Applied Research and Technology Program of Distinction

Western Kentucky University

ARTP
Leading Edge

Issue 10, 4th Quarter April 2006 thru June 2006

Kentucky Climate Center Receives Funding to Develop Mesonet

The Kentucky Climate Center and the people of Kentucky received good news when U.S. Senator Mitch McConnell announced a National Weather Service earmark of $1.5 million for development of the Kentucky Mesonet. This appropriation covers the first year of a planned two-year project to develop a high-density, meso-scale, network of automated environmental monitoring stations across Kentucky. Instruments will measure precipitation, temperature, relative humidity, solar radiation, wind speed and direction, soil moisture, and soil temperature. Further, Kentucky Mesonet stations will be platforms to which other critical environmental monitoring sensors can be added as the need arises.

Nearly 100 automated stations will be deployed across the state. Each station will include a set of instruments located on or near a 10-meter-tall tower. Measurements will be packaged into observations every 5 minutes, and then transmitted to the Kentucky Climate Center every 15 minutes, 24 hours per day throughout the year. The data will undergo quality assurance checks and become available to customers and the public within minutes.

Data collected by the Kentucky Mesonet will provide wide-ranging benefits. Some of these are highlighted below:

- As Kentucky's agricultural economy diversifies, the mesonet will provide data that can help producers assess the viability of entering new high value markets, while enhancing the efficiency of traditional crop and livestock operations.
- When severe weather threatens, the mesonet will provide data that can help forecasters target watch and warning areas and help emergency responders save lives and property.
- As Kentucky faces the challenge of educating the next generation, the mesonet will provide data that can help teachers challenge their students in math and science through innovative and engaging activities.
- When drought grips the state, the mesonet will provide data that can help managers of scarce water supplies address the needs of urban and rural communities.
- As cities address challenges of erosion, flooding, sedimentation, and pollution from storm water, the mesonet will provide data that can aid planners in developing best management practices tailored to their communities.

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Figure 1: Mesonet site at Lost River Cave & Valley in Bowling Green.

Inside this issue:

- Fall Semester begins August 28th
- Labor Day, Monday, September 4th

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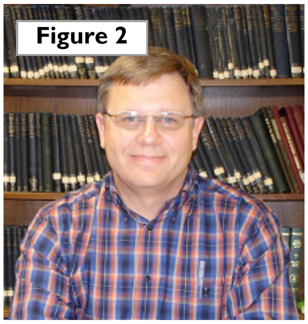


Figure 2: Dr. Stuart Foster, Director of the Kentucky Climate Center.

Figure 3: Probe for monitoring soil moisture levels.

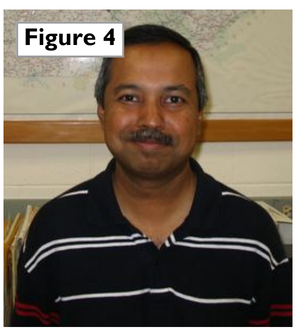


Figure 4: Dr. Rezaul Mahmood, Associate Director of the KCC and the Kentucky Mesonet

Figure 5: Baker Natural Area, Russellville, KY. Site reflects a partnership between the Kentucky Climate Center and the North and South Logan Conservation Districts.

As a member of the National Climate Services Partnership, the Kentucky Climate Center is working closely with representatives of the National Weather Service (NWS) and the National Climatic Data Center. "Representatives of the five NWS Forecast Offices that serve portions of Kentucky have displayed great enthusiasm for the project," said Dr. Stuart Foster, Director of the Kentucky Climate Center. "They will play a vital role in helping us to develop the best possible network to serve the needs of Kentuckians."

The Kentucky Mesonet will require investments in three divisions. An instrumentation division will support technicians responsible for ongoing site maintenance of mesonet stations and an on-campus laboratory for testing and calibrating instruments. An information technology division will handle ingest (which refers to the process by which the server receives and stores data from weather stations around the state) and quality assurance procedures in near real time for data acquired from the mesonet sites across the state. Data will then be archived at the Kentucky Climate Center and other remote sites. Finally, an applied research and service division will focus on development of web-based applications and outreach programs to add value to mesonet data for a variety of users.

"The Kentucky Mesonet will create some exciting opportunities for Western," Foster said. "In addition to offering an array of services across Kentucky, the mesonet will provide rich learning experiences for students. Many of these experiences will involve opportunities for students to work with faculty on applied research in areas ranging from meteorology and climatology to environmental planning. The mesonet promises to help attract quality students on a regional and even national scale."

In the coming months, the Kentucky Climate Center will be building partnerships to support the development and ongoing operation of the mesonet. For more information regarding the mesonet and opportunities for partnering with Western Kentucky University, please contact Dr. Stuart A. Foster by email at stuart.foster@wku.edu or by phone at (270) 745-5983.

~Submitted by
Stuart Foster, Director
Kentucky Climate Center

Area Development Districts Host Kentucky Mesonet Kickoff Meetings

The Kentucky Climate Center and the Kentucky Council of Area Development Districts are working in partnership to invite local stakeholders to become involved with building the Kentucky Mesonet. This summer, kickoff meetings have been held at the Lincoln Trail, Pennyrile, Green River, Kentucky River, and Cumberland Valley Area Development Districts. Representatives of the Kentucky Climate Center and National Weather Service have provided information about the Kentucky Mesonet and the variety of applications and benefits that it will provide. Local stakeholders at these meetings have been invited to participate by recommending potential sites where mesonet stations can be installed. "In building the mesonet, we want to maximize the benefits to people throughout Kentucky, and the best way to do that is to involve them at the local level," said Dr. Foster. "Our meetings thus far have provided some valuable information from people with expert knowledge about the opportunities and challenges associated with finding the best possible sites for environmental monitoring stations in their areas."

As development of the Kentucky Mesonet continues over the next two years, the Kentucky Climate Center will schedule additional meetings around the state.

~Submitted by
Stuart Foster, Director
Kentucky Climate Center

Engineering Services Center and The Center for Water Resource Studies Collaboration: A Device for On-Site Sample Filtration at Water Treatment Plants

WKU's WATERS Laboratory is preparing to become the first contract laboratory in Kentucky to be certified for Cryptosporidium and Giardia testing under the EPA's LT2 rule, which goes into effect in October. Public water systems (PWS) serving populations greater than 10,000 will be required to submit 10 liters (2.5 gallons) of source water for analysis each month for two years.

WATERS Laboratory and Engineering Services have collaborated to build a water filtration unit that will allow water treatment plant operators to filter their water on site according to parameters specified by the EPA. The unit ensures proper and consistent filtration parameters by providing the means to accurately control the water pressure and flow rate through the filter and to measure the amount of water that the filter passes.

PWS will save money by shipping a small filter weighing a few ounces to the lab by overnight courier, rather than shipping a bulky carboy of water weighing 45 lbs. Furthermore, lab processing time will be reduced and sample capacity increased because filtration will be done before sample delivery.

The design of a prototype water filtration system is a good example of the type of small design and build project that Engineering Services can effectively collaborate on. A pair of Mechanical Engineering juniors (Kyle Ketterman and Jimmy Sandusky), together with faculty member Kevin Schmaltz and staff engineer Chris Moore have worked with Rick Fowler and Christal Wade of the WATERS lab to design a simple manual system that would achieve the control and measurement requirements.

The final prototype design (see Figure 1) includes pressure and flow rate control valves, flow rate and total flow measurement instruments, piping and valves to permit system purging and a steel system case for transporting and protecting the system. Other design considerations were to insure reliability of the system while making the system easy for the operators to use on an infrequent basis. Ease in manufacturing additional units cost effectively was also a high consideration.

This project reveals opportunities for continuing interactions between Engineering Services and other ARTP centers. The water filtration project will be continuing with an investigation into the feasibility of constructing a more fully automated system and the possibility of constructing multiple filter systems for WATERS lab customers. Engineering Services has also constructed instrumentation platforms and integrated instrumentation systems for the National Park Service.

Engineering Services has the capability to investigate the design and construction of a prototype instrumentation system, which can benefit businesses and agencies.

~Submitted by Kevin Schmaltz, Director Engineering Services Center and by Rick Fowler Center for Water Resource Studies

"WATERS Laboratory and Engineering Services have collaborated to build a water filtration unit that will allow water treatment plant operators to filter their water on site according to parameters specified by the EPA. "

Figure 1

Figure 1: Prototype of water filter test system.

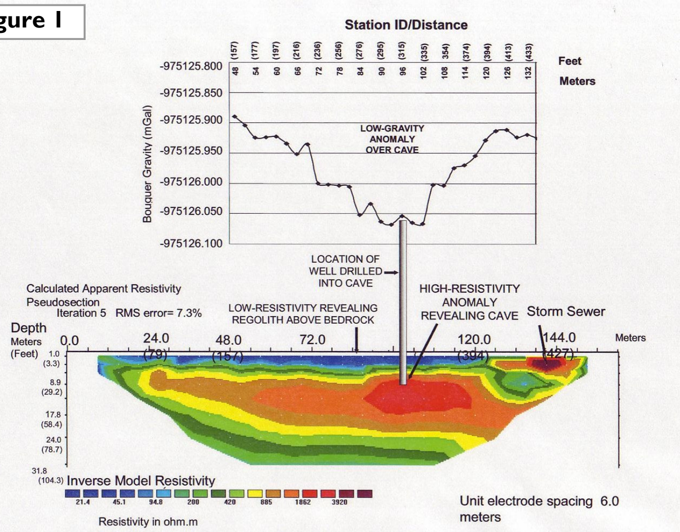
"The Void Detection Robot (VDR) was designed to be simply and efficiently used to locate subsurface voids."

Center for Cave and Karst Studies and Engineering Services Collaboration: Void Detection Robot

WKU's Center for Cave and Karst Studies has a long and successful history of determining the location of caves using microgravity technology. (See Figure 1). However, the microgravity equipment (MGM) is cumbersome and must be manually moved to take measurements. The Center for Cave and Karst Studies and Engineering Services have collaborated to design and construct a robot that extends the capabilities of microgravity measurement. The device built by Engineering Services will have the ability to traverse rugged terrain and make remote microgravity measurements.

The project began in 2001 when funding was secured from the Kentucky Science and Technology Corporation for a three-year project to develop a robot that was capable of gathering microgravity data to determine tunnel location. During the first year of funding, the robot design concept was determined under the direction of Dr. Stacy Wilson. The Void Detection Robot (VDR) was designed to be simply and efficiently used to locate subsurface voids. The user would operate a laptop to control the robot maneuvering and location, and direct the MGM operation and data collection. (Figure 2).

Figure 1



Low-gravity and high-resistivity anomalies reveal previously unknown cave.

Figure 2

Figure 3

Figure 1: (Above Top Left) Graph showing Microgravity and Electrical Resistivity for a low-gravity and high-resistivity anomalies that reveal a previously unknown cave.
Figure 2: (Above Left) Ron Rizzo, Dr. Stacy Wilson and Stephen Miller from the Engineering Department demonstrating the Void Detection Robot prior to the trip to the US-Mexico Border.
Figure 3: (Right) Modified ATV

In the second year of funding, five mechanical engineering students (Tim Clayton, Chris Goebel, JD McQueen, Jessica Scott and Josh Slaughter) with faculty Joel Lenoir and Kevin Schmaltz made the design decision to modify a Honda Rancher ES 350 All-Terrain vehicle for remote control rather than building a unique vehicle to transport the microgravity equipment. The Honda ATV was chosen for the drive and suspension system of the robot because the robot must be able to cross rough terrain, and this particular ATV has an electric starter with auxiliary recoil, automatic clutch, and electric shifting five-speed transmission with reverse.

Work on the ATV by the mechanical engineering students included steering, braking, starting and shifting system modifications for future remote operations, and platforms for both future electronics and the gravimeter itself. The platform for the MGM required the ability to level the instrument to an accuracy of one arc second (1/3600 degree). The status of the vehicle after the second year is shown below in Figure 3.

In the third year of the project, three electrical engineering students (Michael Howard, Steven Miller and Tommy Rippy) with Dr. Stacy Wilson completed the work of the mechanical engineering students on the robot platform and implemented the robot control and data collection phase of the project. A user controls the VDR with a rugged laptop computer designed to withstand extreme conditions. This laptop then communicates with wireless technology to an onboard computer mounted on the ATV. The onboard computer is an Embedded Micro System that was chosen because of its capabilities of operating at higher temperatures than the average PC. The onboard computer is also capable of operating at high humidity levels common in cave systems.

Electromechanical actuators installed on the VDR by the mechanical engineering students are driven by electric signals delivered remotely from the laptop computer. Superlogics Data Acquisition Modules act as the gateway for communication between the onboard computer and each of the motor drives and the remaining components on the robot. A platform for the Data Acquisition Modules (DAQ) was created by the mechanical engineering students and mounted near the onboard computer on the ATV.

A GPS System and the leveling sensors are mounted on the leveling platform on the front of the ATV that houses the MGM. A device to measure the distance to the ground is also located on the platform to permit accurate interpretation of the MGM readings. The onboard computer is mounted at the seat location and controls the actuators through the DAQ modules. Figure 4 demonstrates the various components that are being used on the VDR.

In May, faculty, staff and graduate and undergraduate students from the Center for Cave and Karst Studies and the Engineering Services Center participated in a blind test to evaluate their ability to locate clandestine tunnels extending beneath the US-Mexican Border at Calexico, California. Dr. Crawford, Annie Croft, and graduate students, Gina Cesin and Nathan Rinehart and undergraduate students Matt Coffelt, Tom Rippy, and Michael Howard spent 3 days using microgravity and electrical resistivity along the border to locate clandestine tunnels.

The VDR was also tested and demonstrated along the border at Calexico (Figures 5,6, and 7 are from the trip in May). Several geophysicists from various government agencies were there to observe the test of the techniques and equipment. The demonstration has resulted in the U.S. Geospatial Intelligence Agency and the U.S. Geological Survey providing over $130,000 in new instrumentation to assist with the continuing research to develop ways to locate caves and clandestine tunnels. Also, graduate student Gina Cesin, who is doing her graduate thesis on locating clandestine tunnels along the US-Mexican Border, has received a grant of $25,000 from Los Alamos National Laboratories to finish her MS Thesis. Building the VDR and research along the Border was an excellent experience for the students and involved learning through applied research and national public service. If the microgravity and electrical resistivity techniques pioneered by WKU faculty and students to locate and map caves from the ground surface can also be applied to locate clandestine tunnels, it could be an important contribution to National Homeland Security. However, the existing techniques are slow and very labor intensive which makes the VDR a critical component to the use of these geophysical techniques.

At this point, all of the equipment on the robot including the MGM and GPS systems are controlled by the laptop via the onboard computer. The next phase of the project is to create a measurement grid and pre-program the laptop with this grid. The operator will then only start the process, and the VDR will make the necessary measurements using the grid on the GPS system. The next portion of Phase II is to create a vision system on the robot so that the distance between measurement points or a measurement grid can be entered by the operator and the robot can find its own way across the test ground. The robot will then be able to maneuver around obstacles as it traverses from point to point.

~Submitted by Kevin Schmaltz, Director Engineering Services Center Dr. Stacy Wilson, Professor Engineering and Dr. Nicholas Crawford, Director, Center for Cave and Karst Studies

Figure 5

Figure 6

Figure 7

Figure 5: Annie Croft using the surveying equipment along the US-Mexico Border.
Figure 6: Tommy Rippy running along side the computer controlled VDR .
Figure 7: Annie Croft, Dr. Nicholas Crawford, Tommy Rippy, Michael Howard, Matt Coffelt and Gina Cesin demonstrating the Void Detection Robot along the US-Mexico Border. *(Nathan Rinehart was not in the picture, but also participated in the project)*

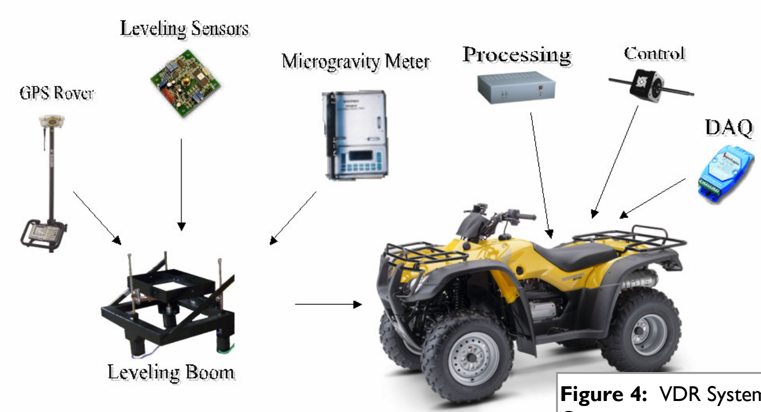


Figure 4: VDR System Components

Neurobiologist Michael Smith joins Biotechnology Center

"The Biotechnology Center would like to welcome Dr. Michael Smith as its newest Member." "His primary research interest is the sensory biology of fish hearing."

The Biotechnology Center would like to welcome Dr. Michael Smith as its newest member. He joined the Department of Biology at WKU this fall after his postdoctoral research at the University of Maryland. His primary research interest is the sensory biology of fish hearing. Projects in his lab examine the fish auditory system in biomedical, environmental, and evolutionary contexts.

The auditory sensory cells of fish are called hair cells. These cells are similar in form and function to mammalian hair cells but are regenerated upon damage by loud sounds while mammalian hair cells cannot. Thus, humans and other mammals cannot regain their hearing once deafened, but fish can. The Smith lab is studying the process of hair cell death and regeneration following acoustic trauma in goldfish and zebrafish. Such baseline data are needed to understand how hair cell regeneration occurs in fish and why it does not occur in mammals. Recently, hair cell development in mammals was shown to be regulated by specific genes (e.g., Atoh1, Rb1, and p27Kip1) and manipulating the expression of these genes can result in hair cell regeneration. Julie Schuck, a graduate student in Dr. Smith's lab, is starting to examine the natural expression of these genes in fish ears undergoing hair cell regeneration. The studies will provide a basis for future investigations in hair cell regeneration research and may be critical in establishing a link between hair cell proliferation and development of new therapeutics to treat deafness.

Studying the process of hearing loss in fish also has environmental implications. Although there has been recent concern about the effects of loud man-made underwater sounds (such as those produced by Navy sonar or seismic surveys) on marine mammals, little is known about their effect on other marine life. The Smith lab is examining how such intense sounds can impact fish, using an electrophysiological technique called the auditory brainstem response (ABR). With ABR, fish hearing tests are performed by placing electrodes on the top of the fish's head and recording the electrical activity of the brain in response to pure tones.

It is generally agreed that the sense of vertebrate hearing first evolved in fish. Thus they provide a wonderful opportunity to study the evolution of hearing. One group of interest is a family of catfish (Loricariidae) that have a unique bi-lobed swim bladder and holes in their skull adjacent to their swim bladder. These catfish also produce sounds by stridulating (rubbing) their pectoral fin spines. Mannie Webb, an undergraduate in the Smith lab, is starting to record these sounds with the goal of understanding their behavioral context. The recordings should also contribute to an understanding of the evolution and acoustical significance (in terms of hearing and sound production) of these unique structures.

~Submitted by Sigrid Jacobshagen Director, Biotechnology Center

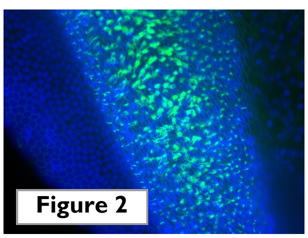


Figure 2: Fluorescently-labeled hair cells in the inner ear of a goldfish. Photo by Julie Schuck.

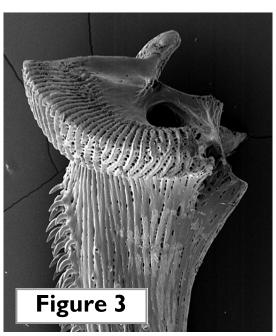


Figure 3: Scanning electron micrograph of the ridges along the head of an armored catfish spine that is used to produce click-like sounds. Photo by Mannie Webb.

Figure 1: The Smith Lab. Back row, left to right: Mannie Webb, Brian Rogers, Michael Smith, Shubash Seroa, Jyoti Sahi. Front row: Reagan Gilley, Julie Schuck, Cassandra Cantrell. Photo by John Andersland.

MCC acquires an Atomic Force Microscope.

Atomic force microscopy (AFM), often called the "Eye of Nanotechnology," is a high-resolution surface imaging technique that can resolve features as small as an atomic lattice in real space. It allows researchers to observe and manipulate molecular and atomic level features. AFM has broad potential and application because it can be used for imaging any conducting or non-conducting surface. The number of applications for AFM has exploded since it was invented in 1986 and now encompasses many fields of nanoscience and nanotechnology. AFM provides the ability to view and understand events as they occur at the molecular level, which allows us to better understand properties and interactions at the molecular level. Many fields utilize AFM, including life science, materials science, electrochemistry, polymer science, biophysics, nanotechnology, and biotechnology. AFM has a number of advantages over other imaging techniques. It provides easily achievable high-resolution and three-dimensional information in real space with little sample preparation. In-situ observations, imaging in fluids, temperature and environmental control are all possible.

Four researchers in the Ogden College were recently awarded a $217,000 Major Research Instrumentation (MRI) grant through the Division of Materials Research at the National Science Foundation to purchase an AFM. The research team includes Stuart Burris, Wei-Ping Pan, Young Shon, and Tingying Zeng, all faculty members in the Chemistry Department. They were able to negotiate the purchase of two AFM systems from Molecular Imaging. The lead system is a fully-optioned PicoPlus AFM (Figure 1) with three available scanners: a 100-µm closed-loop scanner; a 10-µm open-loop scanner; and a 1-µm dedicated STM scanner. Figure 2 shows images of the basal plane of highly-oriented pyrolytic graphite (HOPG) that were collected during the demonstration of the PicoPlus system in September 2005 using the dedicated STM scanner. This system has environmental and temperature control capabilities as well as the ability to scan in liquids and maintain electrochemical control of the surface while imaging. The second system is also a PicoPlus AFM utilizing the same three scanners as the lead system, but does not include the electrochemical control option or the ability to do magnetic AC (MAC) mode scanning.

Current research utilizing the PicoPlus AFM systems includes the following areas: new carbon nanotube/polymer composite materials for NASA spacecraft applications by Dr. Pan's research group; organized, nanoscale films, which are targeted for use in high-speed, optical memory devices, by Dr. Shon's group; nanoscale patterning by Dr. Burris' group to assist in the development of nanoscale sensors for proteins and other biologically relevant agents; and the properties of nano-fabricated, high-efficiency solar cells by Dr. Zeng's group. Further, at least five laboratory courses spread across three different departments in the College will also be positively impacted by the availability of AFM.

The acquisition of the AFM systems has strengthened the Chemistry Department and the Materials Characterization Center, and has begun to foster further inter- and multidisciplinary collaborations across the College. The AFM will allow research and teaching faculty from at least four departments within the College to both accomplish their research objectives and integrate topical educational activities that they previously could not. Hands-on experience with modern microscopy techniques is a significant and unique opportunity not offered by many predominantly undergraduate institutions. The Materials Characterization Center is proud to offer this opportunity to the College.

The PicoPlus AFM systems currently reside in the Materials Characterization Center at South Campus. For further information or to request training on the AFM, please contact Stuart Burris at 745-2973 or stuart.burris@wku.edu.

~Submitted by Eric Conte, Director, Materials Characterization Center

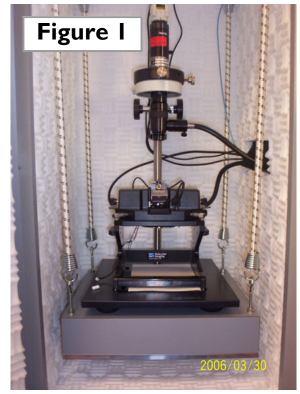


Figure 1: PicoPlus AFM in the acoustic and vibration isolation cabinet.

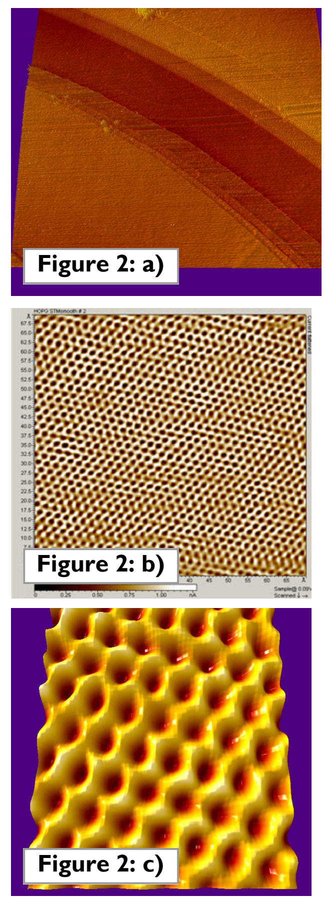


Figure 2:
a) enhanced 1.1 µm image of HOPG showing atomic steps
b) flattened 7 nm image of HOPG showing electron density pattern in carbon-carbon bonds
enhanced 1.5 nm image of HOPG showing electron density pattern in carbon-carbon bonds.

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