SCHOOL OF SCIENCE AND MATHEMATICS

Undergraduate Research Poster Display

April 13-16, 2005

Caputo Hall Lobby

- **BIOLOGY**
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- **EARTH SCIENCES**
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T A B L E o f C O N T E N T S

Note: The names of Millersville University faculty advisors are designated by an asterisk (*) in the abstracts.

B I O L O G Y

1) **A Habitat Suitability Model for Crayfish Species in Lancaster County, Pennsylvania, Streams**

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The introduction of invasive exotic species in previously inaccessible areas provides the opportunity to study the impacts of invasive species on closely related native species. Habitat suitability index [HSI] models offer a coarse estimate of the habitat quality relative to hypothesized physiological tolerances of a species. The distribution and abundance of two native [*Orconectes obscurus* and *Cambarus bartonii*] and one invasive [*Orconectes rusticus*] crayfish along a twenty-three mile length of a Lancaster County, PA, stream and various physical factors at the sample sites were provided by a recent survey (Wagner *et.al.* unpublished). Of the factors provided, stream width, velocity, pH, and temperature were considered as the factors defining the geographic range of each species. An HSI model was constructed based on these factors to identify regions offering suitable habitat for a species and areas of a stream which are at risk for invasion of *O. rusticus*. A subindex describing shelter availability was developed using average rock size and substrate composition. Current work involves the development of subindex describing the availability of food within the stream using stream order, link magnitude, and surrounding land use. The HSI model will be coupled to a model describing the interactions between size-structured populations of native and invasive species under the influence of a predator.

2) **Avian Communities Associated with Streamside Restoration.**

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In July of 2004 LandStudies, Inc. conducted a stream/floodplain restoration project (Fox-Zimmerman) on the Hammer Creek in Lancaster County, PA. The project entailed altering the flow regime of the creek channel as well as providing it with an effective floodplain. In 2002 a similar alteration was performed on another portion of the same creek (Snavely Mill). This study was conducted to assess changes in avian species diversity at theses two locations. My objective was to document avian community changes during the restoration at Fox-Zimmerman and to compare that to the previously restored Snavely Mill location. At each location a point count census was done from May, 2004 through February, 2005. Four sampling points were established between 10 and 20 meters apart and every 10 to 20 days I monitored each point for 10 minutes, recording all birds seen and heard within a 10 meter radius. Species evenness remained fairly constant across locations and throughout the ten month study. Species richness declined in mid-summer at Fox-Zimmerman coincident with the start of restoration. However, a similar decline at Snavely Mill suggests that these declines are likely due to seasonal changes in bird activity rather than the restoration.

3)   Chemical Communication in Octopuses

Prosser, Krista; Walderon, Matthew (MU 2001), Holm, Johanna; Miller, Sean; Nagle, Gregg; Boal, Jean G.*
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Octopuses are solitary and cannibalistic; the ability to recognize conspecifics at a distance could be vital to successful mating. Using ventilation rate as an assay, *Octopus bimaculoides* were exposed to water-borne odors of food (frozen shrimp and live crabs), conspecifics (same and opposite sex), and conspecific eggs (whole and C18 Sep-Pak purified extracts). Ventilation rate increased significantly in response to frozen and live food, conspecifics of the opposite sex, and extracts from eggs; responses to conspecifics of the same sex and intact eggs were less clear. Previous research has shown that odors from conspecifics are important to the reproductive behavior of squid; these results are the first to demonstrate that water-borne odors from conspecifics are salient to octopuses.

4)   Impact of Stream and Floodplain Rehabilitation on Macroinvertebrate Community Structure and Diversity on the Hammer Creek in Lancaster County, PA

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Naturally occurring floodplains act as a barrier to adverse effects from anthropogenic sources, while retaining aquatic organism diversity and potentially increasing stream productivity. The purpose of the study is to examine macroinvertebrate communities in response to stream and floodplain rehabilitation. This is an on-going study initiated with pre-restoration sampling conducted in July/August 2001. Post-rehabilitation sampling began in December 2001 and is continuing until the present. Long-term monitoring is being conducted among five sampling sites: above the restored area (control site), two sites within the restored section of the stream, and two sites 100 and 2500 meters below the impacted reach. Macroinvertebrates were sampled from the sites using a modified Hess sampler (n=6 replicates samples/ site). Macroinvertebrates were identified to generic level and analyzed using several metrics such as, Shannon and Simpson biodiversity indices, percent EPT, Functional feeding group analyses, ratio of scrapers to collector-filterers, and ratio of EPT abundance to Chironomidae. We found that stream restoration in this case may traumatize the macroinvertebrate community reflected in a lag time in recovery with regards to increasing diversity. Because of an increase in riffle habitat, a modification of flow regime, and potential for preservation of habitat heterogeneity within these riffle zones, macroinvertebrate diversity may respond according to this improvement in habitat.

5) **Characterizing the Invasion Front of the Rusty Crayfish, *Orconectes rusticus,* in a Pennsylvania Stream**

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The rusty crayfish, *Orconectes rusticus*, was an unknown species in Pennsylvania during the last major assessment of crayfish as documented in a 1906 survey. An intensive survey of Lancaster County, Pennsylvania in 2000 revealed that O. rusticus had successfully invaded many streams. *Orconectes rusticus* are also sold in local bait shops suggesting its introduction was likely due to its use as bait. *Orconectes rusticus* has the potential to cause serious ecological harm to aquatic systems by displacing native crayfish species via competition and hybridization leading to alteration of food web dynamics. In order to predict the extent of invasions, identification of the physical and chemical parameters predisposing stream habitats to invasion is needed. Our objectives were to determine how a suite of physical and chemical parameters might influence the distribution of crayfish species along a stream continuum, with particular emphasis on characterizing the invasion front of *Orconectes rusticus*. Rather than an invasion front, we encountered a distinct invasion boundary created by a natural series of small waterfalls. Our data suggest that parameters such as water velocity, depth, pH, and temperature have little effect on the distribution and invasion of *Orconectes rusticus* along a stream continuum when natural barriers are present.

6) **Determining a Postmortem Submersion Interval (PMSI) Based on Algal/Diatom Diversity on Decomposing Mammalian Carcasses in Brackish Ponds in Delaware.**

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This study was done to qualitatively analyze the type of single-celled algae, specifically diatoms that colonize a pig carcass in a brackish water environment. Stillborn fetal pigs were submerged in a brackish pond, along with ceramic tiles which were used for to make a comparison of the different algal taxa that colonized both substrates. A Statistical analysis was done to determine any significance of algal diversity between stages of decomposition and also substrate. We found that the pig carcass had a significantly greater algal diversity than the tile substrate. Our results suggest that in the future algal diversity may help determine a post mortem submersion interval (PMSI) in a brackish or marine setting.

CHEMISTRY

7) **Functionalization of Nanowire Arrays for the Detection of Chlorpyrifos**
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The detection of environmental contaminants and biologically important molecules has been identified as one of the major potential applications of nanotechnology. New chemical nanosensors can be developed based on the functionalization of metallic nanowire arrays to bind to specific analytes. Spectroscopic techniques can then be used to identify and quantitatively measure the analyte. Nanosensors have advantages of very high sensitivities and small size as compared to traditional sensors. During this project, gold nanowires have been functionalized for the measurement of the pesticide, chlorpyrifos. Characterization of the gold nanowires was performed using reflectance infrared spectroscopy, cyclic voltammetry, fluorescence microscopy and scanning electron microscopy. Each method showed a dramatic change in the gold surface of the wires after the addition of a bridging molecule and the chlorpyrifos antibody.

8) **Production of Double Mutant Strains in the Inositol Pathway of Yeast**
Meyers, Jodi L. and Miller, Aimee L.*
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Ipk1 production of IP_6 (inositol hexakisphosphate) is known to regulate mRNA export from the nucleus. A genetic interaction has also been found between *IPK1* (the gene that encodes the Ipk1 protein) and *ALR1* (the Alr1 protein is a Mg^{2+} transporter) genes in *Saccharomyces cerevisiae* yeast. An *ipk1Δ* null mutant (Δ indicates deletion of the gene) with an additional point mutation in *ALR1* was inviable. The first goal of this project is to confirm the observed lethality for *ipk1Δ* when combined with an *alr1Δ* null mutation. Since it has yet to be determined how Ipk1 and Alr1 are functionally related, we would further like to determine whether *alr1Δ* shows genetic interactions with two other genes, *IPK2* and *PLC1*. These genes encode proteins involved in earlier steps in the inositol pathway that produces IP_6 in *S. cerevisiae*. A null mutation in either of these genes also causes the strain to be deficient in IP_6 production. The second goal of the project will be to also combine the *alr1Δ* mutation with *ipk2Δ* and with *plc1Δ*. These double mutant strains will be tested for viability or growth. If lethality is observed in these strains, it would suggest that the IP_6 molecule itself might affect Alr1 function or Mg^{2+} transport.

9) **Synthesis and Characterization of Novel Molybdenum/Tungsten Complexes**
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Four novel molybdenum and tungsten complexes containing diphosphine ligands diphenylphosphinomethane(dppm), and diphenylphosphinobutane(dppb) were synthesized and characterized using elemental analysis, IR, and H^1-NMR. $Mo(CO)_2Br_2(PPh_3)dppb$ was synthesized and characterization of the complex indicated that it is seven coordinate with dppb acting as a bidentate ligand. $Mo(CO)_2Br_2dppm_2$ was synthesized and then refluxed to form

$Mo(CO)Br_2dppm_2$. Characterization of the two complexes revealed that the first contained one bidentate and one monodentate dppm ligand while the other contained two bidentate dppm ligands. From $Mo(CO)_2Br_2dppm_2$ $Mo(CO)_2Br_2(dppm)(\mu\text{-}dppm)W(CO)_2Br_2(PPh_3)_2$ was synthesized through a reaction with $W(CO)_2Br_2(PPh_3)_2$. The characterization indicates that the two metal centers are bridged by a dppm ligand. These complexes will serve as benchmarks for further research involving these metal centers which could include catalysts and pharmaceutical development.

10) Functionalization of Nanowires for the Development of Nanosensors
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As part of a comprehensive nanosensor development research initiative we have functionalized gold nanowire arrays with potassium thiocyanate using chemical self-assembly techniques. The purpose of functionalization was to facilitate the binding of hemoglobin to the surface of the nanowire sensor array. Optical spectroscopy was used to detect and quantify both species on these specialized surfaces. Cyclic-voltammetry was used to corroborate the results of the optical methods used. Scanning Electron Microscopy (SEM) was used to image the gold nanowire sensor arrays and determine their wire dimensions and distributions.

COMPUTER SCIENCE

11) Calculating Entry Rates for AAC Access Methods
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The purpose of this project is to investigate the various access methods used with augmentative/alternative communication (AAC) devices, and to develop formulas for calculating text entry speeds for each method. These methods include direct selection using the keyboard, a joystick, and head pointing, and several indirect selection scanning techniques. The thesis will include details about these various access methods, as well as derived formulas for calculating potential text entry rates for each method. These formulas will provide empirical methods for comparing the various access methods, and provide a basis for an evidence-based practice methodology for helping AAC users maximize their entry speeds.

12) High Performance Computing and Computer Aided Engineering
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Advances in 64-bit processors, computer systems, and software platforms are bringing more computing power within the reach of Computer Aided Engineering (CAE) users. In June 2004, Intel released the Xeon Extended Memory 64-bit Technology (EM64T) processor, continuing the decades-long trend of dramatic improvements in processor cost/performance. EM64T is a set of extensions to the Intel IA-32 architecture. Features include full 64-bit wide registers, eight additional general purpose registers, eight additional SSE registers, and native 32-bit capability. With parallel advances in interconnects such as PCI Express and Infiniband, and cluster operating systems and management tools, high performance computing (HPC) has

become affordable for many companies. IBM engineers have taken these advances and turned them into low-cost, reliable, cluster systems capable of scaling to teraflop performance. In fields such as CAE, these clusters are leveraged to reduce product development time, decrease time to market, and improve product quality. Detailed models are used throughout the engineering process to simulate the performance of proposed and existing designs. In this research we investigate how the confluence of HPC technologies has allowed manufacturing companies to deploy new applications that require increasingly complex models.

13) Simulating the Curvilinear Capsulorhexis Cataract Procedure on the EYESI™ System

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This paper describes a technique for simulating the capsulorhexis procedure during cataract surgery on the EYESI™ system. Eye surgery necessitates sub-millimeter precision and demanding hand-eye coordination in a very small workspace, thus making it difficult to simulate. Some researchers have developed eye surgical simulators, but none have attempted to model the capsulorhexis procedure during cataract surgery. The continuous curvilinear capsulorhexis technique can be a difficult procedure for beginning ophthalmology surgeons. In the initial phase of tearing the tissue, the tear vector is tangential to the circumference of the tear circle. However, without the proper re-grasping of the flap of torn tissue close to the tear point, the tear vector angle quickly runs downhill possibly causing severe damage to the tissue. Novice surgeons tend to try to complete the capsulorhexis without the time consuming re-grasping of the tissue flap. Other factors such as anterior bowing of the lens diaphragm, patient age, and shallow anterior chambers add to the problematic nature of the procedure. The tissue area is modeled as a curvilinear mesh of nodes and springs. Deformation is accomplished via a physically based particle model utilizing a heuristic algorithm to constrain the deformation calculations to the locality of the tear area to speed up computations. The software alerts the user of any potential tear problems before they occur thus instructing the novice surgeon. For example, as the user approaches the 12 o'clock position the tear vector unintuitively begins to run peripherally. If the surgeon attempts to redirect it by traction directed in a radial fashion toward the center of the lens, the tear only propagates further peripherally (runs downhill). Continuing to try to redirect the tear can cause severe damage to the tissue in an actual patient. The EYESI™ hardware system (from VRMagic GmbH) provides the user with stereoscopic images thus providing 3D viewing. Our capsulorhexis simulator software models various tear problems and anomalies to provide a useful training environment without the dangers of using live patients.

14) Interfacing AAC Devices to Mac OS X

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The purpose of this project is to develop a program to implement the General Input Device Emulating Interface (GIDEI) protocol for the Apple Macintosh OS X system. Such a program exists under Microsoft Windows® (called AACKeys), but at present there is no

comparable program under any Unix-based system. AACKeys is a widely used (free) software package that allows augmentative/alternative communication (AAC) device users to access Windows-based computers.

This GIDEI protocol defines a connection and data communication protocol between an augmentative/alternative communication (AAC) device and a standard computer. This allows AAC users to issue operating system commands to the standard computer, emulate mouse movements, access storage devices, and operate standard software packages. The emulation software accepts plain text from the AAC device and translates it into keyboard or mouse operations. The emulator must translate the entire range of possible keyboard and mouse signals. In addition, it must provide commands for selecting a particular input port and for setting the communication speed of that port.

Apple Computing is loaning the project team several I-Mac and Powerbook laptop computers for the duration of this project. The resulting program will be distributed free of charge by the AAC Institute (http://www.aacinstitute.org).

15) **Using an Approximation to the Euclidean Skeleton for Faster Collision Detection and Tissue Deformations in Surgical Simulators**

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This paper describes a technique for speeding up collision detection and deformation of abdominal organs in surgical simulation using an approximation of the Euclidean skeleton. Many researchers have developed surgical simulators, but one of the most difficult underlying problems is that of organ-instrument collision detection followed by the deformation of the tissue caused by the instrument. Much of the difficulty is due to the vast number of polygons in high resolution complex organ models. A high resolution gall bladder model for instance can number in the tens of thousands of polygons. Our methodology utilizes the reduction power of the skeleton to reduce computations. First, we compute an approximation to the Euclidean skeleton to generate a set of skeletal points for the organ (black line in figures). Then we pre-compute for each vertex in each polygon the associated skeleton point (minimal distance discs). A spring is then connected from each vertex to its associated skeleton point to be used in the deformation algorithm. The data structure for the organ thus stores for each skeletal point its maximum and minimum distances and the list of associated vertices. A heuristic algorithm using the skeleton structure of the instrument and the skeleton of the organ is used to determine if the instrument collides with the organ.

EARTH SCIENCES

16)   Mechanisms for Almandine Garnet Weathering in Lancaster County, Pennsylvania

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Almandine garnet ($(Ca,Mg,Mn^{II},Fe^{II})_3Al_2Si_3O_{12}$) weathering is a natural mechanism that removes CO_2 from the atmosphere on geologic timescales ($>10^5$ years).   Previous workers found the weathering of almandine garnet to be determined by the mineral's chemical composition. These findings show that when a protective surface coating forms on almandine garnet the weathering process is transport-limited. In environments were weathering is interface-controlled a protective-surface coating is absent and almandine garnet weathers rapidly. Petrographic observations of incipiently weathered Lancaster County almandine garnet shows a two-stage process. The formation of a likely goethite (FeOOH) and gibbsite ($Al(OH)_3$) surface coatings on some grain edges and fractures reflects the fracture patterns rather than the shape of the grain. This can be explained if almandine garnet weathering is controlled by the evolution of porosity rather than by its chemical composition. The incipient stage of weathering is characterized by limited porosity, allowing for saturation of the surrounding fluid by iron and aluminum cations. The iron and aluminum then precipitates in the fractures of the almandine garnet. As weathering progresses, permeability increases and iron and aluminum are dissolved. The removal of these cations allows the almandine garnet to dissolve completely.

17)   Investigating the Thermodynamic Environment of a Mesoscale Convective System

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[2]SOARS Summer 2004

A mesoscale convective system (MCS) is a complex of thunderstorms that is organized on a much larger scale than an individual thunderstorm and can persist for several hours. MCS characteristics (intensity, structure, propagation speed) are thought to be influenced by the thermodynamic properties of the environment and vertical wind shear. Past studies have typically characterized MCS environments on the basis of a single sounding, but there are few studies using detailed thermodynamic measurements of the environments of these systems to validate this approach. Data for this study were from the Bow Echo and Mesoscale Convective Vortices Experiment (BAMEX) to investigate the thermodynamic environment a convective system. This research was unique because there were approximately 35 soundings taken within and near this convective system. To quantify the environmental structure, selected parameters were used to estimate the buoyancy of hypothetically lifted parcels at several levels and the vertical wind shear through the lower and middle troposphere. Results suggest that the northern limit of the MCS is determined by environmental stability, not by processes internal to the MCS. There were significant differences in the intensity of the MCS between the northern and southern halves of the MCS that corresponded to the variation of the lifted index north to south. The variance of soundings in the path of the MCS suggests that it is not possible to characterize the degree of instability in this case. Furthermore, there was nearly a factor of two uncertainties in environmental wind shear. The results of this research further the understanding of the thermodynamic environment of a mesoscale convective system.

18) **Correlating Measured Pollutants in Northeast Philadelphia to Their Source Using ArcGIS**

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Pollution today has become both an important social and economic factor in every American's life. It has been linked to both illness and ecological disaster. Yet, little is known about how emissions spreading across the mid-Atlantic and Northeastern states are affected by the weather. For instance, do areas having normally higher levels of CO_2, SO_2, and NOX coincide with areas of increased precipitation, health problems, and ecological disasters? In order to discover answers to these and other questions, data from a combination of criteria gas analyzers, small balloon soundings, historical regional emissions data, and back trajectories, were incorporated into advanced modeling software (ArcGIS) to study haze and pollution events in Philadelphia. HYSPLIT 48-hour back trajectories were mapped in hourly intervals giving the location of air parcels terminating at three specific heights. Combined with (EPA) emission data, GIS was used to display air parcels on their way to Philadelphia traveling through weak and intense concentrations of CO_2, NO_2, and NOX. Our research focuses on the path the air parcel travels through these regions of varying trace gas concentrations, and their affect on the local concentrations observed in Philadelphia. Future plans include the incorporation of precipitation totals at each of the emissions plants, population demographics, National Weather Service observations, and model output, which will be integrated to help us further understand the effect of meteorology on pollution concentrations.

19) **Estimating Hail Size Using Polarimetric Radar**

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This study investigates the use of polarimetric variables for estimating hail size. Archived data from the KOUN polarimetric radar in Norman, Oklahoma are obtained for three hail-producing events during 2004: 24 May, 29 May, and 2 June. A total of 45 hail reports are used for analysis, including hail sizes ranging from 0.75" to 4.25". Horizontal and vertical structures of reflectivity at horizontal polarization (ZH), differential reflectivity (ZDR), and correlation coefficient (ρHV) associated with these reports are examined using Interactive Data Language (IDL) programs. Comparison of these images allow for the hail to be categorized into two groups based on ZDR and ρHV signatures: hail less than 1.75" in diameter and hail 1.75" or higher in diameter. RHI images reveal differences in the vertical structures of these categories; extended columns of low ZDR and ρHV are observed for the larger hail.
Also, vertical profiles of these variables show a more significant decrease in ρHV below the melting layer for hail 1.75" or larger. Box-and-whisker plots and discriminant analysis are then used to determine the ability of ZDR and ρHV to distinguish between the two categories. Although ZDR appeared promising for estimating hail size, the discriminant analysis revealed that ρHV is the best variable to discriminate between the categories.

20)   Correlation between Atlantic Ocean Storms and Microseisms Recorded at the Millersville University Seismic Station

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Microseisms are small-amplitude, non-local, non-tectonic signals that are ubiquitous on seismic records. One well-known source of microseisms is ocean waves breaking along coastlines, which gives rise to a low frequency peak (around 0.07 Hz), called the primary peak, in the energy spectrum of the seismic data. Another well-known source is non-linear ocean wave interactions occurring near the center of cyclonic storms at sea, which give rise to a higher frequency peak (around 0.14 Hz), called the secondary peak. In this study we perform spectral analysis of the seismic records from the Millersville University (MU) Seismic Station to explore the effects of the intensity of ocean storms, and their distance from the seismic station, on the amplitudes and frequencies of the primary and secondary peaks in the microseism spectrum.

21)   The Role of Undergraduates in LEAD Learning Communities: Developing LEAD-TO-LEARN Modules

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Each year across the United States, floods, tornadoes, hail, strong winds, lightning, and winter storms – so-called mesoscale weather events – cause hundreds of deaths, disrupt transportation and commerce, and result in annual economic losses greater than $13B. Although mitigating the impacts of such events would yield enormous societal and economic benefits, the ability to do so is stifled by information technology (IT) frameworks that cannot accommodate the real-time, on-demand, and dynamically-adaptive needs of mesoscale weather research; its disparate, high volume data sets and streams; and its tremendous computational demands. In response to this pressing need for a comprehensive national cyberinfrastructure in mesoscale meteorology, LEAD will address the challenges needed to create an integrated, scalable framework for identifying, accessing, preparing, assimilating, predicting, managing, analyzing, and visualizing an array of meteorological data and model output, independent of format and physical location. The transforming element of LEAD is dynamic workflow orchestration and data management, which will allow use of analysis tools, forecast models, and data repositories as dynamically-adaptive, on-demand systems that can a) change configuration rapidly and automatically in response to weather; b) continually be steered by new data; c) respond to user input; d) initiate other processes automatically; and e) steer remote observing systems to optimize data collection. Learning Communities are established to ensure that education and outreach are integrated throughout the entire LEAD program, and will help shape LEAD research into applications that are congruent with the needs of the education communities, including access to data and the tools required for analysis and visualization, pedagogical requirements, national and state science and technology standards, and evaluation metrics. Millersville Earth Sciences undergraduates are directly involved in the creation of 4-D visualization modules that will be used to enhance pre-college and undergraduate education in the atmospheric and related sciences nationwide.

22) A Field Study of Particulate Matter Concentrations in the Wintertime Boundary Layer

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A detailed examination of the structure and evolution of the wintertime boundary layer was conducted from 3 January - 14 February 2004 near Lancaster, PA in support of the research objectives of the Mid-Atlantic/Northeast - Visibility Union (MANE-VU). Two tethered balloons were used to deploy meteorological sensors, condensation particle counters, laser-diode scatterometers, and filter samplers to altitudes of 750 m AGL, while a suite of ground-based instruments measured trace gas and particle concentrations and meteorological parameters. January 2004 was characterized by a very active synoptic pattern that frequently brought Arctic air into the mid-Atlantic region and resulted in this being the 10th coldest January on record. Tethered balloon measurements were primarily limited to times when progressive anticyclones moved over the site, bringing clear skies, strong nocturnal radiational cooling, and relatively light boundary layer wind speeds. The measurements obtained using the single-site tethered balloons are being integrated into a regional context by incorporating surface and aloft observations from the NWS network, as well as regional profiler data and WRF and Eta model output. Laser-diode scatterometers (DustTraks), condensation particle counters (TSI CPCs), and Teflon filter samplers (PEMs) were deployed on tethered balloons, and the data then integrated with meteorological data from onboard sensors to characterize the variability of aerosol concentrations and relate it to ground-based measurements using similar instruments. It can be demonstrated that above average PM2.5 dry mass concentration from the filter samplers and analyzed at the Harvard School of Public Health are highly correlated with high DustTrak concentrations observed in the soundings when the atmospheric boundary layer was well mixed. In comparing the ground PEM data with the ground DustTrak data, total and size partitioned particle counts, black-carbon data, and scattering coefficients, it can be concluded that there is a direct relationship between the period averages of these data and meteorological events. The time periods of above average concentrations for each of these data correspond to episodes when the region was dominated by an upper level ridge in the east coupled with warm air advection into Pennsylvania. These data can be used in analyzing and interpreting the variability of aerosols and air pollutants in a wintertime boundary layer.

23) Atmospheric/Soil CO_2 Consumption at Coweeta Hydrologic Laboratory, Western, North Carolina, USA

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Atmospheric/soil CO_2 consumption has been calculated using watershed flux-based mass balance methods for Coweeta Hydrologic Laboratory in western North Carolina. The study area watersheds are located in a humid temperate climate and are developed on granitic bedrock. The methods of this study differ significantly from previous studies of CO_2 consumption because accurate watershed solute flux-based mass balance calculations permit CO_2 consumption to be attributed exclusively to the silicate minerals that are weathering. The weathering of silicate minerals is a natural mechanism by which atmospheric CO_2 is consumed on geologic timescales ($>10^5$ years).

At Coweeta, no carbonate minerals are present in the bedrock, and chemical weathering is attributed to plagioclase feldspar, almandine garnet, biotite, and allanite. If it is assumed that carbonic acid is solely consumed by the weathering of these minerals, then CO_2 consumption values range from 890 to 1300 moles/hectare/year for the three watersheds investigated. These CO_2 consumption rates are lower than those reported in the literature for other localities, often by as much as an order of magnitude.

 For Watershed 2 (W2) at Coweeta, bicarbonate data are available. CO_2 consumption in W2 based on the stream bicarbonate flux is 640 moles/hectare/year, approximately a factor of two lower than the CO_2 consumption calculated from the mineral weathering rates (1300 moles/hectare/year). This difference likely reflects that mineral weathering at Coweeta is consuming acids other than carbonic. Other acids may originate from atmospheric deposition, or from sulfuric acid produced by the weathering of pyrite.

Relatively low CO_2 consumption by silicate weathering at Coweeta may reflect the temperate climate of the region, and/or being underlain by granitic bedrock. However, it is also possible that other methods which calculate CO_2 consumption by separating carbonate-derived bicarbonate from silicated-derived carbonate may overestimate CO_2 consumption.

MATHEMATICS

24)   **Periodic Orbits in Triangular Air Hockey**
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We explore the existence of periodic orbits on a triangular air hockey table, a problem also known as billiards on a triangle. The equilateral triangle admits an infinite number of periodic orbits, and period n orbits on an equilateral triangle are counted for any natural number n. Results by others regarding whether all triangles admit periodic orbits are summarized as well.

25)   **Positive Solutions to a Diffusive Logistic Equation with Constant Yield Harvesting**
Marks, Ken; Shivaji, Ratnasingham[1] and Shao, Zhoude*
Department of Mathematics, Millersville University, Millersville, PA 17551
[1]REU program at Mississippi State University

We consider a reaction diffusion equation which models the constant yield harvesting of a spatially heterogeneous population which satisfies a logistic growth. In particular, we study the existence of positive solutions subject to a class of nonlinear boundary conditions. We obtain our results via a quadrature method and *Mathematica* computations

26)   **Log-Linear Models and an Analysis of the Pennsylvania Department of Education High School Mathematics Field Test**
Martin, Joel M. and Fenwick, James *
Department of Mathematics, Millersville University, Millersville, PA 17551

The results of the Pennsylvania System of School Assessment 2002 High School Level Mathematics Field Test are analyzed using log-linear models. The statistical methods of log-linear analysis are explained and used to model the propensity of students (N = 5,308) to answer questions correctly based on the variables of question type, use of a calculator, school district, and gender. Best fit models were selected for different questions or groups of questions. The best fit models then were compared to the content of the questions to see if any logical conclusions could be inferred about the reason behind the inclusion of certain variables in the model. Multiple replications and validation trials proved log-linear analysis to be a robust procedure for modeling the high school test data.

27) **The General Brachistochrone Problem**
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The original brachistochrone problem, solved by Newton in 1696, asks the following question: "Consider a frictionless vertical plane Π in a uniform gravitational field. Given two points A, B in Π, what curve is traced out by a particle that starts at A and reaches B in the shortest possible time?" This project studies this problem for particles constrained to some other simple surfaces such as surfaces of revolution. We solve this more general problem using conservation of mechanical energy and the Euler-Lagrange equation. Whereas the original the problem assumes a uniform gravitational field, we also solve the brachistochrone problem in more general settings such as inverse-square fields.

28) **Measuring the Index of Refraction of Air**
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An optical cell is placed in one leg of a Michelson interferometer. The cell can contain a gas or fluid which, effectively changes the optical path length. The change in optical path length can be calculated from the number of fringes displaced when the content of the cell is changed. The experiment has been used to calculate the geometry of the cell two within half a wavelength and to measure the refractive index of air as a function of pressure.
To calculate the cell geometry it was filled with water. A 1mm HeNe laser beam traverses the interferometer and passes through the cell. The cell is then moved perpendicular to the optical path by a known amount using a micrometer. Fringes are displaced while the cell is moved. The number of fringes displaced was used to that the separation between the adjacent cell surfaces varied by 3/2 a wavelength over a vertical distance of 680um.
To measure the refractive index of air as a function of pressure a cell of known geometry placed in the interferometer as described above. Now instead of filling the cell with water it was filled with air and then hooked up to a vacuum pump. As the vacuum pump lowers the air pressure in the cell, the optical path length is effectively changed. It was found that the refractive index varied linearly with pressure in the range of 2-100 kPa absolute. This result is consistent with the result expected for an ideal gas.

29) **Electrical Anisotropy in Sculptured Thin Film**
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The Sculptured Thin Films (STFs) exhibit a property of unidirectional nonhomogeneity which is responsible for a subsequent electrical anisotropy in the films. The Montgomery method is used to measure the anisotropic resistivity in the films. The goal of this project is to characterize sculptured thin film and understand the relation of electrical anisotropy to the structural nonhomogeneity of the films. The films under investigation are each deposited onto a glass substrate with thicknesses ranging from 100-3000 nm. This is ongoing project in collaboration with Penn State University.

I N D E X