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Feature Center: Hoffman Environmental Research Institute

The Hoffman Environmental Research Institute is a consortium of scientists and students dedicated to research and higher education at the frontiers of environmental science. Its primary mission is to be a leader in the development of innovative, basic, and applied research programs aimed at understanding the dynamics of human-landscape-atmosphere interactions. A major goal of the Institute’s activities is to actively involve undergraduate and graduate students in all aspects of this research as an integrated part of their academic programs. The purpose is to nurture their intellectual growth, critical thinking skills, and technical experience in the environmental discipline.

Dr. Chris Groves is director of the Hoffman Environmental Research Institute. He received a Ph.D. in Environmental Sciences at the University of Virginia in 1993 where he designed mathematical models to study karst aquifer evolution. Since then, with his students and NPS hydrologist Joe Meiman, he has developed an active research program in and around Kentucky’s Mammoth Cave System, most recently concentrating on problems associated with karst landscape evolution, landscape/atmosphere CO₂ interactions, and drinking water source quality. He is also working on a variety of hydrogeology and environmental research efforts in the karst areas of southwest China, and is an active member of the China Environmental Forum at the Woodrow Wilson International Center for Scholars in Washington D.C. Chris currently co-directs (with Yuan Daoxian and Giuseppe Messana) the United Nations scientific program, IGCP 448 World Correlation of Karst Geology and Relevant Ecosystems, and serves on the national Board of Directors of the Cave Research Foundation. In September, he will travel with a Hoffman Institute group to Hanoi, Vietnam and present an invited keynote address entitled Recent United Nations Efforts for the Global Study and Protection of Karst Resources at the “International Transdisciplinary Conference on Development and Conservation of Karst Regions.”

For more information about Hoffman Institute or Dr. Groves go to http://hoffman.wku.edu
Mercury is a toxic, persistent pollutant that accumulates in the food chain. Fossil fuel-fired utilities are the largest source of human-generated mercury emissions in the United States. The U.S. Environmental Protection Agency (EPA) announced its regulations on mercury emission standards in accordance with the Clean Air Act on December 15, 2003 and required compliance from the power industry. The regulations required the power industry to implement the maximum achievable control technology to reduce mercury emission 30% by 2010 and 70% by 2018. The Combustion Laboratory at Western Kentucky University (WKU) is one of five laboratories in the nation capable of performing mercury sampling, measurement testing, and analysis. Specifically, the Combustion Laboratory operates a unique facility. The Mobile Mercury Monitoring Laboratory contains numerous analytical instruments to provide real-time, on-site, and validated information quantifying mercury emission correlated to power plants' operating parameters. In order to comply with the EPA mercury emission standard, it is critical for the power industry to determine the emitted amount of mercury within the existing control devices. Such analysis is not an easy task. Imagine the emission environment as the Houston Astrodome filled with 30 billion ping-pong balls with only 30 balls as the mercury content. To correctly determine this mercury content, the WKU Combustion Lab must always invest in the latest technology. Consequently, nineteen power companies with 29 different generating units have contacted the WKU Combustion Lab for help since 1999. Furthermore, the laboratory staff has been strictly instructed to come up with operation and QA/QC procedures consistent with the EPA specification and conduct field tests according to these. Specifically, the data collected from the CEMS has been validated with the American Society of Testing and Materials (ASTM) Method D6784-02, commonly known as Ontario Hydro Method (OHM). All the effort devoted is to provide the customers with the most valid data.

The Combustion Laboratory at WKU has built up an industry-wide reputation due to its highly trained personnel, most up-to-date instrumental and operational specifications reflecting the EPA requirements, and the desire for efficiency, accuracy, and honor. In 2004, the WKU Combustion Laboratory is anticipating substantially increased funding, for example, the "Large Scale Mercury Control Technology Field Testing Program" funded by the Department of Energy. Based on increased awareness of environmental quality issues, as well as advancing measurements and control technologies implemented by the WKU Combustion Laboratory in 2004.

Submitted by Wei-Ping Pan, Ph.D.

Materials Characterization Center
Combustion Laboratory
Electrical Engineering

WKU- Engineering Dept.

Hosts Robot Competition on November 8th, 2003

Last November the Department of Engineering sponsored the 4th annual robot competition. The competition motivates students by challenging them to build a remotely controlled robot that accomplishes a defined task within a competitive setting. Using only the materials provided, students have eight weeks to design, develop, and test a robot that can outperform their competitors. During this time, the students experience the same problems, challenges, and breakthroughs that an engineering team encounters when it takes a product to market. There are team dynamics, time constraints, material constraints, and pressure from other teams who are trying to solve the same problem.

Teams met in September for a kick-off day where the rules were revealed, and the teams were given the components for their robots. These components included a variety of electronics such as RC controllers, motors and batteries and also building materials such as wood, PVC and aluminum. The teams were instructed to construct their robot from the provided materials.

In November, nine high school teams and one middle school team from across South Central Kentucky met for competition. The theme of the game was “Building Our Future,” and the teams had to simulate building the new Engineering and Biological Sciences building. Teams had to gather building material with their robot and move the material to their building site while avoiding the “runaway” bulldozer! Points were awarded based on the number of building pieces used, type of material used, and height of the structure. In the past, the games have included saving artifacts from a fire in the Smithsonian, crossing a rotating time warp, and creating an inverted robot to stop a nuclear meltdown.

This annual high school robot competition is a successful means for promoting engineering to high school students. Last year, fourteen teams composed of approximately 150 students from south central Kentucky and Tennessee began the competition in September. Ten teams built robots and actually competed in the event. This fall a maximum of sixteen teams will be recruited to participate.

In addition to this competition, the Department of Engineering also sponsors a LEGO robot competition on the same game day. This competition is for children in grades 5-8. The students build miniature robots from LEGO Mindstorm kits. The 2004 competition was the second LEGO competition. In this competition, the students had to build a robot that could travel to Mammoth Cave (via interstate or highway) and then travel through the cave. In last year’s game, the LEGO robots had to search the WKU campus for parking spaces while avoiding cars and pedestrians. Fourteen elementary and middle school teams competed in the competition this year.

The annual robot competitions are a successful means for promoting engineering to pre-college students. This event complements the project-based education focus of the new engineering programs by providing the students with a chance to solve a real-world engineering problem.

Hoffman Institute Initiates  
New Karst Water Work in China

Chris and Deana Groves returned to Western Kentucky University in January from a research visit to a remote area of Hunan province in southwest China, where they laid the groundwork for assisting Chinese scientists in a new karst water resource development project.

Along with karst hydrologists from the Chinese Academy of Geological Sciences and the Xiangxi State (Hunan) Hydrogeology Bureau, they investigated several huge caves and underground rivers on western Hunan's Guizhou Plateau and negotiated details for a WKU-led cave expedition to the area this March.

The project, which entails building a large in-cave dam along an underground river, will attempt to raise water levels in the cave system almost 600 feet to make water more accessible to poor and dry communities that lie on the high plateau above the cave system.

More than 100 Chinese geologists, geophysicists, and engineers are at work on the effort. The March expedition, which will include several WKU graduate students, will assist the Chinese scientists with expertise in cave exploration and survey methods, cartography, and Geographic Information Systems to support the project.

Dr. Jiang Zhongsheng of the Institute of Karst Geology in Guilin, who has made several visits to WKU and who directs the cave research aspects of the Hunan project, explained to the team that economic development is difficult if people in the area are expending a great deal of effort just to get sufficient water and if irrigation is limited.

"There are over 40,000 people in eight remote towns and rural area between them who will immediately and directly benefit from the project if it is successful," said Dr. Chris Groves, who directs WKU’s Hoffman Environmental Research Institute. He and WKU students have been working on karst research in China for eight years.

The local area, which is dominated by people of the Miao minority nationality, is generally poor. In one town, the average annual salary is less than $60, and for several months during the winter dry season, residents must carry drinking water as far as two miles from the nearest cave stream or small spring.

"Even under those difficult circumstances, the people we met were friendly and very kind," Dr. Groves said. "The improvement project in the area will make a tremendous difference in people’s lives, and the project works, will be enormous."

Dr. David Keeling, Geography and Geology Department Head, who has traveled to China twice to work with the consortium, noted that research conducted by the Hoffman Institute "is critical not only to addressing sustainable social and economic development issues in China but also to helping us understand our own community’s challenges."

"The department’s international programs," Dr. Keeling said, "provide faculty and students the opportunity to apply geoscientific techniques to myriad problems in communities around the world. First-hand experiences in China, Argentina, Mexico, England, Mexico, and other field sites demonstrate how critical geosciences solutions to contemporary problems have become."

Fig. 3: American and Chinese Scientists hike toward Coffin Cave near Jishou, Hunan. The name presumably refers to a water buffalo that locals said met its demise in the cave’s reported 200 meter deep entrance shaft. Mapping of the cave, which is unexplored, is a key objective of the WKU-led team in late March 2004.

Fig. 2: The main river of Thunder Cave Hunan is very low during the dry season, as here in January 2004, but can have a flow of more than ten billion liters per day during the summer monsoon rainy season.

Fig. 1: Deana Groves hikes toward a spring for water sampling in a classic tower karst region of northern Guangxi Province.
Cooperative Research: The Hoffman Institute and Mammoth Cave National Park

Going back at least to 1925 when the Western Kentucky University football team helped in the unsuccessful rescue of the trapped cave explorer Floyd Collins, deep ties existed between WKU and Mammoth Cave. Since then, there have been many field trips, research projects, and the very successful Center for Cave and Karst Studies Field Studies Program.

An active research program between the Hoffman Institute and Mammoth Cave National Park has been underway for six years and continues to flourish and evolve. Undergraduate and graduate students have been actively involved in this work, which focuses on the details of karst hydrogeology, geochemistry, and landscape evolution in one of the world’s great natural cave laboratories. Over this period, the work has resulted in eight masters’ theses, 22 publications, 31 presentations at national and international conferences, and 41 presentations at regional meetings.

Active student projects currently underway in the Park include both basic and applied research investigating the behavior and evolution of karst landscapes. A new project started this spring seeks to understand the extent of contamination of the Park’s waters by the herbicide atrazine, widely used in Kentucky in corn production. Although none of the chemical is applied in the Park, it is making its way there through several pathways, including rainfall, and may be impacting the Park’s ecosystem health. We are also studying groundwater hydrology, cave evolution, and carbon dioxide chemistry in both underground rivers and vertical shafts at several sites off tourist trails back within the cave system, where electronic probes and computer data loggers make continuous, high resolution measurements of water flow and chemistry.

The excellent relationships between our group and NPS, along with several other groups and departments at WKU, have led to internships and work-study programs providing great student experiences. These have been especially helpful in the support of an evolving graduate program that is in its fourth year which allows federal land managers with responsibilities for karst resources to earn specially tailored master’s degrees focusing on cave and karst science and management.

Recent publications resulting from the project:

Photo Caption. Hoffman Institute/National Park Service research at Mammoth Cave National Park: 1) Historic Entrance to Mammoth Cave, 2) Hoffman Institute graduate student Katie Seudler, manager of the Park’s Water Quality Lab through the NPS Student Career Enhancement Program, 3) graduate student Joel Despain on a water sampling trip in Mammoth Cave’s Logsdon River, 4) NPS Hydrologist Joe Meiman programming a water sampler in Logsdon River, and 5) graduate student Johnny Meredith installing equipment to measure cave evolution rates at Edna’s Dome within Mammoth Cave.
Remote Control Microgravity Robot To Be Developed by the CCKS and the EES

Over the past 16 years, the Center for Cave and Karst Studies faculty, staff, and students have performed microgravity subsurface research in order to locate cave (voids) from the ground surface for numerous government and private clients. Microgravity meters (pictured at right) are usually used to locate variations in subsurface rock density for petroleum exploration. However, the Center has developed a technique through which mine sites, proposed highway routes, tunnels, pipelines, hazardous spills, and sinkhole collapse and flooding sites can all be investigated. This technique can determine precise drilling locations so that monitoring wells can be installed into underlying cave streams.

The Center for Cave and Karst Studies is essentially the only one in the country performing these types of microgravity investigations. The Center was contacted by both FEMA and NASA to use microgravity to locate possible pockets or voids in the rubble at the World Trade Center site in New York so that wells could be drilled into them to look for survivors. Unfortunately, the debris piles were too uneven for our technique to be used.

As a result, The Center for Cave and Karst Studies has been awarded a grant through The Innovation Group of the Kentucky Science and Technology Corporation to invent and develop a remote controlled robot transport vehicle for microgravity meters. With the Center’s experience and reputation in this area of study, along with the help of Dr. Stacy Wilson and staff in the Electrical Engineering Center, the grant will be used in the development of a robotic transport system that will make microgravity investigations faster, less expensive, and applicable to sites where it cannot be used today. This remote controlled robot will carry the microgravity equipment across rugged terrain and have the ability to make remote measurements. Please stay tuned for future updates as this project develops!

New Schedule is released for 2004 Field Studies Courses Offered this Summer:

Western Kentucky University, through its Center for Cave and Karst Studies, and in cooperation with Mammoth Cave National Park, offers a series of one-week summer courses focusing on caves, karst, and caving. While some courses require previous subject knowledge, other courses are designed for those with merely an interest in caves. Course professors who are internationally recognized authorities in their fields, and have been chosen to lead these courses. These intense field courses combine daily lectures with field observations and excursions. Many of the courses involve rigorous trips into rarely visited portions of Mammoth Cave. The Karst Hydrology course is more surface-oriented and less physically demanding.

June 6-12, 2004
Cave and Karst Stewardship (Carlsbad, NM)

June 13-19, 2004
Karst Geomorphology (Mammoth Cave, KY)
Cave Geomicrobiology (Mammoth Cave, KY)
Hydrology of the Edwards Aquifer (San Antonio, TX)

June 14-19, 2004
Karst Hydrology (Bowling Green, KY)

June 20-26, 2004
Cave Surveying and Cartography (Mammoth Cave, KY)
Cave Ecology (Mammoth Cave, KY)

June 28-July 3, 2004
Karst Stormwater Management (Bowling Green, KY)

For more information contact
The Center for Cave & Karst Studies
Office Coordinator 270-745-3252
http://caveandkarst.uky.edu

The Kentucky Climate Center Develops GeoProfiles Initiative

Users of data collected at Kentucky’s climate stations expect those data to provide a reliable record of Kentucky’s climate. David Logan, a geography major specializing in meteorology and climatology, is working with Kentucky State Climatologist, Stuart Foster, to develop GeoProfiles for Kentucky’s climate stations. GeoProfiles consist of spatial metadata documenting physical characteristics of the sites where climate stations are located across Kentucky.

A GeoProfile is created through a multi-step process. First, the precise location of a station is verified either through a site visit using a global positioning system receiver or by consulting aerial photographs and site sketches from National Weather Service climate station reports. Second, the station’s location is georeferenced with respect to a digital elevation model using a geographic information system. The elevation, slope, and aspect of the climate station can then be recorded and displayed (Figure 1). Third, a digital image or set of images of the station site is added to the GeoProfile (Figure 2). The images provide visual documentation of the station’s exposure. While the preferred sites for climate stations are unobstructed, grassy surfaces, a variety of exposures have been documented, including stations located adjacent to asphalt parking lots, near buildings, or under a dense canopy of trees.

Research conducted at the Kentucky Climate Center has demonstrated that significant annual and seasonal temperature variations exist between stations located only a few miles apart. The development of GeoProfiles will play an important role in better understanding our climate record.

- Written by Stuart A. Foster,
Director, Kentucky Climate Center
The Scott Center has been involved in the construction of the Science Replacement Building since the project broke ground over a year ago.

Matthew A. Detman, P.E., the James D. Scott Professor of Civil Engineering, has been responsible for overseeing the installation of the foundations, the quality of the concrete, the placement of compacted fill, and several other engineering services for this project. Two students, Josh Moore and Will McDonough, have also had significant involvement in the project as they have been primarily responsible for collection of material samples in the field and performing much of the laboratory work.

The first critical part of the project was the installation of the foundation system. Since the structure is being constructed in a hillside, a significant amount of soil and rock was excavated in this phase of the project. As is common in construction, the bedrock was not as it was expected to be as it contained a significant amount of soft, highly fractured shale at the elevation of the foundations. This required the foundations to be excavated about 3 feet deeper than anticipated. To ensure that the foundations were on the appropriate material, Detman and his students oversaw a process that required the contractor to drill "pilot" holes into the bedrock to make sure that solid rock capable of supporting the building loads was encountered at each foundation location. Once solid bedrock was found, the highly fractured shale was excavated to the appropriate depth and the concrete foundations were poured.

The placement of the concrete was an aspect of the project that required extensive involvement from the Scott Center. Each and every time concrete was poured on this project, a representative from the Center had to be on-site to collect test samples to make sure that the concrete being placed was of the correct strength. In addition to strength, the air content of the concrete was also monitored. The purpose of monitoring air content in concrete is to make sure that not too much or too little air is contained within the concrete itself. Air is useful in concrete in that it increases its resistance to the "elements" of nature, such as freeze thaw for exposed concrete. This characteristic of the concrete must be tightly monitored because too much air can have a detrimental impact on the strength of the concrete.

In addition to the strength and air content of the concrete, the Scott Center monitored the placement of the concrete for compliance with current methods of concrete construction. A key area where the Center was involved was during the placement of concrete during very cold weather. The winter of 2002-2003 was very cold, especially during a time when concrete was being placed almost every day. Detman and his students monitored the temperature of the concrete being delivered to the site and had to continue monitoring the temperature of the concrete in place up to 7 days after it was poured. The project specifications required that the concrete be maintained at a temperature of over 50 degrees Fahrenheit for the first 3 days and over 32 degrees Fahrenheit for the next 4 days. The critical issue here is that fresh concrete contains water and if that water freezes during the initial stages of the concrete curing process (the first 7 days) then long term strength can be reduced. One characteristic of concrete, that is very beneficial, is that during the curing process it generates heat internally as the cement chemically reacts with the water to form hardened concrete. The internal temperature of concrete in the first 24 hours is often over 100 degrees Fahrenheit, even if the ambient air temperature is below freezing. In order to keep that heat in, the concrete was covered with thermal blankets during the 7 day initial curing process so that it would not freeze. Fortunately, the contractor was prepared for the cold weather and was able to comply with Detman’s recommendations without slowing down the project.

In one case during the cold weather, a large amount of concrete was poured on a Friday and wrapped in thermal blankets to keep the heat in. Josh Moore, one of the students working on the project, was responsible for taking surface temperatures of the concrete every 12 hours during the weekend. During that weekend, high winds blew the blankets off the concrete resulting in surface temperatures of around 40 degrees Fahrenheit over the weekend. As a result, some additional testing of that concrete was performed to assure that it had achieved the desired strength. Twenty cores were taken out of the in-place concrete and tested for strength, and the results showed that there was no detrimental effect on the concrete as a result of the exposure to low temperatures. In addition, 30 non-destructive tests were performed on the in-place concrete, and these results supported the results from the cores. These non-destructive tests consisted of the rebound hammer test which is a calibrated device that measures the rebound of a steel piston after it has been impacted onto the concrete with a known force. The distance of rebound indicates the strength of the in-place concrete.

To date, almost 7000 cubic yards of concrete have been poured on this project. That’s enough concrete to cover an entire football field to a depth of over 4 feet. During this process, over 700 concrete test samples have been collected and tested for quality control purposes on this project. The project is still underway and the job of the Scott Center is not done. This really is an excellent example of how ARTP provides valuable services to the community.

written by Matthew Detman
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