THE CENTER FOR GLOBAL AND REGIONAL ENVIRONMENTAL RESEARCH

iowatch

Fall 2008

The floods of 2008

This past summer, floodwaters flowed through Iowa City for 32 days. This meant that the Iowa River was still running strong on June 29 and 30, when National Science Foundation (NSF) Director Arden Bement Jr. made an unusual visit to the University of Iowa (UI). Responding to an invitation from CGRER members **Larry Weber** and **Witold Krajewski**, Bement toured flooded areas in Cedar Rapids, Iowa City, and the UI, and attended a half-day flood meeting where he listened to presentations from UI faculty and administration, including many CGRER members: half of those present at this invited symposium were thus classified.

At this meeting, Bement suggested that researchers apply for grants within NSF's SGER ("Small Grants for Exploratory Research") program, which funds small-scale, exploratory, high-risk research, such as the rapid collection of ephemeral data associated with catastrophic events. Thus, just two weeks after peak flood flows ran through the UI campus, researchers were addressing the flood's destruction in the manner that they knew best: by planning research studies to learn more about such events, in hopes of better understanding and reshaping future similarities. Within a month, over a dozen research proposals had been submitted to the SGER program. By late summer, eight SGER proposals had been awarded to CGRER members (see page 5). The projects ranged from studies of flood flows, their sediments, and their nutrient contaminants, to examinations of flood impact on the education of young children.

The SGER grants were not the only expression of this flood focus. Even before Bement's

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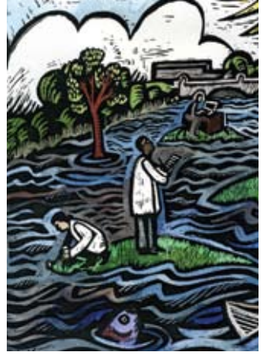
This issue of IoWatch focuses on Iowa's massive 2008 floods.



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visit, CGRER member **Witold Krajewski** had arranged for the NSF's National Center for Airborne Laser Mapping to measure river water levels at extremely high resolution, using lidar (laser radar) technology. This produced an extremely detailed map of Iowa River floodwaters near their peak. Knowledge of exact patterns of floodwater distribution could be critical to future flood mitigation decisions. In addition, **Larry Weber** and Nate Young were kept busy conducting scour evaluations of bridges in flooded areas, to ensure that the bridges remained safe. And **Peter Thorne**, along with staff of the UI Environmental Health Sciences Research Center (EHSRC) that he directs, was working intensively with the Linn County Health Department and Iowa Department of Natural Resources to analyze ambient air samples for indicators of bacteria and mold proliferating because of the floods. They sampled UI campus buildings to determine when the buildings were safe for re-entry, and carried on a Cedar Rapids-based research project to measure mold, lead, and asbestos hazards in flood-evacuated houses, to develop guidelines for deciding when a home is safe for reoccupancy. Thorne was able to redirect and obtain supplemental EHSRC funding for these efforts. Once the waters started to recede, IIHR commenced putting together a database on multiple aspects of the 2008 floods. IIHR and its many CGRER members are also spearheading the development of a multi-disciplinary proposal for a UI-based, NSF-funded Science and Technology Center to focus on flood-related research.

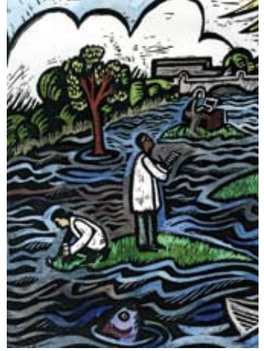
CGRER headquarters at the Iowa Advanced Technology Laboratories - one of twenty buildings on the UI campus to be affected by this summer's floods – were evacuated on June 13. Although first floor laboratories and office space suffered major damage, CGRER fortunately was saved by its location on fourth floor. The building will be reopened this autumn.

Studies focusing on floods and other extreme weather events are nothing new to many in CGRER. **Krajewski**'s long-term research on the remote sensing of rainfall has always been motivated by the needs of flood forecasting. And he is a participant in the multi-institutional Hydro-Kansas project, which has as its main goal the development of a theory of floods. He and **Thanos Papanicolaou, Marian Muste, Craig Just, Jerry Schnoor,** and colleagues have also established the Clear Creek Hydrological Observatory, just northwest of Iowa City, to trace and describe in detail the multiple aspects of this drainage's hydrology. **Krajewski**, **Brian Hornbuckle, Bill Eichinger**, and colleagues are currently completing a NASA grant to validate remotely-sensed observations of soil moisture. (Floods depend, in part, on the land's ability to absorb precipitation, which in turn relates to soil moisture). **Rhawn Denniston** and his students are looking south and using stalagmites to investigate Holocene variability of the Australian monsoon, discerning trends that are tied to flooding and water resources on that continent. And **Jeff Dorale**, using stalagmites to trace flood events of past millennia with high resolution, has constructed a continuous 8000-year record of Midwestern Holocene flooding. In California, **Konstantine Georgakakos** has been developing and deploying flash flood forecasting systems in many parts of the world. **Greg Carmichael**, through the UNEP project Atmospheric Brown Clouds, is studying the impact of black carbon and other aerosols on the Asian climate, including the timing and intensity of the monsoons and the rates of glacial melting and their implications for flooding. Other flood-related research has been described in earlier CGRER newsletters.

CGRER researchers have thus been moving toward a more sophisticated understanding and measurement of water's flow (and flood-flows) over and through the earth's surface. But is it enough simply to understand these processes? History begs a negative answer: In 1993, extensive floods along the Iowa River brought a harsh warning of nature's destructive power to all who witnessed them. Yet a mere 15 years later, the 2008 floods appeared with greater strength, bowled unmoderated over larger areas, and found more, not fewer, floodplain structures to destroy. With today's magnification of nature's expression, one might question the benefits of science. What is the use of greater knowledge about extreme weather events if researchers, the public, and policy makers do not work together to feed information about environmental issues into applications – for example, into policy and land-use decisions?

To encourage that end, CGRER members are moving forward on their second area of expertise: propelling scientific knowledge forward into educational offerings. This summer's floods are feeding into several UI courses. **Paul Greenough** has organized a new disaster-response course in which students will review how disaster-affected communities and their governments have responded to a variety of past environmental catastrophes. **Craig Just** is incorporating content into existing coursework on how floods in developing countries create suffering and death, and is requiring students to serve local flood-impacted areas as a service-learning course requirement. **Keri Hornbuckle** is incorporating a number of flood-related lectures into the

Are the 2008 floods challenging us to reach beyond our academic comfort zone, into using our expertise in ways essentially different in form and substance? And if so, what expressions will be most effective? What can we do to move our society toward solid science-based policy and economic solutions to environmental problems, irrespective of their political and economic implications?



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UI's Civil and Environmental Engineering seminars. And **George Malanson** and **Larry Weber** will both be presenting guest lectures in Jim Throgmorton's new UI course, *Learning from the Flood*.

Reaching beyond university walls, **Gene Takle** has been presenting multiple talks on extreme weather events, including extreme rainfall, and their relationship to climate change. **Bill Gutowski** participated in an Ames-based "Science Café" on this summer's floods, an open discussion sponsored by Sigma XI that focused on communicating science to the public, where he spoke on "Future Extreme Rainfall in Iowa." And **Peter Thorne**, with his expertise in respiratory hazards, plunged into flood outreach and education, speaking with the media about mold hazards, monitoring, and mitigation, and personal protection in flooded buildings, and filming a video on these subjects that has been aired on public health websites and YouTube. On a broader level, this past spring saw the publication of a book written by CGRER editor **Connie Mutel**, which was initiated with CGRER funding. *The Emerald Horizon: The History of Nature in Iowa* (University of Iowa Press) describes the history of Iowa's intertwined natural and human-built landscapes, and traces (among other things) the changes in Iowa's flood resistance resulting from the prairie's agricultural and urban transformation.

Perhaps the most obvious CGRER response to this summer's flooding will be another book, now in preparation, explaining the science (as currently understood) of the summer's floods. This edited volume will include 22 chapters by 31 experts, eight of whom are CGRER members. Topics covered will range from the hydrology and frequency of floods in Johnson and Linn Counties; to the contributions of land use, the Coralville Reservoir, and climate change; to the floods' multiple effects on people, farmlands, and nature; to an exploration of potential responses to these extreme weather events. The intent is to publish the book rapidly enough to educate the lay public, even as it helps to shape policy and responses to the flooding. The book is being co-sponsored by CGRER and IIHR-Hydroscience & Engineering, edited by Connie Mutel, and published in 2009 by the University of Iowa Press.

All of these research and educational efforts are moving forward in good form. But still one wonders where they are taking us. What more must we – and all those who understand Earth's ongoing changes – do to address accelerating environmental degradation? A recent major report concluded that one of the clearest trends in recent US climate is the 50% increase in rainfall events exceeding four inches in the upper Midwest, with most coming in the warm season[1]. Thus this summer's floods not only prove that our perception of "the impossible" can happen. These floods could be demonstrating an even harsher future: more floods, perhaps stronger than this year's, will come. Accelerating rates of environmental change may destine us to playing catch-up with ever intensifying weather – even as the funding necessary for research and healing our planet is increasingly allocated to relief and clean-up efforts.

How should academia respond to this challenge? Can we, personally and academically, favor returning to "business as usual" when the "usual climate" is becoming a moving target? Is it conscionable to restrict our academic activities to research and teaching focused on extreme weather events, even as they increasingly batter our lands and lives? Or are the 2008 floods challenging us to reach beyond our academic comfort zone, into using our expertise in ways essentially different in form and substance? And if so, what expressions will be most effective? What can we do to move our society toward solid science-based policy and economic solutions to environmental problems, irrespective of their political and economic implications? The floods of 2008 brought scientists and policy-makers closer together, introducing each to the other's visions. But how will this introduction play out? What crisis will keep us engaged long enough to push environmentally-necessary economic, administrative, and lifestyle shifts into reality?

We have a long ways to go. The resulting frustration was expressed by **Jerry Schnoor** in an editorial, "Lessons from the flood" that he wrote for the journal *Environmental Science & Technology* (August 1, 2008, page 5379), which he edits. After discussing our need to eliminate construction on floodplains, understand hydrological fluctuations, proceed beyond our trust in levees, and celebrate the strengths of human community when tackling oncoming floods, he wrote the following about our blindness to the insidious role of climate change in worsening extreme weather events:

… How many Katrinas can society withstand if we are the cause of climate change? As the planet warms, many climate models predict more evapotranspiration, more humidity, more clouds, and more precipitation. There's more energy to dissipate. It's impossible to say with certainty that the floods of 2008 were caused by climate change; there have been larger floods in the past, and there will be larger ones in the future. But to ignore the substantial evidence that our massive disruption of global biogeochemical cycles on earth could amplify climatic extremes, and to not at least take action to prevent such an outcome, is reckless and irresponsible. Denial still runs rampant through the U.S., like a flood on the Iowa River.

[1]Kunkel, K.E., P.D. Bromirski, H.E. Brooks, et al. "Observed Changes in Weather and Climate Extremes in Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands." IN T.R. Karl, G.A. Meehl, C.D. Miller, et al (eds.). 2008. *A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*, Washington, DC.

Flood photos: Tom Jorgensen and Tim Schoon University Relations

National Science Foundation Small Grants for Exploratory Research Awarded to CGRER Members

Keri Hornbuckle and **Thanos Papanicolaou** (UI, Civil and Environmental Engineering - CEE - and IIHR-Hydrosciences & Engineering): *Transport of Sediments and Pollutants into the Terrestrial Regions of a Small Urban-Industrial City: The June 2008 Flood of Cedar Rapids, Iowa.* $99,168. Purpose: To determine the sources of the extensive sediments that were transported and deposited throughout Cedar Rapids by the flood, and to develop predictive sediment transport models, using chemical pollutants as sediment tracers.

Craig Just (UI, CEE and IIHR), **Gene Parkin** (UI, CEE), Nathan Young (UI, IIHR), Teresa Newton (U.S. Geological Survey): *The Impact of Extreme Flooding on Mussel and Microbial Nutrient Dynamics at the Water-Sediment Interface.* $75,613. Purpose: To determine the effects of historically high floodwaters on the delivery of sediment and nutrients (agricultural fertilizers) to the Mississippi River's Pool 16, and to the nutrient cycling carried out by mussels and microorganisms within this pool.

Witold Krajewski (UI, CEE and IIHR) and Ricardo Mantilla (UI, IIHR): *Anatomy of the 2008 Iowa Flood: Exploring the Interplay Between Successive Storms and Basin Drainage Topology*. $52,514. Purpose: To better understand the causes and effects of the 2008 floods by analyzing the sequence of multiple storm events and their combined results, and by relating these events and results to a broader geophysical theory of floods currently under development.

Witold Krajewski (UI, CEE and IIHR) and Ricardo Mantilla (UI, IIHR): *Theoretical Design of a Flood Warning System for Eastern Iowa*. $69,471. Purpose: To determine how flow aggregation patterns of the Iowa River and its tributaries can be used to determine the best placement of new rain and stream gages, in order to improve real-time prediction of coming flood events.

Marian Muste (UI, IIHR): *Evaluation of the Rating Curve Hysteresis Due to Unsteady Channel Flows Using Non-Intrusive Measurements Acquired During the Iowa 2008 Flood*. $56,869. Purpose: To assess the accuracy of existing rating curve (graphs that relate discharge with measured stage at stream gaging stations) during unsteady flows using an image-based velocity measurement technique.

Gerard Rushton (UI, Geography), Kevin Leicht (UI, Sociology), and David Bills (UI, Education): *Determining the Effects of Severe Flooding of Residential Areas on the Educational Development of Public School Students who Live in Such Areas*. $62,879. Purpose: To systematically assess the longitudinal effects of the disruptions caused by a natural disaster – namely the 2008 floods – on the subsequent educational performance and careers of flood-involved youth.

Jerald Schnoor and **Craig Just** (UI, CEE and IIHR), Nancy Rabalais (Louisiana Universities Marine Consortium), and Eugene Turner (Louisiana State University): *Contribution of the 2008 Midwestern Flood to Gulf Hypoxia*. $99,343. Purpose: To monitor the nitrogen and phosphorus fluxes of floodwaters flowing down the Mississippi River and their contribution to hypoxia (the "Dead Zone") in the Gulf of Mexico, and compare these nutrient balances to those of the floods of 1993.

Kathleen Stewart and **David Bennett** (UI, Geography): *Understanding Spatiotemporal Dynamics of Community Response to Natural Disaster*. $44,484. Purpose: To understand how decision-makers deployed resources among Iowa City communities during the flood, and study how objectives shifted as the flooding continued, in order to better guide decision-making behavior during extreme weather events.

Names in bold indicate CGRER membership.

seeds

In 2008, CGRER funded five new seed grants for the coming fiscal year, for a total of $143,873.

Development of Prototype Instrumentation for Ultra-High Resolution Measurement of Land Surface Relief. PIs: William Eichinger, Witold F. Krajewski, and Thanos Papanicolaou (UI, IIHR-Hydroscience & Engineering and Civil and Environmental Engineering), and Anton Kruger (UI, IIHR-Hydroscience & Engineering and Electrical and Computer Engineering). $30,000.

Studies of land-atmosphere interactions, and surface-fluid processes such as soil erosion, are limited by researchers' abilities to characterize, in detail, the shape and roughness of the earth's surface. This project hopes to develop instrumentation capable of mapping small areas (about 50 square meters) at extremely high resolution (less than 1 centimeter). Most of the funding will be used to construct a portable framework that will hold and move a lidar (light-radar) measuring instrument over the study area. The lidar instrument will bounce a pulse of light off the soil surface, and map soil roughness by measuring the light's return time—a capability that has already been proven for the instrument.

Tailoring the Surface Properties of Nanocrystalline Zeolites for Environmental Applications: Insights from DFT Calculations. PI: Sarah C. Larsen (UI, Chemistry). $30,000.

Zeolites are alumino-silicates with very large surface areas, and with pores of molecular dimensions, that are already widely used in catalysis and in water softeners. This research project involves very small zeolites – nanocrystalline zeolites with crystal sizes less than 100 nm in diameter. These tiny particles remain porous, but have larger surface areas and decreased diffusion path lengths relative to microcrystalline zeolites. As such, they can be tailored to environmental applications, such as adsorption of air or water pollutants. The study will use DFT (Density Functional Theory) calculations to model surface properties of functionalized nanocrystalline zeolites, so that their properties can be optimized for these environmental applications.

Climate Change Impacts on Cold Season Hydrologic Processes and Spring Soil Moisture Recharge in the Upper Midwest. PI: Kristie J. Franz (ISU, Geological and Atmospheric Sciences). $27,073.

This grant will initiate studies of past and projected changes in the Midwest's cold-season climate: its snow cover, snow melt rates, and frozen ground traits. These traits are crucial to understanding spring soil-moisture recharge, spring flooding, and water availability to summer crops; yet Midwestern cold-season climate has not been previously studied in much depth. Weather records for the past 50 years will be used to assess and model historic weather, streamflow, and soil moisture trends for six Minnesota and Iowa watersheds; hydrological models will then be used to estimate expected climate-change-related alterations of 2041-2070 cold-season hydrologic processes. Such numerical models are vital for assessing the impact of a changing climate on the water cycle, thereby producing information that can help guide future land use, agricultural practices, and natural disaster planning.

Discovering the Vertical Dimension of Atmospheric New Particle Formation: Aircraft Profiling Proof of Concept. PI: Charles O. Stanier (UI, Chemical and Biochemical Engineering). $30,000.

Ultrafine atmospheric particles (under 100 nm in diameter) play important roles in regulating climate because they are potential seeds for cloud droplet formation. However, although the technology for counting these very small particles became available a decade ago, concentrations of ultrafines throughout the atmosphere have never been systematically measured in the Midwest. This grant will allow the first such Midwestern tests, to be performed on a vertical transect (via research aircraft, and from static atmospheric devices), from the ground up to 5 km elevation. These measurements should help address one of the largest uncertainties in climate-change assessments and models.

Observations on the Movement of Bedload Using Motion-Sensing Radio Transmitters. PIs: Thanos Papanicolaou and Jerald Schnoor (UI, IIHR-Hydroscience & Engineering and Civil and Environmental Engineering). $26,800.

Characterizing the movement of sediment along river bottoms has always posed a challenge: the movement of these bouncing particles is confounded by both the variability of the bed material itself, and by streamflow's turbulent nature. This project will develop techniques to use thousands of minute, motion-sensing, radio-tracking techniques (RFIDs, or Radio Frequency Identification systems) to simulate individual sand-sized sediment particles and to study their movement. Their use will enable the researchers to study the displacement, rate of motion, and pathways of individual "sediment" particles, and will feed into predictive models of sediment movement. In future years, this technology could be used for applications-oriented field monitoring of sediments, for example their problematic deposition around hydraulic structures.

newcomers

CGRER greets new member Paul Kleiber, a faculty member in the University of Iowa Physics and Astronomy department. Kleiber received his B.A. in physics from Occidental College in 1976 and his Ph.D. in physics from the University of Colorado in 1981. After a year working in industry, he came to the University of Iowa in 1983. His research interests have included studies of excited state chemical kinetics and dynamics in the gas phase, and the application of laser photo-dissociation spectroscopy techniques to study structure, bonding, and chemical dynamics in ion-molecule clusters. In recent years, his research has shifted toward studies of the optical and chemical properties of atmospheric aerosols. Kleiber collaborates extensively with CGRER members Vicki Grassian, Mark Young, and Greg Carmichael, in projects that examine the role of dust aerosols in shaping the chemical and physical equilibrium of the earth's atmosphere. Paul's main focus has been on studies of dust optical properties, related to the scattering and absorption of light by aerosols. His CGRER membership is a reflection of his shift in research emphasis toward problems in atmospheric and environmental science.

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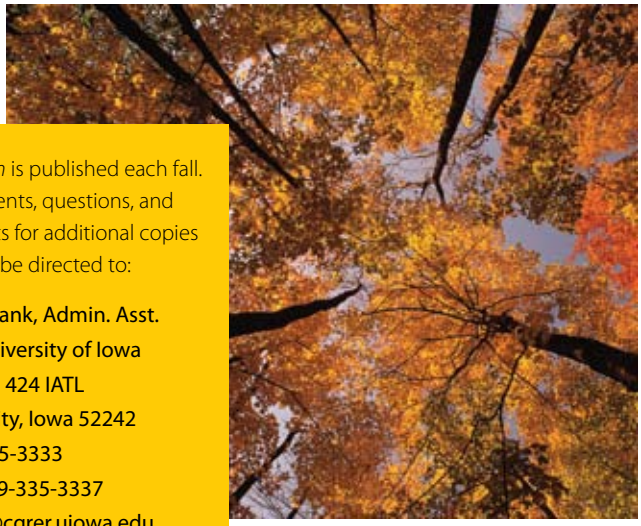

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The University of Iowa's Center for Global and Regional Environmental Research (CGRER) promotes interdisciplinary efforts that focus on the multiple aspects of global environmental change, including its regional effects on natural ecosystems, environments, 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 multi-disciplinary 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.

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