

Session: Environmental & Earth Sciences

Amber Walter

University of Montana-Western - Environmental Sciences

Historic Climate Change at Ennis, Montana

I am reporting my part of a larger class research project into temperature and precipitation change in Southwest Montana, using historic climate data available online from the Western Regional Climate Center. The research was conducted in a class taught by Drs. Sheila Roberts and Craig Zaspel, at University of Montana Western, in fall, 2010, with NASA Space Grant funding. We studied average monthly temperature and total monthly precipitation for 12 sites in southwestern Montana, ranging over about the past 100 years. The data were reviewed and months or years with significant missing data were omitted from analyses. Annual and seasonal temperature and precipitation change were graphed as time series. I chose Ennis, MT as my research site. The 92 years of Ennis temperature data indicate a rate of increase of 2.2 °F /100 years, with the greatest increase occurring in winter; January temperature increased at 5.7 °F/100 years. Summer months had the lowest increase, at 0.74 °F/100 years. Spring and fall increased at rates of 2.8 °F/100 years and 1.1 °F/100 years. This amount of temperature increase is consistent with changes in global and regional climate. Total annual precipitation at Ennis increased at a rate of 5.6 inches/100 years, with seasonal variability similar to the temperature record. All seasons were warmer, but winter and spring had the largest increase, at 0.73 inches/100 years. Summer showed the smallest increase, with 0.19 inches/100 years. At Ennis, although there is large yearly variation in average annual temperature and total annual precipitation, over the entire period of record, both have increased. The general trend and rate of temperature increase for Ennis were similar to many of the other stations in this study. Precipitation trends are more variable across SW Montana. Over all sites studied, precipitation has decreased by 0.9 inches/100 years.

Session: Environmental & Earth Sciences

Jeremiah Hill

University of Montana Western - Environmental Science

Historic Climate Change in Northwestern Montana: Trends in Average Temperature and Total Precipitation

Northwestern Montana is experiencing significant climate change, with important variations locally. This study is an analysis of average annual or monthly temperature and total annual or monthly precipitation at ten sites in northwest Montana, over about the last 100 years, using historic climate data available online from the Western Regional Climate Center. Study sites include: Fortine, Hamilton, Kalispell, Libby, Missoula, Polson, Seeley Lake, St. Ignatius, Superior, and Trout Creek. Sites were chosen to provide good spatial distribution across northwest Montana and to obtain the longest possible records. The periods of record range from 115 to 72 years, with an average of 101 years. A working file was created from the original data sets; months or years with significant missing data were omitted from analysis. Time-series graphs of annual temperature and precipitation were created. Change, normalized to rates per 100 years, was obtained by regression analysis for each site for both temperature and precipitation.

In eight of the ten sites, average annual temperature appears to be rising at rates of 0.59 °F to 4.40 °F per 100 years. Two of the sites showed no significant change. Total annual precipitation increased at four sites, at rates of 1.03 to 3.52 inches/100 years, with one site unchanged. At three sites, precipitation decreased at rates of 0.25 to 3.41 inches/100 years. An average of the ten sites shows a temperature increase of 2.28 °F/100 years and a very small precipitation decrease. Superior and Trout Creek had the highest temperature increases, at rates of over 4 °F/100 years. Fortine and Trout Creek show the highest drop in precipitation, at rates of over 3 inches/100 years. All sites are experiencing static or rising temperatures, but the combination of temperature rise greater than 2°F/100 years and precipitation decrease greater than 1 inch/100 years at three sites is of particular concern.

Session: Environmental & Earth Sciences

Douglas Brinkerhoff

University of Montana - Computer Science

Toby Meierbachtol, Jesse Johnson, Joel Harper

Sensitivity of the frozen-melted basal boundary to perturbations of basal traction and geothermal heat flux: Isunnguata Sermia, western Greenland

A full-stress, thermo-mechanically coupled, numerical model is used to explore the interaction between basal thermal conditions and motion of a terrestrially terminating section of the west Greenland ice sheet. The model domain is a two-dimensional flow-line profile extending from the ice divide to the margin. We use data assimilation techniques based on the adjoint model in order to optimize the basal traction field, minimizing the difference between modelled and observed surface velocities. We monitor the sensitivity of the frozen-melted boundary (FMB) to changes in prescribed geothermal heat flux and sliding speed by applying perturbations to each of these parameters. The FMB shows sensitivity to the prescribed geothermal heat flux below an upper threshold where a maximum portion of the bed is already melted. The position of the FMB is insensitive to perturbations applied to the basal traction field. This insensitivity is due to the short distances over which longitudinal stresses act in an ice sheet.

Session: Environmental & Earth Sciences

Adam Gunderson

Montana State University – Electrical Engineering

Mark Chodas

An Investigation of Cloud Cover Probability for the HypsIRI Mission Using MODIS Cloud Mask Data

Cloud cover has an overall negative impact on hyperspectral and multispectral Earth observing sensors; the Hyperspectral Infrared Imaging or HypsIRI mission carries such instruments. A key feature of HypsIRI is its ability to revisit the same point on the equator every 19 days. This allows for better knowledge of the planet's seasonal ecosystem changes. Understanding the likelihood and frequency in which clouds will cover the scenes imaged is necessary to better quantify the science return of HypsIRI and other related missions. Current cloud prediction models are too conservative and only sample small time frames of the available satellite data. This results in a low degree of accuracy with respect to cloud-sensor obscuration and predicts far less of a science return than actual. This study uses a 2007-2009 data set from the Moderate Resolution Imaging Spectrometer (MODIS) on-board the Terra satellite to produce a more accurate prediction of the effects cloud cover has on HypsIRI. The NASA Goddard Spaceflight Center developed Giovanni application was used to extract MODIS data at one-degree spatial resolution. This data created a monthly cloud mask that was averaged into three month blocks to represent seasons. Results show the seasonal data collection probability for HypsIRI's Visual Shortwave Infrared Imaging Spectrometer.

Session: Environmental & Earth Sciences

Jonathan Four Colors

Stone Child College – Natural Resources

Recording and calibrating soil moisture contents using Gypsum soil moisture probes

Report on the calibration of a series of watermark Gypsum soil moisture probes at three different depths. Correlating gravimetric soil moisture data with meter readings at two locations, located at the Stone Child College Agricultural research station during the summer of 2010.

Session: Remote Sensing

Luke Humphrey

Montana State University – Mechanical Engineering

CHAOS: Mechanical design of a controllable, high-altitude experiment platform

This presentation examines the work done so far in designing and building a controllable, high-altitude experiment platform for use in the BOREALIS high-altitude balloon program or the MSI / Ground Remote Sensing Project. During ascent, balloon payloads are subjected to significant rotation due to rotation of the balloon itself. Therefore, in order to observe a stationary point on the ground or in the sky, it is necessary for the payload to compensate by rotating opposite the direction of the balloon. Due to the unpredictability of the rotation, the control system also must be able to self-orient. Several mechanical design iterations are presented as well as preliminary work on the command and control capabilities under development. Possible applications of the design include solar physics and earth observation experiments.

Session: Remote Sensing

Sam Sorensen and Nathan Little

Montana State University – Computer Science

BOREALIS Weather Station

BOREALIS' new weather station will be a central platform for monitoring and recording various atmospheric qualities such as humidity, pressure, and temperature. By utilizing a GPS receiver, the station will be able to log when and where measurements were taken, allowing for easier and more accurate analysis of data. In addition, several expansion ports are available for additional sensors to utilize the positional and data logging capabilities of the weather station. The goal of this project is to make a reliable and accurate platform that is adaptable to the needs of the end user.

Session: Remote Sensing

Ed Jones and Wayne Roundstone
Chief Dull Knife College - Science

Soaring to New Heights: Tethered Blimp Technology at Chief Dull Knife College

We will share the projects that we have worked on and discuss other avenues of interest for future projects. We will discuss the different hardware that the CDKC tethered blimp carries aloft, its usages and functions. We will also talk about some of the other hardware that we use such as the winch and payload platform. Lastly we will touch on some of the unique problems that we encountered and how we resolved them.

Session: Physics

Nick Childs

Montana State University – Physics

Richard Smith, Stephen Sofie

Electronic Current Distribution in a Ni-YSZ Solid Oxide Fuel Cell Anode

A simulation of a Nickel-Yttrium supported Zirconium Oxide solid oxide fuel cell anode was used to determine the electronic current distribution within the percolating clusters of nickel particles within the anode. The anode is simulated via a Monte-Carlo percolation model and current distribution is calculated via a relaxation algorithm. The current is then related to typical reported current densities. In some simulations current densities of nickel particles exceeded experimentally found failure values.

Session: Physics

Steven Barton, Richard Shular, Matthew Barton, Bryan Peterson, Frank Kestner
Montana State University Billings – Physics
Stuart Snyder

Two-Photon Laser Induced Fluorescence of Atomic Sodium

Two-photon laser induced fluorescence (LIF) was used to determine the concentration of sodium in water aspirated into a flame. A forbidden transition between the $^2S_{1/2}$ ground state and the $^2D_{3/2,5/2}$ excited state of sodium atoms vaporized by the flame was induced by two-photon absorption of laser light generated by a pulsed dye laser tuned to 578.89 nm. The $^2D_{3/2,5/2}$ state decayed to the $^2P^{\circ}_{3/2,1/2}$ state emitting a photon with at a wavelength of 568.26 nm. The intensity of this fluorescence signal is proportional to the concentration of sodium atoms in the water. Because the lower energy level of the fluorescence transition is above the ground state, self-absorption was not significant. LIF signal intensity as a function of sodium concentration was found to be linear over a wide concentration range. Further application of this technique to determine flame temperature is discussed.

Session: Physics

Kevin Lalli, Page Bailey, Geoffrey Whitt, Tyler Huffman

Montana State University –

Physics, Electrical Engineering, Mechanical Engineering, Computer Science

**Student Feedback on the IRIS Student Spectrograph Competition 2010-11
Pilot Run**

This year's pilot run of the IRIS Student Spectrograph Competition will conclude with a competition at the end of April. The competition provides interdisciplinary teams of undergraduates the opportunity to design, build, and operate a device that obtains spectral data using the sun as a light source. Currently two teams - one from Montana State University and one from Salish Kootenai College - are completing work on their devices. The MSU team will present an overview of their work this year as well provide feedback on the goals and criteria of the competition. This has been a unique and challenging experience for us, which we hope will be true for many other participants in the future.

Session: Ballooning

Abby Thane

University of Montana – Physics and Astronomy

Jennifer Fowler

The Implications of Increased Sounding Data in the Amazon Basin for Global Climate Models

Correct predictions of changes in global atmospheric temperature are of critical importance to the validity of climate models. However, there exists an extensive and ongoing debate, started in the early 1990s, on whether radiosonde data can be treated as reliable or not since observations have not shown warming of the troposphere as models predict (Hansen et al., 1995; Spencer and Christy Science, 1990; Seidel et al., 2009). Of particular focus is the distinct signature models show of a more intense warming of the troposphere over the tropics compared to other locations (Hansen et al. JGR, 2002). These differences have been attributed to a variety of causes over the years and have recently been narrowed down to the temporal inhomogeneity of observed radiosonde data (Gaen, 1994; Parker and Cox, 1995). These time-varying biases are generally induced by the change of instrumentation, the scarce quantification of related uncertainties and the lack of documentation. Most recent works support the current conclusion that there is no strong evidence of the existence of discrepancies between observed and modeled tropospheric trends within comprehensive, overlapping uncertainty intervals (Thorne et al., 2011; Trenberth et al., 2007). We present a summary of the evolving quest to obtain better balloon sounding data as a direct measurement of atmospheric trends and characterize balloon-borne radiosonde uncertainties. This is the motivation for our field research in Leticia, Colombia, as we assessed the feasibility of increasing available sounding data in the Amazon Basin. Our focus in characterizing radiosonde uncertainties rests on the use of vertical profiles of the environmental lapse rate trends to facilitate higher resolution in the next-generation of climate models. We had six radiosonde flights over five days in an initial attempt to understand the constraints to performing flights over the Amazon jungle. After each flight we analyzed the data for the environmental lapse rate and debriefed participants on flight procedures in order to define parameters for future consistency. Our results show some infrastructure constraints to regular and consistent balloon-borne soundings, although realistic solutions are possible. We have also identified a definitive need for an increased concentration of long-term and homogeneous radiosonde data in the Amazon Basin.

Session: Ballooning

Drew Moen

Montana State University - Electrical Engineering

Transformer of Energy from Atmospheric Resistance

The "TEAR" experiment involves looking into an alternate form of energy for high altitude balloon experiments to find out if anything can be made to outperform lithium batteries. This system utilizes the resistance of the atmosphere as the balloon travels upwards to generate its energy. The final setup tested the specifications of four different DC motors per flight and recorded the voltage information with a data logger.

Session: Ballooning

George Council

Montana State University – Electrical and Computer Engineering

Real-Time Remote Control of BOREALIS Systems with a Focus on Implementing a Cutdown Method

The BOREALIS have a desire to control balloon-based assets in real-time, specifically with a focus on severing the payload from the balloon. A radio-external control circuit is in development to control a wide range of systems with an HCS08 micro-controller via dual-tone multi-frequency sampling (DTMF) signaling from a ground station to activate a specific subsystem, and respond to real-time commands. The desire to correlate with a cutdown system is necessary as no real-time cutdown system currently exists for the BOREALIS platform.

Session: Ballooning

David Riesland and Joe Lutgen

Montana State University – Electrical and Computer Engineering

Zero Pressure Ballooning: Cutdown

Zero pressure balloons are high altitude balloons that can stay at a certain altitude for a discriminate period of time. A consistent cutdown system is a prerequisite for this flight, since one must be able to terminate the flight reliably. This presentation will show a cutdown system using a timing system and nichrome wire.

Session: Biology & Chemistry

Kristen Crandell

University of Montana - Biological Sciences, Organismal Biology & Ecology

Bret Tobalske

Unsteady Aerodynamics in Avian Flight

The seemingly effortless flight of animals has long held human fascination, yet much remains to be understood about the morphological and aerodynamic mechanisms that animals use to remain airborne. Although bird wings initially inspired the development of human aircraft, engineering interest in improving manmade aircraft quickly diverged from direct emulation of flapping animals. Only recently have engineers returned to animals to gain insight into the design principles that allow effective flapping flight at low Reynolds numbers (i.e., $Re < 1,000,000$). At these low Re , insects are known to exhibit significant wing deformation during flapping flight due to inertial or aerodynamic loading. Unlike aircraft, these organisms use a variety of “unsteady” aerodynamic mechanisms to capitalize on the constantly morphing wing shape. These mechanisms include delayed stall (leading-edge vortex production), rotational circulation, and clap-and-fling. Recent studies of the smallest flying vertebrates, hummingbirds and nectar-feeding bats ($Re \sim 7,000$), demonstrate similar use of unsteady effects. However, almost nothing is known about the relative importance of unsteady effects in larger animals. Here, I present aerodynamic and kinematic data during take-off and accelerating flight on two species of bird, the Diamond Dove and Budgerigar, and directly link wing motion to aerodynamic force production. My results suggest that birds at much higher Reynolds numbers ($15,000 < Re < 100,000$) are capable of utilizing a similar suite of unsteady effects to their advantage.

Session: Biology & Chemistry

Joshua Beaulaurier

University of Great Falls – Biology

Paul Hershberger, Nate Bickford

Commercially made fish feeds could potentially contain pathogens and have different growth rates on P.Herring

Viral Hemorrhaging Septicemia Virus (VHSV) is a serious problem with marine and freshwater fish. In order to study these pathogens in the laboratory setting, a pathogen free environment is required for experimental purposes with fish and pathogens before the study starts. This study was developed to identify any possible exposures of VHSV pathogen particles that are in commercially made fish feeds such as Bio-diet feeds, Bio-Vita, and Washington Fish Wildlife Parks feeds over a two years span. In addition, a growth study was initiated to find out which feeds increases growth in herring the greatest.

P. Herring eggs were collected on macrophytes by the Washington Department of Fish and Wildlife. Herring were raised to metamorphosis stage then switched to the different feed types. The fish were fed to cessation daily until there was a visible difference in the size of the fish. The fish were then exposed to VHSV in a controlled environment and all results were recorded. The feeds could potentially be exposing the fish to the pathogen. The feed types fed to P.herring caused different growth rates in the fish.

Session: Biology & Chemistry

Trista Vick

Montana State University - Land Resources and Environmental Sciences

John Prisco

Life in the cold and dark: carbon cycling in ice-covered Antarctic lakes

Photosynthetically driven carbon fixation is the primary mechanism through which organic carbon enters most ecosystems; however, carbon fixation in the absence of light (dark C-fixation) has also been observed in aquatic ecosystems, including the permanently ice-covered lakes of the Taylor Valley, Antarctica (Fryxell and Bonney). Dark C-fixation is typically considered to be negligible when compared to carbon fixation via photosynthesis, and is commonly subtracted out as background. Dark C-fixation rates were between 9 and >100% of light carbon fixation rates in the photic zone of Lake Fryxell, and between 2 and 78% of light carbon fixation rates in the Lake Bonney photic zone. A majority of the dark C-fixation occurred in the bacterial size-fraction, implying that chemolithoautotrophic microorganisms are responsible. The geochemical environment of Lake Fryxell, which includes a sulfide gradient and oxic-anoxic interface, is particularly suited to support chemolithoautotrophic bacteria. Results show that dark C-fixation in Lake Fryxell is reduced by as much as 94% by adding nitrapyrin, which blocks some chemolithoautotrophic metabolisms by inhibiting the oxidation of ammonia to nitrite. Dark C-fixation by chemolithoautotrophic microorganisms may be important in supplying organic carbon to Taylor Valley lakes during the dark Antarctic winter.

Session: Biology & Chemistry

Shane Nowack

Montana State University – Mathematics

Isaac Clapper, David Ward, Eric Becraft

Modeling Niche Partitioning of Synechococcus Species in Yellowstone Hot Spring Microbial Mats

We are developing a theory of niche structure for *Synechococcus* species inhabiting microbial mats in the effluent channels of Yellowstone alkaline siliceous hot springs, basing both modeling and microbiological approaches on the physical, chemical and biological realities of this community. Most mathematical speciation models assume that a predetermined Gaussian curve describes how fitness relates to an environmental parameter. In contrast, we developed a procedure that optimizes the shape of the fitness curve subject to given environmental parameters (e.g., temperature fluctuation). Our model output for one parameter (e.g., temperature) was not a Gaussian curve with mean value at the parameter average. Rather, it was a flattened u-shaped curve with maxima at the parameter extremes, possibly resulting from longer exposure times at the extremes than at the average. Given the improbability of bimodal temperature optima in a single organism, these results suggest that two species may be better than one in a fluctuating environment, i.e., fluctuations in environmental conditions may lead to niche partitioning. We have used our model to perform competition experiments between two hypothetical species where the first species has Gaussian fitness and the second species has fitness represented by a sum of two Gaussian curves. We have observed combinations of curve width and separation that allow the second species to outcompete the first, further supporting our niche partitioning theory. We are currently considering two fluctuating environmental parameters and incorporating temperature and light data we have empirically measured in situ into our model. In addition, we have cultivated numerous *Synechococcus* isolates and have characterized them as to species, using *psaA* sequence variation and an evolutionary simulation, Ecotype Simulation. Studies of the isolates' temperature and light adaptations will allow us to test the accuracy of our model results.

Session: Biology & Chemistry

Nathaniel Windy Boy

Stone Child College

Tashina Russette

Field Bindweed and Canadian Thistle Experiment

Report on the efficacy of mechanical versus Herbicidal control of the two most common noxious weeds of the Rocky Boy Reservation, Field Bindweed and Canadian Thistle.

Session: Education & Outreach

Kathryn Williamson

Montana State University – Physics

Shannon Willoughby

Introductory Astronomy Student Understanding of Gravity

Understanding gravity is foundational for astronomy students to understand planetary and star formation, the motion of satellites, and the general behavior of bodies in space. Investigations of student understanding of gravity have mainly focused on young children, and the few studies of college students are limited to one or two questions in Physics-specific contexts. The present study is the first comprehensive study tailored specifically to introductory college astronomy students' understanding of gravity. Twenty-four free-response questions and 14 student interviews explore student understanding of gravity in a variety of contexts, including the strength of gravity in and around Earth, throughout the solar system, and in other hypothetical situations. The exploratory, open-response format allowed themes to emerge naturally, and in addition to the typical documented misconceptions about gravity, previously undocumented misconceptions were observed. The breadth of questions allowed complete mental frameworks to be defined for the first time. Alternative mental models will provide distractor choices in the future development of a multiple-choice Gravity Concept Inventory.

Session: Education & Outreach

Lucas Jones

University of Montana - Physics and Astronomy

Nate McCrady

Capturing the Probabilistic Nature of Light for Undergraduate Astronomers

In Autumn 2010 the Department of Physics and Astronomy at the University of Montana introduced a new advanced undergraduate laboratory course in modern observational astronomy. At present, this course is the only advanced astronomy lab offered to undergraduates in Montana. The course is designed to give physics majors with a concentration in astronomy experience working with modern instrumentation, including charge-coupled device (CCD) cameras, fiber-fed spectrometers and high spectral resolution echelle spectrometers. The statistical behavior of light is of particular importance in astronomy, and is the basis for the first two lab units. These experiments on the Poisson statistics of photon counting and detection of faint sources in the presence of noise require a photon detection apparatus and a Graphical User Interface (GUI) to operate data acquisition. In this talk I present my methods in completing the apparatus and designing the programming needed for the GUI. I successfully integrated a photomultiplier tube and light-emitting diodes in conjunction with a data acquisition device, and frequency counter. I developed LabView programming software to handle both the graphical and data interfaces. Undergraduate students that completed these first two lab units successfully obtained data using the experimental setup and demonstrated in their analysis the Poisson behavior of light as well as the ability to detect very faint ($< 1\%$) signals in the presence of high background noise.

Session: Education & Outreach

Katherine Kalachev

University of Montana – Physics and Astronomy

Nate McCrady

Montana's new advanced observational astronomy lab course

Observational astronomy relies heavily on digital imaging, and the calibration and interpretation of data. The practical skills related to charge coupled device (CCD) operation and the knowledge of how to reduce and analyze data obtained from CCDs is essential for an astronomer today. The new advanced observational astronomy lab course ASTR 362 at the University of Montana Department of Physics and Astronomy provides students with the fundamental skills necessary for in-depth research. Our class received hands-on experience in planning and conducting full-night observations, operating a telescope and acquiring images with CCDs. In this talk I will present three-color BVR mosaic images of the Galactic star cluster NGC 884 and a color-magnitude diagram based on aperture photometry calibrated with photometric standard stars. I will also present preliminary results from my ongoing research on star formation in the starburst galaxy M82, where I am applying new skills that I learned in ASTR 362 to analyze Hubble Space Telescope images. This course was funded by an Educational Enhancement Grant from the Montana Space Grant Consortium (MSGC).

Session: Education & Outreach

Casey Kanode and Kate Webbink

Montana State University – Science and Natural History Film Making

SPOT, The Gadget Generation, and Picturing Science-Oh My!

It is fortunate that science communication focuses on a subject inherently fascinating to a broad audience, but we must constantly ask how to maintain that fascination and make complex ideas accessible to the public. Furthermore, at a time when new research and technology seem to be accumulating at an overwhelming rate (or perhaps that's the story of humanity), how do we overcome generational barriers to speak the language of increasingly tech-savvy children? We will address one approach offered by MSGC's Space Public Outreach Team (SPOT), and similar visual media and presentation techniques.

Session: Astronomy & Space Physics

Sofia Tanberg

University of Montana - Physics and Astronomy

The Terrestrial Magnetopause and Bow Shock: A Comparison of New Data to Existing Models

As charged particles from the Sun (solar wind) encounter Earth's magnetic field, they are impeded by it, forming the region in space known as the magnetosheath. Here, these ions in the solar wind are slowed and deflected around the Earth. The magnetosheath shares its inner boundary, the magnetopause, with the edge of the Earth's magnetic field. Its outer boundary, called the bow shock, represents the region where the solar wind abruptly decelerates from being supersonic to subsonic. The position and shape of these two boundaries have been studied since the 1950s, mostly in a region within 20 Earth-radii (R_{\oplus}) of the planet, or in the distant tail region (about 200 R_{\oplus} downstream of the Earth with respect to the flow direction of the solar wind). The data set I used was collected by the Interstellar Boundary EXplorer (IBEX) and encompasses the area between 15 and 55 R_{\oplus} of Earth. This data set is unique in that the structure of these boundaries in space has not been extensively studied between 20 and 55 R_{\oplus} , the region where IBEX is observing. Therefore, I have explored how well the leading published models match the shape of these boundaries in this unexplored region.

Session: Astronomy & Space Physics

Courtney Peck

Montana State University – Physics

Determining the Relationship Between Cosmic Rays and Our Atmosphere

Cosmic rays detected on Earth originate from the Sun and the universe. These cosmic rays constantly bombard Earth and interact with our atmosphere. The interaction of the cosmic rays with the atmosphere causes the cosmic ray flux seen on Earth's surface to vary based on the atmospheric conditions. The relationship between cosmic ray flux and our atmosphere can be monitored using a simple Geiger counter set-up. The purpose of this project is to compare cosmic ray flux to atmospheric pressure to measure a quantity known as the barometric coefficient.

Session: Astronomy & Space Physics

Judy Hudgins, Ryan Young
Salish Kootenai College – Computer Engineering

Tashina Russette
Stone Child College – Science

Tyler Huffman
Montana State University - Computer Science and Electrical Engineering

Aurora Borealis trip to Poker Flat Research Range in Alaska

Students from tribal colleges were given the opportunity by the Montana Space Grant Consortium (MSGC) to participate in an exciting trip to Poker Flat Research Range in Alaska to learn about the Northern Lights. While there students toured the facilities on the range and learned about the different sensors used to detect aurora. Students also became slightly acquainted with the MSU-built Optical Aurora Detectors. These detectors will be given to the tribal colleges across Montana to help start their own Aurora Borealis research program. This trip has provided tribal students with wonderful learning experiences about the Northern Lights on both a scientific and cultural level.

Session: Computing & Aerospace Technology

Celena Byers

Montana State University - Space Science and Engineering Laboratory

Explorer-1 [PRIME]: Montana's First Satellite

Originally designed to commemorate the 50th anniversary of the first US satellite, Explorer-1, the Space Science and Engineering Laboratory has designed and built a CubeSat class satellite that was set to launch on 04 March 2011. Although this first flight unit was lost due a launch failure, the scientific payload has been designed to repeat the science of Explorer-1 which involves taking measurements from the Van Allen Radiation Belts near the North and South Poles of Earth.

The payload, consisting of a high energy cosmic ray detector, was designed and built by Montana State University students to repeat the science of Explorer-1. The design, test and composition of the payload aboard the satellite has been a hands on learning experience to several students over the mission development lifetime. I will discuss the background and history of the Explorer-1 [PRIME] satellite as well as the design and testing involved for this payload of the satellite as the students in the Space Science and Engineering Laboratory prepare to deliver a second flight unit in June of 2011 for a 25 October 2011 launch.

Session: Computing & Aerospace Technology

Clinton Hadwin

Montana State University – Electrical Engineering

Cube Satellite Fabrication, Integration, and Systems Testing

The fundamentals of Explorer 1 Prime's (E1P) fabrication, integration, and systems testing procedures are key components to its success and launch. Fabrication procedures are adopted under strict guidelines set forth and adopted by NASA and other industry leaders' protocol. Several different assembly methods were developed, attempted, and reanalyzed in house during the process of the multiple builds that the satellite went through before its completion, particularly in terms of solar cell fabrication. Component selection, contaminant protection, and ESD safety are also some of the measures that have been outlined in this study. Integration procedures fall under similar scrutiny, as each populated printed circuit board (PCB) is methodically tested before mating them with one another. Each individual board is a system in itself, and must meet predetermined criteria before becoming a part of the system as a whole. Lengthy testing of these individual systems must be performed, to assure that the system is operating as expected as a standalone component of the satellite, before its ability to operate in tandem with the other systems can be verified. Once each system has been qualified for integration, the entire system is tested using the ground station equipment (GSE). Software and hardware tests are performed, to simulate every function that the satellite will be expected to execute while in orbit. Trouble shooting and reworking of the satellite in this stage of testing becomes a significant component to the time it takes to get a satellite prepared for flight. Many of the procedures outlined in this study have room for improvement, however every step of the learning process that E1P offered the SSEL team in terms of efficient testing has been, and will continue to be implemented in future satellite missions.

Session: Computing & Aerospace Technology

Jennifer Hane

Montana State University - Electrical and Computer Engineering

Jylissa Whisenhunt

Redundant Binary Counter System with Scrubber

This presentation will describe the creation of a simple computing system, implemented on an FPGA, that achieves radiation tolerance through redundancy and scrubbing. This system consists of sixty-four binary counter tiles, three of which are active at any given time and configured in triple modulo redundancy (TMR). The TMR system can automatically detect a fault in one of the active counters and bring a spare online. A blind scrubber periodically refreshes the configuration data to correct faults in the spare tiles.

Session: Computing & Aerospace Technology

Matt Voll

Montana State University – Electrical Engineering

Power System Design Considerations for Small Satellites

For any space-based mission, the power system is the beating heart of the spacecraft. It must harvest, store, and distribute energy to all other electrical systems on-board, and monitor vital system health data at the same time. In the small-satellite application, the power system must be very efficient with its use of energy and space since every watt and every inch counts. Also, there are many factors to be considered in the design of a power system for a small satellite. These factors include the power available to be used, power required by other systems, circuit protection, required health data, and operating modes of the spacecraft. If designed well, a power system can be used for many different small-satellite missions and maximize the efficiency of the spacecraft while minimizing its cost.

Key components of a power system include solar panels, peak-power tracking, batteries and charge regulation, DC/DC conversions, distribution and protection circuitry, system control, and system telemetry. The design of each of these components can range in complexity, depending on the needs of the mission. As the satellite grows in complexity, the functionality of its power system must also mature.

This talk will describe why the design of the power system is an important part of small-satellite missions. The CubeSat developed at the Space Science & Engineering Lab, Explorer-1 Prime, will be used as an application example. The power needs of this particular mission and how they were met will be discussed. Then, the talk will conclude with a look at present research in power system design. In fall 2010, an ECE department senior design group proposed a modular design approach for a new power system design (“Smart Power System Design for Small-Satellite Applications”). This approach to power system design will be outlined.

Session: Computing & Aerospace Technology

Dan Schwendtner

Montana State University – Mechanical Engineering

Development of a Thermal Vacuum System for Spacecraft Environmental Testing

Since 2001 the Space Science and Engineering Lab (SSEL) at Montana State University has been designing and building a variety of space hardware, as well as developing the facilities necessary for environmental testing of flight hardware. In late 2005 the SSEL began developing a system to simulate the vacuum environment of near-space which would allow for outgassing measurement and rudimentary thermal testing of electronics and spacecraft components. To truly test hardware and validate hardware analysis and design, the ability to cycle between the expected temperature extremes in a similar environment is essential. Usage and operation of thermal vacuum systems is investigated, requirements for SSEL's Thermal Vacuum System are defined, and possible design options are considered. A Finite Element Analysis (FEA) is performed to predict the heat load on the system when a 40 kg nanosatellite (50 x 50 x 60 cm) is cycled between -40°C and +80°C. Based on the results, a design is selected for the system Base Plate on which the nanosatellite rests, and testing is performed to validate both the FEA model and the physical hardware.

Additional research, analysis, and design is performed on a thermal shroud surrounding the nanosatellite. Radiation heat transfer between the satellite on the shroud's inside and the vacuum chamber on the shroud's outside is calculated using the radiation network approach. The LU Decomposition method is used to solve the resulting set of simultaneous equations. Temperature measurements are taken during system testing to validate the design and compared to the FEA model. Ongoing tests indicate that the system functions as designed and that it is capable of completely and safely testing satellites and other space hardware developed at SSEL.

Session: Engineering

Adam Gunderson

Montana State University – Electrical Engineering

Designing a University CubeSat Radio Using Commercial Off the Shelf Parts

Designing a radio for use in CubeSats can present quite a challenge. During the long design process of Montana State University (MSU) Space Science and Engineering Lab's (SSEL) Explorer 1 Prime (E1P) radio, many hurdles were encountered that are outlined in this presentation. The objective of this presentation is to provide a reference for further developments concerning CubeSat radios by ham radio amateurs or universities. A large lesson learned by SSEL concerning this project was the necessity for complete documentation and implementation thereof. Other realizations relate to the parts selection process and the need for more research into choosing the component makeup of the radio. In contrast to the E1P's radio, today's technology allows for the development a non-motherboard design. Many aspects of the design process outlined in this presentation will be related to such advances. A short study of time constraints on the project will be discussed; many time-consuming errors were made due to rushing designs to meet certain deadlines. Proper documentation is tied to this topic as well. The process that has been outlined in this document will be used as a reference in future CubeSat radio designs by SSEL and other organizations. Much of this process is being improved upon and the greatest importance is to recognize the major problems during such a development, so they may be avoided.

Session: Engineering

David Driscoll

Montana State University – Mechanical Engineering

*Adam Weisenstein, Stephen Sofie***Investigation of Engineered Pore Structures in Powdered Metals by Means of Freeze Tape Casting**

Engineered metal foams have strong potential in applications such as fuel cell electrodes, sensors, differential springs, filtering media, and composite scaffolds. In this study the variation based on direction of mechanical and electrical properties were characterized in engineered porous metal foams with aligned porosity prepared by freeze tape casting of ferritic stainless steel. After directional solidification, the solvent was sublimed from ~1mm thick tapes, yielding porous green metal compacts which were sintered in a vacuum furnace from 900 – 1100°C. Densification was shown to begin at 1000°C, yielding shrinkage variations relative to pore alignment. The resulting disks exhibit highly ordered acicular pores with substantial anisotropy in the mechanical and electrical properties. DC conductivity testing revealed up to 62% variation depending on direction of measurement relative to the alignment of pores. Examination of flexural rigidity showed directional variations of up to 89%.

Session: Engineering

Allen Ream

Montana State University – Mechanical and Industrial Engineering

Statistical Qualification of Stereopsis and Color Correction for Stereo-Endoscopy

An innovative technique for capturing three-dimensional images with a single lens has been developed using a multi spectral light source paired with multiple band-pass optical filters. Unlike conventional 3D systems that use two cameras paired together, this method establishes disparity by blocking half of the illumination wavelengths from entering either side of the lens system. However, this method decreases the inter-pupillary distance substantially while also deviating from standard color schemes. Two studies have been proposed in which human subjects will be asked to perform simple tasks to create a correlation between the psychophysical aspects of depth and color perception while in the regime of this system. The first test seeks to find the limit of the human brain to resolve depth in a scene as a function of viewing distance, while the second will attempt to correct the viewed colors based on the sensitivities of the eyes color receptor cells. These results will aid in optimizing working distances as well as creating a true color image for applications where color identification is necessary.

Session: Engineering

Justin Krohn, Charlie Ferguson, Chad Willett, Donovan Ferrin, Terrell Thomason, Joe Stack, Steve Lobst, Kris Bengtson

Montana State University – College of Engineering

Brock LaMeres

Design of a Robotic Lunar Regolith Excavator

The Montana State University lunar regolith excavator (named MULE 2.0) is an interdisciplinary design project that is tailored to compete in the Lunabotics Mining Competition at Kennedy Space Center in May of 2011. The overall goal of the competition is to collect as much regolith as possible using a wireless robot as defined by the competition rulebook. To meet NASA's systems engineering goals, the MSU excavator is an interdisciplinary effort that includes four collaborating majors, resulting in the establishment of three major subsystems: Mechanical (frame and structure), Electrical (motor control and sensors) and Computer (wireless communications and basic controls). All of the students involved used this project as part of their senior capstone. The project is intended to help develop interest in space activities as well as science, technology, engineering, and mathematics in general.

Session: Poster

Steven Barton, Richard Shular, Matthew Barton, Bryan Peterson, Frank Kestner
Montana State University Billings – Physics
Stuart Snyder

Two-Photon Laser Induced Fluorescence of Atomic Sodium

Two-photon laser induced fluorescence (LIF) was used to determine the concentration of sodium in water aspirated into a flame. A forbidden transition between the $^2S_{1/2}$ ground state and the $^2D_{3/2,5/2}$ excited state of sodium atoms vaporized by the flame was induced by two-photon absorption of laser light generated by a pulsed dye laser tuned to 578.89 nm. The $^2D_{3/2,5/2}$ state decayed to the $^2P^{\circ}_{3/2,1/2}$ state emitting a photon with at a wavelength of 568.26 nm. The intensity of this fluorescence signal is proportional to the concentration of sodium atoms in the water. Because the lower energy level of the fluorescence transition is above the ground state, self-absorption was not significant. LIF signal intensity as a function of sodium concentration was found to be linear over a wide concentration range. Further application of this technique to determine flame temperature is discussed.

Session: Poster

Timothy Brox

Montana State University – Physics

Nuclear magnetic resonance study of polycrystalline ice

Recent work has demonstrated that microorganisms can occupy the liquid filled inter-crystalline veins in ice and maintain their metabolic activity under these conditions. While these discoveries have increased the extent of the biosphere, to include the large continental ice sheets of Antarctica and Greenland as biomes, the habitat of the microorganisms within the inter-crystalline liquid veins is poorly understood. Additionally, certain cold tolerant organisms produce extra cellular proteins (i.e., ice-binding proteins) that have the ability to bind to the prism face of an ice crystal and inhibit ice recrystallization. This phenotype affects the physical ice structure and the liquid vein network, potentially providing ice-inhabiting species a protective mechanism with which to control their habitat. One such microorganism is *Chryseobacterium* sp. V3519-10, a bacterium isolated from a depth of 3519 m in the Vostok Ice Core. This study examines the impact of extra cellular proteins from this ice-adapted bacterium on the formation of ice crystals and characterizes the inter-crystalline liquid filled vein network using nuclear magnetic resonance (NMR) spectroscopy and magnetic resonance imaging (MRI).

Session: Poster

Benjamin Gilboe

University of Montana, Western – Biology

Michael A. Gilbert

Characterization of the *Borrelia burgdorferi* Bb0769 ORF

Borrelia burgdorferi, the causative agent of Lyme disease, has an enzootic life cycle alternating between Ixodes ticks and mammalian hosts, typically small rodents. Although humans are only inadvertently infected, Lyme disease remains the most common arthropod-borne disease in the United States and combating this disease requires a thorough understanding of the molecular mechanisms of pathogenesis used by this organism. Complete sequencing of the *B. burgdorferi* genome did not reveal any obvious virulence factors, but did reveal a single ORF (bb0769) with significant sequence similarity to a variety of bacterial glycoproteases. Since these enzymes often function as virulence factors in pathogenic bacteria, we hypothesized that BB0769 may serve a similar function in *B. burgdorferi*. Therefore, we took on the challenge of cloning, expressing and purifying the BB0769 protein with the hope of confirming its proteolytic activity. This information will provide further insight into the possible role of this protein in the enzootic life cycle of *B. burgdorferi*.

We amplified the bb0769 ORF from *B. burgdorferi* using Vent DNA Polymerase, cloned it into the expression vector and then transformed inducible *E. coli* cells. We assessed BB0769 expression by SDS-PAGE and Coomassie staining. We are able to test BB0769 for non-specific proteolytic activity by zymography. Finally, we made an initial attempt to purify BB0769 using affinity chromatography.

PCR amplification of bb0769 resulted in a single product with the expected size of 1071 bp. Restriction digests of the construct indicated that the construct contained the bb0769 ORF in the correct orientation for expression. The cells expressed a 41kD protein when grown in the presence of IPTG. BB0769 has a predicted molecular mass of 37kD, but additional recognition sites add 4kD. In our initial attempt to purify BB0769, a protein of the correct size was eluted but the yield was too low.

BB0769 can be expressed in *E. coli* BL-21 cells at levels sufficient for future purification and analysis.

Session: Poster

Adam Gunderson

Montana State University - Electrical and Computer Engineering

VSWIR Solar Calibration

The Hyperspectral Infrared Imager (HyspIRI) Mission, outlined in the Earth Science Decadal survey, provides science data that will assist in the assessment of seasonal ecosystem trends, helping monitor climate changes on a global scale. The mission utilizes two optical instruments: the Visible Shortwave Infrared (VSWIR) and Thermal Infrared Imager (TIR). VSWIR is a hyperspectral instrument that will provide global ecosystem monitoring through a 19-day revisit time at the equator. VSWIR collects images by measuring the spectra produced by solar radiance of the Earth's terrestrial and coastal regions. The instrument is tilted 4° off-nadir to minimize sun-glint and has 145 km swath width. HyspIRI's VSWIR instrument requires many separate calibration cycles; these periods are completed by the scheduled viewing of targets that have a spectral response which can be verified through other sources. This is done to assure the sensors measurements contain the least amount of error; weekly solar calibration is one of these cycles. Calibration will be completed through the use of a solar reflectance panel which does not require satellite perturbations for measurements. An ideal solar -calibration occurs when the vector from the center of sun is precisely perpendicular to the plane of the reflective panel. The calibration panel will deploy from its housing during a calibration window; defined when the solar vector is at 90° elevation (vector normal to plane). Since the panel will block VSWIR's view during a cycle calibration also cannot occur during science data collection. Current mission design calls for the calibration panel to be offset by 45-pitch and 4-roll, with respect to the satellites axis (negative z being nadir). The objective of this study was to better understand when a solar calibration cycle would occur as well as quantize the dynamics of the solar vectors' azimuth and elevation with respect to the reflective panel.

Session: Poster

Ryan Hannahoe

Montana State University – Department of Education

Turning Eyes to the Big Sky Project

The Turning Eyes to the Big Sky Project (TEBSP) focuses on strengthening 4th through 9th grade science instruction in light and optics. It was implemented in 15 classrooms in southwestern Montana, reaching 380 students. TEBSP implemented a nationally established informal science curriculum on light and optics, the Terrific Telescopes Curriculum (TTC), into the formal classroom setting. The project's rationale addresses the following research questions: (1) how did participating teachers respond to the curriculum and what would they change about it, (2) what was the relationship between student learning outcomes and their teachers' knowledge and experience in teaching science, and (3) how well did students learn and what science concepts and principles did they grasp best through TTC? In October 2010, 15 public-school teachers were trained to implement the curriculum in their classrooms. The implementation is currently underway and will be completed by the end of the academic year. We are collecting student and teacher data on the curriculum implementation and student learning. TEBSP will contribute to our understanding of how students learn key light and optics-related principles, as well as document the learning outcomes of the TTC.

Session: Poster

Travis Harrer

Montana State University - Chemical Engineering

Robin Gerlach, Al Cunningham

Microbially Induced Calcium Carbonate Precipitation Under Radial Flow Conditions

Biologically induced carbonate mineralization is a process by which microorganisms reduce the solubility of carbonates, causing them to precipitate. The goal of this project is to apply pulse flow strategies to deposit calcium carbonate in a radial flow system in order to better understand how biomineralization could be controlled around injection wells at geologic carbon sequestration sites. The rock immediately around an injection well may be compromised due to drilling resulting in an increased risk of injected carbon dioxide potentially leaking back to the surface. By promoting the localized deposition of calcium carbonate around injection wells, leaks can potentially be sealed and carbon dioxide leakage can be reduced.

The laboratory-based study showed significant calcium deposition within the radial reactor along with complete effluent plugging in some of the effluent ports. Destructive sampling further revealed the degree of calcium precipitation throughout the reactor.

Session: Poster

Saiichi Hashimoto

Montana State University - Computer Science

Routing and Adaptive Power Control for Green Networking

Network power consumption can be reduced considerably by adapting link data rates to their offered traffic loads, turning off unused nodes (routers) and carefully routing traffic flows. In this paper, we examine how to perform routing and adapt network power control in order to reduce the energy use in wired networks: Given a set of end-to-end communication sessions, determine how to route the flow (data traffic) through the network such that power consumption is minimized, subject to the constraint that the traffic demand of each session is satisfied. We adopt a simple power usage model: each network link $e = (u,v)$ contains N_e bundle links that can be turned on or off selectively. The power usage of a single bundle link is assumed to be a constant P_l . Nodes can also be turned on or off; the power usage of an on node is a fixed constant P_n . In order for a network link to be operational, both of its endpoint nodes must be turned on. The capacity of an operational network link e is $x_e C_e$, where x_e is the number of bundle links N_e turned on and C_e is the maximum capacity of the link e . We formulate the problem as an optimization problem, the Multi-session Flow Allocation with Power Adaption Problem (MF-PAP). We first present a Mixed Integer Linear Programming (MILP) formulation for the MF-PAP to provide optimal solutions. Then we present a simple shortest path based algorithm and a more sophisticated tree routing algorithm that has improved and near-optimal performance in our simulation results.

Session: Poster

Josi Herron

University of Great Falls – Biology

Robyn Hannigan, Alan Christian

Water Quality Analysis of Heavy Metals As, Cd, Cu, Pb, and Hg from Etang Saumatre lake in Haiti

Etang Saumatre (Lac Azuie) in Haiti is a saline lake on the border between Haiti and the Dominican Republic. This lake will soon be facing a population increase of thousands of people as a result of the recent January 2010 earthquake. These people will be using the wells surrounding the Etang Saumatre for drinking water and domestic purposes. Etang Saumatre is also an important resource for subsistence fishers, feeding 25,111 people annually. It is important that water quality in the lake and groundwater be investigated in order to ensure that the resources are sufficient for human consumption. Moreover we need to better understand the connections between the lake and groundwater system to potentially mitigate any possible health concerns. Water samples were taken from Etang Saumatre and surrounding wells and the dissolved concentrations of arsenic, cadmium, copper, lead, and mercury were determined by ICP-MS. These heavy metals, known to be most hazardous to human health, are considered toxic at certain concentrations according to World Health Organization's Drinking Water Quality Standards (2008). The results showed that the concentrations of these metals were above the toxic level in most of the sampling sites. The results for cadmium, lead, and mercury also showed that there were similar concentrations between the groundwater wells and the lower depths of the lake which would provide evidence for groundwater flow into the lake.

Session: Poster

Kendra Kaiser

Montana State University - Land Resources and Environmental Sciences

Brian McGlynn, Ryan Emanuel, Fabian Nippgen, John Mallard

Ecohydrology: Disturbance and the intersection of vegetation pattern and landscape structure

Watershed ecohydrology is a function of the intersection of vegetation pattern and landscape structure. The hydrologic implications of vegetation disturbance depend on the spatial extent and pattern of change on this ecohydrologic template. Here we investigate this intersection with a focus on a recent mountain pine beetle (*Dendroctonus ponderosae*) epidemic that is increasingly affecting areas in the Rocky Mountains. Our research area was the Tenderfoot Creek Experimental Forest (TCEF), Montana, USA. We calibrated QuickBird remote sensing imagery with leaf level measures by developing a spectral library for TCEF vegetation. The spectral library was used to determine which vegetation indices were optimal for differentiating between stages of infestation; thereby maximizing the information obtained from the QuickBird image. These indices were applied to the QuickBird imagery to establish baseline mortality, and the extent and magnitude of infestation across the watershed. In addition, we calculated LiDAR based topography and vegetation structure indices for joint topographic, vegetation, and disturbance analyses. We seek to determine which forest stands are most susceptible to beetle infestation, and how these infestation patterns are related to hydrologic, topographic, and forest ecosystem compositional characteristics. Our efforts to monitor vegetation mortality across space and time provide a context for assessing the drivers of mountain pine beetle infestation and how outbreak patterns may affect watershed ecohydrology via energy, water, and biogeochemical cycles.

Session: Poster

Amanda Kortum

University of Montana Western – Department of Biology

Michael Morrow

Characterization of the *Candida albicans* Sec63 Protein

Candida albicans is one of the most common fungal pathogens, which causes many human infections. In order to switch to a pathogenic form, this yeast undergoes a number of physiological changes, which require the secretion of various proteins. The first step of the secretory pathway is the translocation of secretory proteins into the endoplasmic reticulum (ER) from the cytosol. In *Saccharomyces cerevisiae*, the essential Sec63 protein plays crucial roles during ER translocation, and is 56% similar to *C. albicans* Sec63p. The focus of this study is to determine if *C. albicans* Sec63p is also essential, and if it is involved during the translocation of secretory proteins into the ER.

A strain was constructed in which one SEC63 allele was disrupted and the endogenous promoter of the other allele was replaced by the tightly regulated MET3 promoter which represses SEC63 expression when cells are grown in the presence of methionine. When this strain was plated on medium lacking methionine, Sec63p was expressed and growth was observed. However, this strain did not grow when the cells were plated on medium containing methionine, suggesting that the *C. albicans* SEC63 gene is essential.

In vitro translocation assays were performed to determine if *C. albicans* Sec63p is involved during the translocation of proteins into the ER. ER microsomes were isolated from cells grown under inducing or repressing conditions. These were combined with radiolabeled pre-pro alpha factor, pp α f, a secreted yeast protein that serves as a translocation substrate, and an ATP regenerating system. When translocated into the ER, the signal sequence of pp α f is cleaved, resulting in p α f. To determine if pp α f translocated into the microsomes, trypsin was added to degrade proteins outside of the microsomes, and the presence of preserved p α f was determined. Microsomes isolated from cells expressing Sec63p translocated an average of 31.7% of the pp α f, while microsomes isolated from cells depleted of Sec63p averaged translocation efficiencies of 10.7%. These data support the hypothesis that the *C. albicans* Sec63 protein plays a role during the translocation of secretory proteins into the ER of this human pathogen. This work was supported by NIH grant number P20 RR-16455-11 from the INBRE-BRIN program of the NCRR and the Montana Space Grant Consortium ARES program.

Session: Poster

Chandra Macauley

Montana State University - Chemical and Biological Engineering

*Kathryn Hoyt, Paul Gannon, Preston White***The influence of CrxOy microstructure on the oxidation behavior of CoMn coatings on SOFC/SOEC interconnects**

Cobalt manganese (CoMn) coatings are promising candidates to inhibit high-temperature surface oxidation of stainless steel (SS) interconnects in solid oxide fuel cells (SOFCs) and solid oxide electrolyte cells (SOECs). This study investigates the influence of the pre-oxidation layer microstructure on the oxidation behavior of CoMn interconnect coatings. SS441 samples were either pre-oxidized for 3 h in 800°C laboratory air to develop a thermally grown chromium oxide layer or were coated with CrxOy via radio frequency (RF) magnetron sputtering. Using these methods, chromium oxide layers with differing microstructures were produced. The samples were then coated with metallic CoMn via direct current (DC) magnetron sputtering. Field emission scanning electron microscopy (FE-SEM), energy dispersive x-ray spectroscopy (EDX), profilometry, and x-ray photoelectron spectroscopy (XPS) were used to analyze the samples before and after 10 and 100 h of oxidation in 800°C laboratory air. Significant differences in oxidation behavior were observed. Possible mechanisms for the observed oxidation behavior are presented and discussed.

Session: Poster

Rebecca Millsap

University of Montana - Physics and Astronomy

Deborah Ross

University of Montana - Geosciences

RIMM-CAPP (Ripple Mark Mapping – Camas Prairie Project)

As our imaging capabilities stretch further into space the use of digital elevation models (DEM) as a comparison model to the mapping of other planets, particularly Mars, has become a necessity. An area in Camas Prairie, Montana, just south of Hot Springs, has long been acknowledged as one of the prime examples of preserved ripple marks produced by prehistoric Glacial Lake Missoula. These topographical features provide a wealth of information for geologists and geomorphologists interested in fluid flow and how it carves and affects landscapes as well as reconstructing prehistoric landforms and climate history. The depth and expanse of the reconstructed lake model is a scenario completely unmatched on the face of our earth today which holds invaluable information for theoretical facets of such sciences as geomorphology. This project focuses on the integration of a three dimensional camera system and a tethered balloon to attain stereoscopic photographs of the prominent glacial ripples in Camas Prairie Montana. These images will in turn be paired with light detection and radar (LIDAR) images to give the basis for a digital elevation model. This system will be replicable at a fairly low-cost, minimal production level, lending to the possibility of use by other learning institutions or scientific facilities.

Session: Poster

Lars Osborne

Montana State University – Mechanical Engineering

Armando Hernandez, Robert Rucker, Katherine Blackburn

Distributed Swarming Robotic System

The robots built by this team will provide a framework for combating Kessler syndrome. A pseudo-swarm of small satellites with this framework will intercept and deorbit space debris in order to clean up Low Earth Orbit. The robotic system uses several modified iRobot Create capable of moving in coordinated patterns. The Create have been modified with a microcontroller, voltage regulator, and a wireless adapter to communicate with a central computer via a wireless TCP connection. The location of the robots will be determined using information gathered from two rotating infrared emitters at fixed locations. Using C++ with Qt, a graphical user interface (GUI) was developed to control the robots and the infrared emitter. In addition to removing and extracting space debris, this project will provide a framework for future exploration and research of practical applications including, but not limited to, military or geographical reconnaissance, transportation of supplies, formation flying or movement, or multiple satellite coordination.

Session: Poster

Briana Peck

University of Montana – Physics and Astronomy

*Michael Schneider***Measurement of the Pulse Duration of an Ultrafast Laser**

Ultrafast lasers emit electromagnetic radiation with pulse durations as short as a few femtoseconds (10^{-15} seconds). The fastest photodiode detectors can only resolve pulse widths on the order of 10 picoseconds (10^{-12} seconds); therefore we must use other methods along with electronic sensors to determine the duration of ultrafast pulses. The pulses from ultrafast lasers cover a range of wavelengths that is subject to dispersion from optical components in the beam path, which lengthen the pulse duration. For this reason, different experimental setups can have different pulse durations even if they use the same ultrafast laser. To measure the pulse duration we used a pump-probe setup with a Ti:sapphire laser operating at 90 MHz. Using a Beta Barium Borate (BBO) crystal, a photo detector, and a linear stage to change the path length of the probe pulse, the full width at half maximum (FWHM) of the pulse is determined using the autocorrelation of second harmonic generation (SHG) between the pump and probe pulses within the crystal. We are in the final stages of pulse duration data collection and analysis. After the pulse duration is well characterized, the setup will be used to study the influence of spin-orbit coupling on the ultrafast magnetic response in ferromagnetic metals.

Session: Poster

Meredith Rainey

Montana State University – Ecology

*Andrew Hansen***Exploring the use of MODIS data to improve prediction of wildlife corridors and enable prediction under climate change**

Advances in remote sensing technology and GIS software have enabled development of models capable of predicting locations of wildlife corridors in large, complex landscapes. These corridor models are now considered integral tools for planning connected reserve networks. However, their performance has never been comprehensively assessed, and they have never taken into account habitat variables expected to be sensitive to climate change such as vegetation indices and snow cover. These oversights severely limit confidence in the application of corridor models as well as their utility for predicting the effects of climate change on reserve network connectivity. In the past year as a MSGC Fellowship recipient, I have worked to address these issues by first using the two corridor models most commonly applied in conservation practice to predict migration corridors for elk in the Madison Valley, then evaluating the models' performance using GPS collar data depicting actual migration routes. I first built models using only standard habitat variables such as land cover and elevation, then compared their performance to those based on more advanced methods to include time-varying MODIS phenology data. This allowed me to quantify model performance as well as determine whether the use of climate-relevant NASA data products improved predictive success. If so, this would indicate that projections of these datasets under climate change may be useful for predicting future climate-driven shifts in corridor locations. I found that models that did not include climate variables outperformed those that did, most likely due to MODIS data being quite noisy at the scale of elk migration movements. Work is currently underway to test similar methods in wolverines, which disperse over larger areas and are known to respond strongly to snow cover, and upcoming work will test the utility of more sophisticated MODIS-derived phenology metrics for corridor prediction.

Session: Poster

Russel Ricker

Montana State University - Physics

Investigation into the Growth of Calcium Sulfate Crystals

Resonant optical materials are of interest for many applications such as high-bandwidth optical signal processing and quantum information applications. Rare-earth doped anhydrous calcium sulfate has been identified as a prime candidate for these applications due to its low concentrations of nuclear spin in calcium, sulfur, and oxygen. For use in optical applications, large (5mm³), transparent, and high-purity crystals must be grown. With this motivation, we report on our investigation into effective growth techniques to obtain optical-quality crystals. In this project we investigated techniques to grow large single crystals of calcium sulfate anhydrate for optical applications in the 1.5 micron telecom band. We adopted the method of dissolving calcium nitrate tetrahydrate crystals into 98% sulfuric acid at high temperatures until the solution is saturated. The solution is then evaporated over a long period to induce nucleation of calcium sulfate. Results of growth apparatus and solutions will be discussed on the poster, as well as implications for optical applications.

Session: Poster

Jeremy Schwend

Montana State University – Physics

*Laura Sampson, Neil Cornish***Finding deviations from General Relativity using gravitational waves**

To date, numerous tests have been performed on General Relativity in regimes where gravity is weak, like the solar system. However, in the area of strong gravitational fields, the theory remains virtually untested. The approaching detection of gravitational waves promises to open a new door for testing General Relativity in the strong-field regime. We have modeled the gravitational waves coming from the inspiral of non-spinning binary black holes using the perturbative BCV templates (Buananno-Chen-Vallisneri templates) [1], to first order in the Post-Newtonian perturbative expansion of gravitational waves. We began by analyzing a specific type of deviation from GR by adding an extra term of order 0.5 in the expansion, with a new unfixed parameter that we labeled *beta*. The signal response was modeled for various signal-to-noise ratios and *beta* values. Through a Bayesian statistical analysis of the instrument response, the true size of *beta* required for a deviation from General Relativity to be clearly detectable was then analyzed at various signal-to-noise ratios. The analysis was done assuming the detection was made by the upcoming gravitational wave detector Advanced LIGO.

[1] Alessandra Buananno, Yanbei Chen, and Michele Vallisneri, Phys. Rev. 104025 (2003) pp. 20, 22.

Session: Poster

Nicholas Silverman

University of Montana – Geosciences

Marco Maneta

Calibration of Vegetation Parameters within an Ecohydrologic Model using Remote Sensing Techniques

Ecohydrologic models explore the dynamic feedbacks between plants and water. By incorporating these feedbacks into watershed modeling we are able to identify relationships within complex systems that can be challenging to explore through experimental work alone. Connection between the real-world and the model is accomplished through parameters that are specific to the site location being studied. Often these parameters are evaluated numerically through the process of calibration. In this work we present the calibration of a newly developed ecohydrologic model using identifiable spatiotemporal patterns of leaf area index (LAI) calculated from Landsat Thematic Mapper (TM) imagery. This information is then used to identify the ecologic parameters in the model that most adequately represent our research area.

Specifically, we present an analysis of the LAI using Landsat images from the Upper Yuba River Watershed in California for a 6-year time period. LAI is calculated using a mid-infrared corrected normalized difference vegetation index (NDVI). This data is used in an inverse modeling problem to identify the value of selected parameters which minimize the difference between the modeled LAI and the LAI derived from the satellite imagery. Selected parameters to calibrate include leaf turnover ratio, carbon allocation coefficients, and specific leaf area for different species in the research area. Reliable calibration of these ecologic parameters is necessary for future research examining plant-water interactions at the watershed scale under climate change scenarios.

Session: Poster

Matthew Urschel

Montana State University – Microbiology

Mark Skidmore, Gill Geesey

Dissimilatory iron reduction in subzero brines

Ferric iron (Fe³⁺) minerals are potential electron acceptors in cold and icy environments, such as those in the ice-hosted sediments in icebergs and glaciers [1]. Microbial dissimilatory iron reducers have been found in many icy environments, such as subglacial sediments [2], Arctic marine sediments [3], permafrost [4] and Antarctic sea ice [5]. Theoretical and laboratory studies have reported that supercooled, solute-rich veins within ice samples are viable habitats for microorganisms [6,7]. Further, it has been suggested that dissimilatory iron reducers may reduce iron at temperatures as low as -9°C in the solute-rich vein network within basal ice [8], however, no direct evidence of microbial iron reduction at subzero temperatures has been reported to date.

The gammaproteobacteria *Shewanella frigidimarina* was originally isolated from sea ice in eastern Antarctica [5]. This organism can respire on ferric iron, and has been demonstrated to grow at temperatures from 0 to 28°C, and salinities up to 8% NaCl [5]. We quantified the effect of temperature and salinity on the growth and iron reduction rates of *S. frigidimarina* at subzero temperatures. Cultures were incubated at 15°C, 4°C and -5°C, over a range of salinities from 0-8% NaCl. Our results indicate that *S. frigidimarina* is capable of growth at temperatures as low as -5°C at 2% and 4% NaCl in the presence of ferric citrate as sole electron acceptor and lactate as sole electron donor. No growth was observed at 8% NaCl over the temperature range tested. To the authors' knowledge, these results represent the first direct evidence of an organism respiring and growing on ferric iron at subzero temperature and increased salinity.

[1] Raiswell R., et al. (2008) *Min. Mag.* 72, 345–348. [2] Foght J., et al. (2004) *Microb. Ecol.* 47, 329–340. [3] Vandieken V., et al. (2006). *Mar. Ecol. Prog. Ser.* 322, 29-41. [4] Zhang C., et al. (1999) *FEMS Microb Ecol* 30, 371. [5] Bowman, J. et al. (1997) *Int J of Syst. Bact.* 47, 1040-1047. [6] Price B. (2000) *PNAS* 97, 1247-1251. [7] Mader H., et al. (2006) *Geology* 34, 3, 169–172. [8] Tung H., et al. (2006) *Astrobiology*, 6, 1, 69-86.

Session: Poster

Geoffrey Wicks

Montana State University – Physics

Benjamin Soukup, Kevin Repasky, John Carlsten, Jamie Barr, Laura Dobeck

Sub-Surface Carbon Dioxide Concentration Measurement Using a Fiber-Based Sensor in a Call/Return Geometry for Carbon Sequestration Site Monitoring

Geologic carbon sequestration is a means to mitigate the increasing atmospheric concentration of carbon dioxide (CO₂) by capturing the CO₂ at a source such as a power generation facility and storing the captured CO₂ in geologic formations. Many technologic advances will need to occur for successful carbon sequestration including near surface monitoring tools and techniques to ensure site integrity and public safety.

Researchers at Montana State University (MSU) are developing a scalable fiber sensor array in a call/return configuration for monitoring near sub-surface CO₂ concentrations. The low cost fiber sensor array being developed at MSU for sub-surface CO₂ detection for monitoring carbon sequestration sites will utilize a series of fiber probes connected to a detector and a 1 x N fiber switch that can direct the light to one of the N fiber probes. The fiber sensor array will utilize a single tunable distributed feedback (DFB) diode laser with a center wavelength of 2.004 μm to access CO₂ absorption features. The fiber sensor array can easily be reconfigured by simply moving the fiber probes. Low cost is achieved by using inexpensive passive components in the fiber probes while limiting the number of the more expensive components including the DFB laser, the detector, and the 1 X N fiber switch.

A single probe fiber sensor system was tested over a thirty day period at the Zero Emission Research Technology (ZERT) facility that was developed for testing surface and near surface carbon sequestration monitoring instrumentation using a controlled underground CO₂ release. In this presentation, the design of the single probe fiber sensor system will be presented, along with the system performance during the thirty day controlled underground CO₂ release.