at the end of the day, while some of the details of course look much different than they did in the first part of 2020, OVPR continues to do what it's always done: help researchers and scholars succeed, provide opportunities for collaborations and training so they can share their stories with the world, and celebrate their successes."

A video on the OVPR website encourages a 'swiss cheese' approach to reducing the risk of exposure to the COVID-19 virus.



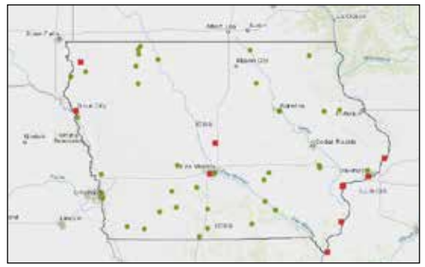
INTERACTIVE MAP IDENTIFIES "FOREVER CHEMICALS" IN WATER

The state has created an interactive map for Iowans to track whether or not their drinking water has detectable amounts of cancer-causing chemicals.

Perfluoroalkyl and polyfluoroalkyl, more commonly known as PFAS or "forever chemicals," are synthetic chemicals known to contaminate water. PFAS can be found in common everyday items such as stain-resistant furniture and non-stick cookware. PFAS are problematic because they pose serious public health and environmental risks. The Environmental Protection Agency, which is in the process of revising its guidance for drinking water contamination, currently advises water utilities that 70 parts per trillion is safe for consumption, however the agency has also suggested that the number should be smaller.

The Iowa Department of Natural Resources tested and treated water sources in 59 Iowa cities for PFAS. The data from this testing has been integrated into the online map. Initially, West Des Moines was the only city to have its water utility shut down when one of its three wells were found to be contaminated.

The map, which continues to be a work in progress as more sites are tested throughout the state, neglects to identify areas where passable-level PFAS were detected in drinking water sources. Iowa City is one such place. The map indicates that no PFAS were detected in the treated drinking water, yet one drinking water source, the Iowa City Sand Pit pond, is recorded as having 2.4 parts per trillion of a PFAS known as perfluorooctane sulfonic acid. The Iowa City Sand Pit pond can account for up to 10% of the city's water supply.



The interactive map can be viewed on the Iowa DNR website.

EDUCATION

UI LAUNCHES CASE COLLOQUIUM

Climate change has a lasting impact on our planet. At the same time, day-to-day weather impacts every aspect of our lives. Climate and atmospheric research are of high interest to fourteen federal funding agencies that are collectively coordinated by the U.S. Global research Program. These topics are also of great interest to many local communities, state governments, NGOs, and private sector stakeholders. There are enormous opportunities for society when it comes to research that can be done on changes to climate and atmospheric systems.

In the spring of 2021, the UI launched a new virtual platform designed specifically to facilitate intellectual exchange related to climate and atmospheric research. The Climate and Atmospheric Science and Engineering (CASE) Colloquium fosters research collaboration and facilitates discussions among researchers both within the UI and outside the Iowa campus through virtual research exchanges that take place once per month via seminar presentations.

The CASE Colloquium is co-sponsored by the Iowa Technology Institute, CGRER, IIHR Hydroscience and Engineering, Environmental Health Sciences Research Center, Iowa Superfund Research Program, UI College of Engineering, UI College of Liberal Arts and Sciences, UI College of Education, UI Tippie College of Business, and the Office of the Vice President for Research. The Colloquium is intentionally designed as a virtual forum in order to save travel costs and mitigate the greenhouse emissions associated with travel.

2021 CASE Colloquium Roster

Jens Redemann
University of Oklahoma
May 21, 2021
Observations of atmospheric aerosol properties and their use to constrain models at various scales.

Larry Di Girolamo
University of Illinois
June 4, 2021
Confronting spatial heterogeneity issues in passive satellite remote sensing of cloud properties.

Ralph Kahn
NASA Goddard
Space Flight Center
July 30, 2021
Desert dust, wildfire smoke, volcanic ash, urban pollution—satellite contributions toward grasping the role particles play in global climate and regional air quality.

Bradley D. Cramer
University of Iowa
August 25, 2021
Nutrients, teratology, and extinction events in the geological record and an introduction to the Ashton Prairie Living Laboratory.

Jun Wang
University of Iowa
October 4, 2021
Environmental sensing from space and in agricultural fields.

V. Faye McNeill
Columbia University
October 12, 2021
Multiphase atmospheric chemistry: from the lab to the atmosphere.

Delphine Farmer
Colorado State University
November 12, 2021
The curious case of the catechol in the night and other atmospheric tales.

UI COLLEGE OF ENGINEERING WEBINAR SERIES

In the fall of 2021, the College of Engineering, in partnership with CGRER and the CASE Colloquium, hosted a series of three webinars focused on climate, extreme weather, and the impacts these forces have on infrastructure and society. Throughout the series, world-renowned scientists explained the latest scientific findings, discussed measures to mitigate the impacts of climate change, suggested ways to adapt to the effects of extreme weather, and generated ideas on engineering infrastructure designed for resilience in the face of change.

Gregory Carmichael & Jerald Schnoor

September 23, 2021
Climate Science Report AR6: What the IPPC's latest climate report says about the changing climate, extreme weather and impacts on natural and engineered systems

Bhupesh Adhikary

October 28, 2021
AR6: Short Lived Climate Forcers in the IPCC Sixth Assessment Report

Gabriele Villarini

December 9, 2021
Iowa's Flood Future

UI ANNOUNCES NEW MS IN SUSTAINABLE DEVELOPMENT

In response to increased student demand for more sustainability and climate action-focused courses, the UI announced a new masters degree designed to train students to become professionals in sustainability. The MS in Sustainable Development is an interdisciplinary graduate program awarded by the graduate college. It will equip students to work in national laboratories, state and federal agencies, policy think tanks, and the private sector.

"There's a growing demand from students on topics like climate change, how to have a lower environmental footprint, or build more sustainably," says **David Cwiertny**, UI Civil and Environmental Engineering. "Many students these days want the work they're doing in graduate school to help improve society. We're giving them that opportunity."

The program is application based. Admitted students will be grouped with 5-10 others in a cohort to complete ten classes rooted in sustainable development, impact, and engagement. Second-year students are given the opportunity to participate in a thesis-based project with local community partners and public organizations. The first cohort will begin in the fall of 2022.

CARBON SEQUESTRATION IN IOWA

Charles Stanier, UI Chemical and Biochemical Engineering and CGRER Research Engineer, served as a task force member for The Iowa Carbon Sequestration Task Force (ICSTF).

Carbon sequestration captures, transports, and stores underground the atmospheric carbon dioxide that is emitted from smokestacks. Sequestering carbon in the soil reduces the amount of CO_2 in the atmosphere. Members of the ICSTF included key stakeholders representing industries and interests integral to the carbon sequestration supply chain in Iowa. The task force brought together two specially convened groups with the goal of exploring carbon sequestration and the opportunities it presents for further economic development in Iowa. The workgroups operated under the vision that Iowa will become the leading state for creating carbon value through agricultural stewardship and energy generation.

The ICSTF was a direct result of the work of the Governor's Economic Recovery Advisory Board. Together, the workgroups provided input, reviewed relevant data and policy assessments, and shaped goals and strategies for Iowa's administration. The proposals brought to the group discussions focused on Iowa's ability to trade carbon credits through Carbon removal (carbon farming and carbon capture) and reduced greenhouse gas emissions (materials conservation and low carbon dioxide equivalent energy). The recommendations made by the task force were included in the final report for the state's efforts on economic growth and sustainability.

Stanier attended four virtual meetings wherein he advocated for transparency in carbon accounting, clear thresholds for projects to receive public funds, a community solar program modeled after Illinois or Minnesota, and for a public commitment by the governor—backed by a numerical target—to reduce greenhouse gas.

"I was not successful at these," Stanier said, "but I'm glad I spoke up. I also argued for a role for all three regent's universities in any future research or research institute, rather than something done by Iowa State only. It remains to be seen how successful I was at that."

Stanier researched the likely impact of a number of the policies pushed by the Carbon Sequestration Task Force, such as CO_2 capture at ethanol plants, as well as the widespread sequestration of carbon in agricultural soils.

The task force's final recommendation noted that while carbon sequestration offers potential economic and environmental benefits, many questions still remain. A state-level task force would provide the opportunity to better understand sequestration's economic value to society and farmers, as well as the short- and long-term agronomic impacts on row crop production in the state.

ASHTON PRAIRIE GROUNDWATER MONITORING NETWORK

The Ashton Research Prairie (ARP) is an intentionally restored prairie and living laboratory on the UI campus.

In 2019, a collaboration between the Office of Sustainability and the Environment, the Environmental Science program, and the Athletic program led to a one-acre Prairie Restoration Project on the grounds of the Ashton Cross-Country Course. In the fall 2020, a six-acre expansion was approved to begin in 2021. The expansion provides an ideal opportunity to deeply embed the site throughout a range of courses and research across multiple units in multiple colleges. A coalition of faculty, researchers, and staff members from 10 units across campus in two colleges have united to turn this accessible and highly visible prairie site into a living laboratory for research and education with instrumentation that spans from the bedrock to the atmosphere.

Group working at the Ashton Research Prairie. Photo: Michael Fallon.

Jessica Meyer, UI Earth and Environmental Science (ESS); Matthew Streeter, UI Assistant Research Scientist, Iowa Geological Survey (IGS); Stephanie Tassier-Surine, UI Research Specialist, IGS; Brennan Slater, UI Intern, IGS; Riley Kniptash, UI Graduate Student, ESS; Thomas Doyle, UI Graduate Student, ESS; and Phil Kerr, UI Research Associate, IGS, devoted much time over the summer and fall of 2021 collecting sediment cores and installing eleven monitoring wells at the ARP to support teaching and undergraduate research.

Two CMT multilevel systems (MLS) have recently been installed on the site as part of the groundwater instrumentation. The installation of the final system is planned for the spring of 2022. Multilevel systems are engineered devices that divide a single borehole into many depth-discrete monitoring intervals. Meyer routinely utilizes MLS's in her research and is excited to introduce UI students to the scientific technology that is frequently used in investigations of contaminated sites.

The groundwater instrumentation at APR is an exceptional resource for faculty and students across campus who are both learning about and researching groundwater flow and contaminant transport problems. The undergraduate and graduate students working with Meyer and her collaborators will be conducting research at the site that is focused on the role of paleosols in water table flow systems and the evolution of groundwater quality underlying land converted to tallgrass prairie.

***Jessica Meyer** checks a monitoring well at the Ashton Research Prairie.*

PLANNED PRAIRIE RECONSTRUCTION

In 2021, the UI will expand the current prairie by six acres using $7,500 in financial support from an EPA Farmer-to-Farmer Cooperative Agreement grant, whose PI is **Craig Just**, UI Engineering and Environmental Science. Just's grant is focused on improvements in water quality, habitat, and environmental education.

FIELD ECOLOGY COURSE AT ASHTON PRAIRIE PROJECT

Neil P. Bernstein, UI Department of Earth and Environmental Sciences, taught a Field Ecology class in the fall of 2021 that conducted two projects on the Ashton Prairie Project. The projects helped elucidate ecological methodology and contributed to long-term monitoring of the site.

Daisy Fleabane

Red Clover

The first project involved establishing a grid system to sample the distribution and dispersion patterns of the more common flowering plants that remained identifiable in the late fall weather. For the purposes of replication, Bernsetin created a GPS location for the sampling and established 1 x 1 m grids in the prairie for a 30 x 30 grid pattern. The class then counted the number of easily identifiable flowering plants in each grid and analyzed the findings in three ways for dispersion patterns (random, uniform, or clustered). They looked specifically at Red Clover (a non-native forb probably established when the area was farmland), Daisy Fleabane (a fairly common prairie forb), and Black-eyed Susan (another common prairie forb). The class found, as expected for dispersion in nature, all the plants were clustered.

The second project involved the Prairie's Cardinal Creek. Students took water samples and measurements of stream flow before and after a rainstorm in order to measure sediment load and fish populations. The class sampled the fish populations in the immediate area of the bridge to establish a baseline of species present and population diversity. Creek Chubs were the most dominant, followed by Green Sunfish, Bluegill, Sand Shiners, Blacknose Dace, and a single largemouth bass. "I was surprised to see the sand shiners and blacknose dace, the latter of which are found in clear water," said Bernstein. "The largemouth bass and sunfish were all small, and they must be swimming upstream from a larger river. We also caught a bullfrog."

Benjamin Swanson, UI Earth and Environmental Sciences, also monitors Cardinal Creek. The fish data collected by Bernstein's Field Ecology course will provide a facet to the water chemistry information that Swanson is gathering. It will also inform the aquatic invertebrate data collected by UI Biology professor **Andrew Forbes**.

Above; Creek Chub, at right top to bottom; Sand Shiner, Blacknose Dace, Green Sunfish. Below; group establishes grid system in the Ashton Prairie. Photo: Michael Fallon.

RESEARCH

IOWA WASTEWATER AND WASTE-TO-ENERGY RESEARCH PROGRAM

Craig Just at the Iowa City Municipal Water Resource Recovery Plant. Photo: IIHR-Hydroscience & Engineering.

Craig Just, UI Civil and Environmental Engineering, was awarded a five-year, $4 million Iowa Economic Development Authority grant to catalyze the Iowa Wastewater and Waste-to-Energy Research Program (IWWERP). IWWERP will provide real-world, pilot-scale data that can be applied by technology developers, the industry, and Iowa's Department of Natural Resources to advance the state's ability to treat waste, generate renewable energy, protect the environment, and develop the state's economy.

The grant will be used to build and install instrumentation at the IWWERP Tech Park located at the Iowa City Municipal Water Resource Recovery Plant. One component of the IWWERP Tech Park is a 2,200 square-foot greenhouse equipped with four commercial scale revolving algal biofilm (RAB) systems, installed in distinct wastewater reservoirs, continuously dosed with high-nutrient anaerobic digester supernatant that can be diluted with treated effluent to produce feedwaters of various concentration.

The proposed Iowa Wastewater and Waste-to-Energy Research Program aims to save Iowans over $100 million in wastewater upgrade costs.

"The IWWERP will apply the most advanced science and engineering research to create practical solutions to municipal wastewater and industrial waste-to-energy challenges in Iowa," said Just. "It will feature a Tech Park on the grounds of the municipal water resource recovery facility in Iowa City. This strategic location provides access to a continuous supply of raw and partially treated wastewater to feed multiple pilot-scale systems."

This unique combination of new and existing infrastructure will support private technology developers that currently assume all the risk and expense required to bring innovative treatment solutions to market in Iowa.

The IWWERP laboratories will also house pilot-scale anaerobic digesters to support industrial and municipal entities that increasingly meet their high strength organic waste disposal needs through waste-to-energy partnerships that benefit and diversify Iowa's economy. "The overall goal of the IWWERP is to accelerate the availability of robust, affordable, and profitable wastewater treatment and waste-to-energy solutions for Iowans," said Just.

The IWWERP Tech Park will allow researchers to develop and test new technologies in partnership with commercial vendors while trying out new ideas in a real-world water resource recovery facility environment. The use of advanced scientific processes and engineering will equip stakeholders to better serve the unique needs of each community, business, or industry.

The IWWERP works closely with the Iowa DNR to monitor research results from new treatment options tested by the IWWERP and approve their use in Iowa as appropriate. The IWWERP will also collaborate with the Iowa Water Environment Association "small community" committee. The small community committee is led by consulting engineers who know how to work with Iowa communities.

DENNISTON RECEIVES UNDERGRADUATE RESEARCH MENTOR AWARD

William Harmon Norton Professor of Geology at Cornell College and CGRER member **Rhawn Denniston** received the 2021 Undergraduate Research Mentor Award which was awarded by the Geosciences Division of the Council on Undergraduate Research. Denniston accepted the award at the October annual meeting of the Geological Society of America.

The award was established to recognize the importance of undergraduate research and celebrates those who support and mentor students. Denniston began his teaching career at Cornell College in 2000 and has since mentored more than 50 undergraduate students across the majors of geology, environmental studies, and archeology.

Right; Rhawn Denniston studying past climate variability in the Australian tropics.

EMILY SCHMITZ WINS 3MT COMPETITION

Emily Schmitz, PhD candidate in Civil and Environmental Engineering, won the UI Graduate College's annual *Three Minute Thesis* (3MT) competition. Schmitz was awarded $500 for the grand prize and an additional $250 for being selected as People's Choice.

The 3MT competition equips graduate students to clearly and concisely articulate their research to non-experts in three minutes or less. Though typically held before a live audience, the competition has shifted online due to the pandemic.

"I see my future career aspirations aligned with science communication," Schmitz said. "The 3MT process provided a wonderful opportunity for me to practice communicating my research in a more digestible form without all of the jargon." To underscore this point, Schmitz added, "an added bonus of the 3MT competition is that my grandma finally understands what I am doing in grad school and has more hope that someday I will get a job."

The competition provided Schmitz an opportunity to share what she loves: her research. "I am slightly obsessed with bacteria and truly think they are the coolest," Schmitz said. "Bacteria serve such vital roles in our day to day lives ranging from impacting our climate to keeping us happy and healthy. Did you know that the bacteria in your stomach are responsible for producing over 90% of your body's supply of serotonin, the chemical responsible for making you feel happy? That's so cool! They are truly the invisible workforce that keep the world operating as it does. I am always excited to learn more about them; specifically, how to harness their power to better the world in which we live."

Schmitz was first introduced to bioremediation, a strategy that uses microbes to clean up pollution in the environment, during her freshman year. The course sparked her interest and led her to pursue her PhD in the very same field. Schmitz currently studies how to use bioremediation to treat nitrate, methane, and nitrous oxide pollution from agricultural sources.

"Environments and ecosystems can act like self-cleaning ovens. We engineers and scientists just need to figure out what buttons to press and provide the time for nature to run its course. In my case, the button is M. Oxyfera, a unique bacterium that feeds on nitrite and methane without creating the potent greenhouse gas nitrous oxide. Through my research, I have shown that these bacteria are already present in Iowa soils. My next step is to figure out where and under what conditions these bacteria are most abundant and thriving. This will enable us to engineer strategies and best practices on farms using these bacteria to minimize pollutants in the soil and air."

Emily Schmitz

Studying microbes in the environment can be tricky since their abundance, diversity, and interactions with other microbes make measuring their impacts difficult. Which is all the more reason why Schmitz is grateful for the support she has received during graduate school. "My department does a really great job supporting a holistic approach to environmental engineering and supporting opportunities where we can practice communicating our science. In this way, we can grow into effective environmental engineers in the future."

"Grad school is incredibly challenging and sometimes you get bogged down in the details and forget the big picture," Schmitz said. "The 3MT competition reminded me of why my research is important and why I enjoy doing what I do."

Emily Schmitz takes a soil sample from the Johnson County Historic Poor Farm for her research.

JUMPSTARTING TOMORROW

Two CGRER members have been awarded research funding as part of the *Jumpstarting Tomorrow* initiative. *Jumpstarting Tomorrow* is a hybrid pilot grant and community-building program launched by the UI Research Development Office within the UI Office of the Vice President for Research that is designed to support innovative and collaborative research. Funds were awarded to applicants that presented interdisciplinary projects where research was driven by specific and compelling problems.

Combating Harmful Algal Blooms

Corey D. Markfort, UI Civil and Environmental Engineering, and Head of the Environmental Fluid Mechanics and Renewable Energy (EFRE) Laboratory at IIHR-Hydroscience & Engineering, was awarded funding for a *Jumpstarting Tomorrow* project titled "Iowa Healthy Lakes Initiative: A multi-dimensional approach to measuring, informing, and solving Iowa's Harmful Algal Bloom Challenge."

Markfort's research focuses on improving measurement and prediction of environmental systems, specifically those related to complex environmental turbulence. These findings are applied to environmental boundary layers, wind power generation, and environmental hazards such as blowing and drifting snow and harmful algal blooms in lakes.

"The goal of this research is to develop a framework for detecting and predicting toxic harmful algal blooms in Iowa lakes and to develop strategies for communicating health risks with the public and for mitigation for lake management authorities," Markfort said. "Harmful algal bloom events are happening more frequently and are more severe in recent years, as highlighted by bloom events in Lake Erie where in the city of Toledo, Ohio, the drinking water system has been shut down on several occasions."

To counter this problem, Markfort, **Gregory LeFevre**, and graduate student Sarah Douglas Greene proposed a strategy for monitoring CyanoHABs using low-cost unpiloted aerial vehicles (UAS). UAS's, commonly known as drones, are equipped with multispectral cameras that can detect algal blooms.

"Another aspect of our research was to evaluate a strategy to determine the health risk of toxins produced by harmful algal blooms. Due to their ephemeral and highly dynamic nature, as well as their associated health risk, there is a need to improve monitoring approaches," Markfort said. "Drones fill a critical gap to characterize spatial distributions of harmful algal blooms formation that occur in small midwestern lakes that otherwise cannot be detected by satellites or weekly sampling conducted at swimming beaches."

Many of the project's PI's and collaborators are connected to CGRER including: Susan Meerdink, UI Geography and Sustainability Sciences; Elise Pizzi, UI Political Science; Xun Zhou, UI Business Analytics; **Peter Thorne**, UI Occupational and Environmental Health; Kylah Hedding, UI Journalism and Mass Communication; **Marc Linderman**, UI Geography and Sustainability Sciences; **Charles Stanier**, UI Chemical and Biochemical Engineering; **Elizabeth Stone**, UI Chemistry; and **Mary Skopec**, ED, Lakeside Laboratory.

Decarb Iowa 2040

Charles Stanier, UI Chemical and Biochemical Engineering, was awarded *Jumpstarting Tomorrow* funding for the project "Decarb 2040—Positioning Iowa as an Energy Exporter in the Coming Era of Deep Decarbonization."

The project seeks to create carbon-free energy infrastructure that will combat the anticipated large-scale negative impacts of climate change. Iowa's abundant wind, bioenergy and solar resources make it a strong contender in the emerging green energy landscape. By 2040, Iowa can become a net exporter of energy.

According to Stainer, achieving net export status will bring energy independence to Iowa and will attract industries supplying and demanding clean energy. To achieve this, Iowa needs to accelerate research, development, and adoption of low-carbon energy production and storage methods. These technical elements must be coordinated with workforce development, innovation ecosystem, and public policy.

By combining their expertise in engineering, data science, public policy, environmental science, and business, the research team will investigate how Iowa can become a net exporter of energy by 2040. "Iowa's abundant wind, bioenergy and solar resources make it a strong player in the emerging green energy landscape," said Stanier, the project's principal investigator. The project team includes Jerry Anthony, UI Urban and Regional Planning; **Marc Linderman**, UI Geography and Sustainability Sciences; and Wei Li, UI Finance. The project will incorporate partner organizations from the state and local government, energy companies, agriculture stakeholders, and several UI departments.

P3 GRANT AWARDS $3.6 MILLION TO SPACE-BASED INTERDISCIPLINARY RESEARCH

Seven interdisciplinary projects were awarded more than $12 million in 2021, year one of the UI's public-private partnership (P3) program.

One of the selected projects, *Extending Iowa's Success in Space-Based Research Across Campus*, is led by Philip Kaaret, professor and department chair, Physics and Astronomy, and by **Jun Wang**, James E. Ashton professor of Engineering. Kaaret and Wang are co-principal investigators for the project with Wang serving as the project's Earth-observing mission lead.

Extending Iowa's Success in Space-Based Research Across Campus builds on the UI's success in space-based research by drawing on the expertise of faculty across multiple departments to create an interdisciplinary research enterprise. The project will strengthen the UI's ability to successfully compete for NASA funding for space missions and instruments. It also includes a space instrumentation summer program that will position the UI as the destination of choice for students interested in space research.

The project was approved for funding totaling $3,595,237 over three years and is the collaborative effort of a 12-member research team that brings together expertise in physics, astronomy, geographical and sustainability sciences, chemical engineering, industrial engineering, computer and electrical engineering, and geochemistry. Two faculty, in the Department of Chemical and Biochemical Engineering and the Department of Earth and Environmental Sciences, are expected to be hired for the project.

Joining Kaaret and Wang on the project are Thomas (Mach) Schnell, Industrial and Systems Engineering; Craig Kletzing, Physics and Astronomy; Jasper Halekas, Physics and Astronomy; Casey DeRoo, Physics and Astronomy; Allison Jaynes, Physics and Astronomy; David Miles, Physics and Astronomy; **David W. Peate**, Earth and Environmental Sciences; **Marc Linderman**, Geographical and Sustainability Sciences; **Susan Meerdink**, Geographical and Sustainability Sciences; **Ananya Sen Gupta**, Electrical and Computer Engineering.

CGRER INVESTS IN HIGH PERFORMANCE STORAGE SERVER

CGRER provides high-performance computing resources that support the interdisciplinary research of its members and their students. The research computing power focuses on a shared high-performance computing cluster capable of delivering extensive resources and software in a parallel computing environment. This computing cluster, known as Argon, is located at the Information Technology Facility at the UI's Oakdale campus.

CGRER is an investor in the Argon cluster. This resource provides researchers with dedicated resources when conducting research and analysis. The Argon cluster continually evolves and includes graphical processing units, built-in machine learning, and artificial intelligence capabilities. CGRER implemented a 400-terabyte high-performance storage server in 2021 to use in conjunction with the computer cluster, ensuring CGRER researchers access to vast amounts of data storage space in the years to come.

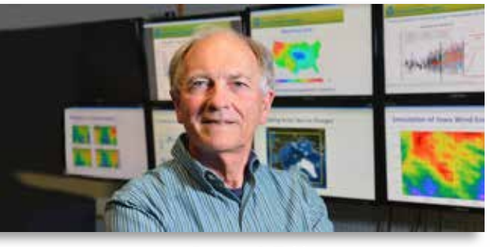
The UI has transitioned to an ArcGIS Online license for Environmental Systems Research Institute products. CGRER is a part of a coordinated campus support system. **Jeremie Moen** is a member of the campus GIS Technical Advisory Committee and facilitates requests for support of ArcGIS Online.

The Argon Computing Cluster on the UI campus. Photo: Ben Rogers.

MEMBER SPOTLIGHT:

EUGENE TAKLE: 3 DECADES OF CALLING ATTENTION TO CLIMATE CHANGE IN IOWA

It was 1988 and I was in the library at the Wind, Energy and Atmospheric Physics Department at Risø National Laboratory in Roskilde, Denmark. I picked up the latest copy of *Science* where I read about James Hansen's recent testimony before the US Senate. In his testimony, Hansen, who worked for NASA Goddard Institute for Space Studies (GISS), warned that increases in atmospheric carbon dioxide were likely to have major impacts on the Earth's climate.



Eugene S. Takle

At the time, I was in Denmark collaborating with meteorologists on numerically modeling the atmospheric boundary layer. Though I wasn't studying climate change, the article caught my eye for two reasons: I knew Dr. Hansen was a native Iowan with a physics degree from University of Iowa, and, having spent the summer of 1966 in New York in a special program on space physics, I was aware of the scientific culture and prestige of GISS. By the end of the day, I was convinced I somehow had to become part of the climate-change research community.

When I returned to Ames, I was able to obtain output from Hansen's latest GISS model and in 1991, with the help of a very talented graduate student, Shiyuan Zhong (who is now a professor of Geography at Michigan State), published an article in the *Journal of the Iowa Academy of Science*. This was the first published paper reporting numerical model results providing a scenario (a doubling of atmospheric carbon dioxide) for Iowa's future climate.

My climate change-based interactions with UI faculty began in the early nineties when CGRER was launched. During that time, statewide conferences on midwest climate change were organized by UI faculty and held at the Iowa Memorial Union. These conferences brought together faculty from colleges and universities across the state. The second of these conferences included a poster session from which short papers were compiled and published, including, most notably, *Preparing for Global Change: A Midwestern Perspective* which was edited by **Gregory Carmichael**, G. Edgar Folk, and **Jerald Schnoor.** This, to my knowledge, was the first statewide publication calling attention to the potential impacts of climate change on a wide range of environmental factors in Iowa.

Many collaborations brought ISU climate modelers, agriculturists, and natural resource scientists together with hydrologists, and civil and environmental engineers from UI. One such collaboration, requested by the Iowa DOT, launched a federally funded pilot study. The triangulated team used current and future climate scenarios for Iowa to provide input for the IDOT construction design software that is used to evaluate the impact of Iowa's climate trend toward increased flooding on bridge design. The team concluded that the previously used once-in-100-year flood scenario occurence from Iowa's past climate would need to be adapted to a once-in-25-year occurrence for the Cedar River at Highway 30 west of Cedar Rapids in Iowa's projected future climate. This project underscored the need to consider future climate information when designing infrastructure that is expected to last several decades. It also demonstrated the effective use of complementary expertise at three Iowa state institutions to advise our government in wise use of taxpayers' dollars.

As current observations have made climate change more evident and more sobering, so too has the scope of scientific attention within the state increased. Implemented by CGRER over ten years ago, a self-organized group of scientists from the Iowa's universities annually assembles to choose and expand on an example where climate change is or will be affecting Iowans. The annual Iowa Climate Statements are circulated to science teachers and researchers at Iowa's institutions of higher education for their input. Scientists and teachers are invited to endorse the statement and voice their concern about climate change in Iowa. Recent statements have drawn more than 200 signatures from statewide colleges and universities.

My Risø library epiphany, triggered by the Hansen testimony, was not my first awareness of climate-change science, but rather a realization of the profound impact this area of science would have on society. My own delay in coming to this realization has helped me to be patient with those who have yet to come to this understanding.

Eugene S. Takle
Emeritus Professor of Agronomy, ISU

A SAMPLING OF PUBLICATIONS BY CGRER MEMBERS

Sit, M., R.J. Langel, D. Thompson, **D.M. Cwiertny**, and **I. Demir**. "Web-based Data Analytics Framework for Well Forecasting and Groundwater Quality." *Science of The Total Environment*, doi:10.1016/j.scitotenv.2020.144121.

Zhang, J., Y. Zhang, G. Sun, C. Song, **M.P. Dannenberg**, J. Li, N. Liu, K. Zhang, and Q. Zhang. "Vegetation greening significantly reduced the capacity of water supply to China's South-North Water Diversion Project." *Hydrology and Earth System Sciences*, doi:10.5194/hess-25-5623-2021.

Zhang, Y., C. Song, T. Hwang, K. Novick, J. Coulston, J. Vose, **M.P. Dannenberg**, C. Hakkenberg, J. Mao, and C. Woodcock. "Land cover change-induced decline in terrestrial gross primary production over the conterminous United States from 2001 to 2016." *Agricultural and Forest Meteorology*, doi:10.1016/j.agrformet.2021.108609.

Sermet, Y. and **I. Demir**. "A Semantic Web Framework for Automated Smart Assistants: A Case Study for Public Health. Big Data and Cognitive Computing." *Knowledge Modeling and Learning through Cognitive Networks*, doi:10.3390/bdcc5040057.

Alabbad, Y., J. Mount, A.M. Campbell, and **I. Demir**. "Assessment of transportation system disruption and accessibility to critical amenities during flooding: Iowa case study." *Science of The Total Environment*, doi:10.1016/j.scitotenv.2021.148476.

Teague, A., Y. Sermet, **I. Demir**, and **M. Muste**. "A Collaborative Serious Game for Water Resources Planning and Hazard Mitigation." *International Journal of Disaster Risk Reduction*, doi:10.1016/j.ijdrr.2020.101977.

Collins, M., R. Knutti, J.M. Arblaster, J.L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, **W.J. Gutowski**, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver, and M. Wehner. "Long-term Climate Change: Projections, Commitments and Irreversibility." *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, doi:10.1017/CBO9781107415324.024.

Lawrence, N., C. Tenesaca, A. VanLoocke, and **S. Hall**. "Nitrous oxide emissions from agricultural soils challenge climate sustainability in the US Corn Belt." *Proceedings of the National Academy of Sciences of the United States of America*, doi:10.1073/pnas.2112108118.

Douglas Greene, S.B., **G.H. LeFevre**, and **C.D. Markfort**. "Improving the Spatial and Temporal Monitoring of Cyanotoxins in Iowa Lakes Using a Multiscale and Multi-Modal Monitoring Approach." *Science of the Total Environment*, doi:10.1016/j.scitotenv.2020.143327.

Zhi, H., A.L. Mianecki, D.W. Kolpin, R.D. Klaper, L.R. Iwanowicz, and **G.H. LeFevre**. "Tandem Field and Laboratory Approaches to Quantify Attenuation Mechanisms of Pharmaceutical and Pharmaceutical Transformation Products in a Wastewater Effluent-Dominated Stream." *Water Research*, doi:10.1016/j.watres.2021.117537.

McFadden, M.E., E.V. Patterson, K.P. Reber, I.W. Gilbert, J.D. Sivey, **G.H. LeFevre**, and **D.M. Cwiertny**. "Acid- and Base-Mediated Hydrolysis of Dichloroacetamide Herbicide Safeners." *Environmental Science and Technology*, doi:10.1021/acs.est.1c05958.

Woodell, J.D., **M. Neiman**, and E.P. Levri. "Matching a snail's pace: Successful use of environmental DNA techniques to detect early stages of invasion by the destructive New Zealand mud snail." *Biological Invasions*, doi:10.1007/s10530-021-02576-7.

Matoo, O., and **M. Neiman**. "Bringing disciplines and people together to characterize the plastic and genetic responses of mollusks to environmental change." *Integrative and Comparative Biology*, doi:10.1093/icb/icab186.

Xu, F., S. Xu, **U. Passe**, and B. Ganapathysubramanian. "Computational study of natural ventilation in a sustainable building with complex geometry." *Sustainable Energy Technologies and Assessments*, doi:10.1016/j.seta.2021.101153.

Fagbule, O., R. Patel, **U. Passe**, and **J. Thompson**. "Utilizing a novel mobile diagnostics lab to validate the impact of vegetative wall coverings in building cooling load reduction." *Journal of Physics*, doi:10.1088/1742-6596/2069/1/012126.

Beissinger, S.R. and **E.A. Riddell**. "Why are species' traits weak predictors of range shifts?" *Annual Reviews of Ecology, Evolution, and Systematics*, doi:10.1146/annurev-ecolsys-012021-092849.

Riddell, E.A., K. Iknayan, L. Hargrove, S. Tremor, J.L. Patton, R. Ramirez, B.O. Wolf, & S.R. Beissinger. "Exposure to climate change drives stability or collapse of desert mammal and bird communities." *Science*, doi:10.1126/science.abd4605.

Thompson, J., B. Ganapathysubramanian, W. Chen, M. Dorneich, P. Gassman, C. Krejci, M. Liebman, A. Nair, **U. Passe**, N. Schwab, K. Rosentrater, T. Stone, Y. Wang, and Y. Zhou. "Iowa UrbanFEWS: Integrating social and biophysical models for exploration of urban food, energy, and water systems." *Frontiers in Big Data*, doi:10.3389/fdata.2021.662186.

Stone, T., **J. Thompson**, K. Rosentrater, and A. Nair. "A life cycle assessment approach for vegetables in large-, mid- and small-scale food systems in the Midwest US." *Sustainability*, doi:10.3390/su132011368.

Song, R. and **D.L. Zimmerman**. "Modeling spatial correlation that grows on trees,with a stream network application." *Spatial Statistics*, doi:10.1016/j.spasta.2021.100536.

NEW MEMBERS

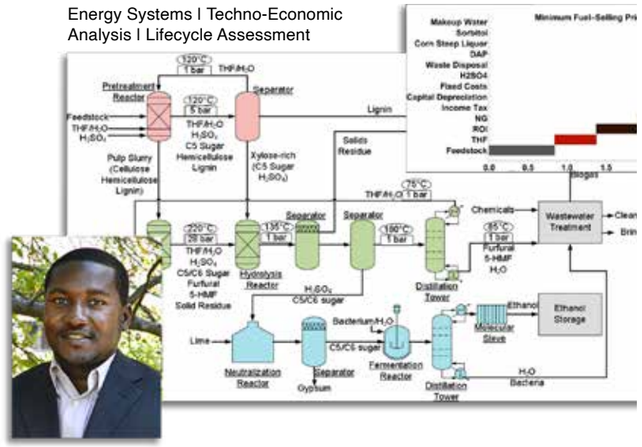
Matthew G. Hill is an Associate Professor of Anthropology at ISU. Hill works at the intersection of archeology, vertebrate paleontology, and ecology to profile the diet and mobility of prehistoric hunters and gatherers in the Midcontinent. Specifically, he is an archeologist specializing in vertebrate remains from archeological and paleontological contexts. Current projects focus on the initial colonization of the region, as well as the timing, causes, and consequences of late Pleistocene megafaunal die-offs.

Eric Riddell is an assistant professor of Ecology, Evolutionary, and Organismal Biology at ISU. His research focuses on understanding the physiological mechanisms that shape the fundamental niche and species diversification. Riddell combines laboratory experiments with computer simulations to understand how physiological traits contribute to climate-driven extinction risk in terrestrial animals, such as salamanders and birds.

*New CGRER member **Eric Riddell** studies woodland salamaders.*

*New CGRER member **Lu Liu**, second from the left, with her research group at ISU.*

Lu Liu is an Assistant Professor in Civil, Construction, and Environmental Engineering at ISU. Satisfying the demand for water, energy, and food under changing environment and socioeconomics is a central challenge of the 21st century. Lu's research seeks to fill important knowledge gaps in water-energy-food-climate nexus and support sustainable resource planning via decision-making tool development and science-policy integration. Lu is a determined optimist in the sustainable development of human society and seeks active engagement of private and public entities in academic activities towards this goal.



Mark Mba Wright is an associate professor of Mechanical Engineering at ISU. His current research interests are in carbon negative energy technologies and their ability to utilize bio- and fossil-based carbon for fuel and chemical synthesis. Wright's research has been sponsored by Advanced Research Projects Agency – Energy, National Science Foundation, and other federal and private agencies. Wright's broader impact activities include serving as a member of the ISU George Washington Carver Faculty Council and as vice-president of the American Institute of Chemical Engineers Sustainable Energy Forum.

WHERE ARE THEY NOW?

The Lasting Impact of CGRER

Bhupesh Adhikary was born and raised in Kathmandu Nepal. He received a BA in Economics from the College of Wooster, OH and BS in Chemical Engineering from the UI. While at the UI, Adhikary was exposed to the world or air quality modeling through CGRER where he worked as an undergraduate research assistant with **Gregory Carmichael**. As an undergraduate, he assisted with the preprocessing and post-processing of air quality data, running of numerical models and the post-analysis interpretation and data visualization. After graduating, Adhikary worked with several US-based companies before returning to work in Nepal.

Adhikary came back to Iowa to pursue a PhD in air quality modeling. His familiarity with CGRER, the UI, and his modeling work experience afforded him the opportunity to work on several international projects such as the NASA-led ICARTT (2004), INTEX-B (2006), ARCTAS (2008), CARB missions (2008), UNEP-led ABC project (2004-2008) and NCAR-NOAA-led PACDEX mission (2007). In 2008, he received first place at the American Institute of Chemical Engineers Environmental Division-National Graduate Student Paper Competition.

After completing his PhD, Adhikary returned to Nepal and joined Kathmandu University as an assistant professor. At the time, there were no academic programs in atmospheric sciences or chemical engineering in Nepal. Adhikary advocated for research and training and helped to establish a chemical engineering degree program. Nepal now has two universities with undergraduate degrees in chemical engineering.

Strong research interest led Adhikary to join the Stations at High Altitude for Research on Environment run by EvK2CNR Committee out of Italy. The project operated an atmospheric station at the base camp of Mt. Everest and later an urban air quality station in the heart of Kathmandu city. As the resident scientific coordinator, Adhikary's work focused on promoting the scientific activities related to EvK2CNR work in Nepal. With the EvK2CNR committee, Adhikary established a numerical modeling center and the urban air quality station in Kathmandu.

In 2014, Adhikary moved to the International Center for Integrated Mountain Development (ICIMOD), a regional intergovernmental knowledge organization, serving eight member countries ranging from Afghanistan, Pakistan, India, China, Nepal, Bhutan, Bangladesh and Myanmar. The Atmosphere Program at ICIMOD looks at air pollution climate issues from a developmental lens. Adhikary's work extends beyond the scientific processes and technological solutions to air quality issues and into the socioeconomic, gender, and

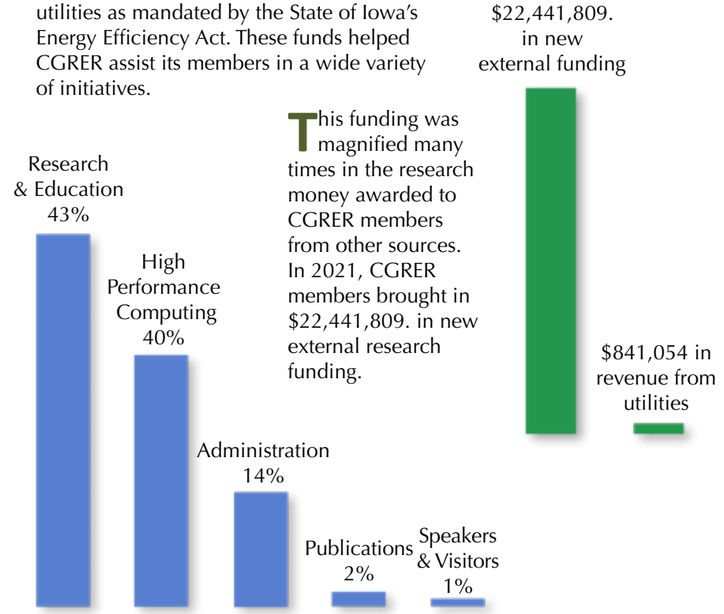
Bhupesh Adhikary

human drivers related to air pollution. At ICIMOD, Adhikary advances the science of air pollution through international scientific publications while also contributing significant time to policy analysis and supporting ICIMOD member governments to monitoring and mitigation action plans.

Adhikary is involved in capacity building activities through mentoring of PhD fellows, formal job training, and outreach to journalists and stakeholders. He recently completed an assignment with the Intergovernmental Panel on Climate Change where he was the lead author of the Working Group I contributions to the Sixth Assessment Report on Short Lived Climate Forcers. He also contributed to the Technical Summary for Policy Makers and a cross chapter box on Climate Change over Hindu Kush Himalaya of the AR6 report. Adhikary is pleased to be able to contribute to local, regional, national, and even global science policy practice stationed out of one of the least developed countries of the world. He greatly appreciates the training and opportunities he received from the UI, Chemical Engineering Department, CGRER and Professor Carmichael.

BUDGET & FUNDING

In 2021, CGRER received $841,054 in revenue from the rate-payers of Iowa utilities as mandated by the State of Iowa's Energy Efficiency Act. These funds helped CGRER assist its members in a wide variety of initiatives.



This funding was magnified many times in the research money awarded to CGRER members from other sources. In 2021, CGRER members brought in $22,441,809. in new external research funding.

CGRER ADMINISTRATION

Joe Bolkcom, Jerry Schnoor, Jeremie Moen, Amy Parker and Greg Carmichael.

CGRER is directed by UI's **Gregory Carmichael**, professor of Chemical and Biochemical Engineering, and **Jerald Schnoor**, professor of Civil and Environmental Engineering. Center activities are guided by Carmichael and Schnoor along with an elected Executive Committee that consists of 10 members (page 3). The Executive Committee meets monthly as needed to plan initiatives and chart CGRER's course. An Advisory Board of 10 members (page 5) from outside the academic community meets annually to lend oversight to CGRER's activities.

CGRER employs two full-time staff members. **Amy Parker** is Research Support Coordinator. **Jeremie Moen** manages the computer facilities with the support of Engineering Computer Services. In addition, **Joe Bolkcom** serves as half-time Director of Outreach and Community Education. CGRER reports directly to the UI Vice President for Research.

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THE CENTER FOR GLOBAL & REGIONAL ENVIRONMENTAL RESEARCH

CGRER

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