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Michigan Space Grant Consortium Virtual Fall Conference October 17th, 2020

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#MSGC20

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Keynote Address: Dr. Andrew Klesh, Engineer at NASA JPL

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4:30 Adjourn

2020 Keynote Speaker

DR. ANDREW KLESH

Diving Deep - Probing Earth's Ocean to Explore Other Worlds

Whether sending robots to explore the deepest parts of our oceans or driving on the underside of the ice in the arctic, we are using miniaturized systems to explore more of our environment. These systems, built from much of the same technology used in today's cell phones and laptops, are often lower cost – and higher risk – than the vehicles of the past. But they also allow scientists to have broader access to a multitude of environments and well complement our larger scientific endeavors. In this talk, we'll discuss a subset of miniaturized systems used in extreme ocean environments and what has made them successful. Vehicles used in the Antarctic to the arctic will be showcased, as well as how they are leading us toward exploring oceans beyond Earth.

Dr. Andrew Klesh is the project system engineer for the Lunar Trailblazer mission and was the chief engineer of the MarCO interplanetary mission – the first two CubeSats to travel beyond Earth. He also serves as engineering lead of the Buoyant Rover for Under-Ice Exploration and Hadal deep ocean teams, supporting scientists exploring the extreme conditions throughout arctic and ocean environments. Prior to his work at JPL, he supported several missions at JAXA and the University of Michigan as a postdoctoral fellow. His degrees are from the University of Michigan (BSE, EE; BSE, Aero; MSE, Aero; Meng, Space Systems; Ph.D. Aero) and has received several awards, including NASA's Exceptional Engineering Achievement Medal and AIAA's 2020 Engineer of the Year award. Outside of work, he volunteers as an EMT with the Pasadena Fire Department and as operations staff for the Catalina Hyperbaric Chamber. As a lecturer at Caltech and adjunct professor at Arizona State University, he teaches Electronics for Space Applications and Macgyver Engineering.

Session 1 Abstracts

#MSGC20

Full video presentations can be found on MSGC's YouTube channel, just search for Michigan Space Grant Consortium or visit our Fall Conference page on our website for the complete list. During the conference, presenters will be giving a 1-minute lighting talk and have a 1-minute Q&A session fielded by a moderator.

Making Waves about Roger: Incorporating a Water theme into the "Roger That!" Symposium

Gipson, Karen – GVSU
Swanson, Glen - Roger B. Chaffee Memorial Scholarship Fund
Rhodes, Samhita – GVSU
Weibel, Deana – GVSU

The "Roger That!" symposium (www.gvsu.edu/roger-that) is a two-day celebration of space exploration, named in honor of astronaut Roger B. Chaffee, a Grand Rapids native who perished in the Apollo 1 fire. Since it began in 2017, "Roger That!" has been collaborative effort of Grand Valley State University (GVSU) and the Grand Rapids Public Museum (GRPM), held in Grand Rapids. The fourth "Roger That!" symposium, held in February 2020, worked in partnership with GVSU's "Making Waves About Water" initiative and created an experience connecting space and water (in its many forms). Alice Bowman of the Johns Hopkins University Applied Physics Laboratory kicked off the event with her keynote address about the New Horizons probe and its visit to "The Icy Heart of Pluto" (and also about the potential subterranean water that may exist on this dwarf planet), to a rapt audience of students and community members. The water theme saturated the rest of the day, too, with a panel presentation on the Adler Planetarium's "Aquarius Project," which searches for meteorite fragments in Lake Michigan, and in our "Design That!" challenge, which included many 4th-6th grade projects focused on space and water. Our 2020 evening keynote was given by astronaut Story Musgrave who used a presentation on "The Way of Water" to encourage the audience to be like water: adaptable, creative, multidimensional, etc. Dr. Musgrave fascinated adults and kids alike with his tales of adventure, all the while emphasizing the importance of education, in both his Friday night GVSU presentation and his Saturday morning talk at the GRPM. In 2021 an online version the "Roger That!" symposium will emphasize the virtual, highlighting the way space exploration (and the arts and sciences inspired by it) has used concepts of simulation and synthesis to help human beings better investigate and understand the cosmos.

Using statistical learning for model selection and estimation of the effects of modified social behavior for mitigating COVID-19 infection

Landon, Edward – Hope

Logistic regression models are useful tools for estimating the odds of disease infection as a function of predictor variables. A modification to the logistic regression model allows for shrinkage of a model's parameter estimates, allowing for predictor variable selection. This allows us to identify relevant predictor variables for COVID-19 infection effectively, which in turn gives insight into the disease's epidemiology. Furthermore, these models allow for assessment of the effects of modified social behavior for mitigating COVID-19 infection.

Investigation of Novel Mg-Zn-Ca Alloys for Bioresorbable Orthopedic Implants
Tom, Emily – MTU

Temporary bioresorbable implants are revolutionizing modern orthopedic interventional medicine. They are needed for open reduction with internal fixation (ORIF) of fractures to eliminate the use of permanent implants in patients, which can cause post-surgery complications, late-stage infection, and potentially fail over the patient's lifetime. At Michigan Tech, we are developing novel Mg-Zn-Ca-Mn alloys of superior mechanical properties and in vivo degradation by using two unconventional non-equilibrium processing techniques, rapid solidification and equal channel angular pressing (ECAP). Early results show that our alloys have reduced corrosion rates, improved corrosion uniformity, and enhanced mechanical performance as compared to other Mg alloys currently used or explored for orthopedic applications. In this talk, novel technology applied to processing of bioresorbable medical materials will be briefly reviewed, and supported by preliminary results on formulation and characterization of the Mg-Zn-Ca-Mn alloys.

Daily Dose Science for the General Public
Stark, Jeffrey – Longway Planetarium

Longway Planetarium created over fifty short videos aimed at the general public and families with children stuck at home with the intent of giving them ideas of activities for them to using household items or things to explore in their back yards. This was an attempt to keep minds busy during the stay at home order and to keep scientific thought at the forefront of our viewers minds.

Engineering the Future: A Hybrid Virtual and Hands-on STEM summer experience for high-needs students
Dummer, Carrie & Slenk, Erica – Hope

Hope College's Engineering the Future Academy provided local area students the opportunity to explore engineering design in a hands-on, problem solving context and professional development for in-service and pre-service teachers. Designed as a learning experience for students and a research and mentorship opportunity for undergraduate science, technology, engineering and mathematics (STEM) and STEM education majors, 22 fourth and fifth graders, 2 Hope students and 2 teachers participated. Professional development focused on inquiry-based methods related to multi-disciplinary engineering experiences with the emphasis on building units of instruction that are transferable to the classroom. Supplies and equipment purchased for the camp activities were transferred to the schools at the end of the summer. Fees were covered and hands-on supplies and electronic devices were delivered to homes for traditionally underserved students to facilitate their participation.

Virtual Air and Space Summer Camp
Percival, Laura & Wininger, Lisa – MiSTEM

After in-person summer learning opportunities were cancelled for most students, a cooperative venture with an out of state educational partner allowed Northern Michigan students in grades 2-12 to learn about aerospace and aeronautics from their own homes.

Michigan Science Center - Adapting to Online STEM Programs During the COVID-19 Public Health Crisis

Sterner, Anna & Epstein, Paulette – Michigan Science Center

From modern medicine to moon walks, the greatest achievements of humankind rely on experts in science, technology, engineering, and math (STEM). The current public health crisis has taught us that we need STEM professionals now more than ever. To continue our mission to inspire the next generation of scientists, engineers, and doctors throughout our extended closure, MiSci offered daily virtual programs to keep children engaged in STEM learning and provided educational resources for parents and teachers. This presentation will describe our virtual efforts which took place throughout our closure and beyond.

Virtual Reality STEM, Real Life Careers

Gersonde, Nicholas & Ipri Brown, Susan – Hope

In order to excite students about science, technology, engineering and math (STEM) careers, undergraduate education majors lead middle and high school students in creating virtual field trips highlighting STEM careers. Working with Holland Public Schools, ExploreHope staff facilitate students creating four virtual field trips which will be made available to area middle schools. Given the limitations on schools for funding field trips and the potential for innovative programming in remote environments, the virtual field trips will function with VR head-sets or as stand-alone videos.

On the selection of inter-chip interconnects materials for electronic chips

Khan, Mohammad – SVSU

The device density increased tremendously, as predicted by Moore's Law, along with decreasing power consumption with the advent of nanotechnology and over the time. Speed of the devices is increased as well. However, the inter-chip interconnects remain as an obstacle to the speed of the multi-module systems for the transmission line; additionally, it causes power loss. One solution is superconnect where multiple chips are fabricated and finally joined by solder in such a way that it behaves as a single chip. The circuits, and the interconnects –solder contacts–on the chip go through temperature cycling during its operation which can limit its life cycle. With the available parameters, the structure–interconnects– can be simulated to explore the elastic and inelastic deformation, the critical areas for failure and reliability. Moreover, the simulation can indicate what materials with specific ductile and fatigue properties would improve reliability and lifetime with constraints such as elastic limit, ultimate strength. The failure cycle is a function of plastic strain, fatigue ductility exponent, and fatigue ductility coefficient based on Coffin-Manson relation. The choice of materials for the interconnects can be made based on the relation if the fatigue ductility exponent, and fatigue ductility coefficient are known for the materials. This can indicate an initial estimate of life cycles for the interconnect. The plastic strain can depend on elasticity, temperature dependent, and amount of thermal stress, which needs to be determined for a structure. With taking this into consideration, the life cycle is found to be a strong function of the fatigue ductility exponent. As a result, it can assist in selecting materials for the inter-chip interconnects for improved performance.

Two Approaches to ECE Pre-College Outreach
Fujita, Liz – MTU

The Department of Electrical and Computer Engineering (ECE) at Michigan Tech received two MSGC awards for the 2020-21 academic year to support pre-college outreach efforts. One program focuses on introducing electronics skills - soldering with older students, component identification, basic circuit theory - but adds a layer of near-peer mentorship. College students will teach high schoolers; high schoolers will teach middle schoolers; and the middle schoolers will teach elementary students, each at the respective age-appropriate level. The second award is for a virtual outreach centered on basic app programming. ECE aims to create a lending library of devices (phones, tablets, etc) to ensure equitable access to all necessary materials for the workshop. Between these two efforts, we intend to reach several hundred Michigan students, energizing them about electrical, computer, and robotics engineering along the way.

Discovering Attacker Cognition Vulnerability from Malware
Bond, Benjamin – Oakland

When a threat actor is discovered in a computer system and is forced to withdraw, oftentimes they leave behind malware binaries that researchers are able to analyze by reverse engineering the code. This code is useful for studying the behavior of malware authors and provides insight into future engagements. However, with the knowledge that they have been exposed, malware authors may chose to change their tactics, techniques, and procedures to throw researchers off their trail. What they cannot so easily change are their cognitive processes and vulnerabilities. We propose a method of malware analysis by which threat actor cognition is discovered via stochastic system modeling. This will help create more robust threat actor profiles and put defenders in a more advantageous position when encountering the same threat actor or threat actor group in the future.

Oakland University's Energy Exploration
Rogers, Alexis – Oakland

Oakland University's research consists of evaluating and analyzing the energy consumption of the campus. One main focus of the research is on a new LEED Platinum building known as the Human Health Building built in 2014. This LEED Platinum building was designed with a geothermal system. Our research investigates the how closely the geothermal system is running to peak efficiency.

EV Penetration for Minimizing Power System Upgrades
Pfeiffer, Brad – Oakland

This work illustrates the potential of Electric Vehicles (EVs) as a grid support tool. EVs can provide peak shaving power to the grid while discharging and valley filling power while charging to flatten the total load curve of a distribution system. The idea is called Vehicle to Grid (V2G). Flattening the load curve will allow utility providers to delay upgrading, or the purchase of new power generation stations, as well as best utilize renewable energy resources that may be uncontrollable in nature. Electrical energy production and transportation combined accounted for 68%, or 2,534 million metric tons of carbon dioxide emissions in the US in 2019. Utilizing EVs for transportation as well as grid support will decrease this figure in each sector. This technology may pave the way to

cleaner, more reliable, cost effective energy systems. To achieve the goal of illustrating the potential of EVs benefits to a power system, a model will be created using MATLAB and several case studies will be presented. A well known distribution system model will be utilized and several of the most popular EVs parameters are chosen for testing. Because of the stochastic nature of EVs, a probabilistic approach will be applied to multiple simulation parameters to ensure the most realistic result is found.

Development of a PPG Sensor Array as a Wearable Device to Monitor Cardiovascular Metrics

Rodriguez-Labra, Jose Ignacio – WMU

Wearable devices with integrated sensors for tracking human vitals are widely used for a variety of applications, including exercise, wellness, and health monitoring. Photoplethysmography (PPG) sensors use pulse oximetry to measure pulse rate, cardiac cycle, oxygen saturation, and blood flow by passing a beam of variable wavelength through the skin and measuring its reflection. A multi-channel PPG wearable system was developed to include multiple nodes of pulse oximeters, each capable of using different wavelengths of light. The system used sensor fusion to perform feature extraction of relevant cardiovascular metrics across multiple pulse oximeters. The wearable system was applied to the plant of the foot for vascular assessment. Wearable PPG systems capable of sensor fusion show promise as continuous methods for the evaluation of wounds and diseases associated with abnormal blood flow.

Statistical and event analysis of phase and amplitude scintillations associated with polar cap patches

Cardenas-O'Toole, Alanah – UM

Global navigation satellite systems (GNSS) or satellite navigation is an important technological advancement; however, it is greatly impacted by the effects of space weather, such as ionospheric scintillation. Ionospheric scintillation is one of the causes of errors in the GNSS signals and also has the potential to cause a loss of access to GNSS. Ionosphere scintillation often impacts the polar region; however, the cause is not always known. One potential source of scintillation is polar cap patches. In Ren et al., [2018], a polar cap patch database was created based on the incoherent scatter radar measurements at Resolute Bay (RISR). Using data provided by the CHAIN Network of ionosphere scintillation detected near Resolute Bay in 2016, it can be determined how polar cap patches impact ionospheric scintillation. A statistical analysis as well as event analysis have been performed. Scintillation data from GNSS satellites with an elevation angle over 40 degrees were collected from each patch in the database and were compared to daily average excluding patch time. It was found that statistically there is no obvious phase scintillation or amplitude scintillation increase associated with patch in the polar cap. For the event analysis, three different patch events with and without enhanced scintillation were chosen for in-depth analysis and cross-comparison. Other datasets , including AMPERE FAC and RISR, are used to understand the plasma characteristics and geomagnetic activity conditions during these events.

Magnetic Nanoparticle Based Motion Sensing

Brennecke, Jackson & Tuttle, Chase – GVSU

The purpose of this research is to explore an emerging inertial sensing technology. Sensor

orientation information can be deduced from the use of magnetic nanoparticles suspended in a solution while exposed to a rotating magnetic field. This "inertial" sensor is simple in design, simple to construct, and relatively impervious to effects of radiation, or impact. The goal of this research is to devise a more accurate experimental set up and to test the limits of the sensor's capabilities. This testing was accomplished through the use of improved current sensing equipment and data acquisition methods. These results are to be compared to the theoretical results obtained through enhanced modeling and simulation data.

Position Sensor Offset Error Quantification in Synchronous Machines

Kuruppu, Sandun – SVSU

Permanent magnet synchronous machines are a popular electro-mechanical energy conversion device due to the efficiency, small form factor and high torque density. However, they require a position sensor for optimal torque generation in high dynamic torque control applications. This research proposes a strategy to quantify a position sensor offset induced in a permanent magnet synchronous machine drive system under field-oriented control while in operation. A position sensor error causes drastic torque degradation or reversal in a sensed PMSM drive system. A real-time algorithm is proposed that detects and quantifies a position sensor offset error while the system is in operation to improve safety and system reliability.

Student Impact in ExploreHope STEM Education Outreach

Bartley, McKenna – Hope

We conducted a literature search to gather information on the best practices to help students gain confidence in STEM settings as well as how innovative technology can be a great tool for students to learn from. We focused on ways to increase students' engagement and attitudes toward STEM. We found that interactive technology and hands on learning was one way to increase self efficacy when it came to students' STEM confidence. Another way to increase the likeability of STEM, from a students perspective, is to allow them to come up with a research question and allow them to collect and analyze the data. Overall, through our literature search we found numerous evidence based practices that increase students' interest and confidence in STEM for us to implement these ways into our camps.

Neural Network based Model Predictive Control of Residual Stress in Powder Bed Fusion

Nieman, Kip – WSU

Long distance missions in space, especially in the case of long term habitation, represent new challenges in logistics for ensuring the survival of astronauts in hostile situations. Given the constant need for an unpredictable variety of tools and replacement parts, it would be tremendously beneficial to have remote production capacity. Traditional fabrication methods such as die-cast molding or subtractive manufacturing are not suitable due to tooling, weight, and waste. Additive manufacturing (AM), however, offers the possibility of producing an unlimited variety of parts on site. One method is powder bed fusion (PBF), where a laser melts successive layers into a bed of powdered metal particles. This capability would offer the speed and flexibility to produce parts for a wide variety of situations, which would allow for significant improvements in safety (in the sense of dealing with short term, emergency needs of unique parts or tools) and sustainability in the long

term. In addition, given the ability to transport smaller overall amounts of raw material instead of copies of a wide variety of completed parts, this would reduce the weight of cargo shipments into Earth's orbit. A primary challenge is residual stress, which accumulates in the part as a result of rapid temperature changes that occur during the process. The traditional method of relieving residual stress through heat treatment would be cost ineffective in space applications, so it is desirable to manage residual stress during part creation. The hypothesis in this work is that to reduce residual stress in the final part, PBF can be controlled using advanced control that directly makes predictions of the resulting residual stress. Model predictive control (MPC) will be investigated to control the residual stress because of its ability to continuously optimize a model of the process during operation under specified constraints, thus taking future states into account. To deal with computational-efficiency, a reduced-order modeling strategy (such as a neural network) will be created from a full ANSYS coupled transient thermal and structural simulation, and then implemented within the controller

Petro-stratigraphic analysis ofplagioclase-rich lavas in northern Kenya reveal prolonged high-temperature storage of magma in a flood basalt province.
Steiner, Alex - MSU

Continental flood basalts (CFB) are among the largest magmatic events on Earthand often occur prior to thedevelopment of continental rifts. Closerexamination of CFBlava pilesrevealdynamic patternsof eruptive pulses and hiatusesthat may be recorded in thelava'scrystal cargo. However, theresidence ofmagmas at any particular crustal level is unknown. To probe the residence time for magmas in part of a CFB's plumbing system, we present an examination of stratigraphically constrained plagioclase-bearing lavas in northern Kenyaassociated with the Eocene CFB province in East Africa. Plagioclase compositions exhibit little intra-crystal or intra-sample compositional diversity and are interpreted to be the result of diffusive re-equilibration during prolonged storage at high temperature.Slowdiffusing elements like Ti and Larequire103–105years to equilibrate for the observed crystal sizes. We conclude that the residence of magmas in the middle to shallow crust in the Eocene CFB province to be ~104years; an observation consistent with geochronological studies of CFBstratigraphy of the Deccan traps in India.This study demonstrates long residenceof magmas at specificcrustal levels allowing for better constraints on the delivery of heat to the crust that may influence subsequentrifting.

Investigating pyroxeniteas the source of Eocene-recent Patagonian back-arc magmatism
Svoboda, Chris - MSU

In Patagonian Argentina,continental back-arc magmatism is linked to a slab window that has been opening since ~16 Ma. This slab window is caused bythe collision of a mid-ocean ridge and a subduction trench. We present Ar-Ar isotopic eruption dateson lavas fromthe areathat rangefrom 2.52±0.04Mato 40.18±0.09 Ma. All of these magmas have trace-element enriched, Ocean Island Basalt (OIB) type geochemical signatures. The fact that many of these magmas predate the opening of the slab window, but have a similar source to younger magmas,presents a problem for the existing model.One possible explanation for this is melting of pyroxenite. Although it is presumed in igneous petrology that mantle melts are derived from peridotite, other lithologies such as pyroxenite can produce magmas. Pyroxenites meltto produce OIB-type magma. We present olivine crystal chemistrythat showselevated Fe/Mn, suggesting it could have been derived from pyroxenite melting. We posit that melt of pyroxenite lithologyisthelikelysource of the Eocene-recentPatagonian-magmatism.

Session 2 Abstracts

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The Michigan Resources on Climate and Land Change Education (MiRCLE)
Lioubimtseva, Elena – GVSU

The Michigan Resources on Climate and Land Change Education (MiRCLE) is a project of GVSU Climate Change Education Solutions Network sponsored by Michigan Space Grant Consortium. Designed as an online learning community, it provides Michigan-specific place-based interdisciplinary resources for 6-12 grade science and social studies teachers integrating NASA Land Cover and Land Use Change (LCLUC) and GLOBE (Global Learning and Observations to Benefit the Environment) materials integrated with to Michigan Science Standards (MSS) and the recently revised Social Studies Standards. Land-use and land-cover changes affect local, regional, and global climate processes. Choices about land-use and land-cover patterns have affected and will continue to affect our vulnerability to the effects of climate change. Integration of these topics is often challenging for middle- and high-school teachers due to their complexity and interdisciplinary nature. Land is both a source and a sink of greenhouse gases and plays a key role in the exchange of energy, water and aerosols between the land surface and atmosphere. Sustainable land-use planning can contribute to carbon sequestration and reducing the negative impacts of climate change through adaptation strategies. The MiRCLE team is currently working with a group of 16 teachers joining remotely from across the state emphasizing collaborative interdisciplinary approach to teaching and learning. With assistance of GVSU faculty and external experts, teachers engaged in the program will develop open-access lesson plans and visualization tools based on NASA educational assets for Michigan case studies.

First Tango? Extant "Mat World" Analog Microbes Synchronize Migration to a Diurnal Tempo
Biddanda, Bopi & Weinke, Tony – GVSU

Animal migrations mark the largest daily movement of biomass on Earth today, but who performed the first diurnal migration? Microbial mats resembling those that once prevailed on early Earth inhabit the bottom of Lake Huron's low-oxygen, high-sulfur submerged sinkholes. Mats here are dominated by motile filaments of purple-pigmented photosynthetic cyanobacteria and pigment-free (white) chemosynthetic sulfur-oxidizing bacteria. We obtained direct evidence of diurnal vertical migration by microbial mat microbes in the field using time-lapse unerwater photography: cyanobacteria rise to surface during day, and chemosynthetic bacteria at night. Such synchronized diurnal "tango", might have been the largest daily mass movement of life on the Precambrian seafloor billions of years ago, optimizing photsynthesis and chemosynthesis – and may have played a critical role in the oxygenation of the early biosphere.

Spatial Ecology and Survival Analysis of a spotted turtle population in Southwest Michigan

Coury, Michela – GVSU

Turtles are arguably the most threatened group of vertebrates on the planet. Anthropogenic influences like habitat loss and fragmentation, road mortality, subsidized predators, and illegal collection have caused global declines. Understanding whether populations are viable when faced with these synergistic threats is crucial for conservation. My goal is to investigate these factors in a specifically threatened turtle species in Michigan, the spotted turtle (Clemmys guttata). With radio telemetry and mark-recapture methods allow me to gain insight into the spatial ecology and demography of this state threatened species, within a biodiversity hotspot of Southwest Michigan and to investigate presence, abundance, and possibly causes for mortality. Our results will inform future conservation and management decisions for threatened spotted turtles and create future measures to improve long-term population viability.

The Effect of Serotonin on Male Responses to Female Ultrasonic Vocalizations and Urine in the House Mouse (Mus musculus)

Kovacs, Madisyn – Hope

Animals communicate with multimodal signals (i.e., a mix of auditory, visual, or olfactory information). Signals spanning several modalities may provide animals with more complete information to allow for more accurate behavioral decisions. In addition, past research suggests that serotonin plays a role in encoding multimodal social information (e.g., social partner presence) during communication events; nevertheless, to our knowledge no experiments have explicitly tested this hypothesis. In our experiment, we asked the question: Does an increase in the precursor for serotonin (i.e., 5-HTP) affect the behavior of mice (Mus musculus) when exposed to multimodal stimuli? Mice are known to use multimodal signals (vocalizations and olfactory signals) during communication and are therefore appropriate models for this experiment. To answer this question, we presented olfactory (e.g., female urine) and auditory (e.g. female ultrasonic vocalizations, USVs) stimuli to male mice. Prior to the behavioral experiment, mice were either given 5-HTP or saline. 5-HTP has been shown to increase serotonin in a region of the auditory midbrain, which plays a role in the processing of vocalizations. We then quantified the behaviors that occurred when male house mice were presented with either female USVs or both female urine and USVs together. We investigated sexual activity (e.g., grooming), anxious activity (e.g., digging), general activities (e.g., rearing and jumping), and investigative behavior. We predicted that sexual activity and interest behavior would increase in 5-HTP animals. Interestingly, our preliminary results show that, contrary to our predictions, investigative and digging behaviors were decreased in animals given 5-HTP. These findings do corroborate past evidence that found the Fenfluramine (a serotonin releaser) decreased activities like digging and rearing but in females. Together, these results shed light on the role of serotonin in multimodal communication during an intersexual interaction

Using Ground Penetrating Radar to Investigate a Sedimentary Archive at PJ Hoffmaster State Park

Duimstra, Peter – Calvin

Sedimentary layers can be deposited by waves or wind in a coastal dune system. These layers can be examined to track deposition and erosion in the dune's history. Lake Michigan has a cycle of

rising and falling lake levels, which means there will be changes recorded in its coastal dune structures. Understanding coastal structures is important because dunes are a vital asset to ecosystems and human developments on the coastline represent significant investments. Ground Penetrating Radar (GPR) provides a noninvasive method to examine the sedimentary layers below the surface. With this technology it is possible to model the dune subsurface which will be used to identify erosional and depositional events. This data will contribute to understanding how lake levels impact the formation and destruction of coastal land forms. Understanding these changes will assist management in preparation for the consequences that come with the volatile lake levels associated with climate change.

Constructing Digital Terrain Models from Lake Michigan Dune Imagery
Harlow, Blake – Hope

Drone imagery taken at dunes along the Lake Michigan shoreline has provided a relatively efficient method for developing high-resolution maps and point clouds of these areas. These dunes evolve as winds and waves erode the sand, causing major topographical changes over time. Digital Terrain Models (DTM's) provide a useful tool for monitoring this landscape evolution. To develop a DTM, the non-ground points must first be filtered out of the data. Next, the resulting ground points are interpolated. Using Python, we designed algorithms that perform both of these functions. These algorithms have provided evidence that they are potentially useful at constructing the desired DTM's, although further field confirmation is required for conclusive results.

Dunes & Drones: A Machine Learning Approach for Mapping Vegetation with Aerial and Ground-Based Photography
Krebsbach, Jackson – Hope

Active coastal dune complexes are dynamic environments in which patterns of surface change are determined by interactions between plant populations and physical processes. To better understand this relationship, we developed a new method for mapping vegetation in coastal dunes using drone-acquired multispectral imagery, and we applied it to map vegetation coverage at Saugatuck Harbor Natural Area near Saugatuck, MI. Our method uses ground-based photographs of the site for calibration. A machine learning algorithm (random forest) was used to classify pixels in the ground-based photographs into categories, including bare sand and different vegetation classes. The resulting classifier has an estimated accuracy of 89%. The same areas were identified in the drone-acquired imagery, and a commonly used vegetation index, the Normalized Difference Vegetation Index (NDVI), was calculated for those areas. An empirical model was then developed to predict vegetation coverage using NDVI at the sample locations. Finally, we produced a high-resolution vegetation density map for the dune complex by applying the model to an orthomosaic stitched from the drone imagery covering the entire site.

Using Machine Learning to Model West Michigan Dune Complexes
Stephenson, Darin – Hope

For the last two decades, the Hope College dune research group has been studying West Michigan sand dune complexes. In recent years, the group has collected remotely sensed imagery using aerial drones. This imagery gives rise to large point clouds consisting of precise position information and multi-band spectral data. Our overall task is to use machine learning algorithms to

create accurate ground surface and vegetation models in an automated way. These models can be used in studying surface movement and vegetation change over time for purposes of scientific understanding and conservation. This talk highlights the group's most recent work in classifying land type, classifying ground points, and predicting the percentage of vegetation coverage.

Building a Dune on Campus: Innovation and Perseverance in Science
Van Dijk, Deanna – Calvin

For the First-Year Research in Earth Sciences (FYRES) project, COVID-19 presented logistical challenges such as travel restrictions affecting the multiple trips to Lake Michigan dune sites during the fall semester. The unusual solution has been to build a dune on the Calvin University campus so that students can walk to their field site. With the purchase of 630 tons of sand from a local source, a 9000 square foot dune area on a slope was created. Preparation for student use included planting dune vegetation and roping off a research area. Several weeks into the fall semester, the dune is producing visible benefits including the continuation of hands-on field experiences, more flexibility in adapting to COVID challenges, and some unique research opportunities. Public outreach impacts include the positive publicity for science as a creative, problem-solving and adaptive activity.

Hydrothermal synthesis and reactivity of amides in habitable environments
Aspin, Alexandria – Oakland

Hydrothermal systems are not only ubiquitous on Earth but also discovered beyond Earth. Hydrothermal environments provide a unique habitat for deep ocean and subsurface biosphere, and possibly, for the origin and evolution of life. Amides are of great interests to geochemistry and astrobiology research, in large part due to their involvement in biological metabolism, such as in the forms of peptides and proteins that maintain the functionality of life. However, the synthetic pathways and reactivity of amides in hydrothermal systems are not well understood. Here we report a non-catalyzed but highly selective synthetic pathway for amides in hydrothermal water. We find that amides (12 examples) are readily synthesized through a direct condensation between amines and carboxylic acids, with yields up to a 90% in hours. However, the presence of metal ions such as copper(II) salts can strongly inhibit the amide formation under similar hydrothermal conditions (250°C and 40 bar). Copper salts are found to easily react with and oxidize amines, forming aldehydes as the major product. In addition, we find that there is a strong pH dependence on both amide formation and reactivity, in which amide synthesis is more favorable around the neutral pH than at very acidic or alkaline conditions. Our findings suggest that both metal ions and pH are important factors in controlling hydrothermal synthesis and reaction of amides, which should be considered when predicting prebiotic synthesis of peptides and proteins in relevant hydrothermal systems on Earth and beyond.

Single-Source Precursors for Mixed-Metal Flourides: Synthesis of Rubidium - Alkaline Earth Trifluoracetates
Szlag, Regina – WSU

Bimetallic trifluoroacetates act as self-fluorinating single-source precursors for mixed-metal fluorides. In this study, we report the synthesis of Rb–alkaline earth (Mg, Ca, Sr) bimetallic trifluoroacetates using a low-temperature evaporation method. Crystal structures of Rb2Mg2(tfa)6(tfaH)2·3H2O,

RbCa(tfa)3, and RbSr2(tfa)5 (tfa = trifluoroacetate) are solved using single-crystal X-ray diffraction (XRD). XRD suggests that fluorinated monocarboxylates are capable of bridging two metal centers and afford extended inorganic hybrids in a unique classification proposed by Cheetham et al. Thermal analyses and Rietveld analysis of powder XRD patterns confirm the chemical purity of the precursors. RbMgF3 decomposes in both the solid-state and solution-phase to give crystalline, single-phase hexagonal RbMgF3. Decomposition in solution yields cubic RbMgF3. Upon heating the solution-phase decomposed RbMgF3 a phase change from cubic to hexagonal is observed. RbCaF3 decomposes in the solid state to yield crystalline, single-phase RbCaF3. Evolved gas analysis reveals the mechanism of the formation of RbCaF3. Our work has contributed to the expansion of the limited library of fluorinated single-source precursors and provided insight regarding the formation of the mixed-metal fluorides.

Effects of differences in cell wall biochemistry on the microbial decomposition of Sphagnum (peat moss)

Hile, Trevor – Hope
Koehl, Alexis – Hope
Lundy, Christian – Hope
Philben, Michael – Hope

Globally, peatlands store about twice as much carbon as there is carbon dioxide (CO2) in the atmosphere. Carbon storage in peatlands is due in part to the resistance of Sphagnum (peat moss) to microbial decomposition, but the biochemical mechanism for their apparent recalcitrance is not well understood. We conducted an experiment comparing the decomposition rates of two Sphagnum species collected from different microtopographies, as well as a terrestrial moss species for comparison. Mosses from drier habits were hypothesized to be more resistant to decomposition due to higher concentrations of structural carbohydrates. Sphagnum collected from the wetter (hollow) microtopography decomposed significantly faster than the other mosses, consistent with our hypothesis. We are currently adapting a method to analyze the carbohydrate and pectin composition of the moss cell walls using gas chromatography-mass spectrometry. We have separated and identified a total of 10 monosaccharides and uronic acids. This method will allow us to connect the observed differences in the rate of decomposition to biochemical differences among the mosses. Identifying the biochemical mechanisms responsible for Sphagnum recalcitrance will help to predict how CO2 emissions from peatland will respond to the warming and drying expected with climate change.

Measuring soil physical, geochemical, and electrical properties to help reveal the hidden world of roots.

Liddle, Amanda – MSU

Landscapes are changing across the globe in response to growing populations, shifting agricultural practices, and changing climate. Plants, the dominant users of water on these landscapes, are responding dynamically in turn, with changing: plant species composition, development cycles, and root architectures. The hidden nature of roots obstructs our efforts to understand how the hydrologic cycle is altered by plant root water uptake. Traditional methods to measure roots are either destructive or costly (or both). Measuring the electrical resistivity of the ground is one method that has shown promise to effectively image plant roots. In addition to roots within the subsurface, the chemistry of soil water as well as soil clay and mineral content can obscure the potential signal of roots. To examine the physical, geochemical, and electrical properties of the subsurface, 3.6m deep cores were taken from two different environments in SW Michigan: deciduous forest and

grassland with some shrubs – where seasonal variation in electrical resistivity of the soil profile has been measured in situ. Results, so far, show a strong inverse relationship between soil moisture and bulk resistivity controlled by the transition from fine to coarse grains at around 1 m depth. Agreement in resistivity and grain size patterns between the two cores suggests that these features remain consistent at the site-scale. With enough information, the effects of soil properties and chemistry can be both understood and simulated across landscapes, which allow for the presence and distribution of roots to be revealed.

Wetlands in time and space: mapping inundation dynamics and connectivity with remote sensing
Walt, Jonathan & Woznicki, Sean - GVSU

Wetlands provide several key ecosystem services, but over forty percent of Michigan's original wetlands have been lost to anthropogenic use. Michigan's wetlands have been mapped, but these maps are static in time and omit inundation dynamics and hydrologic connections within their watersheds. Quantifying the mechanics of how wetlands connect and disconnect with their surroundings through time and space is important to understand fluxes of biota, nutrients, and energy. This research hypothesizes that the inundation dynamics and connectivity of wetlands are a function of landscape context, asking the question: what role does land use play in connecting wetlands with their surroundings? We used Sentinel-1 synthetic aperture radar (SAR) remote sensing and Google Earth Engine, coupled with in-situ river discharge records, to identify wetland inundation extent in wet and dry periods. This presentation covers preliminary results in (1) collating low and high discharge records with Sentinel-1 scenes; and (2) comparing SAR backscatter for a floodplain wetland in wet and dry conditions.

Assessing the Short-term Effects of Translocation on Freshwater Mussels: Is Habitat or Water-quality More Important?
Arnold, Joshua – GVSU

Freshwater mussels (Order: Unionid) are among the most imperiled group of animals in North America. Freshwater mussels are vital to aquatic ecosystems and provide important ecosystem services such as linking the lentic/lotic and benthic community, stabilizing the substrate, and are a vital food source for many species (Vaughn, 2018). Of the 300 species of freshwater mussels native to North America, greater than 70% are currently threatened extinction (Williams et al., 1993). A common management practice in the conservation of freshwater mussels is translocation. Translocation is commonly used when populations of mussels are threatened with extirpation due to anthropogenic effects such as dam and bridge removal. Translocation has been used for decades but it has had varying degrees of success, with some efforts having complete failure and some efforts having greater than 80% survival. However, these papers look at survival as the only measure for success (Cope & Waller, 1995; Stodola et al., 2017). We will look at how the act of translocation effects the individuals on the short term, and how differences in habitat and water quality can minimize or exacerbate any short-term effects.

Increasing the survivability of hatchery raised Red Drum (Sciaenops Ocellatus)
Sanchez, Alejandro – EMU

Sciaenops ocellatus, otherwise known as Red Drum, a recreational sport fish whose population has

declined due to commercial fishing. Governmental restrictions on the fishing of Red Drum has allowed for this decline in population to ease. A solution to boost the natural population of the Red Drum are fish hatcheries, more specifically, Bears Bluff National Fish Hatchery (BBNFH). In this project, the effectiveness of the method used in raising Red Drums and releasing them into the wild is looked at to determine if there are particular factors that will maximize the number of Red Drum placed into the wild. The factors that we are to look at are the ideal average size of the fish, the time of year that the fish are reared, and whether a particular pond does significantly better than others under the same conditions. Data from the BBNFH will be analyzed using statistical methods.

Sinkhole Microbial Communities: Documenting Diversity of These Unique Environments

Hamsher, Sarah – GVSU

Understanding organisms in extreme habitats provides a potential model for extra-terrestrial lifeforms while shedding light on the evolution of life. Groundwater-fed environments with sulfur-rich waters in Lake Huron contain microbial mats, representing conditions similar to those during the oxygenation of Earth's atmosphere and are dominated by cyanobacteria and diatoms. The purpose of this project is to: 1) examine the community for potential secondary metabolites, possibly of great use to humans, and 2) document the alpha-level biodiversity of the mat communities, describing any novel taxa. For this talk, we will focus on the second objective. Sediment cores from Lake Huron benthic microbial mats were collected. Cyanobacteria were initially plated to determine whether any strains produced allelopathic compounds. Zones of inhibition around some colonies were noted and those were isolated. Twelve unique filamentous strains, corresponding to the form-genera Leptolyngbya, Phormidium, Jaaginema, Anagnostidinema, etc. were recovered. However, these genera are well-known to contain extensive cryptic diversity. To assess this possibility, further analyses employing the 16S rDNA and 16S-23S ITS regions are being undertaken this fall. Diatoms isolated into liquid culture medium have been slow-growing. Initial samples collected were dominated by Craticula cuspidata and members of the Bacillariales. Preliminary results of this study will be discussed.

Geophysical investigation and subsurface characterization of Lake Michigan coastal landforms

Higley, Melinda – Calvin

Above long-term average lake levels are contributing to erosion events around the Lake Michigan basin, bringing instability to beaches, dunes areas and bluffs. Coastal sediments along Lake Michigan typically consist of sandy dune deposits that overlie glacial and lacustrine sediment and have developed in response to Holocene lake-level change. However, sediment patterns vary at the local level and detailed mapping of coastal sediments is required to understand vertical and horizontal non-uniformities in the depositional record. The recent erosion at Michigan beaches and bluffs has created fresh exposures and sedimentary layers are visible in subvertical cliffs. These are ideal situations for ground-penetrating radar (GPR) investigations to correlate the visible stratigraphy to the GPR data. We conducted GPR studies at a recently formed dune scarp and a recently failed coastal bluff to test the resolution of the GPR data in those coastal environments and evaluate the subsurface patterns adjacent to subvertical cliffs. Distinct units are visible in the GPR data and can be correlated to the visible aeolian (dune scarp) and glacial stratigraphy (bluff). Direct comparisons between the GPR data and visible sediment layers will aid in the interpretation

of the extent, thickness, and topography of unstable sediment layers, especially in situations without direct access to the sediment.

Chlorophyll-a and land cover in eastern Lake Michigan: Preliminary results

Mader, Megan – GVSU

Lake Michigan's drowned river mouth (DRM) systems are geologically unique due to their riverine inputs and large-lake influences that create ecologically and biologically diverse ecosystems. Serving as focal points for human development and the confluence of upstream watershed impacts, human activity and development has directly altered DRM ecosystems. Using geospatial analyses and the National Land Cover Database (2016), we quantified anthropogenic impact in these systems based on land use and found that development and agriculture increase in southern DRMs while forest cover decreases. We then identified 12 DRM systems to sample for water quality conditions that reflect this latitudinal gradient in eastern Lake Michigan. Using chlorophyll-a as a measure of primary productivity biomass, we found that chlorophyll-a concentrations significantly differ from northern to southern latitudes. Then, we assessed the land use variables that could be associated with the spatial variation of chlorophyll-a and found that watershed human population density and agricultural land use were the greatest drivers of primary producer biomass. Our results support previous findings that land use is a primary driver of chlorophyll-a concentrations in lakes and will be used to better understand the effects of human development on DRM fish communities. The ultimate goal of our research is to assess the impacts of human alteration of watershed land use and shoreline structure on DRM fish assemblages, which will be useful to both managers and researchers concerned with coastal habitats in eastern Lake Michigan.

Bloom or bust: Search for phytoplankton community drivers using long-term time-series observations and field measurements in a model Great Lakes estuary

Mancusu, Jasmine – GVSU

Muskegon Lake, a drowned river mouth estuary that empties Michigan's second largest watershed into Lake Michigan, historically suffers from cyanobacterial harmful algal blooms due to cultural eutrophication. This study provides both a historical take on cyanobacterial blooms in Muskegon Lake and a focus on the year 2019. While visible blooms still form periodically on the lake during the summer and fall, a look into historical data from 2003 to 2019 reveals a major decrease in cyanobacterial abundance over time along with shifts in community composition in response to changes in nutrients and temperature. Additionally, the long-term dataset from the Muskegon Lake Observatory buoy revealed 2019 to be an anomalous year in terms of weather. Biweekly sampling of three sites on the lake during 2019 captured how the aberrant weather affected the phytoplankton community. With an unusually cool spring and the highest precipitation accumulation on record, the phytoplankton community saw domination in all seasons by an unexpected group – the diatoms. Though multiple genera were found, cyanobacteria comprised less than 2% of the phytoplankton community in 2019 – the lowest on record for Muskegon Lake. Further, an in situ bioassay with bottom water and river water as treatments and near-surface water as a control allowed us to explore which nutrients stimulate algal growth, identify the sources of these nutrients (internal loading v. river influx), and determine whether this source changed seasonally. We conclude that nutrient forms and concentrations drive cyanobacterial abundance and composition in Muskegon Lake on a yearly basis, but large-scale climatic events impacting regional temperature and precipitation can override the system. These findings provide an alternate perspective on the impacts of a

changing climate on the phytoplankton community in Great Lakes estuaries. Lessons learned from this model Great Lakes estuary should be applicable to similarly impacted freshwater estuaries and temperate lakes everywhere.

Preliminary Results – Star Wars: Phenology of the aquatic invasive species starry stonewort (Nitellopsis obtusa; Charaeae) in two Michigan drowned river mouth lakes
Neuman, Emily – GVSU

Authors: Emily Neuman1, Sean Woznicki1, Kenneth G. Karol2, James McNair1, and Sarah E. Hamsher1,3 1Annis Water Resources Institute, Grand Valley State University, Muskegon, MI 2Lewis B. and Dorothy Cullman Program for Molecular Systematics, New York Botanical Garden, Bronx, NY 3Department of Biology, Grand Valley State University, Allendale, MI Abstract Aquatic invasive species have become a global threat causing impacts on economic, environmental, and social regimes due to their unique ecological engineering strategies. Nitellopsis obtusa is a green macroalga native to Europe and Asia, but is considered invasive in North America. This macroalga is an aggressive competitor in aquatic systems that once established, forms thick monotypic meadows that could negatively impact native macrophyte communities, but little is known of its impacts. The purpose of this study is to record the timing of the peak biomass of Nitellopsis obtusa in Pentwater and Muskegon Lakes to aid in the management of this invasive species. To accomplish this, three sites in Pentwater Lake and one site in Muskegon Lake were established for biomass sampling. Within each site, samples were collected by destructively harvesting all macrophyte/macroalgae from six random quadrats every other week (twice per month) starting in June 2020. Both wet and dry weights were recorded for each sample to establish growth curves of Nitellopsis obtusa over the growing season. Preliminary results will be discussed. These findings will assist in addressing the uncertainties of the phenology of N. obtusa and aid in determining best management practices going forward with control methods for this aquatic invasive species.

Breathless: Muskegon Lake Hypoxia and Drivers in the 2010s
Stone, Ian – GVSU

Seasonally reoccurring hypolimnetic hypoxia in Muskegon Lake was quantified during the 2010s. A long-term, time-series data set collected from the Muskegon Lake Observatory buoy (www.gvsu.edu/wri/buoy/) was analyzed to gauge temporal changes in hypolimnetic hypoxia and the environmental variables potentially driving observed changes. The collected time-series data showed a continuing presence of hypolimnetic hypoxia in the lake, though the severity and number of hypoxic days may be decreasing. Lower spring and summer temperatures likely contributed to reduced stratification and increased mixing contributing to the overall decline in hypoxia. Yearly variation during the 4-year time set (2011, 2012, 2015, 2019) appears to be most strongly driven by decreasing hypolimnetic pH and an increase in hypolimnetic water temperature.

The problem of Multiple Scale Applied to the Coupled of Water Flux and Heat Exchanges near the Subsurface
Sviercoski, Rosangela – Oakland

In this talk, I will present the development and validation of a new multiscale modelling framework

for the multidimensional coupled system describing soil moisture and heat interactions in a shallow soil profile, capable of predicting upscaled soil-hydrological fluxes under different hydro-climate conditions. The targeted problem is of practical interest as accurate assessments of spatial and temporal variations of soil moisture and infiltration/evaporation fluxes are critical for many environmental and hydroclimatic applications. Currently, existing models are limited to solving this highly nonlinear water and vapor phases, without addressing the various spatial and temporal scales involved. Moreover, when multiscale phenomena are considered in such systems, the high computational cost for such calculations are infeasible to consider. This new multidimensional multiscale coupled system and its respective upscaled, and low computational cost version, use air temperature, solar radiation, and precipitation as parameters to determine the boundary conditions, through the upscaled energy balance equation. This formulation makes it more realistic and ready for coupling with atmosphere processes. The accuracy of this new upscaled formulation has been demonstrated by comparing with both, the fine-scale model and with field data. Thus, the proposed system presents the mathematical and physical based tools to better predict a key boundary condition concerning the evaporation (and water) budget to be used into local and large-scale global climate modelling efforts to better quantify the change of the climate, its forecast and its impact.

Session 3 Abstracts

Full video presentations can be found on MSGC's YouTube channel, just search for Michigan Space Grant Consortium or visit our Fall Conference page on our website for the complete list. During the conference, presenters will be giving a 1-minute lighting talk and have a 1-minute Q&A session fielded by a moderator.

Using Markov Decision Processes for Autonomous Spacecraft

Donovan, Cody – Oakland

Many space exploration missions are subject to significant delays in instructions issued from the ground. This is mainly due to the distance signals must travel through space. This makes real-time instructions sent from the ground inadequate for spacecraft operations. Autonomous systems can help spacecraft respond to stimuli in real-time by assessing the available information without an operator to determine the optimal decision with mission objectives in mind. This research proposes implementing Markov decision processes (MDP) to help spacecrafts with attitude control. Existing research will be consulted to find an appropriate model to implement in Python. The Python model will be used to calculate the optimal attitude at different stages of the spacecraft's mission. Augmentation of the chosen model will be made to increase the level of detail in the model.

Marsnet: A neural network for predicting conditions in the upper atmosphere of Mars

Mikolajczyk, Brian – EMU

The NASA Mars Atmosphere and Volatile Evolution mission (MAVEN) has produced many interesting datasets since entering orbit around Mars on September 21, 2014. The Neutral Gas and Ion Mass Spectrometer (NGIMS) instrument measures the composition and isotopes of thermal neutrals and ions . The goal of my project is to train a neural network using L2 ion data based on solar zenith angle, altitude of the measurement, mass, and abundance to predict the altitude and abundance of neutral gases in Mars' upper atmosphere. After a successful predictive model for NGIMS is achieved, other MAVEN datasets can be folded into the model to provide more robust predictions.

Advanced Structures and Materials Technology Integration for a Lunar Habitat

Bowling, Lauren – MTU

NASA's Artemis program plans to have a sustainable lunar base deployed on the Moon by 2028; the base calls for a foundation surface habitat that can support a crew of four members for a minimum mission duration of 28-days. Due to the lack of lunar atmosphere, typical metallic structures emit secondary radiation, which is a health hazard for exposed astronauts; therefore, alternate structural materials are needed for the foundation surface habitat. Additionally, it is favorable for the structure to be collapsible for transportation to optimize payload and monetary constraints. As a result, inflatable structures are under investigation due to their optimal mass-to-volume ratio and large surface area that can efficiently disperse structural loads and heat. Currently, only two inflatable airlocks have been deployed in space, therefore, the technology

associated with inflatable structures must be improved. This study focused on the inflatable lunar habitat applications of emerging NASA Langley Research Center (LaRC) technologies and their required development steps to become space qualified. The Bowling Habitat architecture was generated by compiling interviews conducted with LaRC researchers and papers on these technologies to demonstrate possible applications of NASA Langley's on-going research and to identify the remaining improvement areas of inflatable lunar habitats. The Bowling Habitat architecture called for 13 NASA Langley technologies, five of which were deemed critical, five determined as enhancing technologies, and three were classified as transformational technologies for the Artemis program. To address the payload constraints, the study also generated a tentative timeline that aligned with the current Artemis schedule for transporting the Bowling Habitat to the Moon. It was estimated to have a mass of 9,000 kg, which would require, at most, three lunar surface missions for the habitat to be fully deployed and equipped for human life; two of these missions were expected to be completed via NASA's Commercial Lunar Payload Service and one via a co-manifested load on the Space Launch System rocket. Ultimately, the Bowling Habitat mainly addressed the structural needs of an inflatable lunar habitat, meaning that major areas pertaining to the life-style aspects of the habitat must be improved. Areas include, but are not limited to, hard connection points, the monitoring of human health, and extra radiation protection for solar photon events.

Understanding the impact of chronic low dose radiation on mental health and behavior in mice.
Gleeson, Benjamin & LaFrenier, Corine - Hope

A major component of NASA's 2018 strategic plan was to send astronauts to and beyond our lunar orbit within the next couple of decades. A risk to mission success is an astronauts' exposure to galactic cosmic radiation (GCR), a mixture of chronic low-dose, high-energy, high-charge ion particles (HZE). Previous high-energy radiation proton studies show lasting inflammation in the eye in humans treated for uveal melanomas. In mice, HZE particles also showed deficits in cardiac physiology, brain electrophysiology, and memory. Of particular interest to long-term mission success are low-dose, low-energy protons due to their high abundance in the space environment. Given the detrimental physiological and cognitive impact on humans and rodents after high-energy proton studies and a lack of low-energy proton studies on skin and inflammation, knowledge of how inflammation might respond to chronic low-dose, low-energy proton radiation is warranted. In our experiment, mice were put into a 50mL conical tube; half were irradiated using the Hope College Pelletron accelerator at a low-dose of approximately 2.5 mGy of protons. After 10 weeks, all mice underwent behavioral tests that looked at stress behaviors. Afterwards, mice were euthanized for molecular studies to examine levels of tumor necrosis factor, which are associated with increased depression, bipolar disorder and schizophrenia. Therefore, the proposed study aimed to test the hypothesis that chronic low-dose, low-energy proton radiation negatively impacts mental health due to lasting systemic inflammation. Future directions are to examine HZE particles (e.g. Fe, Si, and C) at Brookhaven National Laboratories in Long Island, NY, to compare chronic low-energy low-dose particles and high-energy low-dose protons which will help future NASA missions to and beyond lunar orbit.

Determining the Type of DNA Damage Caused by Microgravity
Lowran, Kaitlin – Oakland

The health risks of space travel are not well-defined. Individuals in space are susceptible to DNA

damage caused by UV radiation, which forms crosslinks in the DNA. The DNA damage must be repaired in a timely fashion; otherwise, accumulation of lesions can result in cancer, heart disease, and other genetic abnormalities. Although human cells have repair mechanism to counteract various forms of DNA damage, the effect of low gravity on these repair pathways is unknown. The focus of this research was to assess the type of DNA damage that occurs during long-term microgravity exposure of human cells. This was tested by monitoring the viability and the extent of DNA damage to human heart muscle and kidney cells after exposure to hydrogen peroxide, bleomycin, and camptothecin in microgravity. These treatment conditions generate oxidative stress, double-stranded, and single-stranded DNA breaks within the cells. Prolonged exposure to simulated low gravity caused an increase in single-stranded DNA breaks compared to the other types of DNA damage.

Evaluating the impact of microbial experience on immunity

Renkema, Kristin – GVSU

My lab investigates how environmental exposures influence the immune system during homeostasis and disease. Specifically, we measure how microbial experience shapes immune cell signaling pathways and ability to respond. Previous research has shown that traditional specific pathogen free (SPF) mouse models do not replicate human adult immunity, at least in part due to the lack of microbial exposure. We expose SPF mice to diverse microbes by cohousing SPF mice with mice purchased from pet stores to study how the microbial environment shapes the immune cells throughout development, and how microbial exposure translates into signals that are interpreted by immune cells. Space flight results in both immunosuppression and microbial exposure for astronauts, yet very little is known regarding how these microbial exposures impact their immune systems and overall health. Our studies have significant relevance to NASA's goals because astronaut immune health is critical to successful long-term missions and commercial space industry.

Microgravity enhances self-renewal and proliferation of human pluripotent stem cells by regulating CDK2/4

Timilsina, Suraj & Villa-Diaz, Luis – Oakland

Human pluripotent stem cells (hPS) are a subject of great interest due to their potential applications in regenerative medicine. They are defined as pluripotent cells that have the capacity to self-renew and to generate all cell types of the body. Understanding the mechanisms that regulate the fate of hPS cells will advance their use in biomedical applications. Gravity is a physical force that affects the physiological functions of cells, tissue and organs. There are several studies indicating that self-renewal of stem cells is enhanced in microgravity conditions. However, report on the effects of simulated microgravity (smg) on hPS cells is still lacking. Here, we investigated the biological effects of smg on hPS cells. Undifferentiated hPS cells were cultured and exposed to 0.02g smg for up to 96 h. The smg was done replicating a model that uses modifications of a rotary cell culture system (RCCS) in which cells are located in the axes of rotation. Our results showed that smg prolonged the self-renewal of hPS cells by upregulating the expression of core set of pluripotency transcription factors and genes known to be involved in telomere elongation, and by reducing the susceptibility to differentiate. Interestingly, hPS cells cultured under smg condition were observed to have enhanced cell proliferation as compared to cells cultured under 1g condition. Analysis of human cell cycle regulating genes indicates that CDK 2/4 expression is central in enhancing cell proliferation and maintaining self-renewal of hPS cells under smg condition. In conclusion, smg

prolongs self-renewal of hPS cells with higher cell proliferation, which is modulated by increased activity of cell cycle regulating kinases.

Arm Cranking with Blood Flow Restriction: A Potential Exercise for use in Space?

Wedig, Isaac – MTU

Exposure to microgravity has many negative effects on the human body including decreased muscle size, strength, and endurance. These negative effects can compromise astronaut health, safety, and productivity during long-duration space missions. Blood flow restriction exercise (BFR), which involves exercising with inflatable cuffs around the limbs, is an effective method to improve muscle size, strength, and endurance on Earth. Previous research on BFR has focused on lower-body exercise. Maintenance of upper-body strength and endurance is important for astronauts especially in microgravity environments where the lower-body is used less. The aim of this research is to determine the effectiveness of an upper-body exercise program with BFR to improve arm muscle strength and endurance. These results will help develop more effective exercise programs for astronauts and allow for longer-duration human space missions in accordance with NASA's strategic interests.

Algorithms for Complete Physiological Monitoring During Spaceflight

Zitzelberger, Aven – MSU

Detecting early symptoms of health problems within a spacecraft is both challenging and critically important. Current approaches to comprehensive health monitoring require an array of sensors that are individually prone to malfunction, potentially irreplaceable, and collectively cumbersome to the mobility of astronauts. Blood pressure is one such health index that simply cannot be monitored continuously due to the sensor's invasive and obstructive nature. These challenges motivate the development of physiological interpolation algorithms that can accurately reconstruct missing or unavailable physiological data with high fidelity using other measures. To address this challenge, we will (1) develop deep learning approaches to enable reliable, real-time reconstruction of missing physiological waveforms using one or more other available waveforms and (2) endeavor to discover the minimal subset of monitoring systems needed to obtain the best overall picture of physiological status. To accomplish these goals, we will build software designed to stream sensor data to a central server where they will train our deep learning algorithms. We will be using this system to aid in collecting training data first from an available data set before moving on to our own research.

Rocketry Professional Development Training

DeVillers, Ginger - Plainwell Aviation and STEM Academy (PASA)

The grant will enable the development and dissemination of a virtual professional development module in model rocketry for teachers of students in grades 5-8, consisting of an overview of NASA rocket history, physical science of rockets, and an introduction to model rockets. The module will contain demonstrations of how to complete model rocket builds with students, how to safely launch model rockets, and how to collect and analyze data obtained from the rocket launch. If an actual launch is not possible, a virtual launch with simulated data will also be provided.

Cooperative air and ground based robotic teams for planetary exploration

Boss, Connor – MSU

Cooperative planetary exploration missions between unmanned aerial vehicles (UAVs) and ground based rovers, such as the Mars 2020 mission, provide a number of benefits as well as challenges. The UAV can provide detailed maps of the terrain to enable safe trajectory generation for the rover as well as investigate potential areas of interest for deeper investigation by the rover. These operations will be conducted in uncertain environments, requiring robust control methods. It may be necessary for the UAV to achieve a coordinated landing on the rover, potentially to recharge, or deposit samples. We will focus our efforts on solving the problem of landing a UAV on a moving rover in these uncertain environments. We will rely on our expertise in UAV control design and implementation to ensure these control objectives are met. We will further provide analysis guaranteeing performance metrics and a stable landing.

MTU's Lunabotics Team the Astro Huskies Presents: The Design, Manufacturing, and Testing of our Inaugural Lunabotics Rover

Johnson, George – MTU

This presentation covers the system engineering process our inaugural Lunabotics team took to design, simulate, manufacture, assemble, and test our lunar excavation robot. The newly formed team, the Astro Huskies, started from the basics in Fall 2019 and designed a robot that met all the requirements. Please join us for our video presentation that details the process and results of our Lunabotics team.

Solar Weather Modeling with Neural Networks

Kinkade, Baylee – EMU

Our nearest star, the Sun, is both a source of life and a source of disruption in our modern world. It provides us with energy and warmth, but its geomagnetic storms threaten our technology and infrastructure. Disturbance Storm Time, or DST, is a measure of the intensity of solar storms. Using various machine-learning techniques, a neural network was built to predict DST. The neural network's DST predictions closely follow the graph pattern of the actual DST data, but it is still prone to underestimating sharp changes in DST.

The evolution of contact binary stars

Le, Gia Mien – Calvin
Avery, Anneke – Calvin
Henderson, Lauren – Calvin

A contact binary star system consists of two stars orbiting so closely together that they share an outer atmosphere. Although common, there is not yet a consensus on how these systems form, evolve, and ultimately die. Our goal is to test a comprehensive theory that we have developed over the past year describing the lifetime of these systems, from how the two stars come together to how they eventually spiral together and explode. In this presentation, I will introduce the geometry of contact binary stars and our methods of calculating the evolution of the internal structure of the primary stars and the orbital properties of the binary. Our theory postulates that the binary evolution depends on the changes of the primary star. By using MESA, we computed the evolution of an isolated star, however, each run would only include a fixed mass transfer and rotation rate. Actual mass transfer rate must vary in such a way to keep the primary star in contact and to conserve the total mass and the total angular momentum of the system. Therefore, we adapted to inputting those

two variables at smaller timesteps. Results yielded by this new method of computation were consistent with previous crude approximations and included timescales which we were not previously able to calculate.

Understanding the emerging role of human-computer interaction in human space exploration
Garvin, Matthew - UM

This research is an ethnographic case study of bioastronautics, informatics, emerging technology, and human-computer interaction design in NASA-sponsored university challenges. The goal of this study is to investigate how researchers and engineers interested in human spaceflight, exploration, and habitation conceive of and design for user needs, preferences, and comforts. This study is based on fieldwork conducted at the University of Michigan in Ann Arbor from 2019 to 2021 through participation in the NASA SUITS and X-Hab challenges. It argues that human-computer interaction (HCI) and computer-supported collaborative work (CSCW) are a central facet of successful planning and execution of human spaceflight missions, exploration, and habitation. Using participant observation, contextual inquiry, and archival data, this study evaluates how bioastronautics researchers and engineers manage the "human element" as it relates to cognition and information processing on a scope that includes the implementation of emerging technologies in vehicle habitats and spacesuit design.

Laser Alignment Accuracy and Feedback Control in High-Altitude Quantum Communications System
Goderis, Derek – MSU

Understanding pier-to-pier quantum communication in an upper atmospheresetting is a step-ping-stone for a quantum communication network, as well as quantum space communication. Upper atmospherequantum communication poses many challenges. The aim of this project is to develop a model that simulates laser alignment of two balloons that serves as the "all clear for quantum transmission"key. The model createdduring NASA Michigan Space Grant Consortium Summer Project 2020 incorporateskey challenges in balloon alignment: the random and changing position of the balloons, and Gauss-ian laser beam dispersions at a distance. A novel use of super-resolution microscopy to counter the effect of trans-versedispersion is explored to enhance laser pointing ac-curacy to achieve the ~ 1 arcminute = 60 arcseconds.

Synthesis of 2-Aminoethyl Cinnamate for studying Responsive Liquid Crystal Elastomer Materials
LaDuke, Abby – Hope

Liquid Crystal Elastomers (LCEs) are lightly crosslinked networks formed by reactive liquid crystal molecules. LCEs can exhibit both molecular order and rubber elasticity. Molecular order or alignment is a crucial characteristic of LCEs that enables large deformations in response to certain environmental stimuli. Aligned LCEs hold potential for applications like soft robotics and shock absorption materials. Responsive LCEs have been synthesized through the use of command surfaces and mechanical stretching, which result in aligned flat sheets that have limited initial shape design. Alternatively, some work has focused on fabrication and alignment through 3D printing. This approach is promising, but alignment is restricted to the ink-flow direction. To avoid device geome-

try and alignment restrictions, and improve final material functionality, finding an alternate alignment method is important. Work in the field of low molecular weight liquid crystals found ment method is important. Work in the field of low molecular weight liquid crystals found cinnamate based polymers form aligned rigid cross links when irradiated with linearly polarized uv light. These cross links induced alignment in the low molecular weight liquid crystals. In addition, several recent studies have focused on synthesizing LCEs using accessible chemistries like aza-Michael addition reactions involving primary amine and acrylate functional groups. To explore the effect of cinnamate molecules on LCEs, cinnamates with amine functional groups that can be easily incorporated into an aza-Michael addition synthetic route are needed. The goal of this work is to modify and scale up an existing patent procedure for synthesizing the amine functionalized 2-aminoethyl cinnamate. This molecule is an essential component of future studies addressing the effect of cinnamates on liquid crystal elastomer alignment.

Fake Multimedia Detection and Generation

Masiak, Kyle - Oakland

Detection of fake multimedia, especially deepfakes has become extremely important in recent years and will only continue to grow. Eventually real and fake media will be indistinguishable for the human eye. My research focused on detecting these deepfakes. Most existing works focus on only detecting one type of deepfake. I wanted to take a more universal approach. I combined both audio and visual features as well as fused landmark features for blood flow detection. Both of these help detect deepfake videos.

Accelerating the Gabor Transform with a GPU for SAR Image Compression

McInnes, Conner – Oakland

The Gabor transform can be utilized in an algorithm for compression due to its ability to allow the user to isolate high frequency information to filter. This transform can be implemented using FFT's to aid in calculating the Gabor coefficients of a particular image.In the C programming language, an open source library exists called FFTW that is able to perform FFT's quickly on the CPU. cuFFT does have a bottleneck during the initial allocation of the input, output, and plan for the desired FFT, but with larger images these became less and less impactful. Image compression algorithms using the Gabor transform can benefit in reduced computational time from cuFFT's functions.

A Divide-and-Conquer Algorithm for Computing Voronoi Diagrams

Smith, Elijah – GVSU

Identifying the closest of a set of locations typically requires computing the distance to each of these locations, given a current position. However, Voronoi Diagrams precompute the geometric areas that each of these locations is closest to in order to ameliorate the cost of computing distances later on. Problematically, the initial computations required to generate a Voronoi Diagram can be computationally expensive. Naive approaches to generating discretized Voronoi Diagrams require every discretized position to be analyzed with the set of locations. This presentation introduces a new algorithm to compute discretized Voronoi Diagrams using a divide-and-conquer approach. Rather than calculate every position, our approach calculates the positions at the four corners of a quadrant. If the corners belong to the same region, there is no need to subdivide this quadrant anymore; but if they are different than the original quadrant is subdivided into smaller

quadrants. The process is repeated recursively until the entire diagram has been calculated appropriately. After an explanation of this algorithm, there will be a brief discussion of our ongoing work to adapt it to models that use geodesic distance.

Vapor Initiated Crystal Phase Transition of Cesium Halide Perovskites

Wylie, Zachery – Hope

Vapor Initiated Crystal Phase Transition of Cesium Halide Perovskites Zachery R. Wylie, Peter Ruffalo, Dr. Jeffrey A. Christians In recent years, perovskite solar cells have emerged as a promising new alternative to the current silicon-based panels which have dominated the market. Research was done to characterize the black to clear phase transition undergone by thin films of cesium lead halide perovskite when exposed to various solvent vapors. The thin films of a cesium lead halide perovskite were exposed to a constant partial pressure of different solvent vapors, and the kinetics of the transition from the perovskite phase to the non-perovskite δ-phase were tracked by absorption spectroscopy. We find that other solvents, in addition to the previously known water and alcohols (MeOH and EtOH), will catalyze this phase transition. Furthermore, we find that the rate of the phase change appears to be affected but not wholly governed by molecular dipole strength. This foundational work yields deepened understanding of the mechanisms of the clear to black phase transition in halide perovskites. In future, perovskite solar cells could be designed to resist undergoing this phase transition, so that they remain black and photovoltaically active, or they could potentially be designed to exploit this transition in a product such as a dynamically switching photovoltaic window.

Examining Radial Distributions of Multiple Populations in Globular Clusters

Hoogendam, Willem - Calvin

Globular clusters were once the archetype of a simple, homogeneous stellar population. However, in recent decades more observations have revealed the existence of two different stellar populations in globular clusters distinguished by elemental differences. Our research focuses on using photometry to distinguish multiple populations in globular clusters. We investigated 8 globular clusters using publicly available Sloan Digital Sky Survey data and archival Johnson-Cousins UBVRI data. We found a bias in the literature in the field and re-examined their conclusions. We also found that smaller telescopes are capable of distinguishing multiple populations successfully. These results are an important step in understanding the methods used in handling error as well as providing potentially more accurate information on the radial distributions of multiple populations in globular clusters.