Abstracts from the Proceedings of the 2016 Academic High Altitude Conference

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I. Conference information

THIS is a listing of abstracts accepted to the Academic High Altitude Conference (AHAC) 2016 held June 29–July 1,after undergoing a double blind peer review. The hosts wish to thank Bernhard Beck-Winchatz at DePaul University for his work with the bepress site to collect and manage the abstracts; as well as the papers that will undergo further editorial board peer review. Published papers will be posted on the DePaul University library website after the conference at: http://via.library.depaul.edu/ahac/2016/. This collection of abstracts from the 7th Annual AHAC conference, is a tribute to all of the hard work that you all as educators, researchers and outreach partners are playing to advance the work of ballooning in your communities. The organizing committee submits the following collection for your reading pleasure.

II. Oral Presentations Wednesday afternoon 6-29-2016

The Southwest Minnesota Ballooning Collaboration

Paul Seifert[1] and Ken Murphy[2]
Minnesota West Community[1] and Technical College and Southwest Minnesota State University[2]

Southwest Minnesota State University (SMSU) and Minnesota West Community and Technical College (MN West) are starting a collaboration project involving high-altitude ballooning. This partnership will bring together two different populations of students: those attending a four-year university and those at a two-year community college. The initial goals of the program are modest, involving several students from each institution to plan and conduct some simple flights with basic sensor packages as proof-of-concept. It is hoped the collaboration will strengthen ties between the two institutions and give STEM students a chance to participate in a hands-on technical project that will deepen their technical skill set and demonstrate the benefit of collaboration and teamwork. The Worthington campus of Minnesota West is 60 miles south of SMSU, and the teams will use a variety of methods to stay in contact including email, ITV, Adobe Connect, and face-to-face meetings.

Getting Students Excited about Science with High Altitude Ballooning

Charles Niederriter[1] and Steven Mellema[1]
Gustavus Adolphus College[1]

Many of us dream of exploring space, but there are not many ways to do so. Although it is difficult to get into deep space, near space is within our grasp. High altitude balloons are released into the stratosphere, generally reaching between 60,000 to 120,000 feet before they burst and their payload is returned to earth by parachute. Modern balloon systems generally contain electronic equipment such as radio transmitters, cameras, and GPS receivers, as well as a variety of scientific instruments. Not only is high altitude ballooning a great way to introduce the electronics and programming skills needed to collect and analyze data from the spacecraft, it provides a fun way to explore scientific concepts from pressure, temperature and volume to cosmic radiation. We have begun offering summer camps to high school students in order to capitalize on the excitement of ballooning to get them interested in physics.

In July of 2016, we will offer the five-day camp for the third time, with student numbers increasing from 2 to at least 6 with registrations still coming in. After a brief introduction to atmospheric science, students explore the relationship between rate of ascent, weight, and volume of helium, before using space flight prediction tools to determine potential flight paths. They also learn about a variety of cameras, sensors and data loggers and design and build data collection systems that their group will incorporate into their box for a flight near the end of the camp. Finally, each group prepares and presents a short report on the results of the flight. The numbers of students involved for any statistically significant results to be determined from surveys, but anecdotal data suggests that students' interest in STEM fields and specifically physics and computer science is enhanced by the HAB camp experience.

Progression of High Altitude Balloon Science at a Community College

Nathan Brown[1], Andrea Walker[1], Ron Milbrandt[1] and Steve Keidl[1]
Rochester Community and Technical College[1]

Three community college students from Rochester, MN prepared and successfully launched a high altitude balloon (HAB) with attached scientific payload in 2015 and 2016. This presentation will discuss our experience and adaptations regarding design, tracking, the scientific payload, and troubleshooting along with discussion and presentation of the data and video acquired. The role of retired engineers and HAM radio enthusiasts, who volunteered their time and expertise to help the students, will also be discussed. Key components of the scientific payload launched spring 2016 included a low-cost Geiger array to investigate secondary muon decay as a function of elevation and the relevant applications of modern physics. The projects generated excitement among the scientific faculty and students at RCTC, and the RCTC Physics and Engineering Club is planning to continue annual HAB launches.

Engaging the General Public with High Altitude Ballooning

Kendra Sibbernsen[1]
Metropolitan Community College[1]

The interest and excitement involved in performing a high altitude balloon (HAB) flight can be used to spark interest in science and engineering among members of the general public. High profile launches can highlight a ballooning program, recruit students, gain supporters, inspire children, and can disseminate scientific information to a broad range of citizens who might not otherwise have access. Using a recent HAB flight to commemorate the Grand Opening of the Do Space in Omaha, NE as an example, anecdotes and suggestions will be given on how to engage a large number of observers and how to effectively use social media to the advantage of your HAB program. From prior experiences in the Education and Public Outreach (E/PO) arena, the topics shared will highlight successes using Twitter, Facebook, Google Hangouts, Periscope, QR codes, and blogs.

Cosmic Ray Flux Measurements Versus Altitude

Gordon McIntosh[1]

University of Minnesota, Morris[1]

We have measured the omnidirectional cosmic ray flux, the vertical coincidence cosmic ray flux, and the horizontal coincidence cosmic ray flux during a balloon flight. The horizontal coincidence flux was measured by Geiger counters separated by 40 cm. The horizontal coincidence flux indicates the presence of cosmic ray showers, many high energy particles generated in one initial interaction. Results indicate that the ratio of vertical coincidence flux to omnidirectional flux and horizontal coincidence flux to omnidirectional flux decrease with altitude. All the fluxes appear to be at a maximum near the Pfotzer maximum. These measurements provide data on the structure of the cosmic ray flux versus altitude. Several more flights will be carried out soon to confirm these results or detect differences among the maxima.

We intend to make these measurements during the 2017 solar eclipse to check a prediction (Bhattacharyya et al. 1997) that the Pfotzer maximum is affected by changes in the atmosphere due to the eclipse.
Bhattacharyya, A. et al. 1997, Astrophys Space Science, 250, 313.

Active Heading Control Platform for Instruments Flown on High Altitude Balloons

Andrew Kruger[1], Robert Maksimowicz[1], Alfredo Almaraz-Vega[1] and Jesus Urquiza[1]
City Colleges of Chicago -Wilbur Wright College[1]

Experiments flown on high-altitude balloons are typically free to spin without any control or information collected on the payload orientation during flight, limiting the scope of experiments that can be performed. Projects that include targeting (i.e. imaging the 2017 solar eclipse) have at best a random chance of succeeding, while video footage is often hard to watch due to high payload rotation rates. While passive stabilization reduces the rotation rate, active pointing control is necessary for continuous target acquisition. Here we discuss a project built by students at Wright College called the Controlled Heading Automation Device (CHAD) that actively controls the heading of other instruments (i.e. cameras) and has been proven to work in flight. This project is open source, 3D printable, made from cheap DIY electronics, and has been made available online (http://physi.cz/chad) so the high-altitude ballooning community can create, use, and adapt it to their own projects. We show how to create an attitude and heading reference system (AHRS) that can be used to continuously record payload orientation, which can supplement experiments where pointing information is needed. We then show how to have CHAD use the AHRS to automatically control the heading of other instruments in real-time without any other inputs.

Wednesday Keynote Don Piccard 6-29-2016

Public Talk Title: "Piccard Family Ballooning — a Multi-decade, Multi-generational Affair"

Donald (Don) Piccard, long-time American balloonist, comes from a family with a very long history of ballooning!

Don's mother, The Reverend Dr. Jeannette Piccard, was the first woman licensed as a balloon pilot in the United States by the National Aeronautic Association. (Earlier there had been several women pilots in Europe and many unlicensed ones the U.S. in the 19th and early 20th centuries.) While flying in 1934, she was the only female stratospheric balloon pilot. Aside: She was also the first female ordained to the priesthood in the Episcopal Church.

Don's father, Dr. Jean F. Piccard, was the inventor of the plastic balloon and the multi-balloon. He was a faculty member at the U of MN in Aeronautical Engineering from 1936 till his retirement in 1952. His use of explosives for remote activation was an important, though controversial, innovation with a profound influence on the engineering of the modern spacecraft. He was the origination of the modern plastic balloon industry which was a critical step in the space program under Dr. Robert Gilruth - a favored student and protégé.

Don first flew in a balloon in 1933, enlisted as "crew" by his mother. In 1957 he flew the first multi-celled plastic balloon, getting two pages in LIFE magazine! And in 1963, along with Ed Yost, Don Piccard was the first to fly the English Channel in a hot-air balloon.

He organized the first hot air balloon races and the first balloon championships in the world and also founded the Balloon Club of America, resurrecting the sport in the post WWII era which ultimately grew into the Balloon Federation of America. He operated Don Piccard Balloons and the General Balloon Corporation and was a leader in sport balloon design and manufacture, introducing many important innovations including the suspension load tapes and the bulbous gore load distribution. In more-recent years Don has been working on XAP, the eXtreme Altitude Project, to carry people by balloon to altitudes above 50 km (above 150,000 ft.) – far higher than current altitude records.

(Text includes personal correspondence plus excerpts from Wikipedia and "Don Piccard – 50 Years of Ballooning Memories" by Peter Stekel.)

III. Poster Presentations Thursday Morning 6-30-2016

Development of a Multi-Cut Payload for use in Stratospheric Ballooning Missions

James Flaten [1,2], Joey Habek[1], Noah Biniek[1], Steven Smeaton[1], Austin Langford[1], Jordan Diers[1] and Isaac Krieger[1]
University of Minnesota, Twin Cities[1] , Minnesota Space Grant[2]

The ability to cut strings (AKA lines) during stratospheric ballooning missions has a wide variety of uses including, but not limited to, (a) flight termination (i.e. cutting payloads away from the main balloon), (b) cutting away excess lift balloon(s) to slow ascent rate (and possibly achieve float), (c) cutting away ballast weights to slow descent rate or increase ascent rate, (d) cutting away burst balloon(s) on descent to avoid parachute entanglement, and (e) cutting away payloads which are intended to return to the ground independently, for experimental purposes. We report on the development of a "multi-cut" payload box that uses an Arduino microcontroller that can control the cutting of multiple strings in arbitrary order at arbitrary points during a mission, expanding our options for stratospheric ballooning operations. For example, this device may be used during the solar eclipse of August 2017 to drop a timed-series of independently-recovered Geiger counter payloads from a stratospheric balloon stack to characterize changes to the Pfotzer maximum as the Moon's shadow passes.

High Altitude Cosmic Ray Detection

Jordan Van Nest[1]
Trevecca Nazarene University[1]

Cosmic rays are high energy atomic nuclei travelling near the speed of light that collide with atoms and molecules in Earth's upper atmosphere (primarily with nitrogen and oxygen), breaking down into a shower of particles of various energies in the stratosphere. As they travel earthward, these particles continue to break down and lose energy which results in relatively little ionizing radiation reaching the surface. Due to the scattering of cosmic rays, the angle at which the rays enter the atmosphere can affect the number and energies of ionizing particles detected at various altitudes. When using a standard Geiger counter on a high altitude balloon flight, cosmic rays of all energies and orientations are counted in the same manner making it impossible to determine the origin and history of a particular detection.

To improve cosmic ray measurements at Trevecca Nazarene University's Near Space Research Program, an "off the shelf" Geiger-Muller tube (ranged from .5 to 50 mR/hour and referenced to Cs-137) was modified to restrict peripheral ionizing radiation detection. The tube, which was 1.5 inches long and .5 inches in diameter, was fitted with a lead casing measuring 3 inches in length. This would ideally restrict the detection field for lower energy particles to a range of 0o to 18.5o along the tube axis. Due to the instability of the Geiger counter's position during high altitude flights, the data from the restricted detection field required a method of determining which direction the Geiger counter was pointing relative to the zenith. During the flights, the Geiger counter was logging its data on a micro-SD card through a "Pic Pod" circuit board created at Trevecca. This board was also fitted with a 3-axis gyroscope, accelerometer, and magnetometer. By housing the circuit board and Geiger counter in fixed positions relative to each other during the flights, it was possible to use the data from the circuit board to determine the orientation of the Geiger counter. A LabVIEW program was created to translate the gyroscope, accelerometer, and magnetometer data into a three dimensional orientation.

It is expected that rays coming in from a small zenith angle would contain a higher level of energy since they would have travelled through less atmosphere. Early results showed that when data from the modified counter was compared against the data from a flight with an unaltered Geiger counter, the total counts were considerably less than with the standard Geiger tube. This suggests that the lead column was successful in blocking some, if not all, of the peripheral radiation. Unfortunately, due to a launch failure in the spring, we have limited data so far with the modified Geiger counter. We will present the current results from our collimated and uncollimated data and explain the direction of future research.

The Design, Construction, and Flight of a High Altitude Particle Collector

Bob Bennett[1] and Jason Brown[1]
Arkansas State University – Main Campus[1]

Scientists have discovered that each year over 110 million metric tons of dust are transported from Africa and Asia to the United States through the upper atmosphere. Among these dust particles are many other microorganism such as pollen, plant spores, plant propagules (seeds), bacteria, and viruses. The fact that these microbes can travel such great distances through the atmosphere makes it relevant to human health, spread of crop diseases, and the global distribution of plants. It takes only one viable microbe or plant propagule to establish an organism in a location in which it never previously existed. It is this understanding of the impact of globally spread microorganisms that makes this a relevant scientific problem. The purpose of this project was to design and construct a device capable of sampling airborne microorganisms at 9 to 10 kilometers altitude using weather balloons in order to better understand the impact of transcontinental dispersion. The collector prototype has been constructed and it has been tested in the laboratory, but it has not yet been tested in the field.

High Altitude Ballooning in 3rd Grade

Emily Mathews[1], Briana Marszalek[1] and Bernhard Beck-Winchatz[1]
DePaul University[1]

In this poster presentation we report on a high altitude balloon project conducted with third-graders from Gower West Elementary School in Willowbrook, IL in spring 2016. In the weeks before the launch students used a vacuum jar to investigate the effects of pressure changes on different objects, substances and sounds in the classroom and conducted pressure, temperature and wind measurements inside and outside of their school using Vernier probe ware. To learn how to use the balloon tracking equipment and how to fill a balloon and prepare it for launch, students simulated a flight with a tethered balloon outside of their school.

After these preliminary activities the students designed and built several experiments with everyday objects such as a latex glove, a party balloon, a plastic soda bottle, a flower, a glue stick and bubble wrap, along with Vernier sensors and GoPro cameras. This payload was launched on May 11, 2016 on a 200 g balloon and recovered after a 65 min flight. All launch, tracking and recovery operations were conducted by the students, with minimal help from teachers and staff. After the successful completion of their flight students analyzed their data in the classroom and wrote about their experience in their journals.

We found this project to be a valuable, exciting and engaging open-ended investigation for third graders. We discuss the unique challenges of conducting a balloon flight with such an early grade level, including how to integrate it into the curriculum while supporting instructional shifts called for by the Next Generation Science Standards, how to engage students at a wide range of developmental levels in team-based activities, and how to overcome logistical challenges.

Low-Cost HAB Platform to Measure Particulate Matter in the Troposphere

Mark Potosnak[1], Bernhard Beck-Winchatz[1] and Paul Ritter[1]
DePaul University[1]

High-altitude balloons (HABs) are an engaging platform for formal and informal STEM education. However, the logistics of launching, chasing and recovering a payload on a 1200 g or 1500 g balloon can be daunting for many novice school groups and citizen scientists, and the cost can be prohibitive. In addition, there are many interesting scientific applications that do not require reaching the stratosphere. In this poster presentation we discuss a novel approach based on small (30 g) balloons that are cheap and easy to handle, and low-cost tracking devices (SPOT and 900 MHz spread spectrum) that do not require a license. Our scientific goal is to measure air quality in the lower troposphere. Particulate matter (PM) is an air pollutant that varies on small spatial scales and has sources in rural areas like biomass burning and farming practices such as tilling. Our HAB platform incorporates an optical PM sensor, an integrated single board computer that records the PM sensor signal in addition to flight parameters (pressure, location and altitude), and a low-cost tracking system. Our goal is for the entire platform to cost less than $500.

Preliminary Results from a Ground Based Magnetometer Rotation Table

Rachel DuBose[1], April Gross[1], Jolene Johnson[1], Kaye Smith[1], James Flaten[2], Erick Agrimson[1]
St. Catherine University[1] and the University of Minnesota, Twin Cities[2]

Understanding high altitude balloon rotation is important for many types of scientific measurements, therefore, balloon and payload rotation is a continuing area of interest and research. In this work, we present results obtained from an Arduino logged magnetometer rotated on a ground based rotation table. This table allowed us to precisely rotate and locate the Arduino logged magnetometer. We compare the Arduino logged results with "known magnetic field orientation" using an AIM rocketry altimeter. This comparison allowed us to test the accuracy of our Arduino logged results and the sampling capabilities of our magnetometer system using different rotational speeds.

Exploring the Edge of Space: Streamlining Physics and Earth Science Collaboration in a New Community College Course

David Kobilka[1] and Yoshinao Hirai[1]
Central Lakes College – Brainerd[1]

We designed a new lab science course on stratospheric ballooning (SB), titled Exploring the Edge of Space. The course, which starts in the upcoming semester, brings together two groups of students simultaneously: Mainstream liberal arts students and students in the college's Honors program. The Honors students meet an additional hour weekly, review scientific literature extensively, and complete a capstone project. The course design is a collaboration between the physics and earth science departments at Central Lakes College, and is drawn on the five-year experience of the authors doing SB flights, many in collaboration with the Bemidji State University SB program. Unlike the past SB flights based on a semester project within pre-existing course curricula, the SB project is the kernel of this course. Therefore it will allow students to focus on learning the knowledge, skills, and attitudes necessary for the success of a large science-technology project while also fulfilling the outcomes to assure transferability. Those students who complete the major project activities including, but not limited to, developing experiment and revising draft reports will achieve the learning outcomes in the goal area of Natural Science of the Minnesota Transfer Curriculum as well as some of the Undergraduate Physics Laboratory Curriculum recommended by the American Association of Physics Teachers. Past experience has shown that students need to spend considerable time building competency in the areas of working in teams with diverse groups, working with technology, critical thinking, complex problem solving, written communication, applying knowledge in field situations, and science literacy in both earth science concepts and research. This course will focus on developing those skills, in an entirely inquiry-based, workshop-lab environment. Students will be guided through the learning of essential concepts, and supported in doing their own research, project development, and experimental design.

IV. Oral Presentations Thursday Morning 6-30- 2016

NASA Space Grant 2017 Eclipse Ballooning Project

Randal Larimer[1]
Montana State University-Bozeman[1]

Montana Space Grant Consortium students and staff along with teams from Louisiana State University, University of Minnesota, Iowa State University and University of Colorado Boulder are developing the Common Payload for the NASA Space Grant 2017 Eclipse Ballooning Project. With the underlying goal of student involvement, teams from across the country will build, test and fly the Common Payload during the total solar eclipse on 8-21-2017 that crosses the US from Oregon to South Carolina. An overview of the system is presented.

The primary flight payload is a student designed and constructed low cost platform that can report balloon positions, stream video and take snapshot images all at altitude in real or near real-time. The Iridium satellite modem provides updated latitude, longitude and altitude data allowing the ground station antennas to track the balloon throughout the flight while providing the FAA near real-time tracking information of the balloon. The ground station antennas allow communication both to and from the primary flight payload. Using a 900Mhz radio, students are able to interact with the still image camera settings and take 'on command' images which are then transferred to the ground station. Steaming HD video is accomplished by using a 5.8Ghz modem to transfer video data to the ground station where the feed is then uploaded onto a website for public viewing.

Students are able to send a 'flight termination email' via the Iridum satellite modem which then uses on board XBEE radio pairs to command the cut-down system to end the flight.

Autonomous Camera Tracking of a Solar Eclipse

Dennis Xu[1] and Matthew Nelson[1]
Iowa State University[1]

This paper will discuss the work performed by students at Iowa State University in the creation of a camera system used to record the expected 2017 solar eclipse. This camera system uses a gimbal device made of 3 brushless gimbal motors to control the Raspberry Pi camera. A chip KIT and a Raspberry Pi will be used to keep the camera pointed at the solar eclipse autonomously. This system was designed to utilize a computer vision system as well as a photo resistor sensor array to determine that the camera is pointed at the solar eclipse. This paper will first discuss what work has currently been done on the system. Next we will discuss the tests that have been performed and its results. Finally we will discuss the future plan for preparing for the 2017 solar eclipse.

Location Tracking from High Altitude

David Schwehr[1]
Montana State University-Bozeman[1]

With the increase in developing aerospace technology there is also a higher demand for aerospace programs at the academic level. High altitude balloons are an attractive tool to test and help develop these new technologies due to the potential of less cost and complexity of other test vehicles. For high altitude ballooning to be feasible to academia, the projects must fit size and weight constraints to avoid expensive components such as larger balloons, amounts of helium/hydrogen support, and requirements put forth by the FAA which can require the use of a transponder. If a smaller lighter payload can be used without a transponder but still provide air traffic control location information, high altitude ballooning programs would be more attainable by universities while not affecting the safety of air traffic. Our project aims to demonstrate the possibility for a balloon to provide dependable, near real time location information while remaining small, lightweight, and affordable. The balloon payload will utilize GPS, the Iridium Satellite Network, and the internet to make this goal a reality. Observers will have access to balloon location information through a mapping application and web server. The system will be tested and demonstrated during a total solar eclipse taking place in August of 2017. During the eclipse there will be 60+ high altitude balloons implementing our system that will be used by several air traffic control centers across North America. We can make high altitude ballooning a reality for more academic programs.

Verso l'Alto Atmospheric Observations of Cosmic Ray Shower Primaries and the Pfotzer Maximum in the Declining Phase of Sunspot Cycle 24

Enrique Gomez[1] and Michele Carmichael-Coker[1]
Western Carolina University[1]

Verso l'Alto (Italian for "toward the high") is a student-led, multi-disciplinary research project to study cosmic-ray radiation above the Southern Appalachian Mountains using high altitude weather balloons equipped with Arduino microcontrollers mounted with Geiger-counter shields and data loggers. Eight successful launches have been completed from October 2012 to June 2014. Data from four flights identify the location of the Pfotzer Maximum for this particular geomagnetic latitude and epoch ranging from altitudes 13.4-22 km. We compared our result with simulations of cosmic ray, proton-primary showers. These simulations were performed using CORSIKA (COsmic Ray SImulations for Kascade) for the appropriate, low-energy, hadronic interaction models. We also have baseline data to compare radiation levels with other research teams that are observing a modulation of cosmic ray intensity as a consequence or reduced solar activity as we approach the minimum of Sunspot Cycle 24.

V. Invited Talk Thursday Afternoon 6-30-2016

Bill Brown

High Altitude Research Corporation, Huntsville, AL.

Pico Balloon Design

Pico balloons offer a new frontier for low-cost high altitude missions. Through recent advances in miniature components and ultra lightweight GPS ICs, it is now possible to build a complete solar-powered tracking system for balloons that weighs less than a half ounce. These trackers are now light enough to be flown from an inexpensive 36-inch foil party balloon that requires just one cubic foot of lifting gas. A foil balloon inflated with a positive free lift under 5 grams will become a small super pressure balloon and can float between 7500 to 10000 meters altitude for a week or more. A recent flight from Huntsville Alabama flew across the Atlantic to Europe and ended up off the coast of Sweden after flying for six days. Under the right conditions a foil party balloon can actually circumnavigate the World. The design of amicro-miniature balloon tracker and launch techniques to maximize mission aloft time will be discussed.

VI. Oral Presentations Thursday Afternoon 6-30-2016

High Altitude Atmospheric Measurements using a Vernier Lab Quest 2

John Truedson[1] and Timothy Kroeger[1]
Bemidji State University[1]

The Physics Department and the Center for Environmental, Economic, Earth, and Space Studies at Bemidji State University have operated the high altitude ballooning program since 2011. These flights have included projects and experiments designed by BSU and local K-12 students as part of the Minnesota State K-12 Science Standards. However, due to budget constraints it is not easy to collect reliable atmospheric data that can be readily analyzed by K - 12 students. However, with the rise of relatively inexpensive and and easy to use equipment it is now possible to collect a wide variety of atmospheric data up to 100,000 ft or more.

A Labquest 2 Data Collection and Analysis system from Vernier Software and Technology was used to collect data using six different Vernier sensors every 6 seconds for the entire 2 hour flight of the balloon from takeoff to landing in a lake on March 30, 2016. The data was later analyzed to produce graphs of temperature, pressure, UVA, UVA, and cosmic radiation vs altitude from ground level to 85,000 ft. Students from Bemidji Middle School participated in all aspects of the project including packing the data equipment, the balloon launch and recovery, and analysis of the collected data.

Temperature and Pressure Test Results using Thermocouple, Thermistor and Band Gap Temperature Sensors

Brittany Craig[1], Tenzin Palsang[1], Kaye Smith[1], Erick Agrimson[1], James Flaten[2]
St. Catherine University[1] and the University of Minnesota, Twin Cities[2]

Understanding the precision and accuracy of thermocouple, thermistor, and digital band-gap sensors in low temperature and pressure environments is critical to interpreting high altitude balloon temperature measurements down to -60°C and pressures down to 10 millibars. In this study we used GT-1 thermocouples as our temperature standard, and tested HOBO thermistors, NeuLog thermocouples and DS18B20 digital band gap sensors for accuracy. Results indicate that the accuracy of these temperature sensors varies significantly in the -80°C to 100°C temperature range. In addition, the precision of DS18B20 digital band-gap sensors was tested using a low-pressure chamber at room temperature and -40°C temperatures. Under these conditions, typical sensor-to- sensor variability was no more than ±0.5°C at room temperature, and no more than ±3°C at -40°C. Reduced pressure did not have a significant effect on variability.

Make to Innovate: HABET — Thunderstorm Project

Dakota Calfee[1] and Matthew Nelson[1]
Iowa State University[1]

The High Altitude Balloon Experiments in Technology (HABET) program is located out of Iowa State University within the Make to Innovate program. The Make to Innovate organization is a group of college level engineers and students of other majors doing assorted projects dealing with high altitude ballooning. This paper will discuss a new project that looks at obtaining meteorological information from a thunderstorm using high altitude balloons. The main information that we are looking for is readings of pressure, temperature, humidity and eventually heavy metal testing of precipitation at various altitudes.

Storm fronts can grow to extreme heights and this causes the storm to pull heavy metal gas substances from lower atmosphere levels. The wanted information will be obtained using a mesh network compiled of many sensors attached to several different nodes, this will allow for the collection of data at several locations in the thunderstorm and to aid in moving this data to the ground station. The types of sensors we will be using will include ones for the basic material that was discussed above. The information that we are planning on gathering will be used to aid research and class based activities with the meteorology department here on the Iowa State campus. Recently members from the meteorology program have joined forces with us and this has allowed us to expand our horizon on what we are capable of doing within this experiment. This paper will also discuss what testing has been done this last year and the future work for this project.

Applying Newton's Law of Cooling when the Target Keeps Changing Temperature, Such as in Stratospheric Ballooning Missions

James Flaten[1], Kaye Smith[2] and Erick Agrimson[2]
University of Minnesota, Twin Cities[1] and St. Catherine University[2]

Newton's Law of Cooling describes how a "small" system, such as a thermometer, comes to thermal equilibrium with a "large" system, such as its environment, as a function of time. It is typically applied when the environment is in thermal equilibrium and the conditions are such that the thermal decay time for the thermometer is a constant. Neither of these conditions are met when measuring environmental (i.e. atmospheric) temperature using a thermometer mounted in a payload lofted into the stratosphere under weather balloons. In this situation the thermometer is in motion so it encounters layer after layer of atmosphere which differ in temperature, and the changing environmental conditions can influence the thermal decay time "constant" for the thermometer as well. We have used Newton's Law of Cooling in spreadsheet-based computer simulations to explore how thermometer readings react under these conditions, to better-understand how logged temperature records from stratospheric balloon flights during both ascent (relatively slow) and descent (much faster, especially at altitude) are related to actual environmental temperatures at various altitudes.

BalloonSAT: A Very Low-Cost 'Satellite' Test Platform

Skye Antinozzi[1], Ardlan Khalili[1], Oscar Velasco[1], Jeremy Straub[1], John Nordlie[1] and Ronald Marsh[1]
University of North Dakota[1]

The University of North Dakota has, over the last five years, performed work to significantly lower the cost of the development of a small spacecraft. Despite making significant reductions to CubeSat cost levels, providing increased functionality and customization capabilities, orbital missions still require funding levels that may place them outside the financial capabilities of most K-12 schools along with many colleges and universities. For institutions that can afford CubeSat development, a mechanism is required to allow the institution to gain competency on spacecraft development prior to being a successful proposer for many sources of prospective funding. For both of these reasons, a very low cost CubeSat-like high altitude balloon (HAB) or solar balloon (SB) payload and an associated tracking system solution are being developed.

This paper presents an overview of the BalloonSAT design. It describes the composition of the HAB/SB payload and the differences between this design approach and many typical HAB payload designs. One area of particular notoriety of the design, the use of 3D printing to produce the payload frame, is covered in detail. A discussion of the ease of construction, based on the use of 3D printed frame and inserted side panels (mirroring the CubeSat design) is presented. The comparative benefits and drawbacks of this design approach versus foam enclosures and other common HAB payloads are considered. In addition, communication technologies for the HAB/SB and the decision-making process between HABs and SBs are also reviewed in detail. The paper concludes with a discussion of previous and ongoing test missions and an overview of planned future work.

Thursday Keynote Shaul Hanany 6-30-2016

School of Physics and Astronomy
University of Minnesota – Twin Cities

Professor Shaul Hanany received his bachelor's degree from Tel Aviv University (Israel), his Master's degree from Rensselaer Polytechnic Institute, and his Ph.D. from Columbia University, all in Physics. After spending 5 years at the University of California Berkeley as a Research Fellow/Physicist, he joined the School of Physics and Astronomy at the University of Minnesota – Twin Cities in 1999. His research involves the use of large balloon-lofted telescopes to study anisotropy and polarization of the Cosmic Microwave Background. Results published by Hanany et al. (2000) were cited as "one of the 10 most important breakthroughs in science for the year 2000" by Science magazine (Science, **290**, 2221). Professor Hanany has received numerous teaching and research awards from the U of MN and the wider physics community. He has also been a leading member of the University of Minnesota's "Physics Force" delighting and amazing thousands of students of all ages with the wonders of physics.

Talk Title: "Balloon-Borne Measurements of the Structure of the Universe and its Evolution"

The cosmic microwave background (CMB) is an electromagnetic radiation that is relic remnant from the big bang. By studying the properties of the CMB we can learn about how the Universe began, how it evolved, and we can project to what will happen with our Universe in the future. The CMB contains a treasure trove of cosmological information; four Nobel prizes have already been awarded recognizing ground breaking contributions to our knowledge of the Universe.

Balloon-Borne instruments floating above 99% of our atmosphere are uniquely suited to measure the properties of the CMB because our atmosphere attenuates the signal and is a source of noise.

In this talk I will explain why the CMB is such a fundamental cornerstone of cosmology and describe balloon experiments that have made, and are making key measurements of the properties of the CMB.

VII. Oral Presentations Friday Morning 7-1-2016

Establishing a Ballooning Program at Two Year College in North Dakota

Tony Musumba[1], Bob Arso[1], Mike Holman[1], Doug Niessen[1] and Peter Fettig[1]
Bismarck State College[1]

Bismarck State College (BSC) is a community college in the North Dakota University System (NDUS) that offers a range of two-year technical programs, a bachelor's degree and a liberal arts transfer program. With the goal of increasing student engagement in the sciences and sheer enjoyment of the adventure of space, Bismarck State College founded a High Altitude Ballooning (HAB) Club in the summer of 2015. The HAB club is an informal group comprising 3 faculty members, one retired engineer and an amateur radio operator and APRS enthusiast. All but one of the members of the HAB club are ham radio operators. In fall of 2015 the members of the club began (and continue to work) working with the BSC STEM club comprising faculty from the sciences and primarily engineering students. On September 19th, 2015, BSC STEM club completed its first high altitude balloon flight to the edge of near space. The launch served as training for the BSC faculty and students in launching and retrieval of a high altitude balloon. The payload consisted of a Byonics Micro-Tracker 1000 and a Go-Pro Camera. Feedback from students indicates that ballooning has increased their interest in science and scientific inquiry. Additional feedback provides compelling evidence of increased student confidence in solving challenging open-ended problems, and ability to navigate the challenges of working in a team. Bismarck State College Foundation provided funding for a second successful launch on the 7th of May 2016. We share both the successes and challenges of starting a ballooning program and the lessons we have learned.

Launching a Ballooning Program in a Middle School Setting

Kelly Henry[1] and Erin Boltik[1]
Bloomington School District ISD 271 MN[1]

Stratospheric ballooning is a STEM-rich activity that allows students to design their own experiments and send them into the unique environment of near space. The educational value of stratospheric ballooning includes creative, open-ended discovery combined with the rigors of designing and building experimental payloads that will withstand a launch to over 80,000 feet into the atmosphere.

There are a variety of models for introducing students to stratospheric ballooning. While some educational ballooning programs are set up as after-school activities, we chose to work with two classes of 8th grade earth science students during their regular classroom time. We also chose to both build and fly the students' payloads even though there are organizations that will fly and retrieve student-built payloads on a fee basis.

To create a successful ballooning program in any pre-college setting, there are several important points to consider. We have identified four key areas of interest to help ensure that your ballooning program will be sustainable: Easing the learning curve, managing logistics, ensuring student engagement, and securing program funding.

From training workshops and vendor options to student engagement strategies, we will share our experience starting up a collaborative, team-based ballooning program that is making near-space exploration accessible to middle school science students.

Elementary and Middle School Student Participation in High Altitude Ballooning: Teacher—Student Perspectives

Michael Urban[1], Timothy Kroeger[1], Mark Studer[2], John Truedson[1]
Bemidji State University[1] and Bemidji Middle School[2]

The Bemidji State University high altitude ballooning program has involved middle or elementary school students with high altitude flights since spring of 2013. A total of about 110 students from the Bemidji Middle School (BMS) and 20 elementary students from the Schoolcraft Learning Community (SLC) have participated in four flights over four years. Student projects were designed to help illustrate authentic science investigation and meet parts of the Minnesota State K-12 Science Standards.

One author made five visits to work with SLC students, introducing them to science and engineering fundamentals and payload/experiment construction. Elementary students participated in the launch activity but not the recovery. Two other authors coordinated activities with the BMS through one pre-launch visit—middle school faculty supervised the design and construction of the payloads. An example project involved sending up three types of beans for a controlled experiment. The students visited the BSU laboratory for the final payload construction and review the launch protocols. The students participated and assisted in the launch and recovery activities.

The post-activity feedback from students suggests: additional participation opportunities in HAB be made available; including more involvement with BSU faculty; increasing direct student participation in the launch/recovery; and continuing the current program. Feedback from teachers suggests: modeling the launch activity in the classroom is beneficial; transportation funding is a major issue; students were excited and engaged; multiple state learning standards were met; and middle school students' introduction to STEM activities at a university may potentially encourage them to pursue a STEM degree.

Statistical Tests Exploring a Subset of Variables Related to Weather Balloon Burst Altitude

Marilyn McNamara[1], Erick Agrimson[1], Jessie Lenarz[1], Joseph Roith[1],
Christopher Ross[1], Kaye Smith[1] and James Flaten[2]
St. Catherine University[1] and the University of Minnesota, Twin Cities[2]

The ability to accurately estimate balloon burst altitude is important when modeling flight paths in preparation for a high altitude balloon launch. Variables considered for the study of burst altitude include the manufacturer of the balloon, the time of day of the flight, and the volume change of the balloon during the last ten minutes before burst. To study these variables, we ran statistical tests on data collected from more than sixty balloon flights carried out by researchers across America.

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