GCC 2023

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Abstracts Booklet

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ORAL PRESENTATION ABSTRACTS

Oral Session 1
Morning (8:30am), Friday, November 3, 2023

Paleo-Perspectives on Climate Variability

It's getting cold in here: Evaluating the evolution of the stratosphere in the Last Glacial Maximum to modern climate with long-lived stratospheric tracers

Ariana Castillo (she/her/ella), Harvard University

The atmosphere in the last glacial maximum (LGM) had lower CO2, CH4, and N2O concentrations that coincide with lower atmospheric temperatures. In recent decades, relationships of long-lived tracers in the stratosphere have been used to understand the stratospheric circulation, known as the Brewer Dobson Circulation (BDC). While modeling studies have confirmed a decrease in BDC strength in the LGM, this has not been confirmed with tracer-interrelationships. Despite few direct observations of atmospheric concentrations in the LGM, models can simulate LGM conditions under specific climate parameters. Tracer-interrelationships of N2O and CH4 from the LGM and recent climate (2000-2014) were analyzed using output from Whole Atmosphere Community Climate Model (WACCM) and compared to scale. During the LGM, shifts in relationships between the LGM and modern climate suggest a change in mixing and wave-breaking at specific latitudes. Therefore, results imply a shift in circulation in the LGM consistent with results in previous studies. The framework of understanding past climates could be applied to future model projections, particularly in a warming climate.

Marine Sediment Records of Intense Bering Sea Storms from Unalaska, AK

Kelly McKeon (she/her), Woods Hole Oceanographic Institution

Alaskan coastal populations and industries are becoming increasingly vulnerable to storm induced hazards including flooding, erosion, and infrastructure damage from high winds and waves. To put current storm risk into long-term climatic perspective, we utilize a series of sediment cores from a semi-enclosed fjord on Unalaska Island to extend the physical record of storms and other extreme events ~1000 years into the past. We use a combination of computed tomography (CT) and downcore profiles of grain size to stratigraphically correlate coarse-grained overwash deposits across the basin. Sedimentation rates close to 1cm/year over the last millennium coupled with the robust spatial coverage of the cores show variability in the geographic distribution of deposits that allows rigorous attribution of event beds to Bering Sea storms. Here, we identify 22 storm deposits and one potential tsunami deposit over the past millennium. Results suggest a recent decrease in storm activity at Skan Bay, Unalaska over the past 500 years which we attribute to a strengthening of the Aleutian Low pressure system. This finding is consistent with other regional reconstructions of the Aleutian Low and with observed changes in typhoon frequency from farther afield sites in the lower-latitude western Pacific.

Low Latitude Insolation Forcing of the Eastern Equatorial Pacific in the Late Pleistocene Inferred from Thermocline Reconstructions

Celeste Pallone (she/her), Columbia University

The Eastern Equatorial Pacific (EEP) is the location of dynamic ocean-atmosphere interactions, which result in seasonal and interannual variations in local and global climate today. Paleo-records from marine sediments have proven useful for constraining both the mean state and the variability in this region across centennial to glacial-interglacial timescales. One notable hypothesis is that variations in low latitude insolation influence the equatorial Pacific, driving the region toward a more El Niño or La Niña-like mean state across precession (21 ka) cycles. Here, I will present a paleo-record of EEP thermocline depth from Ocean Drilling Program Site 1240 (2921 m; 0.02°N, 86.46°W) over the last 160,000 years, which is derived from measurements of the oxygen isotope composition of multiple species of planktic foraminifera that lived at different and known depths in the water column. The EEP thermocline deepens during El Niño events and shallows during La Niña events today and is a useful indicator of the mean state in the past. Our results are consistent with precession-scale variability in the depth of the EEP thermocline across the last two glacial cycles, which was likely independent of changes in climate in the high latitudes. We also validate a relatively simple thermocline depth proxy, the difference between the oxygen isotope ratios in shells of the thermocline-dwelling N. dutertrei and surface-dwelling G. ruber, which may be widely applicable across the tropical ocean.

<u>Ocean Biogeochemistry</u>

Models project increased temperature and nitrate, with decreased oxygen for the California Current System by the year 2100

Josephine Dianne Deauna (she/her/hers), University of Hawai'i at Manoa

The California Current System (CCS) is one of the most productive upwelling regions in the world, supporting a variety of fisheries along the Northwest Pacific coast. Changes in ocean density, oxygen, and nitrate content within the region have been evident throughout recent decades, where increased delivery of low-oxygen waters from the equatorial Pacific have resulted in massive fish die-offs and reduced catch in the southern CCS. Similarly, intrusions of cold, relatively fresh water with low-oxygen and high-nitrate levels from the northern Pacific have resulted in low-oxygen conditions in the northern CCS. An important question is whether these observed changes will continue into the future. To make this determination we analyzed projections from Earth System Models (ESMs) after validating them against historical observations. We analyzed temperature, oxygen, and nitrate from 7 ESMs to evaluate the representation of water masses entering the CCS and their variability compared to observations. Results showed that ESMs captured realistic seasonal variability at the surface layers, while low

frequency temporal variability dominated at the deeper layers with a considerable range of values. Projections for the end of the century mean (2071-2100) for low-, mid- and high-greenhouse gas emission scenarios showed an increase in temperature and nitrate, and a decrease in oxygen compared to the historical mean (1985-2014), with the highest magnitude of change for high-emission scenarios. Historically, decreases in ocean oxygen and an increase in temperature have had deleterious effects on fisheries and wildlife, while the effects of increased nitrate tend to vary across species.

Oral Session 2
Morning (9:30am), Friday, November 3, 2023

Cryosphere and Polar Climate

Glaciers in the Sierra Nevada, California are likely unprecedentedly small in the Holocene
Andrew Jones (he/him), University of Wisconsin-Madison
Glaciers in the Sierra Nevada, California, USA are thought to have disappeared in the early to mid-Holocene (~10,000–3,000 years ago) during peak Holocene summer warmth before subsequently reforming and advancing during late Holocene 'Neoglacial' cooling. The degree to which modern retreat is anomalous in the Holocene frames our understanding of climate change in California this century, with water resource implications for wildfires, biodiversity loss, and human consumption. In a multi-proxy analysis including bedrock cosmogenic exposure ages, moraine exposure ages, and lake sediment records, we find evidence that Sierra Nevada glaciers persisted through the Holocene and are only now disappearing. At three glaciers in or bordering Yosemite National Park, in situ 14C and 10Be concentrations (n = 15) in bedrock abutting the terminus of modern ice are largely near AMS system-blank levels, suggesting glaciers were larger than their modern size for the past 10,000 years until present. Moraine 10Be ages (n = 54) and two new distal-lake sediment records suggest an increase in glacier activity in the late Holocene without precluding glacier existence in the early-to-mid-Holocene. Our findings are incompatible with full deglaciation of the Sierra Nevada in the Holocene and imply that the expected disappearance of Sierra Nevada glaciers this century will be a departure from the Holocene interglacial.

Addressing Sparse Observations in Glacier-Melt Models: Insights and Challenges from Physics-Based Approaches
Christina Draeger (she/her), University of British Columbia
The substantial retreat of mountain glaciers in recent decades stands as one of the most prominent indicators of climate change. State-of-the-art glacier models at regional and global scales mostly rely on empirical models, requiring glacier-specific calibration through in-situ mass balance measurements. In the absence of these measurements, the models suffer from large

uncertainties in their projections of glacier mass changes, especially at local scales. One approach to mitigate these challenges is to transition from empirical models to more physics-based models, such as surface energy balance (SEB) models of glacier melt. However, SEB models are notably more complex, relying on a multitude of climatic input variables. In Southwestern Canada, the presence of seasonal mass balance observations is limited to only 17 glaciers, creating a considerable challenge for model calibration. In this study, we assess the performance of a glacier evolution model based on a SEB model, with either no or minimal calibration, for roughly 19,000 glaciers in Southwestern Canada from 1979 to 2022. Specifically, we employ a neural network to predict glacier-specific albedo time series using intermittent remote sensing data. We then evaluate the regional mass balance and area change simulations against observations from satellite imagery. This research contributes to a better understanding of the feasibility of employing physics-based glacier melt models with minimal or no calibration in regional glaciation modeling. Its goal is to mitigate uncertainties in glacier melt projections while also highlighting the profound recent glacier retreat attributable to anthropogenic climate change.

Ocean Circulation and Dynamics

Evidence for anthropogenic aerosols-driven decadal Pacific variability and its influence on the winter-spring precipitation decline over the U.S. Southwest

Yan-Ning Kuo, Cornell University

The winter-spring precipitation over the Southwestern United States (SWUS) has decreased since 1980. This winter-spring precipitation decline has been attributed to the teleconnections from internal decadal Sea Surface Temperature (SST) variability - a phase change of Pacific Decadal Variability (PDV) toward a cooling tropical Pacific (negative PDV). However, recent studies show evidence that anthropogenic aerosols can also induce a negative PDV after 1980. Therefore, the attribution to internal variability for the SWUS multi-decadal drier condition needs to be revisited, with reconsidering the role of anthropogenic aerosols. In this study, we use observations and a climate model large ensemble (by Community Earth System Model version 2, CESM2) with all-forcing (CESM2-LE) and single forcing (CESM2-SFLE) experiments. In one CESM2-SFLE ensemble anthropogenic aerosols forcing held fixed and in another only anthropogenic aerosols evolving, we isolate effects from anthropogenic aerosols with these simulations. We show that there is a higher probability of a negative PDV after 1980 with anthropogenic aerosols, inducing a North Pacific circulation change and the SWUS winter-spring precipitation decline. Notably, this anthropogenic aerosols-forced PDV is associated with the aerosol emission shift from North America and Europe to Asia. Our results highlight the role of anthropogenic aerosols on the recent SWUS drying and imply a potential uncertainty in climate projections from the emission trajectory of aerosols. These findings emphasize the impact of anthropogenic aerosols on circulations and regional hydroclimate. Human emissions, not just of greenhouse gases but also aerosols, are critical for future projections.

Oral Session 3
Afternoon (1:00pm), Friday, November 3, 2023

Advances in Weather, Climate, and Ocean Modelling

Combined Oscillation-Regime Forecasting Framework

Mary Korendyke (she/her/hers), George Mason University

One of the most challenging forecasting problems in atmospheric science is the accurate prediction of weather and climate in the 3-4 week time scale. Skillful forecasts of extreme weather events like heat waves, floods, atmospheric rivers, and severe storms in this range are important for sectors such as forestry, water management, emergency response planning, farming, and many others. In light of the predicted increase in extreme weather events as a result of climate change, this problem becomes more pressing. In the past, two methods of describing large-scale atmospheric pressure patterns (circulation regimes and intraseasonal oscillations) have been used to investigate improving skill in this time range. Circulation regimes hold particular interest, as they are characterizable with extreme weather statistics and persist on average 7-10 days. Accurate prediction of regimes holds potential forecasting skill beyond the synoptic range. Skillful conditional regime forecasts have been made in the Euro-Atlantic region. However, circulation regimes in the Pacific North America region are less predictable. Intraseasonal oscillations have been shown to improve regime forecasting in the Euro-Atlantic region and might be used to improve forecasts for the Pacific North America region. Oscillations and regimes have yet to be examined in a combined operational forecasting framework despite the demonstrated potential for enhanced skill. My research aims to combine these two methods into a new type of forecasting framework and diagnose its regime forecasting skill in the 1-4 week range, which might lead to enhanced extreme weather forecasting in the 3-4 week time scale.

Quantifying Wetland Methane Emissions from the Southeastern United States: A Data-driven Approach, Key Variables, and Spatiotemporal Distributions

Keqi He (he/his/him), Duke University

As the second most significant greenhouse gas (GHG), methane (CH_4) contributes to ~20% of cumulative GHG-related global warming. Among methane sources, wetlands are the largest natural source. However, large uncertainty remains in the estimation of wetland CH_4 emissions due to the complex interactions between climate, hydrology, and wetland ecosystems. To better understand and quantify wetland methane emissions, we developed a random forest (RF) regression model to provide an independent data-driven high-spatial-resolution (1km×1km) and long-term (1982-2010) estimate of wetland CH_4 fluxes over the Southeastern (SE) United States (US), where over 50% of wetlands in the conterminous US are located. The RF-simulated CH_4 fluxes fit well with the measured CH_4 fluxes from the FLUXNET-CH4 Community Product (R^2 = 0.91), outperforming previous CH_4 flux upscaling studies. Mechanism analysis highlighted air temperature (Tair) and Palmer Drought Severity Index (PDSI) as key environmental predictors, and wetland CH_4 fluxes generally increase with Tair and PDSI. By upscaling the wetland CH_4 emissions based on the developed RF model and wetland extent data, we estimated high-spatial-resolution (1km×1km) monthly wetland CH_4 emissions in the Southeast during 1982-2010. We further validated our estimated CH_4 flux against remote sensing-derived wetland CH_4 fluxes from the Carbon Monitoring System Methane Flux product. The consistency between the two CH_4 flux estimations confirms the credibility of our wetland CH_4 flux estimations across the entire Southeast. This first-ever high-resolution (1km×1km) and long-term (1982-2010) monthly gridded wetland CH_4 flux product over the SE US can provide an additional constraint for future CH_4 flux modeling and upscaling studies.

Predicting cloud-to-ground lightning in the western United States from the large-scale environment using explainable neural networks

Dmitri Kalashnikov (he/him/his), Washington State University Vancouver

Lightning is a major source of summer wildfire ignition in the western United States. However, future projections of lightning are uncertain since lightning is not directly simulated by global climate models (GCMs). Previous studies have projected future lightning occurrence by using statistical relationships with meteorological variables that are simulated by GCMs. However, these approaches rely on parameterizing lightning from local conditions without awareness of large-scale weather patterns, which can augment successful prediction of small-scale weather phenomena. Here, we employ convolutional neural networks (CNNs), which are a type of automated image classification, to predict the occurrence of lightning across the western United States based on large-scale meteorological variables for the period of 1995 to 2022. Individually trained CNN models at each grid cell show high skill (AUC >0.9) at predicting lightning days in parts of the interior Southwest where summertime lightning is more common, but lower skill (AUC <0.7) in Pacific coastal states where lightning is relatively rare. We then use an explainable AI technique called layer-wise relevance propagation to investigate the regional importance of individual predictor variables to successful lightning predictions. Results show that measures of atmospheric moisture and instability are substantially more important than other predictors in many grid cells. In future work, we will also apply these grid-based CNNs to output from GCM projections to quantify future lightning occurrence across the western United States, which can inform changes to lightning-caused wildfire risk.

Atmospheric Chemistry, Aerosols, and Clouds

Investigating the evolution of light-absorption properties of biomass burning emissions in the southeastern Atlantic region

Abdulamid Fakoya, University of Oklahoma

"Absorbing aerosols greatly influence the climate through their radiative effects; absorbing sunlight, inducing cloud evaporation, acting as cloud condensation nuclei, and modifying cloud microphysics. Biomass burning (BB) in southern Africa is one of the largest source contributors of absorbing aerosols, accounting for 35% of global BB aerosol emissions. During the austral spring, smoke is transported westward, overlying a quasi-permanent stratocumulus cloud deck above the southeast Atlantic (SEA) Ocean. Since aerosol-cloud-climate interactions contribute the largest uncertainties to estimates of climate forcing, the SEA region exhibits a large model-to-model disagreement of anthropogenic forcing. Understanding BB emissions and the evolution of smoke aerosol is crucial for predicting their impacts on regional climate, health, and for developing mitigation strategies. This study investigates the evolution of BB aerosol during long-range transport in the SEA region using remote-sensed observation. Measurements from ground-based AERONET and airborne 4STAR taken during the ORACLES campaign are combined with simulations from regional model WRF-AAM to explore the changes in extinction, single scattering Albedo (SSA), and Angstrom exponent (AE) of smoke plumes as they age. The aerosol age is determined using tracers from WRF-AAM configured over the region's spatial domain (41 ºS – 14 ºN, 34 ºW – 51 ºE). Preliminary analysis showed distinct longitudinal variation in aerosol age, with near-source samples being younger and having low SSA values, while older samples over the ocean exhibit even lower SSA, suggesting that physical and chemical atmospheric processes associated with the transport drive changes in the radiative properties of smoke aerosols."

The Nonlocal Effects and Radiative Feedbacks of Sea Salt Aerosol Engineering in the GFDL Coupled Model

Cindy Wang (she/her), Princeton University

Geoengineering proposals, such as marine cloud brightening (MCB) which involves increasing sea salt aerosol (SSA) emissions, have gained attention as a means to mitigate the effects of climate change. We employ a simulation of regionally enhanced SSA in the tropics following the G4sea-salt protocol using NOAA GFDL climate models to examine the radiative and nonlocal responses to MCB. Our findings reveal that G4sea-salt induces significant climatic alterations, including reduced surface wind speeds and delayed surface warming in the Southern Ocean, associated with weakened westerlies. As a result SSA emissions decline in the Southern Ocean. Nonlocal temperature gradient impacts result in amplified cooling in the Arctic and modest temperature changes in the Southern Hemisphere, leading to an overall cooling effect along with shifts in the jet stream. Furthermore, we study the climate feedback to investigate and compare the sensitivity of the GFDL model to changes in radiative forcing attributed to SSA and temperature pattern changes, thereby providing a more comprehensive assessment of the potential impact of MCB on the Earth's climate system. Ultimately, our findings underscore the imperative need for the formulation of methodologies to rigorously evaluate climate intervention propositions, recognizing the climate responses and nonlocal effects that permeate regional MCB implementations.

Oral Session 4
Afternoon (2:30pm), Friday, November 3, 2023

Extreme Events in a Warming Climate

Global hotspots of extreme humid heat and air pollution co-occurrence
SamuelBartusek (he/him), Columbia University
Extreme humid heat and air pollution exposure individually represent significant human health hazards, and have been historically and prospectively tied to large excess mortality. While the intersection between pollution and extreme (non-humid) heat events has received much attention, the impact of humid heat on pollution remains relatively unexplored. Here, we analyze surface-level particulate matter (PM2.5) and ozone concentrations in a new 16-year global chemical reanalysis (CAMSRA) and daily-maximum 2-meter temperature and wet-bulb temperature from high-resolution reanalysis ERA5. We identify (for the first time, to our knowledge) regions worldwide where ozone or PM2.5 pollution tends to be higher during humid than non-humid heat extremes—i.e., where increasing heat stress tends to co-occur with increasing pollution burden—revealing a compound extreme tendency that carries hazardous health implications. We find that such regions include several of the globally most-extreme humid heat hotspots and most densely-populated areas, and are focused in subtropical latitudes. They also include some regions where both ozone and PM2.5 are intensified together during extreme humid heat events. Additionally, via detailed regional composites, we characterize the meteorological and chemical drivers of increased pollution during extreme humid heat events, examining the roles of temperature, humidity, horizontal and vertical wind, seasonal timing, and pollutant precursor species emissions.

Predicting the Spatiotemporal Evolution of Marine Heatwaves
Jacob Cohen (he/him), University of Washington
The ocean has absorbed 90% of recent warming associated with anthropogenic climate change; as a result, extreme ocean heat events, known as marine heatwaves (MHWs), are becoming more frequent and more intense. In late 2013 a large MHW formed in the Northeast Pacific Ocean and reached the west coast of North America. This event, known as “The Blob,” resulted in lasting damage to the local marine ecosystem leading to toxic algal blooms, a decline in walleye pollack populations, and die-offs of seabirds. Accurate and understandable MHW forecasts are needed to allow local decision makers and industries to respond to and plan for these events. To demonstrate the predictive capabilities of MHW forecasting, we apply Ocetrac, a MHW tracking tool, to a set of initialized hindcasts using the Community Earth System Model. The Seasonal-to-Multiyear Large Ensemble (SMYLE) Experiment contains 20-member ensembles of 24-month simulations initialized quarterly from 1970 to 2019. Here, we track and visualize the Blob in each hindcast from 2014 to 2016 and compare its path and intensity to the Blob in the SMYLE forced ocean–sea ice (FOSI) simulation. This work will be the basis for the creation of

real-time MHW tracking predictions in LMEs and coastal regions across the world. Providing easy to understand, real-time MHW forecasts will provide essential information to fisheries managers and conservationists in LME regions to help stakeholders prepare for future MHWs.

<u>Social Science, Climate Justice, and Policy</u>

Flood risk and legal recourse in a changing climate

Sofia Menemenlis (she/her), Princeton University

In the aftermath of an extreme rainfall event, individuals may seek legal compensation from cities for flooding-related damages thought to be caused by neglectful maintenance of infrastructure. For example, in the aftermath of Hurricane Ida (2021), over 4,000 New York City residents filed claims against the city seeking financial relief for severe flooding, largely in basement apartments. Defendants in flooding-related negligence cases often argue that a given weather event was an “act of God”—so extraordinary that it could not have reasonably been anticipated and prepared for. In the case of Ida’s aftermath, the New York City comptroller dismissed all claims, citing a 1907 legal precedent (Holzhausen v. City of New York) exempting the city from liability for damages caused by extraordinary rainfall events. However, scientific studies using observations, climate models, and geophysical theory have established that global warming increases the frequency and intensity of extreme rainfall events, with particularly pronounced increases in short-duration rainfall. In a warming climate, the thresholds for extraordinary rainfall change. This work considers legal recourse after flooding in a changing climate. I will present preliminary research on the legal landscape pertaining to flooding in the United States and New York City. I will discuss evidence presented in relevant cases in relation to the science of extreme rainfall and flood risk. This interdisciplinary project has broader implications for how science can be used in the legal system to better protect people impacted by extreme weather events.

Combatting Industry Influence through Fossil Free Research

Adam Cooper (he/him), UC San Diego

Fossil fuel companies have increasingly invested in academic research, influencing the direction and outcomes of climate science. Graduate students in this field have a unique responsibility to lead the charge in challenging this colonization of academia by the fossil fuel industry. This presentation will explore the global efforts of the Fossil Free Research coalition, with a focus on the Scripps Institution of Oceanography and the University of California system. The fossil fuel industry has funded $440 million dollars on research within the UC system over the last decade, prioritizing projects that greenwash their image, develop false climate solutions, and promote pro-fossil fuel policies. Student climate activism has a rich history of success in the divestment movement, which is now evolving into a dissociation movement. This presentation will highlight the work of graduate workers on the front lines, as well as their role in making sure there is a Just Transition for impacted labs.

Human-Driven Environmental Change in Africa's Tropical Mountains

Andrea Mason (she/her), Brown University

High-elevation tropical mountains are believed to be some of the most sensitive environments in the world to climate change. In Africa's tropical mountains, the effects of climate change are already apparent as glaciers have significantly retreated and recent droughts, fires, and floods have impacted local communities and ecosystems. However, the short duration of observational records limits our ability to test whether these changes are a result of natural climate variability or human activity. To determine the driving mechanisms of climate and environmental change in Africa's tropical mountains, we use lake sediment cores to reconstruct fire, temperature, precipitation, and vegetation change in the Rwenzori Mountains, one of Africa's tallest mountain ranges, over the last 12,000 years. Here, we present biomarker records from both high (~4,000 m) and middle (~3,000 m) elevation lakes in the Rwenzori Mountains. We find differential fire activity between high and middle elevations sites, with little to no fires at high elevations, but increased fire activity at middle elevations. The absence of fire in the past at high elevations suggests that the modern fires we observe at these sites are novel in the context of the last 12,000 years. Consistent with our fire results, we find no change in vegetation type at high elevations, but we do see evidence for vegetation transitions at middle elevations where fire activity is enhanced. Hydroclimate, not temperature, was the primary driver of fire variability in the past. However, fire increased dramatically at middle elevations starting around 2,000 years ago, coinciding with the Bronze Age in Africa. This evidence suggests hydroclimate variability has played a significant role in fire in East African fire variability in the past, but human activity has been the primary driver of change over the last 2,000 years.

Oral Session 5
Morning (9:00am), Saturday, November 4, 2023

<u>Ecological Responses to Climate Change</u>

Complex Shifts in Population Dynamics of Beringian Seabirds are Linked to Long- and Short- Term Climate Modes

Amanda Kemp, University of Alaska Fairbanks

Marine ecosystems and their populations are affected by complex long-term and short-term climatic modes climatic modes ranging from interannual and decadal variabilities. Because interactions between abiotic and biotic components of ecosystems, and oceanographic system change are subtle and complex, integrated analysis of these factors is essential to understanding the nature of interactions among them. We utilize a wavelet transform analysis simultaneously to multiple datasets centered on the Beringian marine environment and on the population dynamics and breeding success of selected breeding seabirds (eg., Puffins Fratercula spp, Auklets Aethia spp, Cormorants Phalacrocorax spp, Murres Uria spp. We show that over the last 5 decades, population and demographic parameters of these species fluctuate with a periodicity of 3-5 years similar to that detected in standard oceanographic parameters. Although the major periodicity of these interannual fluctuations is not common to different species and environmental variables, their cyclic characteristics not only show significant change, but diverse patterns of change.

Evaluation of Harmful Algal Blooms in Sea Otters

Emily Mailman (she/her), University of Alaska Fairbanks

Harmful Algal Blooms (HABs) are a concern in coastal communities throughout the state of Alaska. HABs consist of a myriad of phytoplankton, with two species of high concern in coastal Alaskan waters– Alexandrium spp. and Pseudo-nitzschia spp. Alexandrium spp. can produce dangerous biotoxins, such as saxitoxin (STX) which are absorbed in shellfish, and other filter feeding organisms, as they consume algae in their regular diet. HAB events can occur when sunlight, nutrients, temperature, and turbidity conditions combine, and HAB events are expected to increase as ocean temperatures continue to rise. HABs pose a risk to wildlife as well as rural Alaskan residents. Molluscan shellfish have the potential to store paralytic shellfish toxins (PSTs) in their tissues, which can accumulate and be passed through the food chain. Sea otters (Enhydra lutris kenyoni) offer insight as a sentinel species, as their diets closely mirror that of many rural coastal Alaskan communities. This project evaluates the concentrations of paralytic shellfish toxin congeners in sea otter stomachs (n=23) using high-performance liquid chromatography (HPLC). These samples are subsistence-harvested sea otters from Gustavus, Alaska (Icy Straight), a region of Alaska regularly engaging in community subsistence shellfish harvesting. Sea otter diets include a wide array of mollusks such as clams and mussels. Toxin levels are being compared by species and by congeners. The predominant stomach content species identified include horse clams, pink neck clams, softshell clams, horse clams, and butter clams. This project will increase knowledge and understanding of toxin congener profiles in food webs and provide insight for rural communities.

Gotta Fan ‘Em All: Using automated computer vision based tracking to understand the impacts of heatwaves on social thermoregulation in bumble bees

Grace Melone (she/her), University of Wisconsin-Madison

Bumblebees are a diverse group of important wild and managed pollinators in temperate regions across the globe. Climate change, and particularly extreme heat events, are likely negatively impacting bumblebee populations, but the mechanisms underlying these impacts are not well understood. Here, I investigate the impacts of multi-day heatwaves on collective thermoregulation within bumble bee colonies, specifically focusing on how heat wave progression and nutritional status affect thermoregulatory behavior. I predict a decline in fanning, which bees employ to cool the colony above optimum temperatures, throughout the heatwave, through two possible mechanisms: 1) nutrition limiting energetic capacity, or 2) acclimation to heat stress. I exposed groups of bumble bee (Bombus impatiens) microcolonies to a 3-day heatwave and quantified the impacts on fanning behavior. To overcome the challenge of quantifying fanning behavior of individual bees, I automated video capture and analysis using a low-cost, automated imaging system based on RaspberryPi microcomputers and cameras. I integrated tag-based tracking of uniquely-identified individual workers with a classification model to quantify behavior throughout the experiment. These scalable, automated approaches allow for high-resolution studies of dynamic behavioral responses to stressors like heat, nutrition, and pesticides. I found that the proportion of bees fanning declines throughout the heatwave, and no effect of nutrition on fanning behavior. But, I did find that nutrition affects worker and brood survival and nectar consumption throughout the experiment. My research shows that fanning does decline throughout heatwaves, and that nutrition is important for buffering effects of heatwaves.

Water Pathways In the Earth System

Quantifying the Anthropogenic Impact on Vapor Pressure Deficit Increases and Drying Trends over the Southeast Amazon

Alex Chang, University of California, Los Angeles

The Amazon rainforest plays a crucial role in both the global climate system and the carbon cycle. However, recent decades have witnessed severe droughts and wildfires in the Amazon, leading to concerns about its potential to become an atmospheric carbon source. These events, attributed to climate change and land-use changes, have profound implications for the escalating effects of climate change worldwide. Consequently, understanding the factors behind these droughts and their potential future severity is of utmost importance. Vapor pressure deficit (VPD), a key atmospheric variable associated with droughts, has shown significant overall increases across large portions of the Amazon. Notably, VPD values were exceptionally dry during the 2005, 2010, and 2015-16 droughts. However, it remains unclear as to what degree natural climate variability and anthropogenic climate forcings contribute to these VPD increases. As such, we use a flow analog method to determine the degree of natural variability in the observed VPD increases. Our analysis reveals that analog circulations display an insignificant VPD trend and explain only a small portion of the observed VPD increases in the Amazon. Specifically, we find that only about 35\% of VPD increases are explained by natural variability, with the other 65\% of VPD increases due to anthropogenic forcings. Additionally, the VPD increases are primarily driven by factors related to temperature increases rather than moisture decreases, and these factors were paramount in driving the aforementioned extreme droughts. These findings underscore the role of human activities in driving changes in VPD and drought conditions in the Amazon. They highlight the urgent need for climate change mitigation efforts and sustainable land-use practices to preserve the Amazon's crucial carbon sequestration capabilities and mitigate the escalating impacts of climate change globally.

Oral Session 6

Morning (10:30am), Saturday, November 4, 2023

CDR Technologies and Climate Solutions

A 7-year dissolved inorganic carbon time series in the Irminger Sea: implications for carbon dioxide drawdown

Meg Yoder (she/her), Boston College

Climate change is primarily driven by the anthropogenic input of carbon dioxide (CO2) into the atmosphere. However, the climate impact is lessened by the fact that each year, CO2 is also removed from the atmosphere by natural processes. In the ocean, a combination of biological, chemical, and physical forces enable absorption of atmospheric CO2. These processes vary regionally, with the subpolar North Atlantic taking up an outsized amount of CO2 relative to its area. High phytoplankton productivity converts inorganic to organic carbon, some of which sinks or is mixed into the deep ocean where it can be sequestered long-term, while another portion is respired back into inorganic carbon. Extremely deep winter mixing can bring respired inorganic carbon back to the surface, where it has the potential to exchange with the atmosphere. To accurately quantify the climate impact of these competing forces on human-relevant timescales, we synthesize seven years of daily data from biogeochemical sensors (pH, pCO2, and dissolved oxygen) deployed in the Irminger Sea by the Ocean Observatories Initiative and present the first dissolved inorganic carbon and pCO2 time series in this region. We find the amount of summer drawdown varies much more than the winter increase, indicating depth of winter mixing does not strongly control the amount of inorganic carbon in the surface. The amount of carbon removed from the surface ocean each year by biological processes is higher than reported values in other regions and varies significantly from year-to-year (3.5-11.4 mol C m-2 yr-1).

Exploring Reactivity of Ultramafic Mine Waste for Enhanced Carbon Dioxide Capture and Storage

Xueya Lu (she/her), University of British Columbia

Carbon dioxide (CO2) capture and storage (CCS) methods are critical for mitigating climate change, and carbon mineralization utilizing solid wastes from hard-rock mining holds significant promise. Among these waste materials, ultramafic mine waste, characterized by its abundant metal cations, emerges as a highly suitable option for efficient and permanent CO2 capture and storage. However, the implementation of large-scale CCS through carbon mineralization encounters substantial challenges. The primary hurdles lie in the limited understanding of mine waste reactivity and the complex nature of these heterogeneous materials. This Ph.D. research aims to address these knowledge gaps by investigating the reactivity of ultramafic minerals, rocks, and tailings and developing innovative techniques for their characterization. The study focuses on two critical aspects: (1) identifying the sources and controls of reactivity in ultramafic mine wastes and (2) developing efficient and cost-effective methods to analyze and measure this reactivity. The outcomes of this research will enable informed decision-making for ongoing CCS projects, facilitate the optimization of mineral carbonation techniques in practical applications, and yield accurate estimations of the overall CCS capacity. Beyond its significance for CCS, this research holds broader implications for climate-related efforts. Improving our understanding of mine waste reactivity can contribute to a more sustainable mining industry. This transition, in turn, yields multiple benefits, such as substantial CO_2 emission reduction, effective dust mitigation, improved tailings stabilization, and encapsulation of toxic metals. More importantly, this research will provide insights and practical guidance. Ultimately, these advancements will be crucial in addressing climate change and fostering a more sustainable future.

The role of ocean mixing in carbon dioxide removal via ocean alkalinity enhancement
Ruby Yee (she/her), Dalhousie University
Ocean alkalinity enhancement (OAE) is a proposed method for climate change mitigation, in which alkalinity added to the surface ocean initiates a draw-down of atmospheric CO_2 where it reacts to form bicarbonate. Although OAE shows promise as a technique for atmospheric carbon dioxide removal (CDR), in-situ experiments and models are required to confirm theoretical predictions. A brief overview of the challenges relating to monitoring, reporting, and verification of CDR using OAE will be presented. A recent alkalinity and dye release experiment in Bedford Basin, Nova Scotia will be discussed alongside preliminary results from an idealized numerical simulation of alkalinity release. We explore the impact of forcings like ocean stratification and the effects of seasonality on the evolution of CO_2 uptake. The results provide preliminary indications about environmental conditions that are most favourable for CDR via OAE, and may help to guide future decisions about where and when OAE could be implemented.

Environmental Management and Climate Adaptation

Efficient integration of waste into circular economy: case of agro-forestry residues
Behibro Ange-Delon Konan, National Institute of Scientific Research (INRS)
The efficient integration of waste into circular economy is crucial to address climate change challenges such as the reduction of CO_2 emissions. It is estimated that around 10.9 billion tons of CO_2 are released each year from unused agroforestry residues worldwide - an enormous amount. It is now well documented that agroforestry residues are the most relevant ecological alternative for replacing several petrochemical products, including fuels. However, recycling agroforestry residues presents a major challenge. It involves a pre-treatment stage that accounts for around 40% of the total cost of recovery. This affects the economic profitability of using this type of residue. In addition, existing pre-treatment processes are either inefficient or unsustainable. Therefore, we are developing an environmentally friendly and innovative approach of pretreatment that combines reactive extrusion and biodelignification to lower the cost of pretreatment below 10% of the total cost of valorization. The concept is based on the ability of certain microorganisms to pretreat biomass under optimal conditions of particle size, carbon/nitrogen ratio, nutrients, temperature, and humidity. Initial results have demonstrated (1) the ability of these microorganisms to pretreat different types of agro-forestry residues without

external nutrient input, and (2) a pretreatment yield significantly higher than the literature (25%) for the reactive extrusion step alone. The success of this project will pave the way for large-scale valorization of agroforestry waste.

Drinking Water Utility-Level Understanding of Climate Change Effects to System Reliability

Zia Lyle (she/her), Carnegie Mellon University

Climate change hazards, including increased temperatures, drought, sea level rise, extreme precipitation, wildfires, and changes in freeze-thaw cycles, are expected to degrade drinking water utility system infrastructure and decrease reliability of water provision in many regions. Though there is robust literature on these effects to reliability and ample governmental and professional guidance on integrating climate adaptation into utility planning, there has been little qualitative work done on utility manager climate risk decision-making. To assess how drinking water utility manager perceptions of these risks affect utility planning, sixty semi-structured interviews were conducted with utilities of various sizes, source water supplies, and different United States geographical regions. This study analyzes these interviews (1) to evaluate which climate hazards are of primary concern to drinking water managers, (2) to develop a mental model framework for assessing utility-level understanding of climate change risks to system reliability, and (3) to examine the status of current water utility adaptation planning. The results show that concern and awareness of climate hazard risks vary geographically and are grounded in historical exposure. When considering climate change risks to system reliability, utility managers tend to focus on affects to water supply and infrastructure, as opposed to changes in operations and maintenance, water quality, or business functions. Most surveyed utilities do not have comprehensive climate adaptation plans, despite federal and professional guidance and recommendations. The range of beliefs and actions concerning climate adaptation planning indicates utilities need directed guidance.

POSTER PRESENTATION ABSTRACTS

Poster Session A
(A01-A20)
Evening (5:00pm), Thursday, November 2, 2023

Poster Session B
(B21-B40)
Evening (7:00pm), Thursday, November 2, 2023

Poster Session C
(C41-C60)
Evening (6:45pm), Friday, November 3, 2023

Poster Session D
(D61-D80)
Evening (7:45pm), Friday, November 3, 2023

Paleo-Perspectives on Climate Variability

(A01) Floods and streamflow on the lower Mississippi River over the late Holocene

Charlotte Wiman (she/her), Northeastern University

The Mississippi River basin drains nearly half of the contiguous United States and is of critical economic importance due its use for shipping, agriculture, industry, and recreation. Flooding of the lower Mississippi River causes major disruptions to these industries and is economically costly. Our current understanding of flooding on this river comes predominantly from relatively short instrumental steam gage records (~100 years), and extending these records using paleofloods can be used to provide context to recent trends, reduce uncertainties in flood frequency analysis, and evaluate the ability of earth system models to simulate the sensitivity of streamflow to changes in climate. Here, we evaluate overbank deposits in a series of sediment cores from three different oxbow lakes that formed sequentially on the lower Mississippi River near Natchez, Mississippi to reconstruct shifts in flood frequency and magnitude over the last ~700 years. We use a combination of sediment characteristics, including grain size and organic content, to produce the longest continuous flood reconstruction on the lower Mississippi River. Using this record, we evaluate how flood regimes changed over the past millennium in response to changes in climate and river management, and use this to assess the response of Mississippi River flooding to moderate changes in climate. We integrate the paleoflood data with output from the Community Earth System Model (CESM) Last Millennium Ensemble (LME) to show that discharge on the lower Mississippi River decreased during the Medieval era (1000-1200

CE), a period of regionally warm and dry conditions. Consistency between our reconstructions and output from CESM demonstrate that streamflow of the lower Mississippi River is sensitive to relatively moderate changes in climate. Future work will continue to use historical and paleoflood data to validate model output, and narrow uncertainty in projections of Mississippi River streamflow in response to ongoing climate change.

(A02) Hurricane-driven sedimentation and erosion at New England barrier beaches over the last 2,000 years

Lily Sanborn (she/her), MIT-WHOI Joint Program in Oceanography

Storm surge produces characteristic depositional patterns in coastal settings, allowing sedimentary records from coastal lagoons to provide a powerful tool to reconstruct the timing of past hurricane strikes. Sedimentary archives can extend records of hurricane events several thousand years before the interval permitted by historical documentation, providing the basis for analyses which evaluate climate-driven patterns in hurricane recurrence across centennial to millennial timescales. However, these long-term reconstructions rely upon the assumptions that hurricanes consistently produce deposition in coastal lagoon environments and that these deposits are preserved through time. There has been little exploration of the degree to which coastline evolution during the late Holocene (sea-level rise and shoreline retreat) controls the sedimentary signatures left behind by past hurricanes. Here, we examine how shoreline change impacts the incorporation of hurricane event layers into coastal sedimentary archives. Our approach synthesizes sediment core reconstructions from New England coastal lagoons with numerical (XBeach) simulations of hurricane inundation at these study sites. We construct models of present and hypothetical paleo-coastline morphologies and run simulations for a range of storm conditions, allowing us to estimate the characteristics of paleo-hurricane events which left deposits at our study sites. We use this compilation of hurricane simulations to develop expectations for whether our sediment cores represent a complete record of paleo-hurricane strikes. Our results link evolving coastal morphology to changes in recorded hurricane strikes and carry implications for the interpretation of long-term hurricane variability from sedimentary records.

(B25) Physical characterization of 1966 Camp Century sub-glacial sediment indicates preservation of ice-free surface processes

Cat Collins (she/her), University of Vermont

"The future stability of the Greenland Ice Sheet (GrIS) is a major concern for the viability of our society in a changing world. The key to understanding GrIS melt, sea-level rise contributions, and albedo feedbacks is stored in the past. Greenland's paleoclimate has been traditionally studied using ice core analyses, but now we have access to 3.44 meters of sub-glacial sediment from northwestern Greenland, taken from below the Camp Century ice core. Deciphering what mechanisms deposited this sediment is crucial for understanding past environmental conditions which will expand our understanding of Greenland's climate history. I used 26 samples to characterize the physical properties of the core using micro-computed tomography (μCT), x-ray diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive x-ray diffraction. XRD analysis reveals that the mineralogy is dominated by quartz and feldspar throughout with minimal variability. SEM analysis shows that in the lower units there are extensive grain coatings which are minimal in the upper layers. From physical and digital (μCT) sedimentological observations, I defined 5 stratigraphic units within the core, 3 of which indicate the presence of ice-free surface processes. Optimized data collection is crucial given the limited quantities of sub-glacial sediment. This is achievable by the creation of a digital archive (μCT scans) for non-destructive analysis to be used in combination with destructive methodologies for multiproxy analysis. Since this core preserves ice-free surface processes where it is currently covered by ice, it can be a powerful analogue to understand the GrIS in a future of warming."

(B26) 400,000-year-old vegetation and invertebrates below the ice at Camp Century—evidence for a warmer Greenland climate

Halley Mastro (she/her/hers), University of Vermont

Anthropogenic greenhouse gas emissions are altering global climate, with disproportionately large impacts in the Arctic. Understanding responses of the Greenland Ice Sheet and Arctic vegetation to past climate changes is of global importance in evaluating modern ice sheet stability and contribution to sea level rise. The history of the Greenland Ice Sheet beyond the last interglacial period (125,000 years ago) has often been interpreted through indirect records because terrestrial evidence is rare and inaccessible. The 1390 m Camp Century ice core retrieved 3.44 m of subglacial sediment deposited before ~400 ka. Organic remains, including plant and invertebrate macrofossils, are preserved in the sediment. We isolated organic remains from 28 sub-samples of the sediment at ~10 cm intervals after wet sieving. Once isolated, we observed plant macrofossils under a microscope for identification using modern reference collections. We sectioned and identified 12 woody fragments via diagnostic structures using scanning electron microscopy. Using bulk organic material (63-250 μm), we measured total organic carbon and nitrogen and their stable isotope ratios. Vegetation and invertebrates identified in the core are expected in modern Arctic tundra communities. General trends in C/N ratio indicate a shift in dominant source material from terrestrial plants to a mixture of aquatic and terrestrial plants with decreasing core depth. The abundant, well-preserved macrofossils in the Camp Century sediment constitute direct terrestrial evidence for ice absence in the past and ecosystem development in northwestern Greenland. Further identifications will provide insight into the environmental conditions preserved in this analogue for modern climatic changes.

(B27) Proxy-Based Assessment of the Indian and Pacific Ocean Walker Circulations over the Common Era

Shawn Wang (he/him), Woods Hole Oceanographic Institution

Overlying the tropical Indian and Pacific Oceans in the troposphere are zonally oriented cells known as the Indian Ocean Walker Circulation (IWC) and the Pacific Ocean Walker Circulations

(PWC). These large-scale circulation patterns play an important role in moisture and heat transport in the deep tropics of the Indian and Pacific Oceans (Indo-Pacific). While coupled-climate models predict that the IWC and PWC are expected to slowdown in response to global warming, a long-term reduction has not been observed. This discrepancy between observations and model predictions have been attributed to a multitude of factors including model underestimation of internal climate variability, biases in air-sea flux parametrization, and poorly resolved interactions between ocean basins. To clarify these outstanding questions and develop a deeper understanding of IWC and PWC dynamics, we utilize a network of marine and terrestrial paleoclimate records from the tropical Indo-Pacific that span the last two millennia (Common Era) to reconstruct IWC and PWC variability. In this study we present a reconstruction of IWC and PWC variability that distinctly considers each proxy archive's skillfulness in reconstructing each side of Walker Circulation variations: weakened circulation associated with +IOD events and El Ninos, and strengthened circulation associated with -IOD and La Nina. Our results not only provide important insights into Indo-Pacific climate but also the strengths and limitations of utilizing proxy archives to reconstruct climate variability."

(C45) Climate Variability and Sea Surface Temperatures in the Intra-Americas Sea

Alethia Kielbasa (she/her), University of Oklahoma

The Intra-Americas Sea (IAS) includes the Gulf of Mexico and Caribbean, regions relatively understudied considering their importance in moisture transport across the United States, Central and South America. The IAS has been connected to various processes including tropical storms, the springtime sea surface temperature anomaly dipole and the Atlantic warm pool. A typical springtime dipole is noted by cooler sea surface temperatures in the Gulf of Mexico and warmer in the Caribbean. In boreal summer, the Atlantic warm pool is a phenomenon marked by anomalously warm sea surface temperatures, critical for hurricane development. This study uses HadISST dataset to examine the variability of the springtime dipole in the IAS and how it impacts the Atlantic warm pool. Results indicate a potential increase in springtime dipole occurrences over the last 150 years. During dipole years, warmer sea surface temperature anomalies dominate the IAS in the summer months through the end of the Atlantic hurricane season. Non-dipole years display the opposite pattern with cooler sea surface temperature anomalies dominating the IAS in the summer and hurricane season. Future work includes model comparisons using CESM LME and the CoralHydro2k coral proxy datasets. Climate projections indicate an increase in intensity of weather events such as extreme precipitation, drought as well as enhanced Atlantic hurricane seasons, all of which particularly impactful to coastal communities lacking adaptive and resilient infrastructure in the Intra-Americas Region. A better understanding of the variability of sea surface temperatures in the IAS will help these regions prepare for a changing climate.

(C46) The external forcing of the tropical Indian Ocean across timescales

Benjamin Tiger (he/him), MIT-Woods Hole Oceanographic Institution

Due to a lack of instrumental and paleoclimate records, the Indian Ocean is one of the least understood ocean basins. The low-latitude Indian Ocean has warmed at a rate faster than any other part of the tropics in the last few decades. Under high emissions scenarios, its interannual climate variability is expected to increase which will cause whiplash in precipitation extremes across the region. These effects are complicated by high latitude forcing from a weakening Atlantic Meridional Overturning Circulation. Future climate change will likely have substantial impacts on developing Indian Ocean rim countries, so it has become increasingly important to understand the drivers of regional precipitation. Paleoclimate archives and state-of-the-art simulations are powerful tools used to assess the dynamics of external climate forcing across timescales beyond the limited observational record. Here, I will discuss aspects of what is know about the external forcing (e.g. tectonic, orbital, ice volume, and greenhouse gas forcing) of the Indian Ocean from previous studies as well my own work which focuses on the effects of Plinian volcanic eruptions and high-latitude meltwater forcing.

(D64) Developing a 500,000-Year Record of Laurentide Ice Sheet and Climate History from New York Speleothems

Calen Rubin (she/her), Boston College

Studies to understand the drivers of ice sheet response to orbital parameters and CO2 forcing using marine sediment and ice core records show that the Northern Hemisphere has experienced regular glacial-interglacial cycles for millions of years. However, these records do not reflect local North American climate conditions, and there are few long-term terrestrial records that capture Laurentide Ice Sheet (LIS) behavior prior to the Last Glacial Maximum (LGM). Speleothems are a potentially useful tool for paleoclimate studies at higher latitudes because they typically only grow when conditions permit liquid water to percolate through carbonate bedrock and into a cave, and they can remain preserved underground through multiple glacial cycles. We are using speleothems from seven caves in New York state, USA, to develop a proxy record of LIS ice sheet cover in this region over the last 500 kyr. We use both uranium-thorium dating to determine periods of speleothem growth and $\delta 18O$ to capture climate conditions. Initial results (30 ages on 18 speleothems) indicate that at least four caves had speleothem growth prior to the LGM, with ages spanning ~3 to 560 ka during both glacial and interglacial periods. $\delta 18O$ across the dated speleothems covaries with glacial cycles as recorded by marine $\delta 18O$ and ranges from approximately –5.4‰ during glacials to –7.8‰ during interglacials. Further U-Th dating and stable isotope analysis will allow us to develop a more statistically complete growth history and high-resolution record of climate variability. These constraints will inform (1) whether the LIS advanced to near its LGM extent during every glaciation, (2) glacial isostatic adjustment corrections of sea level markers during interglacials, and (3) whether millennial ocean circulation variability during glacial periods was related to the position of the LIS margin routing North American continental drainage to the east into the North Atlantic or to the south down the Mississippi River.

(D65) Mantle Controls on Long Term Oceanic Circulation and Climate: Preliminary Findings from IODP Expedition 395

Claire Jasper (she/her), Columbia University / Lamont-Doherty Earth Observatory

In the North Atlantic region, the climate of the past and the deep ocean's thermohaline circulation have a mutual influence. The cold and saline North Atlantic Deep Water (NADW) plays a crucial role in supplying oxygen-rich waters to the deep ocean. The formation rate of NADW is affected by the southward movement of cold Norwegian Sea deep-water, as well as the collapse of ice sheets and freshwater input. To investigate past circulation, we embarked on the JOIDES Resolution drill ship for the International Ocean Discovery Program Expedition 395. This expedition took place from June 12th to August 12th, 2023, drilling sites located along the mid-Atlantic Ridge, near Iceland and Greenland. We are primarily interested in understanding the influence of Iceland's mantle plume, which is known to undergo periodic pulsations every 3 to 8 million years. These pulsations control the height of oceanic gateways that regulate the flow of cold deep-water from the Norwegian Sea into the North Atlantic. The primary objective is to gain insights into how deep Earth's mantle convection affects these gateways and deep-water currents, shaping past climate patterns. Alongside standard measurements, we also captured X-ray images of the sediment cores. Utilizing a trained convolutional neural network, we will analyze these images to quantify debris carried by icebergs from the Iceland and Greenland Ice Sheets. This analysis will provide valuable information about changes in ice volume in relation to climate and ocean circulation. The presentation will feature preliminary results and initial findings based on the shipboard data.

Ecological Responses to Climate Change

(A03) The effects of severe drought on herbivore movement patterns, physiology, and survival in Etosha National Park, Namibia

Kimberlie Vera (she/her/hers), University of Wisconsin - Madison

"The effects of climate change in dryland ecosystems may include increased temperatures, decreased precipitation, and varying vegetation dynamics, changes that may directly and indirectly affect herbivore physiology, behavior and survival. We evaluated herbivore movement behavior, physiology, and survival during the worst drought on record in Etosha National Park, Namibia. GPS collars and biologgers were deployed on blue wildebeest (Connochaetes taurinus) and plains zebra (Equus quagga), both water-dependent grazers that show partial migrations around the Etosha salt pan. Late in the drought in 2019, 27% of collared zebra and 15% of collared wildebeest died during a one-month period, compared to no mortalities during the same period a year prior. All appeared to be drought-related mortalities. Body temperature and spatial location data indicated a wider variation in daily body temperatures and increased movement rates during peak drought conditions, with variation among individuals and more temperature variation among wildebeest than zebra. We explore how drought affected activity patterns, drinking frequency and movement rates for animals who survived the drought versus those that died. Our results shed light on the vulnerability of water-dependent herbivores to severe climate events.

(A04) Assessing Wildlife Communities in Relation to Land Use in East Central Washington

Allison Stift (she/her/hers), Washington State University

Wildfires in sagebrush habitats in the western United States have been increasing due to human activity, higher temperatures, and drought due to climate change. Sagebrush-steppe habitat and the associated wild vertebrates are a conservation priority in Washington. However, the remaining sagebrush-steppe in east-central Washington has been fragmented by row-crop agriculture on private lands for decades. The increase in anthropogenic land use has added to the frequency of wildfires in addition to climate change related factors. In response, a variety of conservation actions have been implemented such as shifting from conventional to direct-seeding farming and restoring permanent vegetation cover on former croplands through the federal Conservation Reserve Program (CRP). In this study, we examined occupancy of native wildlife within the complex agricultural CRP-sagebrush mosaic within east-central Washington using trail cameras from May-August in 2021 and 2022 in Douglas, Lincoln, and Grant counties. We placed four trail cameras within a 10-hectare plot at 94 study sites in native sagebrush steppe, CRP, and croplands. At each camera vegetation and pellet surveys were conducted along a belt-transect. We are currently identifying wildlife species from camera images to model the occupancy of species in relation to land use, agricultural practices, habitat features, and landscape context. From these models we plan to identify the key local and landscape features that influence wildlife and identify connected areas of high occupancy probability for sagebrush species. Future research will use the results from this study to compare occupancy of sagebrush species in unburned habitats and habitats burned by wildfire.

(C47) Quantifying the Influence of Plant Stomatal Behavior on Photosynthesis

Amy Liu (she/her), University of Washington

Plants on land play a role in regulating carbon fluxes and the water cycle, but there is uncertainty in plant stomatal behavior that impacts local climate and hydrologic extremes. Plant processes are dictated by the stomatal conductance, which correspond to the aperture of plant stomata. In CLM, stomatal conductance is represented by the Medlyn model, and the carbon and water fluxes are influenced by the stomatal slope parameter. The range of the slope parameter within and across plant types is large, which implies a large variance of plant responses on the Earth system. However, typically one value is used to represent each plant type in the model, which has implications on the Earth system and our climate projections. We vary the slope parameter to evaluate its influences on the Earth System. We focus on the differential response of photosynthesis under rising CO_2 with and without the presence of atmospheric feedbacks as well as interactions with dynamic feedbacks of leaf area.

(D79) Assessing Habitat Selection and Drivers of Distribution for the Sierra Nevada Red Fox

MarwaMahmoud (she/her), Washington State University

The Sierra Nevada red fox (Vulpes vulpes necator) is a montane subspecies of red fox that inhabits the Oregon Cascades (Oregon), Lassen Peak (California), and the Sierra Nevada (California). Sierra Nevada Red Fox (SNRF) are listed as endangered in the Sierra Nevada population segment, and little is known about SNRF distribution and habitat preferences in Oregon. SNRFs are associated with low minimum temperatures and high snow water equivalent. Given their reliance on high elevation habitats, climate change may have drastic effects on SNRF distribution and suitable habitat availability. In partnership with the Oregon Department of Fish and Wildlife, we are setting game cameras across Oregon's Cascades, focusing on areas to the south and north of Crater Lake and in the region between the Central Cascades and Mount Hood. This will allow us to gather a better understanding of SNRF distribution and habitat use in montane ecosystems. Our study will identify high priority areas for conservation of SNRF and will be important for wildlife managers engaged in conservation management and planning decisions for the species. Given climate change projections show a drastic reduction of snowpack in the Pacific Northwest by 2100, it is crucial to understand how wildlife managers can conserve species, like SNRF, that rely on, and have evolved in montane ecosystems.

(D80) Effect of re-greening of the Sahel on Elephant (Loxodonta Africana) distribution at the Mole National Park, Ghana

Martin Manu, University of Oklahoma

The northern region of Ghana that harbors Mole National Park (MNP), falls within the Sudano-Sahelian zone. This area is branded and described as degraded and has been concluded by some researchers that extensive desertification could set in (Hänke, 2015). Contrary to this assertion, recent scientific studies indicate a reverse of the extremely dry conditions which has led to the re-greening of the Sahel (Brandt et al., 2015; Douglas, 2015). This could indicate that Mole National Park (MNP) (latitudes 09o11'–10o 06' N and longitude 01o 22'–02o16'W); has also undergone re-greening and subsequently influencing the ecology of wildlife species especially elephant. The research addresses the gap in knowledge of quantifying re-greening in only protected areas within the semi-arid Sudano-Sahelian region and identifying the type of vegetation responsible for the observed re-greening. The project investigates re-greening and how it has influenced the distribution of elephant at Mole National Park in the West Africa country of Ghana. It uses high-resolution satellite data to quantify re-greening at the MNP of Ghana over the past 20 years, identifies the major vegetation responsible for observed re-greening and determines if they make up the diet of elephants as well as their nutritional value. The research again determines the relationship between trends in re-greening and trends in elephant spatial distribution for the past 10 years.

Environmental Management and Climate Adaptation

(A05) Underpinning the Institutional Dynamics of Natural Climate Solutions: A Systematic Review Protocol

Manasi Anand (she/her), Cornell University

This paper seeks to advance understanding of the institutional dynamics of Natural Climate Solutions (NCS) in global forest management. NCS represents a spectrum of policy strategies that protect, augment, and sustainably manage forest cover to store carbon. While NCS has been catalyzing attention from governments, international platforms, and corporations as a panacea for crises, there is still a lack of clarity on what kind of institutional pathways and policy processes support just climate transitions. To fill this gap, our paper develops a systematic literature review protocol to evaluate the a) different kinds of technologies and policy instruments, b) competing political and economic agendas, and c) existing non-climate solution related institutions and regulations that influence the implementation and outcomes of NCS. We will screen and analyze 260 research articles identified on the Web of Science published between January 2016 and June 2023. We assess NCS based on an overarching framework that addresses- spatial characteristics, institutional coordination practices, political economy, and path dependencies of climate change mitigation. Outputs from the review will be used to generate a schematic map of different types of climate solution technologies researched across the globe in the forest sector and provide a thematic assessment of the beneficiaries of forest carbon projects, and the policies and structures that enhance and constrain the ability of NCS to generate innovation.

(A06) Understanding the Impact of Land Use Change on Local Climate Patterns: A Case Study in Urban Environments

Dimo Okeyo, Michigan Technological University

This study investigates the relationship between land use change and local climate patterns in urban environments. With rapid urbanization, cities are experiencing significant transformations in land cover, leading to potential climate implications. This research aims to address this critical issue by examining the impacts of land use change on temperature and precipitation patterns and understanding the underlying mechanisms driving these changes. The relevance of this research to climate is evident as urban areas contribute significantly to the global climate system. Urbanization alters surface properties, such as vegetation cover, impervious surfaces, and building materials, which can influence local climate patterns, including temperature and precipitation. Understanding these impacts is crucial for developing effective climate adaptation and mitigation strategies in urban regions. This study employs a combination of remote sensing data analysis, numerical modeling, and statistical techniques to analyze long-term land use change and its correlation with observed climate data. By analyzing satellite imagery and climate records, we assess the spatial and temporal patterns of land cover change and identify the associated climate responses. The scientific merit of this research lies in its contribution to the understanding of urban climate dynamics. By conducting an in-depth analysis of the relationship between land use change and local climate patterns, this findings will provide valuable insights into the complex interactions between urbanization and climate. Moreover, the broader implications of this research extend to urban planning, policy-making, and climate resilience strategies, aiding in the development of sustainable and climate-resilient cities. This abstract emphasizes clarity by clearly outlining the research objectives, methods, and expected outcomes. I aim to present our findings in a manner accessible to all GCC participants, irrespective of their field of study. By providing a concise summary of this research, I hope to engage attendees from various disciplines and foster interdisciplinary discussions on the topic of urban climate dynamics. In conclusion, this study investigates the impact of land use change on local climate patterns in urban environments. By analyzing remote sensing data, conducting modeling exercises, and examining climate records, the study aims to provide a comprehensive understanding of the complex interactions between urbanization and climate. This research contributes to the broader knowledge of urban climate dynamics and has implications for urban planning and climate resilience strategies."

(C48) A century of urban landslides: the legacy and consequences of altering riverbank landscapes

Bella Bennett (she/her), University of Vermont

In regions where climate change will increase the frequency and intensity of rainfall events, landslides present a growing hazard. Past and present human actions, such as altering the grade, composition, and tree-cover of hillslopes, exacerbate the threat of mass movements. In urban environments, landslides can be both deadly and costly, typically affecting marginalized communities disproportionately. Here, we use a multidisciplinary approach to examine the spatial distribution and cause of landslides over the past century affecting a state highway and adjacent buildings along the top of a steep, urban riverbank in northern Vermont. We then evaluate strategies to stabilize the slope and mitigate future risk within Vermont's changing climate. Over the past century, annual precipitation has increased 26% in northern Vermont. Using maps, photographs, and newspaper articles compiled from this period, we found evidence of 18 landslides along this slope. Most of these landslides occurred following large rainfall events along slopes over-steepened by the addition of unconsolidated artificial fill – added without engineering considerations. Given that annual precipitation is expected to increase another 10% by the end of this century, the risk of future landslides along this slope is imminent. To reduce this risk in the context of increasingly frequent and intense precipitation events, we present solutions including reforestation to increase root cohesion, incentivizing the removal of structures built on fill, and limiting further filling activities through zoning regulations and enforcement of existing municipal codes. The approach we use provides a framework for similar settings and can inform planning and risk assessment.

(C49) Climate Resilience and Ranch Productivity: A Study of the US Midwest Ranching Systems

Caroline Ruto (she/her), Kansas State University

Climate change significantly influences ranching systems with its multifaceted impacts. Contrary to some perspectives, livestock production isn't always the antagonist in the narrative surrounding food systems and climate change. Extensive grazing systems, including ranching systems, present opportunities to manage climate risk through adaptive strategies promoting soil health and carbon sequestration. Given the significant footprint of the US livestock sector and its dual role as a contributor to and victim of climate change, a detailed understanding of this sector is imperative for sustainable development, especially sustainable livestock production.

The research aims to identify strategies and best practices that can enhance the resilience of the US livestock sector, ensuring its sustainability and profitability in a changing climate. The research is guided by a conceptual framework considering the complex interactions between climate change, rancher decision-making, and ranch productivity. The conceptual framework is based on the following assumptions: 1) Climate variability is significant in rancher decision-making, and 2) Ranchers' decisions affect the adoption of practices and ranch productivity. A survey was designed to collect data on these factors. The next steps will involve using the findings from the survey and other data sources to model future scenarios of climate change adaptation of these livestock systems and assess the economic and environmental impacts of climate change adaptation strategies. The research will contribute to the climate debate on livestock production and seek to demystify livestock myths and their perceived effects on climate change.

(D66) Designing a deforestation-free clean cookstove and pellets for household applications in Malawi: preventing deforestation and indoor air pollution and mitigating climate change.

Abel Mkulama (he/him/his), UC Santa Cruz

The goal of this capstone project was to design an improved, deforestation-free, and affordable cookstove and fuel pellets and develop a business case for scaling this technology for urban households in Southern Africa. We want to promote micro-gasifier cookstoves and fuel pellets in Malawi using Lilongwe district as a launchpad and prevent deforestation, indoor air pollution and mitigate climate change. We carried out cookstove and pellet design iterations and lab experiments in Ethiopia and Lilongwe and built on a 2018 needs assessment survey conducted in 2018. We found to scale adoption of clean cookstoves, one should account social, economic and cultural factors in additional to the technical efficiency and local environmental factors.

Advances in Weather, Climate, and Ocean Modelling

(A07) Dynamically Downscaling Tropical Cyclones in the Single Forcing Experiments of CMIP6

George Gyabaah (he/him), Mississippi State University
Tropical cyclones (TCs) rank among the most devastating natural disasters, posing a significant threat to human lives and infrastructure. Understanding their response to human-induced climate change is thus crucial for developing accurate projections of future TC behavior and mitigating the associated risks. However, the prediction of changes in TC frequency, particularly at local scales, remains uncertain. While the majority of studies have focused on the impact of greenhouse gases (GHGs) on TCs, there is a growing body of evidence suggesting that anthropogenic aerosols may also play a significant role in influencing TC frequency. The primary objective of this study is to differentiate and quantify the impacts of anthropogenic aerosols and GHGs on TC frequency by utilizing high-resolution climate models. To achieve this, we will employ the Columbia Hazard Model (CHAZ) to downscale single forcing experiments in the Coupled Model Intercomparison Project Phase 6 (CMIP6). CHAZ offers a unique advantage in simulating the full range of TC intensities and landfall characteristics, which is not achievable with the standard CMIP6 1-degree model resolution. By disentangling and isolating the effects of anthropogenic aerosols and GHGs on TC frequency, this study aims to provide a comprehensive understanding of the various external forcings and their relative contributions to TC activity. The anticipated findings from this study will contribute significantly to enhancing the accuracy of future TC frequency projections. This, in turn, will aid in the development of more effective disaster management strategies, better preparedness for such events, and a more comprehensive understanding of the complex interactions between human-induced climate change and natural hazards like tropical cyclones.

(A08) Enhancing Resolution of Sea Ice Concentration with Machine Learning on the Northern Sea Route
Maria Luisa Rocha Santos da Silva (she/her), Brown University
The sea ice loss in the Arctic region is one of the early consequences of anthropogenic climate change, significantly impacting Arctic coastlines, ice-dependent species migrations, Arctic cultural practices, and global weather patterns. On the other hand, the reduction in sea ice also presents an opportunity for increased human economic activity in a previously inaccessible region for a significant part of the year. One prominent example is the Northern Sea Route (NSR), which offers potential advantages in terms of cost, speed, and environmental sustainability for cargo ships. Assessing the sea ice characteristics in the Straits regions is crucial for understanding the accessibility of the NSR, as these areas often provide safer navigational conditions. While CMIP6 climate models offer valuable insights into future sea ice changes, their limited spatial resolution often fails to represent the NSR straits regions accurately. This study proposes a novel approach utilizing a Super Resolution (SR) GAN model to enhance the spatial resolution of sea ice concentration in the Arctic straits of the NSR. By employing the SR-GAN model, the spatial resolution is functionally increased from 100 km to 25 km. Here, we focus on the period from 2021 to 2022, which is significant for the validation of the SR-GAN model. The higher spatial resolution obtained through the SR-GAN model enables a more precise

representation of the complex dynamics of sea ice, facilitating improved planning and decision-making for stakeholders. The findings of this research would contribute to a better understanding of the evolving Arctic environment and offer better support for the sustainable utilization of the NSR.

(B28) Dynamics and socioeconomic impact of tropical variability in a warming climate: An intermediate complexity modeling approach

Po Cheng Chen (he/him/his), University of Hawaii at Manoa

Tropical climate variability, influenced by phenomena like El Niño Southern Oscillation (ENSO), has global implications for weather, ecosystems, agriculture, and the economy. Understanding how tropical climate variability responds to a warming climate, including human-induced warming, is crucial due to its wide-ranging effects on society and ecosystems. While coupled general circulation models (CGCMs) have been developed to study climate variability, their diverse outputs still result in uncertainty in long-term climate projections. Therefore, there is a need to revisit the fundamental dynamics of climate variability. One approach is to develop an intermediate complexity model that bridges the gap in the hierarchy of climate models. This highly parameterized model allows us to explore and diagnose climate sensitivity by focusing on specific dynamic processes. Additionally, it serves as a valuable tool for studying atmospheric and oceanic dynamics across various parameters, streamlining experiments that would otherwise require more complex CGCMs. In this presentation, I will first introduce the methodology used to develop the Intermediate Tropical Atmosphere-Ocean (iTAO) model. The model aims to investigate the controlling feedback processes of tropical climate variability and warming. Secondly, I will present a framework for measuring the relationship between climate variability and different types of population networks. Moreover, I will demonstrate the use of a Deep Learning-based method to estimate a population forecasting model. By employing an intermediate complexity model and utilizing advanced techniques, we can enhance our understanding of tropical climate variability and its interaction with a changing climate. This knowledge will contribute to more accurate predictions and effective decision-making regarding the impacts of climate variability on our environment and society.

(B29) Improving weather forecasts under a changing climate through statistical postprocessing

Reagan McKinney (she/her), University of British Columbia

To fill this gap in knowledge, the Weather Forecast Research (WRF) model is being used to dynamically downscale the latest Canadian Earth System Model (CanESM2), a coarse GCM, to create high-resolution projections at 3 km grid spacing. Dynamical downscaling is a modeling technique that extrapolates the effects of large-scale climate processes from the coarse models, using them as initial boundary conditions to drive high-resolution models, allowing for small-scale processes, such as deep convection, to be resolved within the model rather than parameterized. A historical period (1986-2005) has been completed for validation, and future simulations (2046-2065) have been created under two climate mitigation scenarios. This model is also being used to drive high-resolution ocean models to investigate changes in temperature, oxygen, and ocean acidification. The goal of this study is to evaluate the added value of convective-permitting simulations over southwestern British Columbia and examine regional changes and extremes, specifically heat waves and atmospheric rivers, in the region for the mid-century.

(C50) Predictability of the Pacific Decadal Oscillation: Remote and Local Drivers
Evan Meeker (he/him), University of Wisconsin–Madison
The Pacific Decadal Oscillation (PDO) is the leading pattern of sea surface temperature (SST) variability in the North Pacific, and fluctuations of the PDO have been linked to climate variability and extreme events in North America and Eurasia. The PDO is defined as the first empirical orthogonal function (EOF) of SST in the North Pacific, and has been found to be an amalgamation of multiple physical processes rather than a single physical mode of oscillation. We assess the predictability of the PDO on seasonal-to-interannual timescales using the Community Earth System Model (CESM) Seasonal to Multi Year Large Ensemble (SMYLE). SMYLE hindcasts are 24 months long, and initialized every 3 months from 1970-2019. We find that the PDO exhibits substantial predictability across all initialization dates, with anomaly correlation coefficients (ACC) remaining above 0.5 for all seasons at leads up to 13 months. ACCs for hindcasts initialized in all seasons also exhibit a peak in October-November, which we hypothesize to be related to the deepening of the mixed layer and reemergence of ocean heat content anomalies from the previous winter. Furthermore, PDO ACC values in the full hindcast prediction outperform a best fit first order autoregressive process at leads greater than 4 months. This linear prediction can be extended through the inclusion of the predicted El Niño Southern Oscillation (ENSO). In this case, we find that the linear prediction matches the full hindcast prediction for leads up to 12 months, indicating the importance of a skillful ENSO prediction to predictability in the North Pacific.

(C51) Wind stress dependence on ocean surface velocity: Impact on ocean energetics and the mesoscale eddy field
Victorine Daubies (she/her), McGill University
What role do the oceans play in maintaining the present climate? Such pressing questions require in-depth understanding of atmospheric and oceanic dynamics and the development of predictive models. This research investigates how to correctly include the effect of ocean surface velocity on the wind stress in climate models. Previous studies have shown that accounting for the wind stress dependence on ocean surface velocity significantly reduces the wind power input into the ocean circulation. This ocean-atmosphere interaction is crucial to understanding ocean mixing (e.g., vertical exchanges of tracers such as CO2), as well as the ocean circulation (including the meridional overturning circulation). Typical wind stress formulations used in ocean models are function of the 10m winds, obtained from quasi realistic atmospheric models. However, recent

studies have shown that this parameterization leads to underestimated ocean mixing and other biases in models' output. This problem arises due to the discrepancy in the specification of stress at the ocean-atmosphere interface in the respective ocean and atmosphere models. Therefore, we propose an oceanic model forced with a stress calculated in such a way that guarantees the two stresses be equal, using boundary layer turbulence theory. Finally, we will investigate errors that ensue when using the traditional parameterizations compared to our new proposed method. Further work will seek to include sea surface temperature effects on the wind stress, which also lead to biases in ocean models' when incorrectly represented.

(D67) Projecting future climate changes and compound extremes using convective-permitting atmospheric downscaling over southwestern British Columbia and Washington

Eva Gnegy (she/her), University of British Columbia

The climate of southwestern British Columbia (BC), Canada and the U.S. state of Washington is influenced by the land-water interactions from the intricate coastlines of the Salish Sea and the complex terrain defined by the Coast Mountains, Cascades, and Olympic Mountains. Future climate projections can provide useful information for how to manage the resources and services it provides in the years to come. However, global climate models (GCMs) are often too coarse in spatial resolution to capture the small-scale features of coastal regions, especially ones like the Pacific Northwest that are also largely affected by topography and mesoscale weather. To fill this gap in knowledge, the Weather Forecast Research (WRF) model is being used to dynamically downscale the latest Canadian Earth System Model (CanESM2), a coarse GCM, to create high-resolution projections at 3 km grid spacing. Dynamical downscaling is a modelling technique that extrapolates the effects of large-scale climate processes from the coarse models, using them as initial boundary conditions to drive high-resolution models, allowing for small-scale processes, such as deep convection, to be resolved within the model rather than parameterized. A historical period (1986-2005) has been completed for validation, and future simulations (2046-2065) have been created under two climate mitigation scenarios. This model is also being used to drive high-resolution ocean models to investigate changes in temperature, oxygen, and ocean acidification. The goal of this study is to evaluate the added value of convective-permitting simulations over southwestern British Columbia and examine regional changes and extremes, specifically heat waves and atmospheric rivers, in the region for the mid-century.

(D68) Predicting AMOC Collapse: An Idealized Model Perspective

Clark Zimmerman (she/they), University of Wisconsin-Madison

"The potential for abrupt and catastrophic climate transitions resulting from anthropogenic climate change sparks intense debate. Particularly concerning is the potential collapse of the Atlantic Meridional Overturning Circulation (AMOC). Destabilizing feedbacks, such as changes in Atlantic salinity gradients, may drive the AMOC from its current "on" state into an "off" or

“reverse” state. However, substantial disagreement exists regarding the AMOC's classification as a tipping element and its proximity to collapse. This study investigates the potential multistability of the AMOC in increasingly complex idealized models utilizing Critical Slowing Down (CSD) indicators. CSD is manifested by an increase in early warning indicators like autocorrelation, variance, and return rate, reflecting the slowed response to external perturbations associated with a loss of stability. Confidently applying CSD necessitates specific assumptions about the system's dynamics and the properties of the time series.
Here, we test the performance of various CSD indicators on a range of idealized models of the AMOC, including a 2-box model, a 5-box model, and a model incorporating meridional dimensions that capture advection and diffusion. These investigations provide insights into expected behavior of universal CSD indicators in AMOC dynamics. Moreover, we assess whether the AMOC's dynamical structure allows for meaningful application of the CSD framework and whether the model's time series fulfill the necessary conditions. This research enhances our understanding of AMOC stability and the applicability of the CSD framework. Furthermore, it contributes to broader knowledge about climate tipping elements and their implications by examining the requisite conditions for meaningful CSD analysis."

Extreme Events in a Warming Climate

(A09) Heatwaves, a Hot Topic: A Regional Analysis of Their Metrics, Drivers, and Homogeneity

Calen Randall (he/him), University of California Davis

Heatwaves are a poster child for climate extremes. Despite capturing the attention of media, policymakers, and scientists, many gaps in our understanding of heatwaves and their geographic relationships remain. My research focuses on several of these questions including:

(1) What is the geographic distribution of heatwave metrics such as heatwave duration, intensity, and frequency? Much heatwave research focuses on historical trends and future projections of heatwave metrics. However, less research has identified regions of similar heatwave characteristics. I explore their geographic distributions within the Contiguous US (CONUS) and analyze their relationships with other variables including soil moisture, latent heat flux, leaf area index, temperature autocorrelation, etc. Particular emphasis is placed on the human and ecological impact of these heatwave metrics and drivers.

(2) What are the statistically homogeneous and distinct regions of the continental USA? Regionalization analysis is often applied to heatwave research by averaging heatwave statistics over regions defined by state or general climatological boundaries, but is this the optimal approach? Using a K-means clustering algorithm, I have identified regions of similar heatwave characteristics and compared their homogeneity with previously defined regions.

(3) The physical drivers of heatwaves are well understood, but how can we quantify which drivers (soil moisture, synoptic weather patterns, etc) are regionally more important? My

research utilizes a regression approach to answer the question "what drives temperature anomaly on a given heatwave day?"

(A10) The Relationship between Kuroshio Extension, the Pacific Decadal Precession, and Marine Heatwaves in a High-Resolution Global Climate Model

Nishchitha Etige (he/him), Boston University

Recent research indicates that there is a correlation between large-scale variations of the Kuroshio Extension and the occurrence of Marine Heatwaves in the Northeast Pacific such as the "Blob". A causal link has been established between Kuroshio Extension and downstream atmospheric pressure patterns. The Kuroshio Extension triggers the North-South atmospheric pressure dipole pattern of the Pacific Decadal Precession – A quasi-decadal mode of climate variability over the North Pacific Ocean. This atmospheric mode of variability is correlated to the Kuroshio Extension related sea surface temperature anomalies and the evolution of the 2013-2015 "Blob", which indicates that Kuroshio Extension variability provides favorable conditions for the emergence of the "Blob". The influence of the Kuroshio Extension further extends to the modification of nutrients in the region that influences the primary productivity, thus affecting the fish and shellfish populations. In this work, we determine how this atmospheric teleconnection between the Kuroshio Extension and the Northeast Pacific will change in future climate. using High-Resolution Community Earth System Model Output (High-resolution CESM). We first establish that the observed correlation between the Kuroshio Extension and the "Blob" are well represented in the present-day climate. Consequently, future climate projections allow us to determine how these links will be modified under a changing climate. Where this work will support a broader scope to determine the future of primary productivity and the fisheries implications in the region.

(C52) Projected Impacts of Extreme Heat on Perennial High-Value Crop growth using CESM2-LENS

Shawn Preston, Washington State University-Vancouver

The Pacific Northwest heatwave of late June and early July 2021 had substantial impacts on biotic and abiotic systems. Record-breaking temperatures in the region caused heat stress and drought conditions that resulted in detrimental effects on several crops. For example, Washington State, the leader of apple production for the U.S. accounting for 70% of total production (USDA NASS, 2021), experienced a 15-20% yield loss during this event (Rajagopalan, 2022). The driving factors behind this yield loss were extreme high temperatures and increased solar radiation, which led to sunburn and necrosis in crops (Schrader et al., 2003). With projected increases in the frequency and severity of extreme weather events and changes in the seasonality of temperature, the phenology (life cycle) of apples and other tree fruits may be significantly altered (Kalcsits et al., 2009). This study utilizes high-resolution observational datasets to quantify historical changes in several temperature-based metrics that influence the overall growth cycle of apple crops such as Growing Degree Days (GDD), frost risk, and sunburn risk, across the United States. In addition, we use a 100-member ensemble of climate simulations generated with the Community Earth System Model (CESM2; 1850-2080) to quantify projected changes and irreducible uncertainties in these metrics because of natural climate variability. Incorporating natural climate variability also allows us to characterize the potential extreme changes in these metrics. While Katzenberger et al. (2021) used large ensembles to model climate impacts on cereal crops, such an analysis does not yet exist for high-value crops such as apples.

(C53) Dynamical climate drivers and forest fire impacts of unexpected atmospheric drying in the interior Southwest

Tess Jacobson (they/them & she/her), Lamont-Doherty Earth Observatory/Columbia University

Over the last five decades, near-surface specific humidity has decreased in much of the Southwestern United States despite the increased moisture-holding capacity of a warming atmosphere. In the interior Southwest, this humidity decrease is partly due to a prior-season precipitation reduction leading to soil moisture deficits and decreased evapotranspiration to the lower troposphere in the spring and summer. This precipitation reduction is in turn related to a trend towards a Northern Hemisphere stationary wave pattern in springtime. Here, we show that the humidity decline in the interior Southwest has contributed substantially to the increase in burned forest area in the region over recent decades. We also show that the stationary wave trend is likely independent of the dominant modes of Pacific sea surface temperature variability and also is not forced by diabatic heating over the extratropical Pacific. Further, we diagnose changes in the spring Northern Hemisphere stationary wave field using wavenumber decomposition of reanalysis data, as well as in historical and radiatively forced general circulation model (GCM) scenarios in CMIP6, to investigate its possible atmospheric and oceanic drivers.

(D69) The Impacts of Precipitation Whiplash Events Across the CONUS

BryonyPuxley (she/her), University of Oklahoma

Precipitation whiplash events, when one precipitation extreme immediately follows the opposite extreme, can result in cascading impacts across a region. When a region rapidly transitions from drought to excessive rainfall (pluvial) conditions, it can pose a significant flood risk. Additionally, drought preceded by excessive rainfall can significantly increase fire risk across a region. Through, utilizing the National Centers for Environmental Information (NCEI) storm events database and the Monitoring Trends in Burn Severity (MTBS) program, this study examines the flood and wildfire impacts of precipitation whiplash events. Out of 465 drought-pluvial precipitation whiplash events identified using a percentile method of precipitation anomalies, only 16 (3.4\%) were not associated with either a flood, flash flood, or heavy rain report within the NCEI database. Additionally, excessive precipitation across Oklahoma during the summer of 2017 supported vigorous vegetation recovery and growth which was desiccated in the subsequent drought period. As a result, dozens of wildfires burned a total of 556,347 acres during March and April 2018 and resulted in at least two fatalities, dozens of homes destroyed, and over 500 personnel dispatched to fight and mitigate the fires. Although there is still so much to learn, we hope this study begins to unravel some of the key challenge areas in defining precipitation whiplash events and their association with flood and wildfire events across the continental United States.

Water Pathways in the Earth System

(A11) South Pacific ARs in different climate states: the thermodynamic and dynamic modulation of their frequency.

Carlos Ordaz (him/his), CUNY Graduate Center

Atmospheric rivers (ARs) play a crucial role in the poleward transport of water vapor and the AR-associated precipitation is a critical component of regional water supplies. In Chile, ARs account for the bulk of freshwater supply, making it critical that we understand how ARs may change in the future. To approach this issue, we use integrations of the NASA Goddard Institute for Space Studies global climate model ModelE version 2.1 (GISSE2.1). We consider multiple configurations of the model simulating different climates: (1) the last-glacial maximum; (2) present day; (3) the end of the 21st century. We also consider a set of idealized cold and warm climate in which present day sea surface temperatures are uniformly changed. We show that the mean state changes in poleward water vapor flux for different climates are dominated by thermodynamic changes. Next, we focus our efforts on ARs in the south Pacific Ocean basin including landfalling ARs over Chile. We contrast frequency and distribution of AR landfall events in the six runs by analyzing changes in the jet stream as well as two metrics for storm activity. We find that latitudinal shifts in the ARs in our integrations are not as tightly coupled to these two storm-related climatological metrics as expected. Finally, thermodynamic factors influencing precipitation associated with landfalling ARs over South America are analyzed through a separation of dynamical and thermodynamical contributors to AR's mean states.

(A12) Impacts of Urban Land Cover on Convective Cell Development and Precipitation Occurrence in Coastal Urban Areas: A Case Study of Houston, Texas

Oluwafemi Omitusa, University of Oklahoma

Understanding the relationships between local land cover, atmospheric conditions, and convective cell development is critical for thunderstorm prediction and preparedness. This research explores these relationships in Houston, Texas using land cover classification, convective cell tracking, and sounding data analysis. Convective cells were tracked from KHGX radar data and categorized as non-precipitating or precipitating using Stage-IV precipitation data. This classification allowed for analysis of differences in convective cell characteristics and development based on precipitation status. Two-year satellite land cover data for Houston were also classified into 17 local climate zones using random forest algorithm. Urban areas with high-rise buildings showed pronounced effects on convective cell development, with increased activity in compact and open high-rise areas. Open, green zones exhibited more non-precipitating cells, while heavy industry zones displayed heightened precipitating and non-precipitating cells, suggesting that aerosol emissions influence convective cell development. Additionally, 321 convective cells were tracked on a day with significant rainfall activity. The cells were grouped by lifetime and composited with interpolated sounding data. The results showed peak percentage changes in temperature, humidity, and wind direction for cells with a lifetime of 1.5 hours, indicating environmental modification during growth phases. Spatial analysis also revealed nocturnal cell initiation concentrated in northeast and northwest Houston, attributed to land-water boundaries and urban-rural contrasts. This research demonstrates sensitivities in atmospheric variables during initial cell stages and distinct geographic initiation patterns associated with local climate zones, providing insights into the connections between the urban environment, atmospheric conditions, and convective cell characteristics in Houston.

(B30) Exploring the Relationship Between Coastal Waves and Wintertime Precipitation in California

Anthony Meza (he/him), MIT-WHOI

California precipitation is highly variable and intense, with the state receiving most of its annual rainfall in 5 to 15 days. Most of this rainfall occurs in the wintertime and as much as 40% is carried by atmospheric rivers. Precipitation in California is correlated with modes of interannual variability within the ocean-atmosphere system such as the Madden-Julian oscillation and the El Niño Southern Oscillation (ENSO). Both climate modes influence regional precipitation through both atmospheric and oceanic teleconnections. The oceanic teleconnections come from equatorial Kelvin waves, which originate in the western equatorial Pacific Ocean by anomalously westerly or easterly surface winds. Equatorial Kelvin waves propagate across the equator, reach the Americas, and may continue propagating along the coastline as coastally trapped waves. Coastally trapped waves alter the vertical structure of the water column, which can effect surface temperatures in the event of mixing. While the influence of ENSO/MJO on regional precipitation via atmospheric teleconnections is well-established, it remains an open question whether oceanic teleconnections, specifically coastally trapped downwelling waves could influence the characteristics of the precipitation. We explore the statistical relationship between coastally trapped waves and wintertime precipitation in California. We find that those coastally trapped downwelling waves with SST signatures are associated with higher precipitation rates. These findings support previous theories which suggest that above-average SSTs can enhance convective available potential energy in storms, potentially leading to increased rainfall.

(B31) Assessing the Role of Arctic Atmospheric Rivers in a Changing Climate

Rudradutt Thaker (he/him/his), University of Wisconsin

The decline of Arctic sea ice in recent decades is closely associated with amplified warming and the heightened occurrence and intensity of storms in the region. Atmospheric Rivers which are usually associated with an extratropical cyclone, have the potential to impact Arctic sea ice through both thermodynamic and dynamic mechanisms. However, our current understanding of the evolving nature of ARs in a warming climate and their specific influence on sea ice remains incomplete. To address these knowledge gaps, we employed the Atmospheric River Detection and Tracking algorithm (ARDT) that utilizes meridional integrated vapor transport to identify ARs in the Arctic within the Community Earth System Model, Version 2 (CESM2). We evaluated CESM2's capacity to simulate intense ARs by comparing it to MERRA2 reanalysis data. Our findings demonstrate that CESM2 generally captures the patterns and prominent hotspots of ARs, exhibiting agreement with MERRA2 data during the 1980-2015 period. Furthermore, we investigated changes in AR behavior under the SSP370 scenario, which assumes high greenhouse gas emissions. A modified ARDT accounting for the moisture changes accompanying climate variations was employed. Our results reveal an increasing trend in AR occurrence during winter, fall, and spring, accompanied by intensified ARs throughout all seasons. Moreover, we assessed the impacts of ARs on sea ice and consistently observed a negative effect. Overall, our findings suggest that the escalating frequency and intensity of ARs could exacerbate the decline of Arctic sea ice, leading to significant consequences for the Arctic ecosystem and global climate.

(C54) Constraining Future Projections of Atmospheric Rivers using Poleward Latent Heat Transport

Ankur Mahesh, UC Berkeley

"Atmospheric rivers (ARs) are extreme weather events that can alleviate drought and cause billions of dollars in flood damage. Because they transport latent energy towards the poles, they are crucial to maintaining the climate system's energy balance. While ARs are characterized by long, narrow filaments of water vapor, there is no first-principles definition of ARs grounded in geophysical fluid mechanics. Therefore, AR identification is currently performed by a large array of expert-defined, threshold-based algorithms. The variety of algorithms has introduced uncertainty in the projected future behavior of ARs (O'Brien et. al. 2020) and the resulting floods and droughts. We propose a physics-based test to constrain future AR projections using the dynamics of the large-scale atmospheric circulation. A key property of ARs in boreal winter is that they dominate the meridional transport of moist static energy. The magnitude and latitudinal variation of this transport can be rigorously derived from the equations of atmospheric dynamics. We assess whether the aggregate of ARs detected by a given algorithm satisfies this physical property. We conduct this test on AR detections in three-hourly MERRA2 reanalysis and CMIP6 historical and future simulations. We find that AR-induced latent energy transport varies significantly across the ensemble of AR detection algorithms. Using an idealized perspective of heat transport and CMIP6 simulations, we explore the implications of this variation on future changes in poleward energy transport and AR-induced droughts and floods. "

(C55) Quantifying the contribution to western United States wildfire area burned due to trends from El Niño Southern Oscillation

Caroline Juang (she/her), Columbia University/ LDEO

In the western United States (US) where summer wildfires are common, warming and drying climate trends from natural and anthropogenic drivers have increased annual area burned ~1300% in four decades. A dominant mode of natural climate variability in the western US is the El Niño-Southern Oscillation (ENSO). From the 1980s-2000s to the 2000s-2020s, ENSO shifted from a predominantly warm-phase state with a weak sea-surface temperature (SST) gradient across the tropical Pacific to a predominantly cool-phase state with an enhanced SST gradient, likely enhancing fire-related hydroclimate beyond the effects from anthropogenic climate change alone. Importantly, coupled atmosphere-ocean climate models generally simulate a weakened tropical Pacific SST gradient in response to anthropogenic greenhouse-gas emissions, which are in contrast to the observed trends thus far. Contrasts between modeled and observed trends, combined with systematic model biases in equatorial Pacific ocean-atmosphere dynamics, potentially indicate a wider range of uncertainty in future western US hydroclimatic trends than is implied by climate model projections. In this research, we quantify the contribution of the tropical Pacific SST gradient to annual wildfire area by geography and vegetation type. Using this model and comparing results of the observed strengthening SST gradient trend to the scenario removing the trend, we found that the strengthening SST gradient was partly responsible for increases in area burned over the past four decades, mostly in forested regions. The La Niña-like SST gradient trend was most important to area burned in the southwestern US, where ENSO leads to reduced precipitation in the region, representing an important contribution to the trend in wildfire activity.

(D70) Understanding the influence of urban form on the spatial pattern of precipitation

Yanle Lu (she/her), Cornell University

Urban areas are known to modify the spatial pattern of precipitation climatology. Understanding their impact is crucial to managing precipitation hazard-related risks, especially amidst climate change and urbanization. While several mechanisms have been proposed to explain how thermodynamic and aerodynamic processes in the urban lower atmosphere interact with meteorological conditions to determine precipitation variability, the relative importance of these mechanisms in modifying urban-induced precipitation remains poorly understood. Existing studies predominantly consist of case studies or single-city analyses, limiting the generalizability of their findings. This study addresses this gap through a cross-city analysis of 25 selected cities to investigate how urban forms influence the climatological precipitation spatial patterns under diverse meteorological conditions. Utilizing Multi-Radar Multi-Sensor quantitative precipitation estimation data from six years' summer months, we find that over 80% of the studied cities exhibit statistically significant downwind enhancement of precipitation. Additionally, the characteristics of precipitation spatial patterns regarding the location of rainfall maxima, the magnitude of downwind enhancement, etc., vary with meteorological conditions such as precipitation intensity, wind speed, and wind direction. The city size, one metric of urban form, also interacts with meteorological conditions and subsequently impacts precipitation spatial patterns. This study provides robust observational evidence supporting that precipitation can be influenced by the urban modification of atmospheric processes. Future studies aim to develop predictive insights on how urban forms, conditioned by regional climate, concentrate the precipitation hazards spatially, thereby impacting urban populations and infrastructures. The implications extend beyond hydrology to other subfields such as atmospheric dynamics and urban design.

(D71) Hydrometeorological Drivers of Western US Summertime Temperature Variability
Lily Zhang (she/her), University of Washington
Year to year fluctuations in summertime temperatures have a large impact on drought, wildfire, and extreme heat across the Western US. We find strong evidence that soil moisture deficits in the preceding spring may be the primary driver of higher-than-average summer temperatures in this region. Our results suggest that memory in the water cycle may lead to greater predictability in the climate system from season to season.

(D72) Contribution of Resolved Mesoscale Systems to the North American Monsoon in High Resolution Simulations of the Mid-Pliocene
Mary Grace Albright (she/her), University of Connecticut
The North American Southwest (SW NA) has recently experienced periods of extreme drought, which is thought to be caused by anthropogenic global warming through enhanced regional evaporation. Yet, there remains large uncertainty in the predicted future changes of precipitation over this region. The North American Monsoon (NAM) is a feature of SW NA hydroclimate that has previously been shown to weaken in response to elevated atmospheric CO_2 in both future climate projections and in simulations of past warm periods. However, when analyzing proxy paleoclimate reconstructions during the Pliocene, various records suggest a wetter NAM region. The mid-Pliocene (3.3 – 3.0 Ma) is often used as an analog for ongoing climate change because it featured topography, geography, and biome assemblages similar to today, but a global mean temperature 2 - 4 °C warmer than pre-industrial. Here, we explore whether a high resolution (HR) simulation (25 km) can better capture the NAM compared to low resolution (100 km) simulations. In our mid-Pliocene simulations using the Community Earth System Model, greater summer precipitation is seen in the HR run on the eastern side of the Sierra Madre Occidental and along the Gulf of Mexico. By adapting a feature tracking algorithm to detect mesoscale convective systems (MCS) in HR simulation, we discovered an increase of MCS frequency and MCS-incurred precipitation during summer in the NAM area, suggesting a strong contribution of resolved mesoscale systems to the modeled increase in HR summer precipitation. This highlights the importance of resolving finer-scale weather systems in both predicting and hindcasting regional climate.

Social Science, Climate Justice, and Policy

(A13) Advancing Equity and Resilience: Community-Based Science for Climate Adaptation

Richelle Moskvichev (she, her, hers), University of Hawaii Manoa

Climate change has a disproportionate impact on marginalized communities worldwide. In pursuit of equitable knowledge exchanges, proactive climate adaptation, and effective science-to-policy strategies, community-based science emerges as a promising approach. This presentation highlights the Thriving Earth Exchange, sponsored by the American Geophysical Union (AGU), which trains volunteer scientists and project managers, matches them with communities in need, and cultivates sustainable relationships. As a participant in the summer 2023 cohort, this presentation shares firsthand experiences as a facilitator of a climate change mitigation project within a community. It explores both the challenges and opportunities encountered and provides practical tips and valuable lessons for conference attendees to apply in their own community science endeavors. By sharing experiences and insights, this presentation contributes to advancing equitable and resilient approaches to climate adaptation through community-based science. It underscores the value of establishing sustainable relationships, fostering knowledge exchange, and empowering communities to actively participate in shaping their own futures."

(A14) Event Based Scenario Planning to Inform Coastal Communities Adaptation Efforts

Olivia Doty (she/her), University of Michigan

In order for coastal communities to be able to adapt to the changing climate, communities need a concrete understanding of the ways that local sea level rise will affect people and infrastructure in the region. However, current projections of sea level rise–even at the local level–are often difficult to quantify and translate directly to community needs and organization. Here, we explore the use of event-based scenario planning approaches to aid community decision making. Event based scenario planning analyzes a range of plausible future states of the climate to assess the impacts of a catastrophic disruption on critical infrastructure, such as hurricanes superimposed on sea level rise that hit coastal communities. Scenario planning with the focus of a critical event has been used previously in Europe and the U.S. to define the risks associated with increased storm surge, and allows for translation of climate risk into succinct event based scenarios, often called storylines, that decision makers can use in developing adaptation plans and addresses the uncertainty innate with such disruptions. Here, we illustrate the potential of event based scenario planning using examples from McIntosh County, on the Georgia coast and the city of Charleston, South Carolina. These communities have a history of flooding and unique socioeconomic stressors that need to be incorporated into community discussion and planning, as well as limited capacity to assess potential co-benefits and trade-offs.

(B32) Improving Conservation Planning in South Dakota with Climate Science, Collaboration, and Public Participation

Vivian Hulugh (she/her/hers), South Dakota State University

Climate change poses a significant threat to both wildlife and fish habitats and populations. With unprecedented ecological shifts taking place, it is crucial for conservation managers to develop plans that are adaptable to future changes. This study aims to explore three critical aspects of conservation planning: the use of climate science, coordination with partners, and engagement with the public. This research will investigate how natural resource managers within federal and state conservation agencies in South Dakota integrate these three components into their decision-making processes. To gain insights into the use of climate information, ten interviews will be conducted with scientists affiliated with climate organizations responsible for providing long-term climate data. Additionally, thirty interviews will be conducted with natural resource managers working within Wind Cave and Badlands National Parks, the South Dakota Game, Fish and Parks agency, and the United States Fish and Wildlife Service. Interviews with managers will also gather information on their efforts to engage the public in decision-making processes. This study will also explore how agencies coordinate with tribes and nongovernmental conservation organizations. To achieve this, ten interviews will be conducted with representatives from organizations such as the American Bird Conservancy, Pheasants Forever, Ducks Unlimited, The Nature Conservancy, Rosebud Sioux Tribe, and Standing Rock Sioux Tribe. A social network map will be developed to identify gaps in representation during planning. The findings of this study will provide insights to improve resilience, foster collaboration, promote inclusivity, and ensure equity in conservation planning; and will inform policy changes in conservation.

(B33) What Have We Learned? Navigating the Climate Change Research Landscape in Nunavut (2004-2021)

Faith Rahman (she/her), McMaster University

Nunavut is one of four land claim regions in Inuit Nunangat (Inuit homelands in the Canadian Arctic), as well as one of three Canadian Territories. In Nunavut, accelerating climate change is impacting ice and weather patterns, key wildlife, and risks for Inuit travel on the land, water, and ice, which in turn affect Inuit health and well-being. In 2022, the Nunavut Research Institute (NRI) and Government of Nunavut Climate Change Secretariat (CCS) identified the need to undertake a situational analysis of the scope and evolution of climate change research conducted in Nunavut over the last two decades (2004-2021). While the NRI research licensing database tracks most research in Nunavut, it does not effectively capture research permitted by other territorial and federal agencies nor community-led research. This study seeks to identify trends in who is leading climate change research in Nunavut, as well as where it is taking place, on what topics, and potential opportunities to improve coordination between research licensing and permitting agencies. Working with project summaries from licensing, permitting, and funding applications, I am using NVivo qualitative analysis software to facilitate thematic content analysis. I will also spend time in Iqaluit, Nunavut collaborating with NRI and CCS partners to share and interpret results. This research is guided by "piliriqatigiinniq", an Inuit principle that prioritizes working together for the common good. Working towards NRI and CCS priorities will inform territorial climate change policy and adaption planning, improve the accessibility and relevance of climate change research for decision-making, and benefit Nunavummiut.

(B34) Heat Stress with Aging in a Changing Climate

Haley Staudmyer (she/her/hers), University of California, Irvine

Anthropogenic climate change is causing extreme heat events to become more frequent, intense, and longer in duration. Hot conditions can cause a variety of health issues. The elderly are more susceptible to adverse heat-health outcomes. Age impairs the body's ability to cool itself down via mechanisms such as sweating. The impacts of age on heat resilience are relevant because the world population is aging on average as healthcare improves. It is presently unclear whether the changing climate or the aging population primarily drives increased future risk to extreme heat events. To accurately project future heat stress, we must strengthen our understanding of the relative impacts of climate change and an aging population on heat risk.

This project will use a nuanced physiologic model to create projections of heat stress, factoring in both the aging population and climate change. The physiologic model projects the maximum metabolic rate a person of a certain age could achieve before experiencing heat stroke given the input climatic conditions. The maximum metabolic rate defines what level of activity is possible (e.g., rest, cleaning, hard labor) in the given scenario. We will estimate future heat stress by applying this physiologic model to CMIP6 SSP2-4.5 climate model output, accounting for the aging population. Additionally, we will perform experiments where one of the two considered drivers of heat stress (age or climate change) is held stable to understand the relative impacts of the drivers.

(C56) How did we get here? From global acceptance of renewable energy as a climate solution to environmental injustice

Chinedu Nsude (he/him), University of Oklahoma

Transitioning to a sustainable energy system, such as adopting Renewable Energy Technologies (RETs), is essential for achieving decarbonization, meeting energy demands, and combating climate change. However, the growing scale of renewable energy technologies has led to severe cases of environmental injustices which jeopardize the lives and well-being of already vulnerable communities. This menace has now led to a global call to ensure that building RETs does not exacerbate environmental and social challenges, especially in the siting process, because these conflicts not only hinder the success of building renewable energy systems but can also create their own environmental and sociological drawbacks. In this study, we first explore 113 global cases of environmental injustice across four RETs (solar, wind, biomass, and geothermal) using data from the Global Environmental Justice Atlas (GEJA). Secondly, we performed an analysis of how these environmental injustices and conflicts have been addressed globally to understand if local or host communities have or have not received justice. Finally, we proposed a novel solution culled from the principles of Critical Restoration Geography (CRT) as a potential solution to how these injustices of future RET projects can be avoided. Our motivation for this study is to ensure that sustainability strategies and justice are applied during RETs siting and implementation and to ensure that already existing RETs siting conflicts are addressed appropriately.

(C57) Climate adaptability and resiliency of wildlife communities in burned sagebrush-steppe landscapes

Katherine Burgstahler (she/her/hers), Washington State University

Sagebrush steppe ecosystems provide livelihoods for humans and essential habitats for wildlife across the western U.S. However, these landscapes have been heavily altered or lost through human activities and wildfire, and climate change is expected to cause changes to the quality and connections between habitat patches that could exacerbate declining populations of vulnerable wildlife species. In Washington, many sagebrush-associated vertebrates are listed or are candidates for listing at the federal or state level. To better manage these ecosystems under shifting climate conditions, my research team is examining how wildfire severity and frequency influence the value of sagebrush patches. This project involves 1) an extensive field survey in the Snake-Columbia sagebrush-steppe ecoregion, focusing efforts on species of conservation or management interest including Greater sage grouse, Sharp-tailed grouse, white- and black-tailed jackrabbit, pygmy rabbit, and Washington ground squirrel and 2) modelling species occupancy to determine how wildlife use previously burned and recovering shrub steppe habitat. Over three summer field seasons (2022-2024), we will survey 120 sites using four camera traps spaced 300 meters apart, two avian point counts, fecal pellet surveys along four 50-meter transects, and various vegetation community measurements. From our data, we will build single-season, single-species occupancy models that predict the likelihood of wildlife communities and individual species occupying various ages and frequencies of burns. This project will benefit a range of stakeholders by providing information needed to make short-term modifications to land management and long-term planning decisions related to climatic resiliency for wildlife.

(D73) Electrifying UCSD: The path to a zero-emission campus

Alexander Andriatis (he/him), UC San Diego

Emission reduction targets across multiple scales of governance state that decarbonization should happen within the next decade. However, despite a growing body of research about the physics and impacts of climate change, many universities have made little or no progress on decarbonizing their own campuses. UC San Diego is no exception, emitting about 300,000 tons of CO_2 per year, primarily by burning fracked methane gas for electricity, heating, and cooling. As a potential path to reducing carbon emissions, previous studies of decarbonizing UCSD have recommended partial electrification, which involves replacing thermal energy supplied by burning fossil fuels on campus with heat produced from renewable sources of electricity. Here, I expand on those previous studies by modeling the energy intensity and cost associated with several decarbonization pathways that use a wider scope of electrification technologies. I find that full electrification could result in the lowest overall energy use, lowest emissions, and cheapest annual fuel costs when compared with other decarbonization strategies. By embarking on an energy transformation that eliminates emissions and reduces energy intensity, a university such as UC San Diego can be a role model for other institutions, and support important climate research by implementing climate solutions.

CDR Technologies and Climate Solutions

(A15) Applications of Machine Learning to Magnetotelluric Data of Geothermal Systems

Jae Deok Kim (he / him), MIT-WHOI Joint Program

As nations strive to limit global warming to well below 2 degrees Celsius above pre-industrial times, transitioning to sustainable and low-carbon energy sources becomes imperative. Geothermal energy holds significant potential as a reliable and clean source of power generation, and in particular, as a candidate for year-round baseload provision. This is because geothermal energy harnesses the heat that occurs naturally at the subsurface of the Earth, and thus, can achieve predictable and stable power outputs, complementing the power generated from other renewable sources that rely on intermittent or unstable weather conditions. However, geothermal energy faces several institutional and economic barriers that have hindered its widespread implementation. Notably, the development of geothermal power plants often involves high exploration and capital risks. These risks stem from the need to understand the structure and characteristics of the subsurface, and geophysics plays a vital role in providing crucial insights into these aspects. The magnetotelluric (MT) method has emerged as a powerful geophysical technique that offers invaluable insights into the electrical resistivity of the subsurface. Geothermal systems are characterized by variations in subsurface resistivity caused by the presence of hot fluids and conductive materials, and thus, MT plays a crucial role in characterizing the properties of geothermal reservoirs. We investigate applications of deep learning techniques for the analysis of MT data collected over various geothermal sites. We leverage deep learning on MT data to extract key information to bypass the need for full inversion and improve physical parameter estimation for key subsurface properties.

(A16) Variations of the efficiency of ocean alkalinity enhancement in the Atlantic Ocean

Mengyang Zhou (he/him), University of Connecticut

To limit global warming to 2°C by 2100, carbon dioxide removal (CDR) from the atmosphere will be necessary. Ocean alkalinity enhancement (OAE) is one of the most promising approaches to achieve CDR at large scale. However, OAE experiments are subjected to incomplete air-sea CO2 exchange that impairs the efficiency of OAE, defined as the excess CO2 uptake per alkalinity addition. Here, we investigated the efficiency of OAE in the Atlantic Ocean.

Simulations of alkalinity perturbations were performed with the fully-coupled 1-degree Community Earth System Model version 2 (CESM2) with Parallel Ocean Program 2 (POP2) as its ocean component. We used an unsupervised machine learning algorithm, K-means, to cluster ocean grid points into 150 unstructured patches that cover the Atlantic ocean from 10°S to 75°N. Alkalinity was added at the surface ocean in each of the 150 patches and in 4 different seasons of a year. Simulations were run for 15 years, from which we generated a gridded dataset ("lookup" map) of CO2 re-equilibration dynamics and timescales. We are working on expanding the map of OAE efficiency to the global ocean. Eventually our study will help the CDR community to identify where in the oceans and in which seasons the OAE deployments are most suited in terms of the risk of insufficient air-sea CO2 equilibration. It will also contribute to a better understanding of how physical regimes and background carbonate states influence the efficiency of OAE, and how to achieve the "unavoidable" gigatone-scale CO2 removal.

(B35) Evaluating the species-specific response of coccolithophores to Ocean Alkalinity Enhancement (OAE)

Chloe Dean (she/her) Woods Hole Oceanographic Institution-MIT Joint Program

In the coming decades, humanity must implement new, effective methods of atmospheric carbon capture if we are to avoid the most dangerous scenarios and consequences of climate change. Ocean Alkalinity Enhancement (OAE) is a promising marine carbon dioxide removal (mCDR) approach that aims to increase seawater’s buffering capacity. However, it is not well understood how marine biology will respond to OAE, especially with regards to changes in carbon fixation, calcification, and downstream effects regarding the export of carbon through the biological carbon pump. Coccolithophores are a group of calcifying phytoplankton that are critical in linking the marine carbon, calcium carbonate and alkalinity cycles. To address the fundamental lack of knowledge regarding coccolithophores and OAE, we conducted laboratory experiments to evaluate the species-specific response of coccolithophores to enhanced alkalinity. We assessed the response of three major species (Emiliania huxleyi, Gephyrocapsa oceanica, and Coccolithus pelagicus subsp. braarudii) to a range of enhanced alkalinity conditions that represent: 1) immediate alkalinity addition with no atmospheric equilibration 2) long term alkalinity addition with atmospheric equilibration and 3) control with no alkalinity enhancement. Over the course of multiple generations, we tracked cellular growth rates, carbon fixation rates (using a novel 13C spike method) into both organic and inorganic carbon pools, coccosphere morphology and mineralogy, as well as physiological metrics for organism and photosynthetic health. This study highlights the species-specific responses of coccolithophores to OAE and provides a foundation for conducting further research in understanding how natural microbial communities may respond to OAE in situ.

(B36) Estimating greenhouse gas emissions by emulating atmospheric transport using machine learning

Nikhil Dadheech (he/him), University of Washington

Carbon dioxide and methane are the two strongest anthropogenic greenhouse gases (GHGs) and account for more than 85% of the GHG radiative forcing since pre-industrial times. Previous work has shown that point sources for CO2 and methane are responsible for a large percentage of their total emission budget. However, these point sources only represent a small physical area. As such, studying these point sources necessitates densely spaced measurements. Fortunately, there has been a proliferation of dense observing systems for GHGs over the past decade including both next generation satellites and surface networks. Constructing source-receptor operator (i.e., "footprint") allows researchers to conduct GHG flux inversions, but constructing this operator is computationally expensive. This often becomes computationally intractable as the number of measurements increases, as is the case for next-generation of GHG observing systems. Additionally, there is a large storage cost associated with these high-resolution footprints. Briefly, we developed a machine learning-based (ML) model to emulate atmospheric transport and generate footprints. This ML model can serve as a surrogate for the full-physics model in a GHG flux inversion. The ML emulator is 1000x faster than the full-physics model and, as such, footprints can be computed on the fly when needed, rather than stored. The accuracy of GHG flux inversion using the ML emulator has been evaluated against a prototypical case from the published literature. The ML model helps in efficiently interpreting high-resolution measurements from next generation dense observing systems. It also addresses the computational bottlenecks which limit our understanding of point sources.

Ocean Biogeochemistry

(A17) Seawater Carbonate Chemistry on Seamounts in the Hawaiian Emperor Seamount Chain, North Pacific

Siobhan Kassem, Texas A&M University

Since the industrial revolution, atmospheric carbon dioxide (CO2) has increased ~50% due to human impacts, including burning fossil fuels and agriculture. Anthropogenic atmospheric CO2 enters the ocean and mixes with water, resulting in a decrease in pH. This process, termed ocean acidification, also causes a decrease in carbonate ions needed for calcifying organisms like corals to make their calcium carbonate skeletons. Corals require seawater conditions that chemically favor calcium carbonate growth (calcification) as opposed to degradation (dissolution). The aragonite saturation horizon (ASH) is the depth at which the aragonite saturation state (Ωar) equals 1. Above this depth (Ωar >1) formation of aragonite coral skeletons are thermodynamically favored, but below this depth (Ωar <1) dissolution is favored. Ocean acidification is causing Ωar to decrease and the ASH to shoal, endangering deep-sea coral reefs that support biological diversity and critical fisheries. Seawater carbonate chemistry was characterized at 9 seamounts in the Hawaiian-Emperor Seamount Chain (HESC) in the North Pacific, where the ASH depth ranged from 550-650 m. Deep-sea coral reefs were found at depths both above and below the ASH, meaning reefs below the ASH should be dissolving. Here, we compare the seawater chemistry directly on the coral reefs using water samples collected via remotely operated vehicle to shipboard samples collected at similar depths in the nearby the open ocean. Offsets between reef samples and nearby open ocean samples may provide insight into processes that enable deep-sea corals to maintain the reef structure when Ωar <1.

(A18) Modeling the Impacts of Climate Change on Water Quality in the St. Louis River Estuary: A System-Wide Approach

Kenny Larsen (he/him), Michigan Technological University

Freshwater estuaries play a crucial role in biogeochemical cycling and ecological diversity, bridging the gap between lentic and lotic systems. Despite their importance, freshwater estuaries, such as the St. Louis River Estuary (SLRE), have received limited research attention, considering the essential ecosystem services they provide. The SLRE, located at the mouth of Lake Superior's largest tributary, has suffered extensive impacts from human activities, resulting in a degraded system designated as a Great Lakes Area of Concern. Moreover, the SLRE and its tributaries are listed as impaired due to pollution on state-level assessments. Climate change poses a significant threat to the SLRE, with the Great Lakes region, particularly Lake Superior, experiencing accelerated warming rates. Anthropogenic climate change is predicted to bring about extreme rain events, flooding, and altered climate patterns. Understanding the combined impact of these changes, including increased nutrient loads, water temperature, and lake levels, on water quality requires a comprehensive system-wide approach. This study uses the Coastal Generalized Ecosystem Model (CGEM), a three-dimensional water quality model, and an Environmental Fluid Dynamics Code (EFDC) hydrodynamic model to simulate the impacts of climate change on spatial nutrient dynamics in a freshwater estuary. RCP 8.5 scenarios potential impacts of climate change on nutrient dynamics in freshwater estuaries. Through this research, we seek to assess the impacts of climate change-related stressors on water quality and nutrient dynamics within the SLRE. The findings enhance our understanding of how climate change affects freshwater estuaries and provide valuable insights for sustainable management and conservation strategies.

(B37) Impact of anthropogenic climate change on phytoplankton community structure through- out the Arctic Ocean

Gabriela Negrete García (she/her), Scripps Institution of Oceanography

The Arctic Ocean environment is changing rapidly due to rising ocean surface temperatures, declining sea-ice extent, increasing stratification, higher river flows, and declining snow cover. Because the growth of phytoplankton in the Arctic Ocean is seasonally limited by light, temperature, and nutrients, these environmental changes are likely to modify phytoplankton community structure, leading to ecosystem-level variations in pelagic and benthic energy flows. Here, we develop the Size-based Plankton Ecological TRAits (SPECTRA) model, a trait-based plankton community model composed of diverse phytoplankton and zooplankton embedded in a global circulation model forced by historic atmospheric forcing, to study the mechanisms underpinning changes in plankton community structure and trophic transfers change in the Arctic on seasonal to interannual timescales. The model simulates the regional and seasonal patterns of abundance for a range of phytoplankton functional groups and cell sizes as well as their zooplankton predators. In this contribution, we discuss how seasonal and interannual environmental variations in the Arctic select for model plankton of varying traits, as well as the response of carbon export to these underlying ecological changes.

(B38) A Spatiotemporal Analysis of Ocean Acidification in the Pacific Arctic Region
Thomas Caero (he/him), University of Rhode Island - Graduate School of Oceanography (GSO)
The Pacific Arctic Region (PAR) is highly vulnerable to ocean acidification (OA) due to its inherently low temperature, buffer capacity, and aragonite saturation state (Ω). Climate change-driven warming has the potential to intensify PAR OA by accelerating sea ice melt, increasing riverine discharge, and shifting ocean circulation, causing pH and Ω to decrease. Due to the financial and logistical challenges of high-latitude deployments, investigators often only measure one CO2 parameter despite the fact that two are needed to determine pH and Ω. Over the past decades, sensors that continuously sample surface pCO2 have been increasingly utilized and provide the bulk of autonomous carbonate system observations for the OA research community in the PAR. Consequently, PAR OA studies predominantly focus on surface pCO2, but not pH or Ω. To address these limitations, we aggregated open-source water column carbonate system datasets throughout the PAR and established spatially dependent relationships between salinity and alkalinity. We then applied these relationships to gridded sea surface salinity and temperature products to obtain monthly surface alkalinity fields. These were coupled with the surface pCO2 product by Jersild et al, 2023 (doi: 10.7289/v5z899n6) to obtain monthly 1x1 degree surface pH, Ω, and dissolved inorganic carbon fields from 1982-2021 for the entire PAR. Preliminary analyses reveal significant decrease in Ω in the Arctic Ocean driven by increased carbon flux due to reduced ice cover, as well as an increase in Ω in the Bering Sea, possibly due to warming and biological activity.

(C58) Decomposing Picophytoplankton Growth Rates with Time Series Analysis
Katherine Qi (she/her), University of Washington
Prochlorococcus and Synechococcus are two groups of picocyanobacteria that contribute to large fractions of global marine primary production. Their widespread geographic coverage and high abundances allow them to dominate the surface oceans, particularly in oligotrophic gyres. Although Prochlorococcus and Synechococcus are typically co-occurring, different environmental conditions and biological interactions affect their distributions and growth rates. Additionally, global models predict increases in abundance for both populations with rising temperatures and decreased vertical mixing. These organisms also have different ecotypes, or subspecies, that have varying ranges of optima and tolerance for subsequent environmental constraints. Thus, understanding patterns in natural cell populations can be complex under dynamic ecosystems, especially compounded with the effects of climate change. In situ

Prochlorococcus and Synechococcus growth rates were calculated from observational flow cytometry data and time series decomposition models. Temperature drove increases in Prochlorococcus daily growth rates up to ~26ºC, which appeared to be a population thermal limit. Hourly growth rates were controlled by light for both Prochlorococcus and Synechococcus, and maximal growth was dependent on the total accumulated light received per day. By detangling and identifying the main drivers of growth and production in picocyanobacteria, many marine ecosystems, especially the open ocean, can be better understood from the bottom up. Quantifying ranges of these biological rates can allow for better estimations from regional and global models, which can help identify high risk ecosystems and predict ecological shifts in potential future climate scenarios.

(C59) Transport Pathways for Iron Supply to the Australian Antarctic Ridge Phytoplankton Bloom

Amanda Vanegas Ledesma (she/her), Stanford University

The unique interactions between biogeochemical and physical processes in the Southern Ocean make this region a critical component of the global carbon cycle. Previous work has shown that waters south of 50S account for 22% of the oceanic yearly uptake of atmospheric CO_2, despite representing only 10% of the total ocean surface. In contrast to oligothropic regions of the ocean, where biological productivity is limited by the availability of macronutrients, such as nitrogen, in the Southern Ocean the productivity is limited by iron and light. Every year during the summer, when light is abundant, a plume of iron rich waters allows the formation of a 266,000 km^2 phytoplankton bloom to the northwest of the Ross Sea, above the Antarctic Australian Ridge (AAR). The source of these iron rich waters is not known. Here, we describe Lagrangian advection experiments to infer their origin and trajectories. The experiments are conducted using the Southern Ocean State Estimate. Results of Lagrangian tracking of bloom waters suggest a pathway of iron rich waters from Antarctica's shelf-slope system to the AAR bloom site. Furthermore, results show how these waters can be advected by the lower branch of the Ross Sea gyre along isopycnal surfaces. A changing climate has the potential to impact iron transport dynamics in the polar oceans, for example, through changes in freshwater inputs. Hence, understanding the origin of iron rich waters supplying the AAR Bloom could bring clarity to the processes that control natural iron fertilization around Antarctica, their impact on CO_2 sequestration, and their evolution through a changing climate.

(D74) Quantifying Biological Carbon Pump Parameters Using Particulate Backscatter Data from Biogeochemical Argo Floats

Ellen Park (she/her), MIT-Woods Hole Oceanographic Institution

The ocean plays an important role in regulating the Earth's climate because it is a large carbon sink for anthropogenic carbon dioxide. This uptake occurs at the air-sea interface due to a combination of physical and biological processes, which are commonly referred to as carbon pumps. The biological carbon pump (BCP) transfers carbon against its concentration gradient via the sinking of particulate organic matter that is produced in the surface oceans. At baseline, the BCP removes an estimated 6-12 Pg C from the surface ocean annually, which is approximately equivalent to annual anthropogenic CO2 emissions. The BCP's magnitude and variability of the of the drawdown of atmospheric CO2 have large uncertainties due to varying ecosystem compositions, ocean dynamics, and limited measurements across space and time. Here, we use Biogeochemical Argo (BGC-Argo) floats, which make year-round measurements across the world's oceans, equipped with particulate backscatter sensors to observe carbon particles sinking from the surface ocean and to quantify BCP metrics across different biomes in the North Atlantic. The particulate backscatter signal can be decomposed into large and small particle contributions. These values will be used to estimate large and small particle sinking rates, particulate matter attenuation coefficients, and transfer efficiencies. Quantifying these values and comparing these differences across time and biomes are important for reducing the uncertainties in the biological carbon pump, and therefore improving our ability to constrain the global carbon cycle.

Ocean Circulation and Dynamics

(A19) Abyssal Oceanographic Conditions in the Clarion-Clipperton Zone: Implications for the Dispersal of Marine Particles and Anthropogenic Pollutants

Sean Chen (he/him), MIT-WHOI Joint Program in Oceanography

The dispersal of marine particles and anthropogenic pollutants in the abyssal ocean is a largely overlooked topic. With the rise of interest in both marine carbon dioxide removal and deep-sea mining, understanding the possible fate of anthropogenic pollutants associated with such activities is critical for assessing the potential impact on benthic ecosystem functioning and deep-ocean biogeochemistry. Here, we present some conductivity-temperature-depth (CTD) cast results from the abyssal portion (with water depth ~ 4000 m) of the Clarion-Clipperton Zone (CCZ) in the tropical northeastern Pacific, where the development of deep-sea mining activities is rapidly gaining momentum. The sporadic casts show the presence of a spatially and temporally varying bottom boundary layer, characterised by bottom mixed layers with varying thicknesses. Current-meter data show anticyclonic flow patterns over time that may be attributable to passing mesoscale eddies in the upper ocean. By examining bottom topography, we find that the variability could also be heavily influenced by a nearby abyssal hill up to 2000 m tall above the seabed. While the bottom boundary layer appears well mixed over varying thicknesses, it is unclear whether mixing is active within and above the layer, due to the lack of in-situ turbulence measurements. To this end, an in-situ deep-Argo turbulence measurement sensor is being developed, with the hope to be deployed for field testing later this year. The sensor will be deployed in the deep CCZ to measure energy dissipation rates in the bottom boundary layer in the future. The measured variables will help estimate the turbulent mixing coefficients to be used for modelling the dispersal of marine particles and anthropogenic pollutants, which will be essential for consolidating policies governing human activities in the deep ocean.

(A20) A first look! The relationship between U.S. northeast coastal sea level variability and the Shelfbreak Jet

Elena Perez (she/her), MIT-WHOI Joint Program

The relationship between coastal ocean currents and sea level variability remains limited, particularly regarding the shelfbreak jet, an equatorward flowing current from the subpolar North Atlantic along the North American shelf break to Cape Hatteras, which Thompson (1986) hypothesized exerts significant control over coastal sea level variability. Despite almost 40 years passing since this hypothesis, no one, to our knowledge, has examined the dynamics between the shelfbreak jet and coastal sea level variability on the U.S. northeast coast. In this study, we develop a simple model for an idealized shelf break jet and discover that coastal sea level is more sensitive to changes in the jet's transport than changes in the overturning circulation's transport (Little et al., 2019). By addressing this research gap, our project enhances our understanding of the factors influencing coastal sea level variability, considering that previous studies have shown that the Gulf Stream does not exert significant control over sea level variability north of Cape Hatteras. Our straightforward model establishes a foundation for future investigations that can predict future sea level variability or even past climate. The next phase of this project involves validating the model's predictions against observations. Should the model demonstrate reliable performance, we could use the model to explore past, current, and future sea level variability, which is relevant to the densely populated U.S. northeast coast. Ultimately, this work expands our comprehension of the factors influencing coastal sea level variability and its implications for human populations.

(B39) Characteristics and Mechanisms of Gulf Stream Variability

Lilli Enders (she/her), MIT-WHOI Joint Program

The Gulf Stream is the western boundary current (WBC) of the North Atlantic Ocean, which transports heat poleward along the east coast of North America. Like other WBCs, the Gulf Stream is a region of intense ocean variability. After its separation from the coast near Cape Hatteras, the Gulf Stream exhibits strong variability in the meridional shift of its path. In addition to being an indicator of climate change, this path variability has been directly linked to many socio-economically important aspects of the climate system, including North Atlantic blocking frequency and the distribution of fish on the Northeast U.S. continental shelf. Despite its importance, the driving mechanism of Gulf Stream path variability remains unclear. This lack of clarity is compounded by large mean biases in climate models over the Gulf Stream region, which translates to minimum prediction skill in climate prediction simulations. In this work, we compare simulations from a standard resolution climate model (CESM1-Large Ensemble, nominal 1˚ resolution in the ocean and atmosphere) and a high-resolution climate model (CESM-High Resolution, 0.25˚ atmospheric resolution, 0.1˚ oceanic resolution) to quantify the regional biases in each model and to investigate whether increased model resolution improves representation of Gulf Stream path variability. We then propose key processes, including wind and buoyancy forcing, responsible for the biases and variability representation in each model with the goal of improving simulations, and subsequently prediction skill, in the Gulf Stream region.

(B40) Role of Mesoscale Eddies and Bathymetry in Ocean Heat Transport from the Atlantic to the Arctic

Esteban Avella Shaw (he/his), McGill University

The rapid Arctic sea ice decline has major consequences for the regional and global climate, as well as for the ecosystems and populations of the far North. Although it is acknowledged that the ocean heat transport plays an important role in this decline, a detailed understanding of its underlying mechanisms is lacking. Specifically, mesoscale structures (10 -- 100 km eddies, fronts, or filaments) could contribute significantly to this transport. Bathymetry (including small-scale structures such as seamounts and canyons) also has a major impact on current trajectories. However, the lack of observations and explicit representations of these scales in models prevents us from accurately documenting and quantifying their contribution to heat transport. In this project, I used two configurations of the GFDL CM2-O model suite differing in their horizontal ocean resolutions (0.25° and 0.10°) to quantify the influence of topography on water trajectories. To do so, I performed Lagrangian tracking experiments using virtual particles advected from the velocity fields of a preindustrial and climate change simulation, produced with each model. These particles are injected in the relatively warm Atlantic waters and tracked up to the base of the mixed layer. Then, the tracking experiment was reproduced only with mesoscale velocities. Analysis of the trajectories of the particles allows to reveal the influence of topography on water trajectories, as well as the contribution of the mesoscale. A comparison between the two configurations will reveal the impact of a refined resolution of topographic structures and of the mesoscale in a preindustrial and future climate.

(C60) Tropical Submesoscale Dynamics as Inferred From an Array of Saildrones.

Mackenzie Blanusa (she/her), University of Connecticut

Submesoscale dynamics are small-scale processes that occur throughout the ocean and may have an important effect on Earth's climate. One field campaign that sought to understand submesoscale dynamics was the Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign (ATOMIC) which took place in the northwest tropical Atlantic in early 2020. This region is dynamically rich, characterized by mesoscale eddies termed North Brazil Current Rings (NBCRs) and influence from Amazon River discharge. ATOMIC deployed three saildrones—uncrewed surface vehicles (USVs) powered by wind and solar energy and equipped with several oceanographic and atmospheric sensors. Saildrones collected upper-ocean velocity measurements with a 150 kHz acoustic doppler current profiler, with a sampling regime consisting of a tight line or triangular formation, separated by 3-5 km, so along-track and across-track submesoscale gradients could be estimated. We investigate the statistics of vertical vorticity, horizontal divergence, and lateral strain rate in the sampling area. Additionally, a unique case study of a submesoscale salinity-driven front is highlighted. The front was sampled in mid-February 2020 as saildrones crossed through a freshwater filament. We investigate the submesoscale processes governing the front and filament. A preliminary analysis of vorticity and divergence suggests the presence of a secondary circulation at the front. Velocity and shear estimates suggest a turbulent environment within the filament with distinct dynamics in the upper 20 meters. Additionally, Argo float data reveals a barrier layer within the filament. The analysis provides insights on tropical submesoscale dynamics, an important step towards understanding the role of these small-scale processes on Earth's climate.

(D75) Drivers of the recent recovery of the Irminger Gyre from an anomalously cold state

Monica Nelson (she/her), UC San Diego

The Irminger Sea, between Greenland and Iceland, drives variability in the global ocean circulation that regulates global climate. In 2015, the Irminger Sea experienced widespread cooling and densification of the upper 1000 m due to strong heat loss to the atmosphere. From 2016 to 2018, the sea remained in a cold, dense state despite a return to normal atmospheric conditions. We study the rate of recovery of the Irminger Sea interior and eastern boundary and investigate what drove the recovery. We find that the recovery has two stages: an initial stage from 2015 to 2018, where the eastern boundary recovered quickly while the interior remained cold and dense; and a second stage from 2018 to 2022, during which the recovery of the eastern boundary slowed and the interior began to recover. We suggest that the recovery of the interior is driven by warm, light eddies that shed from on the eastern boundary as a result of baroclinic instability. The delayed recovery of the interior is explained by the initial lack of a strong horizontal density gradient between the interior and the eastern boundary. However, the initial rapid recovery of the eastern boundary sets up a stronger horizontal density gradient that drives a greater flux of warm, light eddies, enabling the interior to recover. These results show that changes on the eastern boundary of the Irminger Sea, not just the interior, should be considered when investigating drivers of variability in global ocean circulation.

(D76) Why is the monsoon coastal upwelling signal subdued in the Bay of Bengal?

Katy Abbott (she/her), MIT-WHOI Joint Program

The Indian monsoon, which brings heavy rains to the densely populated Indian subcontinent, plays an important role in controlling coastal productivity. During the summer months, land-sea temperature gradients generate alongshore winds from the southwest that blow along the coasts of the western Arabian Sea and the Bay of Bengal. These alongshore winds give rise to an offshore Ekman transport of water that induces a coastal upwelling circulation, bringing cold, dense water and nutrients to the surface and stimulating primary production. Although both coastlines experience similar magnitudes of alongshore wind stress during June-August, we only observe a strong surface signature of upwelling from sea surface temperature (SST) in the

Arabian Sea, whereas SST-based estimates of upwelling for the Bay of Bengal suggest that it is suppressed there. We examine possible explanations for the difference between these two basins and argue that it can be attributed to a combination of wind transience (related to monsoon intraseasonal oscillations) and variability in the stratification, which is dominated by temperature in the Arabian Sea and salinity in the Bay of Bengal. We then explore how these different factors may change under future climate projections and how shifts in the strength of the upwelling circulation will impact coastal fisheries. This work has implications for understanding how upwelling regions will respond to changing wind stress and stratification in a warming climate.

(D77) Radiative forcing cools the subpolar North Atlantic throughout the past century

Yifei Fan (she/her), Pennsylvania State University

In contrast to global warming, the eastern subpolar North Atlantic has experienced long-term sea-surface temperature cooling throughout the 20th century. This cooling, known as the North Atlantic Cold Blob (NACB), has long been hypothesized to arise from reduced poleward oceanic heat transport (OHT) associated with the slowdown of the Atlantic Meridional Overturning Circulation (AMOC). This thesis has analyzed historical simulations from a suite of coupled climate models to diagnose the mechanisms of the NACB. Results show that cooling induced by OHT divergence is largely compensated by decreased heat loss from surface turbulent heat fluxes, resulting in no apparent cooling over the NACB region. Instead, decreased shortwave radiation associated with increased cloudiness, as well as decreased downward longwave radiation associated with a cooler atmosphere and less water vapor, explains local cooling in the eastern subpolar North Atlantic. Further lead-lag correlation analysis reveals that local decreases in surface radiative fluxes are congruent with simulated AMOC slowdown. In addition, the role of internal climate variability to the NACB is investigated. Overall, this study highlights the crucial role of atmospheric processes in the formation of the NACB during the historical period. Although AMOC could be important for the observed NACB, oceanic processes alone would not be a sufficient explanation.

Cryosphere and Polar Climate

(B21) Iceberg Impacts on Prydz Bay, Antarctica

Alan Gaul (he/him/his), MIT-WHOI Joint Program

Grounded icebergs affect regional sea ice cover, coastal ocean circulation, and air-sea interactions, with implications for the global climate. Since 1992, an immense iceberg (the size of Delaware) called D-15 has been grounded upstream of Prydz Bay, Antarctica's 3rd largest bay. Prydz Bay has globally significant impacts as a site of Antarctic Bottom Water formation and high primary productivity. While most observational and modeling studies of the bay have been conducted under a regime where D-15 is present, the iceberg will eventually become ungrounded and leave the region. This research aims to provide an idea of how Prydz Bay may behave in the future once D-15 leaves. Numerical simulations with the iceberg removed are compared to control simulations with the iceberg included. In this way, the study assesses the impact of iceberg D-15 on climate-related processes in Prydz Bay such as sea ice formation and coverage, deep water formation, mixing of water masses, and ice shelf melt. Sensitivity studies are also run to broaden the study's applicability to future climate scenarios.

(B22) The geopolitics of the Russian Arctic in the face of climate change: An exploration of melt and freeze trends in militarily significant locations in Northeast Russia using ASCAT scatterometer data

Abby Beilman (they/them), Clark University

This paper explores changes and melt and freeze timing in the Russian Arctic through scatterometer backscatter and ancillary temperature, as well as current and historical trends in Russian Arctic policy through a geopolitical lens, integrating often-disparate disciplines. It examines the current trend of militarization in Russia, and the applications of scatterometer and temperature data to understanding climate change in the region, as well as how these two areas relate. Using ASCAT scatterometer backscatter data and ancillary temperature data, along with a thorough literature review, it determined that melt and freeze timing are changing in a way that is detrimental to future Russian military activity in the Arctic. Specifically, the overall cold season has shortened to some extent in all locations, in many cases by as much as several weeks. Multiple methodological iterations were used to ensure the best results possible, but there were still some challenges in detecting melt that were not present with detecting freeze, which is an area for future work, along with expanding the spread of study sites and data. Ultimately, melt is getting earlier, freeze is getting later, and navigation overall is going to become more difficult should changes not be made.

(C41) Investigating the impacts of alpine glacier meltwater on mountain groundwater flow processes using environmental isotopes

Ayobami Oladapo (she/her), Purdue University

Alpine glaciers are vital sources of freshwater for high-mountain communities and ecosystems globally. Recent work shows that glacier meltwater is an essential component of the alpine water cycle, contributing recharge that supports groundwater flow processes in the mountains. In the face of drastic climate change, knowledge of residence times of glacial meltwater in mountain aquifers and response times of these aquifers to loss of glacial ice are critical in evaluating the sustainability of alpine water resources for human communities and ecosystems. However, we lack information on the residence times of the mountain aquifer and the response times of these aquifers to loss of glacial recharge. An important step toward addressing these questions is to identify the rock units that host flow paths and how these flow paths are connected across scales. Therefore, my research is focused on identifying water-bearing units, calculating groundwater residence times, and calculating aquifer response times in Glacier National Park (GNP) and Mount Hood National Forest (MH). In this presentation, I use strontium isotopes (87Sr/86Sr) and geochemical tracers to identify the rock units hosting the flow paths and provide insight into where groundwater is stored in the high mountains. The impacts of alpine meltwater on mountain groundwater flow processes have important implications for global water resource management and conservation efforts. Glacier National Park (GNP) and Mt. Hood (MH) are important mountainous regions that show different responses to climate change since their glaciers are in different states of retreat. GNP glaciers are in advanced stages of retreat compared to Mount Hood glaciers. My future research will be focused on residence times and response times with an overall goal of determining the vulnerability of groundwater in these high mountains to an ice-free future.

(C42) An Intercomparison of Recent Antarctic Summer Sea Ice Minimums

Zac Espinosa (he/him/his), University of Washington

Antarctic sea ice plays a vital role in Southern Ocean circulation, and regional climate. In February 2022, Antarctic sea ice extent (SIE) reached a satellite-era record low of 1.92 million square kilometers. This record was broken just one year later in February 2023 when Antarctic SIE dropped to 1.79 million square kilometers. A similar pair of record lows had occurred in February 2017 and 2018. In this study, we perform an intercomparison of the evolution and drivers of the February 2017 and 2022 SIE minimums, and explore mechanisms leading to persistent anomalies in subsequent years. We nudge atmospheric winds and Southern Ocean sea surface temperature in the Community Earth System Model version 2.2 (CESM2.2) and version 1.2 (CESM1.2) in order to recreate the observed 2017-2018 and 2022-2023 SIE minimums, highlight model bias, and quantify the relative contribution of atmospheric and oceanic forcing to each pair of events. Finally, we examine the role of tropical teleconnections and local circulation variability in order to quantify the risk of future extremes.

(D61) Observations of Ocean Surface Wave Propagation in the Chukchi Sea Marginal Ice Zone

Lexi Arlen (she/her), Stanford University

While global climate models project a steep decline in Arctic sea ice over the next century, there is considerable inter-model spread in the magnitude and rate of ice loss in response to climate change. The marginal ice zone is the region of the sea ice pack where surface ocean waves interact with unconsolidated sea ice floes. Unresolved physics in the MIZ likely contributes to this discrepancy between models and observations. Sea ice concentration is not sufficient to characterize the MIZ; instead, a floe size distribution (FSD) is used as a prognostic variable for the MIZ as the FSD is sensitive to changes in floe-scale dynamics. How ocean surface waves modify the FSD is of key importance to understanding and ultimately predicting MIZ dynamics. Limited observations of wave-ice interactions yield strong spatial and temporal variability. Additionally, observations of the FSD are sparse due to remote sensing and image analysis challenges. On the 2023 R/V Sikuliaq Cruise to the Chukchi Sea, we conducted an experiment to quantify the coupling between surface waves and FSD evolution. During the summer melt season, we deploy four drifting wave buoys along a transect perpendicular to the ice edge collecting 4,351 wave spectra. To correlate wave action with modifications of the FSD, we develop an algorithm to process near-daily resolution RADARSAT imagery concurrent with the buoy deployments. Here, we present some preliminary results showcasing how the MIZ responds to a surface wave event and discuss the next steps to evaluate and constrain wave-induced changes to the FSD.

(D62) Elucidating the Chilean Patagonian Late Holocene (the last 2000 years) environmental and climatic conditions using ancient molecular compounds in lake sediments

Godspower Ubit, University of Pittsburgh

The megadrought occurring in Central Chile since 2010 is affecting more than 10 million people, impacting water resources, and shifting ecosystems. The southern-hemisphere westerly winds (SWW) are the strongest time-averaged oceanic winds on Earth and hit continental landmasses only in southern South America, delivering moisture for winter rains and providing snowpack and fresh water to the entire west coast of southern South America. These winds play a significant role in shaping the climate and weather patterns of the southern hemisphere and are an essential factor in the transport of heat and moisture around the globe. Previous studies and current wind observations show a strong positive correlation between the north-south movement of the SWW and precipitation on the seaward side of Chilean Patagonia. Given the sparse spatial coverage of accurate meteorological stations recording localized modern climate information (such as precipitation and temperature) in the Chilean region, it is critical to find other avenues to investigate past climate variability and the mechanisms affecting the region to better predict future change. Also, there are currently only a few high-resolution paleo-reconstructions of Chilean hydroclimate, with tree-ring and pollen datasets being the primary records. I propose to elucidate the climate and environmental changes that occurred in the last 2000 years using molecular compounds in the remains of microbial organisms (e.g., bacteria) and leaf materials. These lakes spread across a wide latitude and elevation range, allowing variation in climate and environmental changes to track differences in temperature, changing vegetation regimes, and SWW intensity in the region.

(D63) A ground-based perspective of rain-on-snow events in northern Alaska

Yan Xie, University of Michigan

Rain-on-snow (ROS) events happen when rain falls on the existing snowpack. ROS events largely affect the surface freeze-thaw dynamics, lead to destructive floodings and avalanches, and have substantial ecological and social impacts. During ROS events, the liquid precipitation stays in or percolates through the snowpack and then freezes. The ice crust on the snow and the underlying ground poses a threat to the wildlife forage access and local transportation safety. Rising temperatures in a warming climate can increase the occurrence of ROS events at high latitudes and amplify their impacts. Studies have shown that ROS events in northern Alaska, especially along the North Slope of Alaska, will become more frequent and intense as the climate warms. Despite the projected increasing ROS occurrence in northern Alaska, large uncertainty remains in the ROS detection. A multi-year record of ground-based observations at North Slope of Alaska can help to improve the detection of ROS events. Therefore, this study aims to detect ROS events in northern Alaska using ground-based observations and evaluate the impacts of ROS events on the snow surface energy budget. The results will help us further understand the roles and interactions of atmosphere, land and ice in the ROS events, improve the ability of climate models to predict such extreme weather events in the future, and inform decision-making processes of climate policy and infrastructure planning to build resilience to climate change.

Atmospheric Chemistry, Aerosols, & Clouds

(B23) Modeling the impact of isoprene emissions on methane's lifetime and the atmospheric oxidative capacity

James Yoon, University of Washington

Isoprene is a biogenic volatile organic compound (BVOC) primarily emitted by broadleaf deciduous trees. As isoprene contributes up to 440-660 teragrams of carbon per year, isoprene is the most significant non-methane hydrocarbon by total emissions, affecting the oxidative capacity of the atmosphere and the global carbon cycle. Since isoprene emissions increase with temperature but decrease with CO2 emissions, climate change's impact on future isoprene emissions is highly uncertain, although some papers predict increasing isoprene emissions over time. However, with the new Cross-track infrared sounder (CrIS instrument) on the Suomi-NPP and JPSS-1/NOAA-20 satellites, we can now obtain direct satellite retrievals of isoprene that will help constrain current and future chemistry and climate models. Recently, CrIS has detected anomalously high isoprene column densities over the tropics in 2020, which can affect the atmosphere's oxidative capacity through its fast reaction with the hydroxyl (OH) radical. We use GEOS-Chem, a three-dimensional atmospheric chemistry model, to model these abnormally high tropical isoprene emissions and to evaluate the local and global impacts of elevated isoprene on decreasing OH concentrations and increasing methane lifetimes, which could amplify methane's contribution to radiative forcing. By understanding how isoprene affects the atmospheric oxidative capacity, we can better understand how biospheric inputs to chemical models affect how long greenhouse gases stay in the atmosphere and how isoprene will change with a warming climate.

(B24) The Influence of Cloud Types on Cloud-Radiative Forcing on the Subseasonal-to-Seasonal Timescale

Hrag Najarian (he/him), University of Oklahoma

Cloud-radiative interactions play a crucial role in shaping the Earth's climate system through cooling or warming the planet by reflecting incoming solar radiation back into space or by trapping outgoing longwave radiation emitted by the Earth's surface. Large-scale atmospheric disturbances in the tropics influence weather locally and globally, producing large cloud systems that warm and cool the Earth. Previous studies suggest that slower and larger-scale disturbances trap more radiative heat than faster and smaller disturbances. To understand why this unique relationship exists, we utilize high resolution observational data collected between October and December of 2011, located in the Maldives. We found that the slowest and largest disturbance, the Madden-Julian Oscillation (MJO), had nearly all cloud types (i.e., shallow, congestus, deep, mid, anvil, cirrus) most frequent after its rainiest period, while faster and smaller disturbances had clouds frequent during their rainiest period. Atmospheric cloud-radiative heating followed a similar trend, with the MJO trapping the most radiative heat after its rainiest period, unlike the faster/smaller waves. We reconstructed a linear relationship between cloud occurrence and cloud-radiative heating to isolate the cloud-radiative heating induced by each cloud type. Rainy (congestus and deep) and thick high (anvil) clouds trapped the most radiative heat within the atmosphere after the rainiest period of the MJO. The added radiative heat drives upward motion that acts to moisten the atmosphere, prolonging the rainy period of the MJO. These results suggest that local rainfall associated with the MJO can be prolonged by cloud-radiative interactions.

(C43) Unveiling the Cosmic Symphony: Exploring the Influence of Galactic Cosmic Rays on Cloud Formation and Climate

Ayesha Saeed, University of Michigan, Ann Arbor

The intricate relationship between cloud formation and climate has long intrigued scientists, but recent studies have unveiled a compelling factor that has been largely overlooked: galactic cosmic rays (GCRs). This research dives into a novel and unique topic, investigating the potential influence of GCRs on cloud properties and their implications for Earth's climate dynamics. This study seeks to understand the complex mechanisms by which GCRs may affect cloud formation by examining long-term climate and atmospheric data coupled with satellite-based observations of GCR flux. We investigate the relationships between GCR flux, the creation of aerosols, the nuclei of cloud condensation, and the following features of clouds using statistical analysis and empirical modeling. According to preliminary research, GCRs may influence cloud cover, cloud droplet size, and cloud lifespan. These findings cast doubt on established climate models and raise the possibility that GCRs may be an underappreciated source of climate variability on different timeframes, such as interannual and decadal fluctuations. Furthermore, we delve into the underlying physical processes linking GCRs and cloud formation, such as ion-induced nucleation and aerosol-cloud interactions. By integrating these mechanisms into climate models, we aim to improve our understanding of the complex interactions between cosmic rays, atmospheric aerosols, and cloud dynamics. This research opens up exciting possibilities for better quantifying the role of GCRs in shaping Earth's climate system. The outcomes have implications for climate prediction, climate engineering strategies, and our overall understanding of the intricate balance of forces shaping our planet's climate.

(C44) Impact of climate variability and change on the ozone response to NOx emissions reductions

Emmie Le Roy (she/her), MIT

Climate variability may introduce a range of air quality and health outcomes for a given air pollution control policy. Quantifying this range of outcomes is important for assessing the likelihood that a prospective control strategy will achieve a desired air quality target. Here, we quantify uncertainties in the projected tropospheric ozone response to emissions controls of precursor nitrogen oxides (NOx) due to natural interannual climate variability and long-term climate change uncertainty. We leverage an ensemble approach using a chemical transport model (GEOS-Chem) driven offline by a global atmospheric model (CAM). We find significant interannual variability (coefficient of variation up to 60%) in the present-day (2000-2015) ozone response over polluted urban areas. Changes in the mean ozone response in the end-of-century (2080-2095) future climate scenarios are small relative to present-day variability but lead to significant changes in the frequency of days per year with ozone 'disbenefits' to NOx reductions (i.e., days per year when ozone increases in response to reduced NOx emissions). Our results confirm the importance of considering natural variability in projections of climate change impacts on air quality.

(D78) Investigating the Use of Hourly Wildfire Potential to Estimate how Evolving Combustion Conditions Impact the Composition of Wildfire Emissions

Lindsey Anderson (she/her), University of Colorado Boulder

Wildfires have become larger and more frequent due to climate change, increasing the number of people impacted by smoke and poor air quality. The composition of wildfire emissions used in air quality forecasts and climate models is based on the dominant fuel type and the amount of area burned. In contrast, laboratory studies have shown that the composition of wildfire emissions changes over time based on the dominant combustion type (flaming vs. smoldering). While field measurements of wildfire emissions are limited, satellite remote sensing has the potential to observe how the composition of wildfire emissions changes over time, for many wildfires globally. Our work suggests that we can see changes in the emissions composition over time for large wildfires, using daily trace gas measurements from the Tropospheric Monitoring Instrument (TROPOMI). The emissions composition has also been shown to correlate with remote sensing measurements of Fire Radiative Power (FRP), which is a proxy for combustion intensity. The High Resolution Rapid Refresh model coupled to chemistry (HRRR-Chem) is currently unable to account for changes in the emissions composition, as wildfires transition from mainly flaming to mainly smoldering combustion. In this study, we show how the Hourly Wildfire Potential (HWP) model diagnostic can be used in combination with trace gas observations from TROPOMI, to adjust the emissions composition online based on the dominant combustion type. Allowing the composition of wildfire emissions to change based on evolving combustion conditions could improve predictions of wildfire smoke impact on air quality, visibility, and communities downwind.