Virginia Space Grant Consortium

Student Research Conference – April 9, 2021

Abstracts are grouped by room number and listed in alphabetical order by presenter's last name. View Conference Agenda at, https://vsgc.odu.edu/wp-content/uploads/2021/03/SRC-2021-agenda-final.pdf

Graduate Research Fellows

Room 1:

INVESTIGATION OF LEAN DIRECT INJECTION UNDER THERMOACOUSTIC INSTABILITY

Yogesh Aradhey, Virginia Tech

Lean Direct Injection (LDI) is a combustion scheme proposed by NASA to reduce NOx emissions in aerospace gas turbine engines. LDI is susceptible to thermoacoustic instabilities. It is widely known that droplet diameters have an impact on heat release in a spray combustion system such as LDI. Additionally, it is known that acoustic waves have an impact on spray atomization and break-up. The present study shows that during a thermoacoustic instability, droplet diameters couple with the frequency of instability by taking Phase Doppler Particle Analyzer (PDPA) measurements at several locations in the flow of an atmospheric pressure LDI rig.

REMOTE SENSING OF MARINE PARTICLE PROPERTIES USING SHIPBOARD OCEANOGRAPHIC LIDAR

Brian Collister, Old Dominion University

Oceanographic lidar can provide remote estimates of the vertical distribution of suspended particles in natural waters, potentially revolutionizing our ability to characterize marine ecosystems and properly represent them in models of upper ocean biogeochemistry. However, lidar signals exhibit complex dependencies on water column inherent optical properties (IOPs) and instrument characteristics, which complicate efforts to derive meaningful biogeochemical properties from lidar return signals. In this study, we used a ship-based system to measure the lidar attenuation coefficient (α) and linear depolarization ratio (δ) across a variety of optically and biogeochemically distinct water masses, including turbid coastal waters, clear oligotrophic waters, and calcite rich waters associated with a mesoscale coccolithophore bloom. Sea surface IOPs were measured continuously while underway to characterize the response of α and δ to changes in particle abundance and composition. The magnitude of α was consistent with the diffuse attenuation coefficient (K_d), though the α vs. K_d relationship was nonlinear. δ was positively related to the scattering optical depth and the calcite fraction of backscattering. A statistical fit to these data suggests that the polarized scattering properties of calcified particles are distinct, and contribute to measurable differences in the lidar depolarization ratio. A better understanding of the polarized scattering properties of coccolithophores and other marine particles will further our ability to interpret polarized oceanographic lidar measurements, and may lead to new techniques for measuring the material properties of marine particles remotely.

DOES LISTING STATUS MATTER? QUANTIFICATION OF THREATS FACING THREATENED AND ENDANGERED SPECIES LISTED UNDER THE US ENDANGERED SPECIES ACT

Delaney Costante, William & Mary

With species increasingly becoming imperiled due to anthropogenic activities, conservation practitioners are tasked with determining conservation priorities in order to make the best use of limited resources. One way of setting these priorities is to categorize species based on their risk of extinction. The United States' Endangered Species Act (ESA) has two listing statuses for imperiled species: Threatened or Endangered. For six broad-scale threats, we investigated whether there is a difference in the number and types of threats impacting Threatened and Endangered species at the time of their listing. We found that they were both faced by a similar number of threats at their time of their listing. The only broad-scale threat that impacted Endangered species more than Threatened species was demographic stochasticity. We further examined demographic stochasticity by breaking it down into finer-scale threats. We found four finer-scale demographic stochasticity threats (few individuals in one population, few individuals in multiple populations, lack of reproduction, and genetic loss) to be strong predictors of Endangered status. The similarities in the number and types of broad-scale threats faced by Threatened and Endangered species suggest that changes recently made to the ESA may be detrimental to the recovery efforts of future Threatened species.

ASSESSING INTRAURBAN AIR POLLUTION INEQUALITY USING HIGH-RESOLUTION NITROGEN DIOXIDE DATASETS

Mary Angelique Demetillo, University of Virginia

Redress of air pollution inequality has been limited by the lack of city-wide observations able to resolve steep spatial gradients of trace gas pollutants such as nitrogen dioxide (NO_2). In this paper, I examine the extent of air pollution inequality in 52 major U.S. cities (~130 million residents) using observations from the recently-launched TROPospheric Ozone Monitoring Instrument (TROPOMI) satellite sensor. For each city included in this study, I oversample the first two full years (May 2018 - February 2020) of TROPOMI NO_2 vertical column densities to 0.01° x 0.01° and produce census-tract NO_2 averages and population-weighted NO_2 averages for several sociodemographic groups. I find NO_2 is 36 ± 2% higher for low-income and nonwhite residents (LIN) than for high-income and white residents (HIW) in the largest cities (New York City, NY; Newark, NJ; Los Angeles, CA; Chicago, IL; and Miami, FL) alone.

EXCEPTIONALLY FAST ION DIFFUSION IN BLOCK COPOLYMER-BASED POROUS CARBON FIBERS

John Elliott, Virginia Tech

Confinement of ionic liquids in hydrophilic porous solid media has previously been shown to disrupt the lattice structures of the ionic liquids. An immobile ion layer adheres to the surface of the material, while the inner layer exhibits increased mobility compared to bulk ionic liquids. In this work, porous carbon fibers (PCF) synthesized from a polyacrylonitrile-block-polymethyl methacrylate (PAN-b-PMMA) block copolymer were used to study the effects of confinement on the dynamics of 1-butyl-3-methylimidazolium tetrafluoroborate (BMIM BF4). PCF contain mesoporous networks with unimodal pore diameters ranging from 8 to 30 nm depending on polymer composition. Elastic neutron scattering scans confirmed confinement effects in 13.6 nm diameter pores due to a lack of a freezing transition point between 20 K and 300 K. Quasi-elastic neutron scattering (QENS) was used to determine the diffusion coefficients of the bulk BMIM BF4 and of the BMIM BF4 confined in the pores. A seven-fold increase in diffusion coefficient was obtained from the QENS data for the confined BMIM BF4 compared to the bulk. The tunability of the pore sizes and the hydrophilicity of the PCF offers opportunities for further work exploring the limits of confinement in the unique mesoporous networks of PCF.

MULTI-AXIS PID GAIN TUNER FOR EVTOL HOVER FLIGHT MODE

Imran Khasawneh, Old Dominion University

With the promise of Urban Air Mobility (UAM) becoming more of a reality with major and startup companies alike creating their own designs the academic space also follows suit with their own experimental configurations and designs. This paper proposes and evaluates a safe way for novice pilots to tune their experimental aircraft's flight PID flight controller successfully.

THE INFLUENCE OF NEGATIVE AFFECT REGULATION AND NEUROPHYSIOLOGICAL MARKERS OF COGNITIVE CONTROL ON DISTRESS TOLERANCE

Alicia Kruzelock-Milam, Old Dominion University

As NASA pursues longer-duration crewed missions, an increased understanding of psychological resilience in high-stress environments will become vital to maintaining human performance. The ability to withstand negative emotions has been associated with mental health outcomes and should be considered during the assessment and training of astronaut candidates. Emotion regulation and cognitive control have individually been associated with distress tolerance, but inconsistent measurement and task demands have left the cognitive-affective mechanisms of distress tolerance unclear. This study aims to elucidate the relationship between neurophysiological markers of cognitive control, emotion regulation ability, and distress tolerance. Undergraduate students completed self-report measures of distress tolerance and emotion regulation in addition to a behavioral task assessing cognitive control. The Go-NoGo task was used to elicit a neurophysiological marker of cognitive control known as the anterior N2 through response inhibition. It was hypothesized that N2 would moderate the relationship between emotion regulation and distress tolerance. Findings indicated a significant predictive effect of emotion regulation on distress tolerance and a non-significant small effect for the N2 predicting distress tolerance. Results indicate that

emotion regulation may represent a valuable target for adapted selection, training, and intervention to ensure adequate distress tolerance is identified in crew members.

VARIABILITY IN THE COMPOSITION OF BIOGENIC VOLATILE ORGANIC COMPOUNDS IN A SOUTHEASTERN U.S. FOREST AND THEIR ROLE IN OZONE REACTIVITY

Deborah McGlynn, Virginia Tech

Despite the significant contribution of biogenic volatile organic compounds (BVOCs) to organic aerosol formation and ozone production and loss, there are few long-term year-round measurements of their concentrations, and even fewer sites that are still collecting data. To address this gap, we present 1 year of hourly measurements of chemically resolved BVOCs, collected at a research tower in Central Virginia in a mixed forest representative of ecosystems in the Southeastern U.S. Concentrations of isoprene, isoprene reaction products, monoterpenes and sesquiterpenes will be presented and examined for their impact on ozone reactivity. Concentrations of isoprene range from negligible, in the winter, to typical summertime 24-hour averages of 4-6 ppb, while monoterpenes have more stable concentrations in the range of tenths of a ppb up to ~1 ppb year-round. Sesquiterpenes are typically observed at concentrations of <10 ppt, but this likely represents a lower bound of concentrations. In the growing season, isoprene contributes ~20-40% to for ozone reactivity while sesquiterpenes contribute a negligible amount year-round. Monoterpenes are the most important BVOCs for ozone reactivity throughout the year. To better understand the impact of this compound class on ozone reactivity, the role of individual monoterpenes is examined. Despite the dominant contribution of α-pinene to total monoterpene mass, the average rate constants for reaction of the monoterpene mixture with atmospheric oxidants is between 30% and 270% faster than α-pinene due to the minor contribution of more-reactive compounds. A majority of reactivity comes from α-pinene and limonene (the most significant low-concentration, high-reactivity isomer), highlighting the importance of both concentration and structure in assessing atmospheric impacts of emissions.

MODELING THE THERMAL AND CHEMICAL EVOLUTION OF THE MARTIAN LITHOSPHERE OVER TIME

Fiona McGroarty, Virginia Tech

Mars is a particularly ideal planet to study planetary evolution and development; as its crust has been preserved over its history, rather than recycled through subduction as happens on Earth. In order to attain a more coherent understanding of martian evolution, we focused on the history of the martian lithosphere. We developed a model that calculates the thermal history and melt composition of Mars over time. This model provides insight into the planet's history and enables us to see how the density and seismic properties have evolved over time. We calculated the temperature profile through the lithosphere and then fit an equation to pre-existing data in order to produce a model to predict the composition of a melt produced at a calculated pressure and temperature. From the model, we see a trend of decreasing mafic composition over time. We calculated the density and seismic properties of the lithosphere and found that they decrease over time; this result matches the observations recently made by NASA's InSight mission.

TAILORING THERMAL AND CHEMICAL PROPERTIES OF MULTI-FUNCTIONAL THERMAL/ENVIRONMENTAL BARRIER COATINGS

Mackenzie Ridley, University of Virginia

Environmental barrier coatings (EBCs) are required for protection of SiC ceramic matrix composites (CMCs) used in gas-turbine hot sections. Design of multi-functional thermal/environmental barrier coatings (T/EBCs), based on the current state-of-the-art EBC material ytterbium disilicate ($Yb_2Si_2O_7$), was accomplished through multiple rare earth cations mixed in solution. High-temperature high-velocity steam resistance and phase stabilization of multi-component silicate EBCs was observed. Thermal conductivity was decreased up to 70% through increasing bonding and mass heterogeneity in multi-component $RE_2Si_2O_7$, suggesting multi-component rare earth silicates can be tailored as multi-functional T/EBC materials for next-generation turbine components.

ANALYSIS OF GALVANIC COUPLING IN FASTENER/PLATE CONFIGURATIONS

Rebecca Skelton-Marshall, University of Virginia

In a realistic aerospace structure, dissimilar metals are used for different components to optimize the final mechanical properties of the assembly. In the presence of an electrolyte, such as rain or condensation, current can flow between the dissimilar metals which induces corrosion via the galvanic couple. In this work specifically, galvanic coupling between AA7075, SS316, and Ti-6Al-4V in a complex fastener-in-panel geometry was studied using finite element modeling (FEM). The model was first validated through comparisons of predictions to experimental results both conducted in-house and from literature. Following validation, the model was extended to predict the severity and location of peak damage. A parameter space was explored that included the effects of both environmental and external variations. It was determined that external surface defects (such as a scratch) and thin water layer thicknesses are important parameters in locating where the peak corrosion will occur. The worst-case scenario found in this work represents thin water layers (44.5 μm) and small defects, which concentrate the corrosion damage inside of the fastener hole, the most highly loaded area. Conversely, the best-case scenario tested represents thicker water layers (>800 μm) and large surface defects.

EFFECTS OF PHASE MIXTURES ON LONG TERM STABILITY OF YTTERBIUM-SILICATE ENVIRONMENTAL BARRIER COATINGS

Eric Stone, University of Virginia

Silica-depletion behavior of air plasma spray (APS) fabricated rare-earth (RE) silicate environmental barrier coatings (EBCs) in steam is a valuable research interest for projecting component lifetimes during turbine service. Model phase-mixture samples were created using 5-50 μm ytterbium monosilicate (YbMS) granules dispersed within a ytterbium disilicate (YbDS) matrix for compositions of 10, 20, and 30 volume percent

YbMS/YbDS. A modified horizontal tube furnace, termed a "steam-jet", was used for high-temperature (T=1200, 1300, and 1400 °C) high-velocity ($50 \frac{m}{s} < \upsilon < 150 \frac{m}{s}$) water vapor exposures at total pressure of 1 atmosphere. YbDS reacted with high-velocity steam to form a volatile silicon hydroxide gas species and a porous YbMS reaction product that increased in thickness with both increasing time and temperature. For the times, temperatures, and steam velocities analyzed in this study, YbMS granules did not display steam reactivity. At 1200 °C the average SiO2-depletion reaction depth of all phase-mixtures was similar. For higher test temperatures, average SiO2-depletion reaction depth was decreased through increasing YbMS second-phase additions, suggesting the relative phase concentration of EBCs can be used to tailor thermochemical stability in combustion environments.

Room 2:

ATHENA TOWARDS IMPROVING SEMANTIC CODE SEARCH WITH CAUSAL REASONING AND KNOWLEDGE GRAPHS

Nathan Cooper, William & Mary

One main idea in software engineering is to reuse existing software instead of building due to the high cost. However, finding existing software that accomplishes a specific use case can be difficult. Code search has attempted to help this by allowing keyword searching for code similar to earlier search engines. Recent work has attempted to leverage the semantics present in the query and code. However, these approaches do not consider the context of methods with the rest of the software. This context can be important when performing a search for determining the relevance of a returned result. To address the current problems in code search we designed Athena, a semantic code search engine that leverages software's context through a knowledge graph and a graph neural network. The current implementation of Athena is the first step towards this and it currently supports searching for methods using a query method rather than natural language. For our preliminary evaluation, we have selected three open-source Java projects and had three computer science students evaluate the relevancy of 891 retrieve methods that Athena returned from 99 queries. We found that in ~70% of cases the first method Athena retrieved was relevant to the query method.

ASSESSING THE ABILITY TO DETECT INVASIVE PLANT SPECIES USING DRONE-BASED LEAF-SCALE VISIBLE AND NEAR-INFRARED IMAGING SPECTROSCOPY

Kelsey Huelsman, University of Virginia

Controlling the spread of invasive plant species requires extensive ecosystem monitoring. Drones provide data with high spatial resolution and coverage, making them an increasingly popular means to observe ecosystems, including invasive plant species monitoring. Spectroscopic images were collected during the 2020 growing season at Blandy Experimental Farm in northwestern Virginia using a DJI Matrice 600 drone equipped with an imaging spectrometer. Spectroscopic data, which indicates plant chemical and structural properties, should vary among species, but it is not known whether the very fine spatial resolution of data provided by UAV is beneficial or detrimental to the process of differentiation. This project examines whether spectral signals from individual pixels can be utilized to detect autumn olive and whether spectral variability impedes its detection. Using two different models from spectroscopic data collected in April and June, intra-individual and intra-specific variability of autumn olive do not impede the ability to differentiate autumn olive, and individuals can be best detected using complex models in either June or April, with the most accuracy in June. Using a simpler model for detection in June also yielded accurate results and demonstrates potential for broader, open access applications.

THE INFLUENCE OF OXYGEN ON THE HER CATALYTIC ACTIVITY OF ELECTRODEPOSITED MOO_XS_Y ELECTROCATALYSTS AND PROGRESS OF 3D CARBON TUBE SUPPORTED MOO_XS_Y CATALYSTS TO ENABLE LONG-TERM HUMAN ACTIVITY ON MARS

Lee Kendall, University of Virginia

Amorphous, polymeric molybdenum sulfide has attracted significant attention as non-platinum group electrocatalysts for the hydrogen evolution reaction (HER). To elucidate the influence of oxygen incorporation on molybdenum sulfide catalysts, MoOxSy electrocatalysts were synthesized via a potentiostatic electrodeposition method. The presence of oxygen and the associated molybdenum oxidation state were modified by post-synthesis treatments of air exposure, annealing in inert atmosphere, and annealing in a sulfur flux. The as-deposited sample exhibited the best performance, requiring only 171 mV to reach a cathodic current density of 10 mA/cm2. While the modified films exhibited worse HER performance compared to the as deposited sample, by utilizing extensive X-ray photoelectron spectroscopy studies, the importance of the Mo5+ oxidation state was highlighted while identifying a previously unreported transition state between Mo4+ and Mo5+, deemed Mo*. Additionally, to further increase the performance of the films, a 3D conductive substrate of carbon paper (CP)/carbon tubes (CT) was synthesized. While the CP/CT substrate has not been successfully synthesized, early results show that the attempts have increased the overall performance, lending credence to the approach that has the potential to rival state-of-the-art water splitting catalysts.

SOLAR INDUCED CHLOROPHYLL FLUORESCENCE: A NOVEL APPROACH TO QUANTIFY PHOTOSYNTHESIS I WETLAND ECOSYSTEMS

Hannah Mast, University of Virginia

Despite their small areal extent, salt marshes serve as a large carbon sink, sequestering carbon through efficient photosynthesis and carbon burial. Quantifying gross primary production (GPP) in an intertidal marsh is complicated by tidal cycles because few methods can measure photosynthesis in all stages of tidal inundation or at large spatial scales. Remote sensing of solar-induced chlorophyll fluorescence (SIF) is a promising approach to address these challenges. SIF is emitted by photosynthetic molecular machinery and has been shown to directly correlated with GPP in multiple ecosystem types. Here, I describe concurrent measurements of SIF using an automated

spectrometer system and eddy covariance (EC) measurements for the 2020 growing season in a salt marsh on the Virginia Eastern Shore. I identify diurnal, tidal, and seasonal patterns in SIF and examine how these patterns are modulated by environmental factors. Our preliminary results have shown a clear diurnal pattern of SIF at 760 nm peaking at midday with maximum intensities reaching 1.5 mW m^{-2} sr^{-1} nm^{-1}. I also investigate relationships between SIF and EC-derived GPP during different stages of inundation in order to improve estimates of GPP at high tides when EC may not yield reliable results.

AUTONOMOUS TASK SEQUENCING AND ASSIGNMENT FOR IN-SPACE MULTI-ROBOT ASSEMBLY

Joshua Moser, Virginia Tech

As endeavors into space exploration and related scientific experimentation expand, the use of autonomous robotic systems to construct and maintain infrastructure will be necessary. To accomplish autonomous assembly in a realistic, stochastic environment, it is necessary to have the ability to reschedule robots and tasks to deal with a changing environment. To this end, the work presented here developed a novel stochastic problem definition that is capable of articulating the different elements present in the autonomous assembly problems through the use of different graph structures and a Markov decision process formulation. While this formulation can be utilized by many different schedule generation methods, a reinforcement learning schedule generation method is explored in this work. It was found that the complexities present in a realistic assembly problem prove to be a challenge for a single policy reinforcement learning formulation which leads to a future work recommendation of pursuing a multi-policy reinforcement learning approach to handle the complexities present in a realistic assembly problem.

INVESTIGATING SPACE BRAIN: HOW DO BRAIN CELLS RESPOND TO THE EFFECTS OF INCREASED INTRACRANIAL PRESSURE?

Carly Norris, Virginia Tech

Recent research suggests that astronauts experience neurological deficits while in space and upon their return. Such changes include neuroinflammation and oxidative stress, which can lead to cognitive decline if not treated. However, the sample sizes for these findings are low and the cause of such damage could be due to a number of factors during flight, including extended effects of microgravity and radiation or exposure to large magnitude accelerations. Strategies need to be implemented to determine the extent of neurological damage and address these deficits with appropriate therapeutic approaches. In this work we outline methods and guidelines for determining injury severity following exposure to impulses of varying magnitude using a preclinical model. We then optimized the quantification of amino acids within the brain using high performance liquid chromatography as an acute measure that can be correlated to intracranial impulse. Lastly, we compare the neurochemical changes at 24 hr following the impulse event. Future work will develop time-course profiles of amino acids for defined injury severities to optimize therapeutic targets so that the neurological safety of our astronauts can be addressed.

CRYPTIC MICROBES IN ANTARCTICA: DETERMINING THE LIMITS OF BIOTIC DETECTION VIA SATELLITE IMAGERY

Sarah Power, Virginia Tech

Autotropic microbial communities are the dominant primary producers in the McMurdo Dry Valleys (MDV) of Antarctica and are therefore the drivers of carbon cycling in this ecosystem. While dense microbial mats occupy aquatic areas in the Taylor Valley, the majority of the landscape is terrestrial where biological surface crusts (i.e., biocrusts) occur at much lower densities. Given the broad spatial extent of the terrestrial landscape compared to stream areas, we anticipate most carbon is contained on the soils. While previous research has shown that satellite imagery can be used to detect areas of dense microbial mat and estimate biomass, there are currently no remote sensing methods for systematically estimating biocrust biomass in the dry soils of the MDV. Considering that soils may contain the largest pool of carbon in this region, it is necessary to develop a method that allows for the monitoring of current terrestrial carbon stocks and for predicting future ones. We found that certain geologic minerals drive relatively high NDVI values, creating a false indication of biological activity. While NDVI is proven in detecting dense microbial mat communities, it is now evident that stronger spectral techniques are required to detect low density biocrust communities in this region.

MODELING AND SIMULATION OF ELECTROMAGNETIC FIELDS TO MAINTAIN BONE DENSITY DURING PROLONGED LOW GRAVITY EXPOSURE

Austin Tapp, Old Dominion University

Astronauts in long-term, low-gravity environments experience bone density loss at 10 times the rate of those diagnosed with osteoporosis. One treatment effective at maintaining bone density in osteoporotic individuals is electromagnetic field (EMF) therapy. Tools that induce EMFs are becoming increasingly prevalent, but to amplify osteogenesis and encourage superior bone density retention for astronauts, ideal EMF therapy parameters must be determined on patient-specific bases. Therefore, this study explores simulation environments that elucidate highly favorable EMF factors. Pulsed electromagnetic field and combined magnetic field generating devices are variably introduced near patient-specific, finite element (FE) models of the femur, spine, and mandible. The FEs of each model are characterized with tissue conductivity values. Magnetic field strengths obtained along key anatomical regions of the FE models are compared against in vivo experimental data to predict features that reflect greater therapeutic impacts. The presented method establishes an adaptable framework for further simulations, which may be modified to test new or existing devices on future patient-specific cases. Using a simulation framework that ratifies parameters for EMF-based bone density retention provides essential insights into combating osteoporosis and negating the similar effects imposed on astronauts enduring prolonged space travel.

EVALUATING THE USE OF ACOUSTIC WARNING SIGNALS TO REDUCE AVIAN COLLISION RISK

Robin Thady, William & Mary

Bird populations have declined sharply in recent years. Collisions with humanmade structures are responsible for a significant portion of this avian mortality, threatening potential ecological consequences and financial burdens to a variety of industries. Acoustic warning signals can be used to alert birds to obstacles in their flight paths in order to mitigate collisions, but these signals should be tailored to the sensory ecology of birds in flight. I evaluated the ability of four different sound signals to elicit collision-avoidant flight behavior from birds released into a corridor containing a physical obstacle. I selected these signals to test multiple frequency levels (4-6 kHz and 6-8 kHz) and temporal modulation patterns (broadband and oscillating) to determine which combination of sound attributes is the most detectable to a bird in flight. I found that sound treatments in general cause birds to maintain a greater distance from potential hazards and to adjust their flight trajectories before coming close to obstacles, with statistically non-significant trends in the data suggesting that the 4-6 kHz oscillating signal does this most effectively. These findings can be used to refine acoustic warning signals and to demonstrate the value in using behavioral data to assess collision risk.

A HIGH-RESOLUTION SPATIOTEMPORAL INVESTIGATION OF CHESAPEAKE BAY WATER CLARITY WITH IMPLICATIONS FOR SEDIMENT TRANSPORT AND PRIMARY PRODUCTION

Jessica Turner, William & Mary

While ecosystem health is improving in many estuaries worldwide following nutrient reductions, ambiguous trends in water clarity often remain. The Chesapeake Bay, a highly populated eutrophic estuary, is a crucial testbed for this issue. Efforts are needed to understand why downstream estuarine water clarity appears uncorrelated with watershed management actions, and these efforts require multiple metrics of clarity. To complement in situ measurements, satellite remote sensing provides an additional measurement platform to assess change over time. In this study, MODIS-Aqua remote sensing reflectance (Rrs) was evaluated from 2003-2020 at multiple wavelengths and spatial resolutions for surface waters of the Chesapeake Bay. Trends show an overall long-term darkening (decreased Rrs) in the upper estuary for all wavelengths yet brightening (increased Rrs) in the lower estuary for green wavelengths. Trends in band ratios show long-term decreasing red-to-green and red-to-blue ratios yet long-term increasing green-to-blue ratios. These trends are generally consistent with a long-term reduction in total suspended solids concentration without as clear a reduction in Chl-a. However, the spatial patterns in long-term trends for single bands (i.e., 645 nm) differ widely from the spatial patterns in trends in band ratios (i.e., 667/488), highlighting the importance of careful algorithm selection for long-term analysis of water clarity trends.

CHARACTERIZING COMPLICATED NEAR-SURFACE GEOLOGIC PROFILES USING NOVEL IN-SITU TESTING AND DATA PROCESSING TECHNIQUES

Kaleigh Yost, Virginia Tech

There are several shortcomings associated with current characterization methods of near-surface (shallow, tens of meters in depth) geologic profiles. Cone penetration testing (CPT) is relied on as an indicator of soil stiffness/strength, but data smearing at boundaries between layers in “complicated” soil profiles obscures the relationship between measured CPT indices and the true properties of the soil at a given depth. Furthermore, CPTs do not collect soil samples. Other methods that do collect soil samples are primitive, e.g., the standard split-spoon sampler (a cylindrical steel tube with an outer diameter of 2 inches) driven into the ground with a hammer at (typically) 5-foot intervals. This type of sampling not only destroys the soil’s fabric, which has a significant influence on the engineering behavior, due to disturbance caused by the small sampler size, but is representative of the soil only at a discrete point, leaving the interpretation of much of the geologic profile up to the engineer. Accurately characterizing the engineering properties of subsurface profiles is essential for effective predictions of soil behavior for applications including pavement, foundation, and earthquake engineering. This paper discusses a new method of in-situ testing and data interpretation to address several of these subsurface characterization limitations.

INVESTIGATION OF METAL ION MOBILITY UNDER EXPOSURE TO DEACTIVATING AGENTS

Ryan Zelinsky, University of Virginia

Interest in metal loaded zeolites as hydrocarbon adsorbents has increased significantly over the last few years. These catalysts however suffer from deactivation due to various processes such as sintering, poisoning, and active site transformation. In this work, a Pd/BEA sorbent was tested under various feed conditions to probe its efficacy in adsorbing hydrocarbon fuels while exposed to deactivating agents, with the model hydrocarbon being ethylene. Deactivation under these feed conditions was observed and further studied using diffuse reflectance infrared Fourier-transform spectroscopy (DRIFTS). Ethylene uptake was partially inhibited by CO and H_2O when fed separately. When both were added, the loss in ethylene uptake was 90% relative to the condition with no H_2O or CO. DRIFTS characterization shows that some form of oxidized Pd was reducible to Pd^0 by CO at 80 °C only in the presence of H_2O. Further, this reduction appears reversible by high temperature oxygen treatment. We speculate that this reduction of ionic Pd is what results in the significant loss in ethylene adsorption capacity.

Room 3:

DEVELOPING A FRAMEWORK FOR MODELING TRANSMISSION THROUGH INHOMOGENOUS GERMANIUM ANTIMONY TELLURIDE (GST) THIN FILMS

Benjamin Belfore, Old Dominion University

Infrared Spectral Imaging is a powerful tool for both atmospheric sciences and astronomy. When trying to determine the composition of Earth’s atmosphere or other planets, a significant amount of information can be gleaned by observing the mid-wave infrared (MWIR) spectrum. While there are various ways to observe this range of the spectrum, there has recently been a push to implement filters in this region that are more precisely tunable to decrease the Size, Weight, and Power (SWAP) burden for satellites. One material that has shown promise is Germanium Antimony Telluride or GST. By annealing the GST at different temperatures, its crystalline structure and optical properties both change. By exploiting this phenomena, it is possible to create a narrowband filter in the MWIR spectrum. Since the properties are changed, typically through heating via laser pulses, it is possible that localized inhomogeneities could remain post annealing. Using phase field simulations for recrystallization and both ray tracing and transfer matrix method, the impact of these potential inhomogeneities are explored.

MAPPING THE SPREAD OF THE PATHOGEN RICKETTSIA PARKERI THROUGH LANDSCAPE GENETIC ANALYSIS OF THE PRIMARY VECTOR AMBLYOMMA MACULATUM

Sara Benham, Old Dominion University

The Gulf Coast tick, Amblyomma maculatum, has expanded into the mid-Atlantic region in recent decades from its historic range along the United States Gulf Coast region. The Gulf Coast tick is a vector of the human pathogen Rickettsia parkeri, the causative agent of R. parkeri rickettsiosis. Gulf Coast tick populations are associated with open habitat types and areas with recent disturbance. Habitat connectivity likely contributes to movement of ticks on hosts, and the establishment of new populations in the region. From 2017-2020, we collected 980 adult Gulf Coast ticks from Virginia and North Carolina. Here we investigate the relationship between tick populations and remotely-sensed environmental variables that can be used to determine habitat suitability and, in turn, habitat connectivity that may permit the further spread of this tick vector. Variables that have significant correlations with Gulf Coast tick populations include National Land Cover Database land cover classes, the normalized difference vegetation index, climate seasonality and the minimum temperature of the coldest month. This work will contribute to development of a habitat suitability map that will enable us to explore the relationship between habitat connectivity and population genetics, and thus to identify hypothetical corridors and barriers to further range expansion.

QUASAR OUTFLOW ANALYSIS: EXTREME ULTRAVIOLET OBSERVATIONS AND BEYOND

Doyee Byun, Virginia Tech

We analyze the spectrum of quasar QSO J1509+2432 to find the physical conditions of its outflow. The analysis is based on the data from the Very Large Telescope/Ultraviolet and Visual Echelle Spectrograph, with an observed wavelength range of 3000 to 9500 Å. The outflow system of interest travels at ~1700 $\mathrm{km\,s^{-1}}$ away from the central source. We have detected absorption troughs of ions Si II and O I, and measured their column densities. In our attempt to find the electron number density of the outflow system from the ratio between the excited and ground state column densities of Si II and O I, we have found that they would each give different results of $\log(n_e) \approx 3$ for Si II, and $\log(n_e) \approx 7.5$ for O I, without a clear method to resolve this contradiction.

NOVEL JOSEPHSON JUNCTIONS FOR CRYOGENIC MEMORY AND FAULT-TOLERANT QUANTUM COMPUTATION

Joseph Cuozzo, William & Mary

Recent advances in fabrication techniques allow the realization of novel Josephson junctions (JJ) with exotic properties that have the potential to enhance the strength and efficiency of high-performance computing resources vital to NASA's mission and advance quantum communication efforts by NASA. Among the many applications of JJ's, Josephson magnetic random-access memory (JMRAM) is an energy-efficient, fast, and memory-dense option for cryogenic memory in classical and quantum computers. JMRAM proposals currently rely on carefully built multilayer JJ's that would be difficult to scale. Here we propose an alternative design to generate spin-polarized supercurrent by implementing a spin-triplet superconductor into the JMRAM design. We also consider JJ's that are predicted to host topological superconductivity which can be used in topological quantum computing schemes. A signature of non-trivial topology is missing odd Shapiro steps. We provide theoretical support for the first strong report of missing Shapiro steps in a topologically trivial JJ. We ascribe our observations to the high transparency of our junctions allowing Landau-Zener transitions. We analyze our results using a bi-modal transparency distribution which demonstrates that only few modes carrying 4π periodic current are sufficient to describe the disappearance of odd steps.

UNDERSTANDING THE ROLE OF MK-STYX IN STRESS RESPONSE PATHWAYS USING COMPUTATIONAL MODELING OF ITS CRYSTAL STRUCTURE

Emma Marie Hepworth, William & Mary

The pseudophosphatase MK-STYX [MAPK (mitogen-activated protein kinase) - phosphoserine/threonine/tyrosine-binding protein] is an atypical noncatalytically active MKP (MAPK phosphatase). The DUSP (dual-specificity phosphatase) domain of MK-STYX lacks critical histidine and cysteine residues in the active site motif (HCX5R), rendering it inactive. MK-STYX also contains a CH2 domain (cell division cycle 25 phosphatase homology 2 domain) interrupted by a KIM (kinase interacting motif). Unlike the KIM of its MKP active homologs, MK-STYX lacks the consecutive arginines necessary to bind MKP target proteins. Despite this, MK-STYX has been shown to be a regulator of multiple pathways such as stress response, apoptosis, and neurite formation, and has been implicated in various cancers. Uncovering the macromolecular structure of MK-STYX is the key to understanding the atypical domains of MK-STYX, the mechanisms they use to carry out their role in signaling pathways and induce particular phenotypes, and how this differs from the other MKPs. Determining the structure of MK-STYX requires a combined approach of protein crystallography and bioinformatics. An investigation using computational approaches revealed that the lack of consecutive arginines in the KIM of MK-STYX results in a different predicted binding pocket compared to that of active homologs, supporting the idea that MK-STYX has a unique function.

EFFECTS OF MANUFACTURING VARIABILITY ON FAILURE CHARACTERISTICS IN AUTOMATED FIBER PLACEMENT COMPOSITES FOR SPACE APPLICATIONS

Von Clyde Jamora, Old Dominion University

The pseudophosphatase MK-STYX [MAPK (mitogen-activated protein kinase) - phosphoserine/threonine/tyrosine-binding protein] is an atypical noncatalytically active MKP (MAPK phosphatase). The DUSP (dual-specificity phosphatase) domain of MK-STYX lacks critical histidine and cysteine residues in the active site motif (HCX_5R), rendering it inactive. MK-STYX also contains a CH2 domain (cell division cycle 25 phosphatase homology 2 domain) interrupted by a KIM (kinase interacting motif). Unlike the KIM of its MKP active homologs, MK-STYX lacks the consecutive arginines necessary to bind MKP target proteins. Despite this, MK-STYX has been shown to be a regulator of multiple pathways such as stress response, apoptosis, and neurite formation, and has been implicated in various cancers. Uncovering the macromolecular structure of MK-STYX is the key to understanding the atypical domains of MK-STYX, the mechanisms they use to carry out their role in signaling pathways and induce particular phenotypes, and how this differs from the other MKPs. Determining the structure of MK-STYX requires a combined approach of protein crystallography and bioinformatics. An investigation using computational approaches revealed that the lack of consecutive arginines in the KIM of MK-STYX results in a different predicted binding pocket compared to that of active homologs, supporting the idea that MK-STYX has a unique function.

USING SPATIAL DATA TO PROTECT NONBREEDING FROG AND TOAD HABITAT

Matthew Kane, William & Mary

Frog and toad species are currently on a global decline (Stuart et al. 2004). This decline is due in part to habitat loss caused by human development compounded by their complex annual habitat requirements which includes the use of wetland during the breeding season and upland habitat during the nonbreeding season. (Collins 2010). Current frog and toad management in the United States often solely focus on the breeding habitat and do not include management of upland habitat (Harper et al. 2008). In order to fill this knowledge gap, I am using a year-long line-transect survey of the area surrounding frog and toad breeding habitats in southeastern Virginia. We are still in the process of collecting data, but so far we have found variation among species in their use of upland habitat. Some species may stay near their breeding area while others are more likely to be found 50 m to > 100 m from their breeding habitat. We have also seen a clustering of frog and toad detections around water features away from the breeding area. My research shows that current management of forests surrounding frog and toad breeding areas should be expanded.

DEDUCING NON-MIGRATING DIURNAL TIDES IN THE EARTH'S THERMOSPHERE USING SATELLITE DATA FROM THE NASA GLOBAL-SCALE OBSERVATIONS OF THE LIMB AND DISK (GOLD) MISSION

Christopher Krier, Virginia Tech

One pathway to troposphere-thermosphere coupling is the upward propagation of non-migrating tides (planetary-scale atmospheric waves whose generation mechanisms include solar absorption by the atmosphere, large-scale tropical convection, and wave-wave interaction). At present, there is a gap of observational constraints on these tides in middle thermosphere temperature and their impact on thermosphere composition is not well understood. In geostationary orbit above the mouth of the Amazon River, the Global-scale Observations of the Limb and Disk (GOLD) mission flies a two-channel far ultraviolet spectrometer that provides valuable daytime images of neutral temperature and the column density ratio of atomic oxygen to molecular nitrogen (O/N_2). Here, we summarize advances made in accomplishing our objective to deduce the dominant non-migrating diurnal tides from the combined temperature-O/N_2 dataset from GOLD. We present results and their associated uncertainties from application to GOLD data for two different seasons. A lesson we have learned is that solar zenith angle effects and ionospheric conta mination are important considerations when deriving tides from far ultraviolet column emissions. We show that our approach is a powerful tool for probing the variability of non-migrating tides in a region of near-Earth space where they are poorly characterized.

UNTANGLING MAGNETIC COMPLEXITY IN PROTOPLANETARY DISKS WITH THE ZEEMAN EFFECT

Renato Mazzei, University of Virginia

With the recent advent of circular polarization capabilities at the Atacama Large Millimeter/submillimeter Array (ALMA), Zeeman effect measurements of spectral lines are now possible as a means to directly probe line-of-sight magnetic fields in protoplanetary disks (PPDs). We present a modeling study that aims to guide physical interpretation of these anticipated observations. Using a fiducial density structure based on a typical ringed disk, we simulate line emission for the hyperfine components of the CN J = 1−0 transition with the POLARIS radiative transfer code. Since the expected magnetic field and typical CN distribution in PPDs remain largely unconstrained, we produce models with several different configurations. Corresponding integrated Stokes *I* and *V* profiles and 0.4 km/s resolution, 1″ beam convolved channel maps are presented. We demonstrate that the emission signatures from toroidally dominated magnetic fields are distinguishable from vertically dominated magnetic field based on channel map morphology. Due to line-of-sight and beam cancellation effects, disks with toroidal B-field configurations result in significantly diminished Stokes *V* emission. Complex magnetic fields therefore render the traditionally used method for inferring line-of-sight magnetic field strengths (i.e., fitting the derivative of the Stokes *I* to the Stokes *V* profile) ambiguous, since a given intrinsic field strength can yield a variety of Stokes *V* amplitudes depending on the magnetic field geometry. In addition, gas gaps can create structure in the integrated Stokes *V* profile that might mimic magnetic substructure. This method should therefore be applied with caution in PPD environments and can only confidently be used as a measure of magnetic field strength if the disk's magnetic field configuration is well understood.

ULTRA-FAINT DWARF GALAXIES: SHEDDING LIGHT ON DARK MATTER

Hannah Richstein, University of Virginia

Ultra-faint dwarf (UFD) galaxies are among the oldest, least chemically-enriched, most dark matter dominated stellar populations discovered to date. Using deep *Hubble Space Telescope* ACS/WFC observations, we perform aperture photometry to generate source catalogs. To characterize the UFDs in terms of age and metallicity, we use distance-minimalization to fit Victoria-Regina isochrones. Specifically, we look at the co-added populations of 27 UFDs, as well as the separate co-added populations of two groups of UFDs, five that are considered long-term Milky Way (MW) satellites and three associated with the Large Magellanic Cloud (LMC). The ``characteristic'' UFD is best fit by an isochrone with age 13.6 Gyr and [Fe/H]=-2.0. The long-term MW satellites are fit by a 13.2 Gyr, [Fe/H]=-1.8 isochrone, while the LMC-associated UFDs are fit with an 11.5 Gyr, [Fe/H]=-1.2 isochrone. These results offer tantalizing evidence for how the environment around UFDs may have affected their star-formation histories.

PREDICTING SEDIMENT TRANSPORT IN HAMPTON ROADS WITH RISING SEAS: QUANTIFYING SHORELINE CHANGE USING SATELLITE IMAGERY

Lauren Sommers, Old Dominion University

Sea level rise is expected to increase flooding and shoreline erosion along the global coasts. Few studies have looked at the role of sea level rise on local hydrodynamic and morphodynamic interactions, which is the purpose of this study. To quantify shoreline erosion and sediment transport in response to sea level rise, we used a computational model Delft3D that solves hydrodynamics of waves and currents as well as sediment transport. We applied the model to the southeast region of Virginia known as Hampton Roads, specifically the cities of Norfolk and Virginia Beach. These two cities have interconnected sandy beaches that experience variable erosion rates and undergo periodic beach nourishments. We used the model to study sediment transport and shoreline erosion in response to short-term processes such as hurricanes considering the impact of sea level rise. The model will be calibrated and validated with existing surveys and satellite data. This gives us an improved predictive modeling framework for short-term and long-term processes in southeastern coastal Virginia which can be generalized to other geographic regions.

X-RAY FLARE DRIVEN CHEMISTRY IN PLANET FORMTING REGIONS

Abygail Waggoner, University of Virginia

Planet formation begins when a molecular dust cloud collapses in on itself to form a young, central star surrounded by a disk of dust and gas known as a protoplanetary disk. T-Tauri stars, or young sun-like stars, are X-ray bright, where the emitted X-ray photons drive chemical evolution in the disk via ionization of H2. Typically X-ray emission, and therefore disk ionization levels, is considered constant on time scales less then thousands of years. However, T-Tauri stars are known to be X-ray variable on short times scales (days to weeks) via X-ray flaring events. We model the chemical responses to flares over the course of 500 years. We find that flares have both a cumulative impact on disk chemistry, resulting in a new pseudo steady state, and a short-term impact, resulting in stochastic abundances on observationally relevant time scales (days to weeks).