I O W A WATCH

THE CENTER FOR GLOBAL AND REGIONAL ENVIRONMENTAL RESEARCH

FALL 2001

"Dust: the particles into which something disintegrates."

So Webster defines the infinitesimal bits of matter, seen and unseen, that float through the air we breathe, enter our body's pores, and cover our possessions.

This issue of *IoWatch* focuses on the great significance of small particles.

Dust Motes

Dust emanates from everything: soil, skin and hair, bark and leaf, rock. All things become dust, and much of life is defined by dust. Dust is the primordial ingredient of planetary systems, including our own. Carried by the wind and deposited by water, dust forms the landscapes that give shape to our world and then commands their plant cover. Atmospheric dust modifies our climate. Light scattered off of dust colors the sky blue and reddens our sunsets. Dust - particulates that define the making and unmaking of our planet - shapes where and how we live and, more often than we realize, determines where and how we die. And, for a number of CGRER members, dust has become the focal point of intellectual exercise.

"Call me Mr. Dust," laughs UI geologist Art Bettis as he proceeds to explain his efforts to determine the accumulation rate of loess (wind-deposited silt) deposits of the last glacial period. "Because of glacial and periglacial baring of the soil, these were the dustiest periods we've seen in quite a while," he explains, stating that dust could have either decreased or increased global temperatures, depending on whether atmospheric dust shaded the earth or heat-absorbing dust layers coated the glaciers. Bettis's National Science Foundation (NSF) and U.S. Geological Survey-funded studies of North American dust deposits will feed into "DIRTMAP," a worldwide effort to fill the knowledge gap concerning the radiative influence of dust fluxes on global climate. Knowledge of dust's impact on past climates will allow validation of numerical models that predict future global climates. As a counterbalance to this broad DIRTMAP survey, Bettis is performing a detailed chronological analysis of two loess deposits in Nebraska that span the last 200,000 years.

(continued next page)

Dust Motes

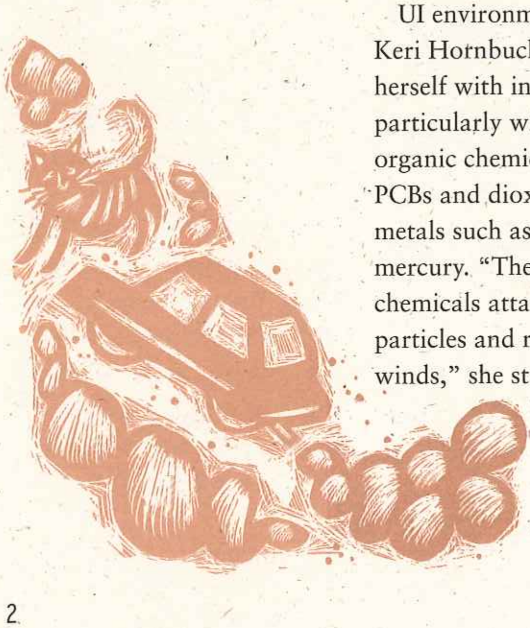
Keri Hornbuckle's student Dave Wethington, stationed on a Milwaukee rooftop, measures airborne particles and persistent organic pollutants that may originate in urban areas, blow eastward, and be deposited in Lake Michigan.

The Burgeoning Cloud

For the vast majority of Earth's history, dust consisted mostly of particles of the sort that Bettis investigates: the soil and mineral particles that were deposited by water, blown into the air, or shot skyward by volcanoes.

Add humans to the scene and the amount of dust increased - first because of people trekking trails or lighting smoky fires, then through agriculturalists opening vast areas of soil and sand to the wind. The Industrial Revolution encouraged the movement and breakdown of earth and rock into dust and fabricated a continuous stream of new products that were emitted as particulates into air, soil, and water. In the past 200 years, dust became ever more abundant and diversified, encompassing countless synthetic chemicals and industrial waste products as well as substances such as pesticides and radioactive particles.

UI environmental engineer Keri Hornbuckle concerns herself with industrial dusts - particularly with volatile organic chemicals (such as PCBs and dioxins) and metals such as lead and mercury. "These toxic chemicals attach to dust particles and ride the winds," she states, and thus they are carried far from their sites of release. Hornbuckle's ongoing research, funded by the Environmental Protection Agency, investigates their eventual deposition in Lake Michigan, where they enter fish and contaminate the food chain. Such dust-borne chemicals are known to cause a variety of human health hazards, ranging from hormonal disruption to neurological damage. Hornbuckle has determined that Chicago is a very large source of contaminated particles that end up in Lake Michigan, but that windborne trace gases (such as volatilized mercury, dioxins, PCBs, and the like) are even larger atmospheric sources of pollutants. Regional background concentrations of these trace gases dominate the overall inputs to the Great Lakes, and probably also to smaller water bodies across the country.



Defining the Small

Our definition of dust has changed through the ages, as technology facilitated detection of smaller and smaller particles.

While the Industrial Revolution produced continually increasing types and quantities of particulates, parallel technological developments enabled humans to redefine their concept of "small." The development of the microscope around 1600 provided humans their first glimpse at kingdoms of life invisible to the naked eye. The steady improvement of various types of microscopes - along with creation of sophisticated instruments that enable us to "see" the miniscule in non-visual ways - has allowed ever-more-precise differentiation and analysis of dust.

Bill Eichinger, another UI environmental engineer, is pushing detection of the infinitesimal to its current limits. As one of a growing number of researchers in the country who are using lidar (the lightwave analogue of radar) for atmospheric science, he is collecting very high-resolution data on concentrations of particu-

lates that are under 10 microns in size, too small to see other than as a haze. Some of his studies involve basic atmospheric physics: for example using lidar to trace the movement of dusts and thus determine air movement and atmospheric stability. However lidar also has enabled Eichinger to evaluate pollution control mechanisms by visualizing evening atmospheric boundary layers. "Cars look really bad," he points out, when viewing how computer-generated maps of miniscule pollutant particulates clearly reveal high levels along major roadways. In a new U.S. Forest Service grant, Eichinger will visit burn sites and trace the concentration, size, and long-range transport of particulates in smoke plumes generated by forest fires.

The Hidden Harmers

Before microscopes enabled us to see disease-producing microorganisms and Pasteur and others revealed their significance, human illness was attributed to imbalance of the humors, supernatural forces, or miasmas.

The acceptance of the germ theory of disease in the nineteenth century, along with tremendous public sanitation efforts, heralded the control of infectious killers. Today cleaning devices (from soaps to vacuum cleaners) and sealed surfaces (from paved roads to plastic flooring) have minimized exposure to many forms of dust. However disease-causing organisms and particles, seen and unseen, remain with us and continue to pose significant health problems around the globe.

Peter Thorne, a UI environmental toxicologist, deals with organic dusts that emanate from living organisms and threaten human health. He's working to control the fungal particles, endotoxin particulates from bacteria, dust mites and their feces, cat saliva proteins, and a variety of other organic dusts that can trigger the allergic response of asthmatic individuals. With the aid of a new five-year grant from the National Institute of Environmental Health Sciences, Thorne will attempt to rid rural Iowa homes of these organic dusts and thus eliminate asthmatic episodes in child residents. His interventions will include educating homeowners about housecleaning techniques and providing equipment for deep cleaning of homes. Thorne also is continuing his ongoing work with swine confinement and compost workers in Europe, trying to minimize their exposure to agricultural dusts that cause a variety of respiratory diseases.

(continued next page)

Peter Thorne investigates dust-induced illness around the world, including respiratory diseases among Europeans (such as these) who work with the routine recycling and composting of household food scraps and garden wastes.

Miscellanea

- This fall, CGRER is renewing its membership in the **University Corporation for Atmospheric Research (UCAR)**. This important organization offers tremendous opportunities to its member organizations and their members and students: fellowship and postdoctoral support, instructional programs, computing assistance, research equipment, support for visiting scientists, and the like. CGRER members are encouraged to acquaint themselves with, and take advantage of, UCAR opportunities. (See <www.ucar.edu>.)

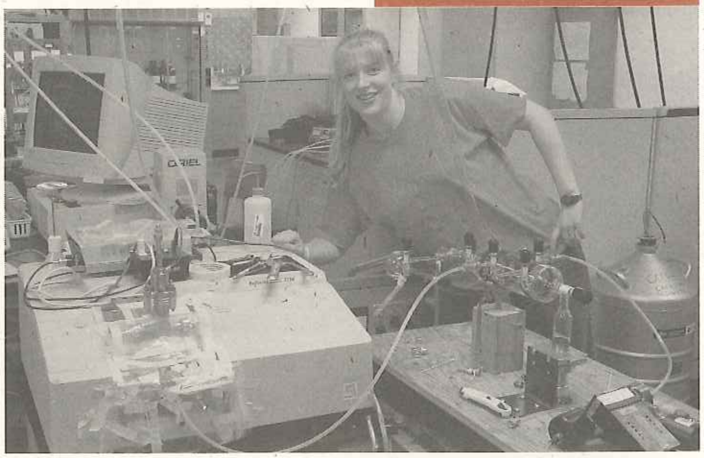
- This year, five members have been elected to CGRER's Executive Committee. Fond welcomes to **Keri Hornbuckle**, **Sarah Larsen**, and **Lou Licht** (elected January 2001), and to **David Bennett** and **Diana Horton** (elected September 2001).

- In August, CGRER's co-directors gave two significant presentations about the Center and its activities. **Jerry Schnoor** spoke at the Iowa Association of Electric Cooperatives' workshop on the environment. He was joined by **Greg Carmichael** for a joint presentation to Iowa's joint Legislative Oversight Committee.

- CGRER's **weather web site** (<www.cgrer.uiowa.edu/iowa forecasting/iowa_index.htm>) is up and running, ready to provide 72-hour forecasts for twelve Midwestern states and 37 Midwestern cities. The site provides still and animated weather maps of our region, as well as connections to national weather resources (such as NOAA and NCEP). The web site, which employs the Regional Atmospheric Modeling System to analyze forecasts, is run as an ongoing research project.

Expanding Clouds, Explicit Clarity

Today we live the contradiction of inhabiting relatively dust-free cities and homes, while simultaneously confronting dust's ubiquitous presence and global importance.



Vicki Grassian's student Brenda Krueger, performing laboratory experiments using Fourier Transform Infrared Spectroscopy (Ft-IR) to investigate atmospheric catalysis.

Dust flies over the highest mountains and crosses the widest seas, spreading problem particles of one country around the world. News media tell us of smoke plumes from burning tropical forests that spread haze around the equator and, along with other soot sources, join carbon dioxide as a potent agent of global warming. North African dust storms threaten human health by sweeping potentially dangerous bacteria and fungi westward to Florida and the Caribbean. The more our technology permits researchers to explore the infinitesimal, the more we are forced to acknowledge the global significance of dust.

UI chemical engineer Greg Carmicheal and Vicki Grassian (a UI chemist) have been instrumental in identifying two previously unrecognized dust-related phenomena: the chemistry of particulates in the troposphere, and the very long-range transport of Asian atmospheric pollutant particles. In the mid-1990s, Grassian initiated laboratory experiments to measure chemical reactions on the surface of mineral dust. Such dusts were hypothesized to alter the atmosphere's chemical balance by catalyzing reactions among the trace gases that adhere to the particles. In recent months, the efforts of field researchers have been demonstrating that Grassian's laboratory studies are indeed relevant: the chemical reactions that Grassian has identified in the laboratory are being used successfully to explain actual field experiments. Grassian's laboratory studies thus are providing accurate data to feed into global climate models of atmospheric chemistry and global warming. These studies of the synergisms between gases and mineral dust in the troposphere have initiated major new program funding in heterogeneous atmospheric chemistry among Grassian's sponsors, NSF and the Department of Energy.

Carmichael has been working with the transport and fate of Asian air pollutants for nearly two decades. In 1999, Carmichael and his colleagues were the first to prove that Asian air pollutants demonstrably reduced air quality in the western U.S. This past spring, with funding from the National Aeronautic and Space Administration and NSF, he was able to predict successfully the movement of a large dust storm which swept from East Asia across the Pacific Ocean, over the U.S., and across the Atlantic Ocean (see "The Perfect Dust Storm" in the News section of CGRER's web page). This dust storm carried along sulfates, carbon monoxide, and other air pollutants, producing a visible haze and affecting the U.S.'s air quality. Complemented by measurements from aircraft, ships, satellites, and the ground, his results will verify computer models for predicting the chemical weather situation, and will eventually enable routine three- to four-day forecasting of pollutant cloud movement around the globe.

Dust: the particles into which something disintegrates, the end product of all, a tribute to the divisibility of matter. A thousand motes of dust occupy every cubic inch of air. We now measure it by the micron instead of by the naked eye. Through history, our activities have increased and complicated dust even while enabling us to differentiate and control it. In spite of all we do, dust remains with us, shaping our perceptions, our globe, our climate, and our diet, and our health. Once understood, dust can never again appear simple.

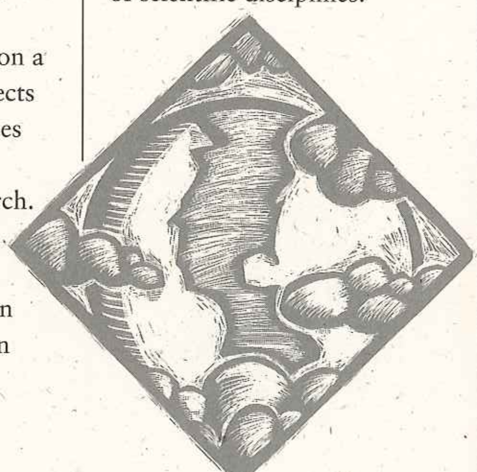
Newcomers

CGRER welcomes three new members to its folds.

DAVID BENNETT came to the UI's Department of Geography in fall 2000 from the University of Kansas faculty. His research focuses on applying geographical information science (GIS) to environmental systems and policy. Ultimately he hopes to use GIS to examine multiple criteria and objectives, thus optimizing solutions to complex problems and satisfying the needs of multiple stakeholders. Bennett, who is currently teaching the course "GIS for Environmental Studies," joins CGRER members and fellow geographers **Claire Pavlik** and **Marc Armstrong** in teaching GIS techniques to UI students. Bennett hopes that CGRER membership will help him connect with other academicians interested in linking human and environmental systems, and also will stretch the geographic range of his research projects to the regional and global level.

JONATHAN CARLSON has taught at the UI's law school since 1983. His research in past years has focused on international trade and business. This interest was redirected toward international environmental law in the mid-1990s, when he joined CGRER member **Burns Weston** and others in coediting *International Environmental Law and World Order: A Problem-Oriented Coursebook*. In particular Carlson's research examines the intersection of international trade rules with international law. His primary interest is in assessing how international environmental policies can be structured so that they achieve their goals without undermining the international community's commitment to free trade and the economic development of poor countries. He hopes that his CGRER membership will help him develop a better understanding of the range of technological solutions to environmental problems, as well as their underlying science.

SCOTT CARPENTER came to the UI's Paul H. Nelson Stable Isotope Laboratory (PHNSIL) in 1999 from the University of Texas faculty. In addition to managing the laboratory's day-to-day operation, Carpenter collaborates on a variety of research projects across campus, supervises student research, and conducts his own research. Much of the latter focuses on measuring stable isotopes to discern changes in ancient ocean chemistry and paleoclimates. Over the last decade, Carpenter has studied modern calcareous organisms (brachiopods, algae, corals, clams) to examine their potential as paleo-climate proxies. Carpenter's work with ancient climates and close association with fellow CGRER members **Greg Ludvigson, Art Bettis,** and **Luis Gonzalez** make his CGRER membership an obvious choice. He hopes that he can use the PHNSIL to increase CGRER's regional and international visibility and to encourage collaboration among a variety of scientific disciplines.



Miscellanea

- CGRER has just put out a new **Greenhouse Gas Action Plan** report titled "Final Report: Greenhouse Gas Phase III - Carbon Storage Quantification and Methodology Demonstration." The Iowa Department of Natural Resources, for whom the report was prepared, has responded positively to the publication. The report's executive summary can be viewed on CGRER's web page.

- Last winter's experimental **burning of switchgrass** at the Ottumwa Generating Plant has been getting significant press coverage, as demonstrated by a March 2001 article in the national magazine *Power Engineering*. This project's co-firing of grass with coal will reduce carbon and sulfur dioxide emissions significantly claims Jerry Schnoor, primary instigator of the effort.

- CGRER's **George Malanson** has been appointed by the National Research Council (NRC) to a two-year term at the National Academy of Sciences/NRC Committee on Research Priorities in Geography at the U.S. Geological Survey (USGS). As a committee member, he will help set research priorities for the USGS, where geography is a major emphasis.

- ISU member **William Gutowski** was one of the organizers of a regional climate model training workshop for southern African scientists held this past January at the University of Cape Town, South Africa. The workshop nurtured the African climate modeling community by weaving together tutorial lectures and hands-on sessions with the MM5 regional climate model. Follow-up activities are now engaging students in research programs.

Miscellanea

- **Peter Thorne** is the new director of the Environmental Health Sciences Research Center (EHSRC), a core center for environmental programs at the UI, and **Keri Hornbuckle** will be directing EHSRC's Exposure Assessment Facility. As Center director, Thorne will oversee interdisciplinary research in rural environmental exposures, especially those stemming from agricultural activities, and related disease. The EHSRC, founded in 1990, is one of 21 Centers of Excellence funded by the federal National Institute of Environmental Health Sciences.

- **Keri Hornbuckle** is undertaking a review of air quality in Voyageurs and Isle Royale National Parks. Although these sites are geographically remote, visitors may be exposed to atmospheric pollutants if they eat fish that have ingested dissolved toxins. The National Park Service will use her report to develop educational materials for visitors, among other things.

- CGRER's most distant member, **Konstantine Georgakakos**, continues to perform research relevant to CGRER's mission from California. Years ago a CGRER seed grant helped him investigate whether climatic information would be useful in shaping water resource management at Iowa's Saylorville Reservoir. He and his colleagues have since developed demonstration projects at major reservoir sites across the country, hence showing that within certain parameters, global

SEEDS

CGRER has awarded $149,874 of grant funds to eight new projects for FY 2001-2002

Scott J. Carpenter, UI Department of Geoscience: **High-Resolution Stable Isotope Analysis of the Last Deglaciation as found in the Sediments of Glovers Pond, New Jersey** - $20,000

If we are to develop a critical perspective on modern human-generated climatic alterations, we must understand the timing, rate, and intensity of ancient global climate change. However creating a high-resolution picture of ancient climates is not easy. Carpenter has identified one window to the past through his studies of Glovers Pond, a small lake in New Jersey, whose sediment cores present a unique record of Earth's last deglaciation or past 20,000 years. His CGRER grant will defray the cost of dating these cores. Because of the lake's proximity to the North Atlantic Ocean, these data will be valuable for understanding the relationship between ocean circulation and continental climate change.

Mohammad Z. Iqbal, UNI Department of Earth Science: **Use of Environmental Isotopes to Determine the Predominant Sources of Moisture that Drive the Precipitation Events in Northeast Iowa** - $14,320

The hydrologic cycle, which traces water's flow around the globe, is integral to the climate system. It also is a crucially important determinant of life on Earth as well as the success of human activities. However the details of the hydrologic cycle require clarification. Iqbal proposes to investigate one facet of this cycle: evaporation-precipitation processes in Northeast Iowa. He will analyze rainwater isotopes to determine what portion of our precipitation is derived from local sources (e.g. evaporation from nearby lakes and streams) rather than distant sources such as the Pacific Ocean or the Gulf of Mexico. This analysis also will provide a mechanism for tracing shifts in regional precipitation patterns through time.

Witold F. Krajewski, William Eichinger, and Keri Hornbuckle, UI Department of Civil and Environmental Engineering and IIHR-Hydroscience and Engineering: **Conceptual Network Design Studies for Iowa Hydrologic and Environmental Validation Site** - $20,000

Satellite, radar, and other remote sensing data as well as results of numerical models of land and atmospheric processes need to be validated against high quality in-situ data before they become credible bases for operational, management, and policy decisions. Krajewski et al propose to create a hydrologic and environmental validation site, to be run jointly with the University of Iowa's IIHR-Hydroscience and Engineering. The permanent, 400-square-kilometer "natural laboratory" will house numerous measuring devices that will record precipitation, soil moisture, stream flow, water quality, energy balance, and other hydrometeorologic and biochemical variables over long time periods. CGRER's seed grant will provide planning funds so that detailed proposals for this national site can be submitted to other funding agencies.

Johna Leddy, UI Department of Chemistry: **Magnetically Modified Nickel-Metal Hydride Batteries for Reduced Environmental Emissions** - $20,000

The environmental impacts of automobiles could be greatly reduced if automobiles were powered by electricity rather than by internal combustion engines. Given current technologies, the first commercially viable zero-emission vehicles will be battery-based, and nickel-metal hydride batteries have fewer environmental repercussions and less toxicity than other batteries. Leddy proposes to increase the performance of this type of battery through magnetic modification, a process that enhances rates of electron transfer and interfacial reactions.

James W. Raich, ISU Department of Botany: **Grass-type Controls over Carbon Fluxes from Grasslands** - $16,104

The U.S. government currently pays farmers to remove nearly 34 million acres of cropland from production. This Conservation Reserve Program (CRP) provides numerous benefits, including the promotion of carbon sequestration in soil. Raich proposes to compare the soil carbon dynamics (sequestration and turnover) of non-native, cool-season (C3) grasses to those native, warm-season (C4) prairie grasses. His investigations and large field experiments will help determine how landscape carbon budgets can be influenced by the types of grasses that are planted.

Jerald L. Schnoor and Richard A. Ney, UI Department of Civil and Environmental Engineering: **Measuring Net Greenhouse Gas Emissions from Wetlands** - $20,000

Growing plants can be used to capture and store carbon dioxide, thus decreasing atmospheric concentrations of this greenhouse gas. Reconstructed wetlands could serve this end, but their decomposing plant material also release the greenhouse gases methane and nitrous oxide into the atmosphere. Schnoor and Ney propose to investigate the overall balance of greenhouse gases emitted from wetland systems. They will review literature and investigate models for these greenhouse gas flows, and develop a verification protocol for wetland greenhouse gases that is suitable for field testing.

Eugene S. Takle, ISU Departments of Agronomy, and Geology and Atmospheric Science, and **Zaitao Pan,** ISU Department of Agronomy: **Basin Scale Water Quality Change and Uncertainty under Global Climate Change** - $19,500

Predictions of the effects of climate change are based largely on numerical, computerized global climate models (GCMs) and on regional climate models (RCMs) that cover a smaller area but have a finer resolution than GCMs. Takle and Pan propose to evaluate the differences between GCM and RCM predictions of future water quality accompanying climate change. They will quantify uncertainties in these water quality models, and will specifically explore water quality problems associated with Gulf of Mexico hypoxia and Upper Mississippi River basin erosion.

Mark A. Young, UI Department of Chemistry: **Mass Spectrometric Probes of Photochemistry in Natural and Model Water Samples** - $19,950

Solar irradiation of surface waters that contain inorganic and biological materials can result in complex photochemical reactions. The resulting product species can have enormous consequences for the greenhouse gas effect and global carbon cycle. Young proposes to develop a mass spectrometry apparatus that will allow researchers to better understand, quantify, and monitor these photochemical reactions.

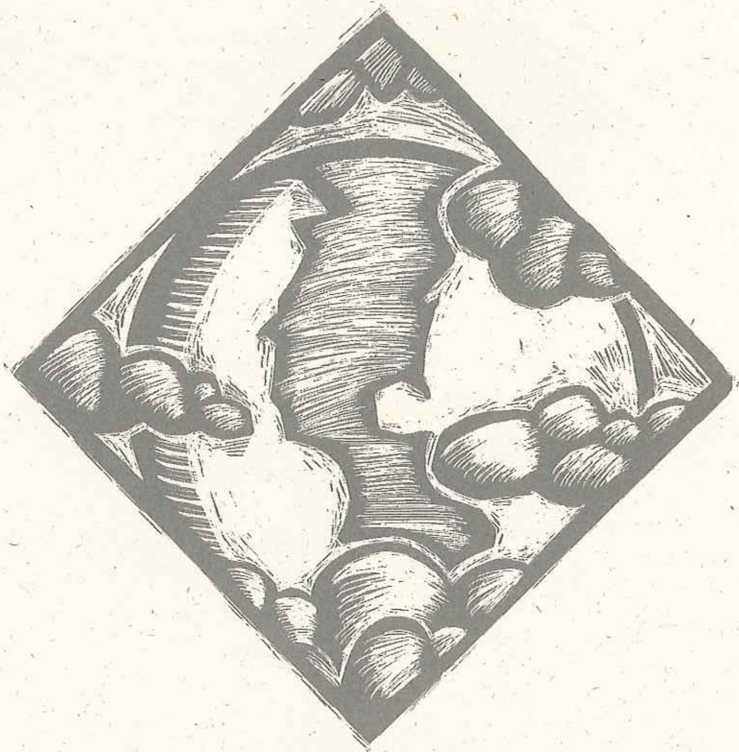
For more information on any of these projects, see the proposal abstracts on CGRER's web page.

Miscellanea

climate model forecasts are indeed useful in managing their water resources.

- **Jim Yienger**, year 2000 graduate who conducted research for his master's degree at CGRER, is now head of India's "Cities for Climate Protection Program" (CCP). This U.S. Aid for International Development-funded program is attempting to help cities around the globe (including 100 in the U.S.) create and implement aggressive strategies for reducing greenhouse gas emissions. Jim reports that a June CCP strategy-sharing session held in Berkeley was quite successful.

- A recent study states that the Midwestern large-scale **conversion of forests to croplands** over the past century has led to measurable cooling of the region's climate. The cooling is attributed to crops reflecting more sunlight back into space than forests. This study is significant because it establishes the first documented link between regional climate change and a major change in temperate forest cover. The study also demonstrates the need for knowledge about historical plant cover, and the significance of interdisciplinary centers such as CGRER, which link botanists, climate modelers, and researchers of many other disciplines. (Reference: Bonan, G. B., 2001: "Observational evidence for reduction of daily maximum temperature by croplands in the midwest United States." *Journal of Climate* 14: 2430-2442.)



IOWA WATCH

THE CENTER FOR GLOBAL AND REGIONAL ENVIRONMENTAL RESEARCH

The University of Iowa's Center for Global and Regional Environmental Research (CGRER) promotes interdisciplinary efforts that focus on the multiple aspects of global environmental change, including its regional effects on natural ecosystems, environments, and resources, and on human health, culture, and social systems. Center membership is composed of interested faculty members at any of Iowa's colleges and universities.

Center goals are promoted by encouraging interdisciplinary research and dialogue among individuals whose disciplines touch upon any of the multifaceted aspects of global change. More specifically, the Center awards seed grants, fosters interdisciplinary courses, provides state-of-the-art research facilities and equipment, and holds seminars and symposia. The Center encourages students to broaden their studies and research through considering the multidisciplinary aspects of global and regional environmental problems. Through such activities, the Center attempts to assist Iowa's agencies, industries, and citizens as they prepare for accelerated environmental change that may accompany modern technologies.

Housed in the Iowa Advanced Technology Laboratory at the University of Iowa, the Center was established by the State Board of Regents in 1990 and received funding from a public utility trust fund, as mandated by the State of Iowa's Energy Efficiency Act.

IoWatch is published each fall. Comments, questions, and requests for additional copies should be directed to:

Jane Frank, Admin. Asst.
The University of Iowa
CGRER, 204 IATL
Iowa City, Iowa 52242
319-335-3333
FAX 319-335-3337
jfrank@cgrer.uiowa.edu
http://www.cgrer.uiowa.edu/

THE CENTER FOR GLOBAL AND REGIONAL ENVIRONMENTAL RESEARCH

Written and edited by Connie Mutel
Designed by Leigh Bradford
Printed by The University of Iowa Printing Department
Illustrations by Claudia McGehee
26869/10-01

Printed on Recycled Paper