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Abstracts Booklet

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ORAL PRESENTATION ABSTRACTS

Oral Session 1
Morning (9:00 am), Saturday, November 2, 2024

Extreme Events - Drivers and Observations

Quantifying the Drivers of Compound Heatwaves and Drought Events in The Contiguous United States (Withdrawn)

Henry Olasunkanmi Olayiwola, University of Oklahoma

Over the years, several studies have examined heatwaves and drought events within the CONUS as singular extreme events, but few studies considered these two weather extremes simultaneously as compound or concurrent extreme events. However, profound implications of concurrent arid and high-temperature events exist, including reduced crop productivity, stress on energy infrastructure, and mortality. This research quantifies the major drivers of compound heat and drought events all year round, within the contiguous United States (CONUS). We used several variables from the observationally informed PRISM datasets (e.g., daily 2m temperature and precipitation) and 500MB Geopotential heights from ERA5 reanalysis datasets, all from 1981 to 2022. We first create a database of compound heatwave and drought events and compute associated trends, frequencies and intensities of these events across the CONUS. We considered percentiles of temperatures at the 90th percentile for heatwave events whilst using common drought indices like the Standardized Precipitation Index (SPI) to define drought events. These multiple thresholds and indices enable us to present a robust and comprehensive analysis of the compound dry, hot extreme events as a function of space. Results indicate that coupled with known increases in heatwaves and drought occurrences individually in recent years, compound hot, dry extreme events are also on the rise across regions such as the Southwest US, Southern Great Plains, and the Corn Belt. The results from the study would be beneficial in advising the agricultural sector on the potential of compound heat and drought events to enable them to minimize losses. Moreso, the results will also aid socio-economic planning, especially in the aspect of energy management, on how to plan for and mitigate the effects of compound hot and dry events during its season and in the future years going forward.

Temporal Clustering of Wintertime Atmospheric Rivers over Southern South America

Surabhi Biyani (she/her), University of California - Los Angeles

Landfalling Atmospheric Rivers (ARs) are linked with extreme precipitation events and associated hydrologic impacts. When ARs occur in rapid succession in one location, they can exacerbate these impacts, leading to increased risks of flood, landslide, and water-infrastructure damage. As extreme precipitation events have been shown to increase in frequency and magnitude with climate change, it is crucial that we better understand weather phenomena such as ARs and how they are linked to extremes. In this study, we investigate the temporal clustering of historic wintertime ARs over Southern South America (SSA). We identify AR events using an integrated vapor transport (IVT)-based detection algorithm, then apply a statistical framework to compare observed AR clustering rates in reanalysis data with synthetic randomly distributed sequences of ARs. Then we determine the locations and timescales at which sequences of ARs (referred to as "clusters") exhibit significant (greater-than-random) clustering.We explore the regional patterns that arise when considering cluster characteristics such as length, number of ARs, and contribution to local precipitation. In some regions, we find that a high fraction of extreme precipitation events are associated with AR clusters. Additional analysis is done to quantify the influence of ENSO on regions where clusters form. While this study focuses on SSA, this framework can be applied to other regions across the globe that also have landfalling ARs, and results provide an important historical context. Having this historical context is critical to understanding how future ARs and their associated impacts will evolve in a changing climate.

Heatwaves a Hot Topic: How Well Do Climate Models Represent Heatwaves?
Calen Randall (he/him/his), University of California - Davis
Heatwaves are an omnipresent climate extreme. They occur frequently from the tropics to the poles and cause harmful impacts to human health, ecology, and industry. Heatwave length, intensity, and frequency are increasing due to Climate Change. In order to design more climate resilient communities prepared for future heatwaves, high confidence climate datasets are required. While temperature biases in climate models are well researched, little work has centered on how climate models represent heatwaves within the contiguous USA (CONUS). This is problematic, as stakeholders and scientists alike need to use climate models that accurately represent heatwaves. Thus, this presentation will explore regions of heatwave metric bias within CONUS found in the recently produced RRM-E3SMv2 Medium Ensemble (VR-E3SM) dataset. Analysis will focus on three components: (1) the differences in heatwave metrics (including mean heatwave length, intensity, frequency, and seasonality), (2) comparison of model and observation temperature distributions, and (3) relating metric bias to bias in process level drivers (sensible & latent heat flux, soil moisture, subsidence, etc).

Hydrological Cycle - Hydrometeorology

What is happening to summer? A global and multi-scale analysis of the changing summer season length under global warming

Ted Scott (he/him/his), University of British Columbia

Summer is changing dramatically in our lifetimes. The increasing frequency and severity of extreme events under global warming has been connected to changes in the timing of summer onset, duration, and withdrawal, which impact phenology, economic cycles, and energy demand. My work updates and expands prior studies of summer timing and duration by separately considering midlatitude land, ocean, and coastal margins, where many of the global population resides. I find that each of those areas has seen a substantial increase in summer length since 1990, and compared with previous work, the average rate of growth has doubled to nine days per decade when including more recent data. While changes to summer are not uniformly distributed, in most areas the onset of summer is rapidly moving earlier. If the length of summer continues increasing even under an apparent linear warming rate, associated impacts can increase non-linearly, exceeding thresholds for human health, ecosystems, and infrastructure.

Hydrological Cycle - Groundwater and Streamflow

Site Suitability Analysis for the Study of Vertical and Horizontal CO_2 Fluxes in Michigan's Kalamazoo River Watershed

Abby Beilman (they/them), Michigan State University

The carbon cycle is an essential component of how climate change is understood and consequently, there are many aspects of it that are well studied, both theoretically and quantitatively. However, one area that is often left out is inland waters. Despite making up a relatively small proportion of Earth's surface area and the global water budget, inland waters have outsized impacts on carbon cycling, especially when considering how much carbon enters these waters as compared to how much exits, and where those exits are occurring. Streams and rivers are not just passive transporters of terrestrial material but play a large role in the transformation and movement of biogeochemical elements. This project is part of a larger whole intended to advance the understanding of carbon cycling in inland waters, how we can quantify it, and the larger implications that these results have for climate change and carbon cycling together. Furthermore, this project aims to determine the different contributions of horizontal (through drainage networks) and vertical (water to atmosphere) carbon fluxes and how they connect overall to terrestrial carbon fluxes. Here, we seek to

identify suitable study sites within Michigan's Kalamazoo River Watershed to carry out data collection, using a combination of suitability analysis with GIS and field assessment. Ultimately, we hope to identify 10-12 sites at which we can monitor pH, dissolved organic carbon, particulate organic carbon, dissolved inorganic carbon, carbon dioxide/CO2, and methane/CH4. Eventually, this will result in a greater knowledge of carbon cycling and climate change contributions for inland waters.

Oral Session 2

Morning (10:05 am), Saturday, November 2, 2024

Climate Adaptation - Policy and Perceptions

Evaluating the capacity of UNCLOS to address the imminent effects of climate change

Samuel Filiaggi (he/him/his), Roger Williams University School of Law / University of Rhode Island

Climate change is a worldwide issue demanding a global response, and it is unclear whether existing legal frameworks—including the United Nations Convention on the Law of the Sea (UNCLOS)—will adequately address maritime management needs as the climate shifts. In effect since 1994, UNCLOS has been ratified by 168 countries. UNCLOS delineates how nations are to measure their coastlines to determine their maritime borders and how to collaboratively manage fisheries across boundaries. As climate change causes sea level rise to inundate coastlines and islands, and marine species' ranges shift, UNCLOS is increasingly challenged to govern the shared international use of the seas and their resources. This May, the International Tribunal for the Law of the Sea (ITLOS) even issued an advisory opinion on climate change in response to a request from the Commission of Small Island States to address this issue. My legal research evaluates the viability of UNCLOS to withstand climate change's imminent impacts. I coherently break down existing articles in UNCLOS which dictate how States must use coastlines and islands to create maritime boundaries and sustainably manage transboundary fish stocks. Furthermore, I explore how climate change's impacts are straining international boundaries and fisheries and assessed proposed solutions. I also detail the ITLOS decision and its implications for global climate action. I conclude that, while fisheries management guidance under UNCLOS is robust enough to be workable, UNCLOS will ultimately need to be amended to adequately account for countries' borders shifting due to sea level rise.

What have we learned? Navigating the climate change research landscape in Nunavut, Canada (2004-2021)

Faith Rahman (she/her), McMaster University

Climate change in Nunavut is rapidly impacting key wildlife, ice and weather patterns, and Inuit travel on land, water, and ice. This, in turn, affects Inuit livelihoods, culture, health, and well-being. In 2022, the Nunavut Research Institute (NRI) and Government of Nunavut Climate Change Secretariat (CCS) identified the need to understand the diversity of climate change projects that have taken place across the territory over the last two decades (2004-2021). Recognizing that not all climate change research conducted is published in academic literature, an analysis of climate change research in Nunavut was undertaken according to licensed and permitted research (from the NRI, Government of Nunavut Department of Environment, Fisheries and Oceans Canada, Parks Canada), as well as federal climate change funding programs targeted to support northern- and Indigenous-led initiatives (Climate Change Preparedness in the North Program, Indigenous Community-Based Climate Monitoring Program, Climate Change and Health Adaptation Program). CCS priority themes were used to analyze licensed/permitted/funded project summaries, including: Built Infrastructure & Services, Community & Connection; Food Sovereignty; Health, Safety & Wellness; Healthy Environment; Inuit Culture & Heritage; and, Livelihoods & Growth. Key findings highlight that: 1) climate change research has increased in Nunavut since 2004; 2) climate change research is led primarily by Canadian Universities, followed by the Government of Canada, and Nunavut Inuit Organizations; 3) most research projects relate to Healthy Environments, with predominant emphasis on physical/natural sciences; and, 4) Nunavut licensing, permitting, and funding agencies can enhance coordination and collaboration to reduce duplicated effort and streamline review processes.

Climate Change and Flood Perception: Mission Bay's Vulnerability

Jared Livingston (he/him/his), San Francisco State University

This project looks to reevaluate the intricate connection between flood risk perception and flood management strategy in San Francsico's Mission Bay North neighborhood. Mission Bay's geologic and hydrologic characteristics leave the neighborhood susceptible to flooding in the face of climate change. Mission Bay has a significant history of land cover and land use change, with the current land use development established in 1998. Due to its recent development, many residents may be unaware of the area's susceptibility to flooding. As a consequence of increased precipitation and sea level rise, the built environment of Mission Bay is prone increased flooding and prolonged inundation. Flood risk perception aims to understand how an individual or group analyzes worry, awareness, and preparedness for a flood. However, social factors can potentially influence flood risk perception and must be counted for. This project seeks to understand the flood risk perception of the Mission Bay North neighborhood and the potential social factors that may influence it. The methods used include quantitative questionnaires to Mission Bay residents supplemented by a cognitive mapping exercise to provide a visualization of where residents perceive the highest areas of flooding to be located. The findings of this project will provide insights into flood management adaptations to serve the residents of the Mission Bay North neighborhood more effectively.

Perceptions of Climate Smart Agriculture Among Small-Scale Vegetable Farmers in Washington State

Katie Webb (she/her), University of Washington

In 2022, the United States Department of Agriculture (USDA) announced the Partnerships for Climate-Smart Commodities and will invest $3.1 billion to support adoption of greenhouse gas reduction and carbon sequestration in US agriculture through technical assistance and market development. All funded projects must provide meaningful engagement with small and under-served producers. Current research primarily focuses on large-scale producers and emphasizes adaptation over mitigation. To our knowledge, no current research has directly explored the value of CSA mitigation strategies to small-scale vegetable farms, which play an important role in nutrition and local food security. This qualitative study examines CSA's value for small-scale vegetable farms in Washington including relevance to consumer relationships and marketing. Data were collected Spring of 2024 via semi-structured interviews conducted in English or Spanish with 17 farmers growing vegetables and selling in direct-to-consumer markets. All participants met the USDA definition of small farm (less than $250,000 in gross annual sales) and comprised a variety of racial, cultural, and gender identities. Thematic analysis using an emergent approach is currently underway. Early results indicate vegetable farmers actively implement adaptation techniques but are less aware of their contributions to climate change. Results will support tailoring practical greenhouse gas reduction resources relevant to the priorities and business models of small farms in Washington. Opportunities exist for both farmer and consumer education to create demand and motivation for implementing mitigation strategies.

Climate Adaptation - Technology

What is the Scaling Potential of Marine Carbon Dioxide Removal?

Connor Mack (he/him/his), University of California - San Diego

By some estimates, including the latest reports from the IPCC, the world will need 5-10 gigatons of novel carbon dioxide removal (CDR) annually by mid-century—over a thousand times more than all CDR today. However, these findings are based on models that work backward from a goal (e.g., limit warming to 1.5 or 2ºC) without regard to the real-world constraints that affect how a novel CDR industry may arise and spread—that is, scalability. One way to assess scalability is to look to the history of analogous industries. We apply this approach to the case of ocean alkalinity enhancement (OAE)—a leading marine CDR strategy that stores atmospheric CO2 in seawater. Using historical technology analogs as a basis, we've developed an integrated techno-economic, ocean, and climate modeling framework that estimates potential OAE deployment rates and their implications for global mean surface temperatures. Marine CDR is not yet proven at scale, and deep uncertainties remain around both the carbon removal potential of these technologies, and their impacts on the ocean and communities that rely on it. The need to support emerging CDR methods while also responsibly regulating and preserving ocean health presents a unique policymaking challenge. The results from our interdisciplinary modeling framework can help decision makers better understand scaling pathways that will define the development of a marine CDR industry, and inform effective policy choices around these nascent technologies.

Oral Session 3

Afternoon (1:30pm), Saturday, November 2, 2024

Ecosystem Monitoring

Climatic adaptability and resiliency of North American sagebrush-steppe mammals and birds

Katherine Burgstahler (she/her), Washington State University

Climate change is and will continue to be associated with biodiversity loss and changing distributions of species across the globe. Redistributions of fauna, in many cases poleward expansion of ranges, will have large implications for ecosystems and human societies, and the ability of species to move through landscapes is fundamental to climate change adaptation going forward. Knowing whether species are vulnerable to range shifts or regions are vulnerable to biodiversity decline is vital for planning management actions. Climate change in the upcoming decades will alter the North American sagebrush biome, given semiarid regions are particularly sensitive to climate variability. A key unknown to address is the extent to which shifts in suitable climatic conditions will occur for sagebrush wildlife, and how those shifts relate to the integrity and connectivity of the landscape. The main objective of this study is to identify changes in climatic suitability for mammals and birds throughout the sagebrush biome. We hypothesize that predicted species' distributions will shift northward compared to historical distributions in response to changing temperature and precipitation patterns. We will build species distribution models (SDMs) for sagebrush-obligate and -dependent birds and mammals using historical species presence data collected across North America. These single-species SDMs will identify changes in climatic suitability between historic, current, and future climates using a maximum entropy approach (MaxEnt). 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.

Sediment Dynamics of Willapa Bay

Clara Stanbury (she/her), University of Washington

Willapa Bay, Washington is a large tidal embayment that supports aquaculture, tourism, recreation, and local biodiversity. However, coastal and intertidal ecosystems such as Willapa Bay are vulnerable to sea level rise and local industries have been suffering due to rapid changes in this shallow intertidal system. The goal of this project is to evaluate how this intertidal ecosystem will evolve in response to sedimentary processes associated with sea level rise and changes to sediment supply. Specifically, we are exploring how wave energy and sediment transport across a mudflat changes with distance from shore, water depth, biota, grain size, and sediment composition. We deployed instruments to measure waves, currents, and water properties, and took sediment cores from four sites in Willapa Bay in summer 2023, spring 2024, and summer 2024. These four sites are primarily sandy, but have higher mud content near the shore. We have concluded that wave height correlates positively with water level and that turbidity is a function of wave height and water depth. We saw the greatest wave heights furthest from shore, with an average wave height of 0.3 meters, and during a three day storm period. With a future of sea level rise and more dynamic weather events, wave heights and turbidity are predicted to increase meaning more sediment will be suspended and possibly transported. Willapa Bay is not immune to sea level rise or climate change, and this research may help the community better prepare for and mitigate against climate change impacts.

Mapping and protecting rock habitat in the Cascades Mountains for the conservation of climate sensitive speciesEx

Allison Stift (she/her), Washington State University

Broken rock (e.g., talus) habitats play a key role in the survival of many species in the Cascades, yet high resolution maps of these habitats over broad scales are lacking. The crevices between rocks in these habitats provide protection from both predators and extreme temperatures for alpine small animals, which is critical to species that are vulnerable to high temperatures and must also survive cold, snowy winters either by hibernation or by staying active and consuming cached food. Due to climate change, extreme climate events are likely to occur more frequently which emphasizes the importance of understanding and mapping the rocky habitats and how alpine animals use them. The aims of our project are to 1) use handheld and satellite imagery to create maps of rocky habitat across the Cascade Mountains, and 2) use these maps coupled with animal surveys to determine characteristics of these habitats that are selected by wildlife such as hoary marmots, American pikas, and Larch Mountain salamanders with the goal to estimate distribution and habitat use throughout the Cascade Mountain rage of Washington. Our high-resolution maps and models of habitat use can then be used by wildlife and land managers to identify potential habitat and distribution of rock-dwelling wildlife, and how management activities (including visitor experience and infrastructure projects) and climate change might affect species distribution.

A Tail of Two Cats – Estimating Current and Future Density of Canada Lynx and Bobcats in a Changing Climate

Sujay Singh, Washington State University

Several wildlife species are experiencing climate change induced range shifts that in some instances have increased spatial overlap between cold and warm adapted species. A prominent example of such range shifts and increases in overlap is one of the warm adapted bobcat (Lynx rufus), and the federally “Threatened” cold adapted Canada lynx (Lynx canadensis) in Washington. Both cats exist at their respective range margins in Washington and are presumed to exist at lower densities in relation to core populations. This is particularly concerning for lynx, as they are predicted to experience population decreases, while bobcats (which may outcompete lynx) are predicted to experience population increases. Despite predictions of differing population trends, there is a lack of reliable density/abundance estimates of the two cats in Washington. Here, I use camera trap data from summer of 2023 to predict density of lynx and bobcats in a region of overlap in Washington, and associate density of the two cats with a pertinent climatic variable – temperature. I also predict future density of the two cats based on three differing climate change scenarios – RCP 2.6, 4.5, and 8.5. Preliminary results indicated that lynx existed at their highest densities in regions of low temperatures, while bobcats existed at their highest densities in regions of medium temperatures. A general trend of decreasing lynx density and increasing/constant bobcat density was supported across all three RCP scenarios. These results will be critical for identifying priority areas for lynx conservation, and important for setting bobcat harvest regulations in Washington.

Oral Session 4

Afternoon (2:40pm), Saturday, November 2, 2024

Climate Adaptation - Technology

Machine Learning for Carbon-Aware Energy Systems

Christopher Yeh (he/him/his), California Institute of Technology

Energy systems and markets have traditionally been designed to prioritized reliability, followed by cost, with less attention paid to carbon emissions. The proliferation of renewable energy has increased volatility in the electricity grid, though, and opened new avenues for combining energy storage systems with predictive algorithms to increase grid efficiency. In this work, I will present two specific works on applying state-of-the-art machine learning algorithms to energy systems. First, we have built a suite of reinforcement learning (RL) environments called SustainGym which simulates realistic energy systems ranging from carbon-aware EV charging systems to grid-scale battery storage operation. SustainGym is the first multi-agent RL test bed featuring distribution shifts, and we find that existing RL algorithms perform poorly under distribution shift. We demonstrate the benefits of designing novel RL algorithms to exploit natural structures in the environments. Second, we develop a new end-to-end framework for robust decision-making under learned uncertainties which we apply to energy storage applications. Our framework provides a formal mathematical guarantee for robustness while also providing significantly better empirical performance than existing two-stage approaches. Together, these works suggest that meaningful efficiency gains and emissions reductions are possible by designing predictive algorithms for handling real-world uncertainty and volatility in the electric grid.

Climate Resilience - Built Environments

Coastal Flooding and Adaptation in Delaware's Coastal Communities

Caitlin Wilson (she/her), University of Delaware

Coastal communities within the US are demographically and economically important areas. Around 40% of the population of the US lives in a coastal area and those areas contribute approximately 48% of the National GDP. Coastal flooding due to sea level rise and climate change is an unmistakable threat to coastal communities and has broader implications for the United States as a whole. Certain states, such as Delaware, are in unique positions when it comes to dealing with coastal flooding and sea level rise. Delaware is a low-lying state with little topographic relief. It is estimated that 8-11% of the land in the state is at risk for inundation from sea level rise. This estimate includes economically important coastal towns like Rehoboth and Dewey

Beach. Therefore, understanding how people in Delaware's coastal communities are being impacted by flooding; how they are adapting to those impacts; and how they are considering planning for the future is important to understanding the future of Delaware's coastal communities. Semi-structured interviews with seven community leaders, from Lewes to Fenwick Island, were conducted in the summer of 2024. Interviews were transcribed, thematically coded, and analyzed. Results indicated that local governments were concerned about impacts to infrastructure and elderly community members from flooding. Community leaders were planning and implementing a variety of adaptation methods including education and policy strategies as well as raising houses and roads. However there were barriers such as funding and lack of regional partnerships that are hindering adaptation efforts.

Climate Resilience - Croplands

West Africa food security and climate change: The role of agrarian credit, population, and green energy

Momodou Barry, University of British Columbia

Factors like unfavorable weather patterns, political unrest, trade restrictions, growing oil prices, rapid population growth, and restricted funding assistance for farmers, etc., have had a part in the volatility of West Africa's food security. This study aims to explore the connections between climate change, agrarian credit, population dynamics, use of renewable energy, and food security in West African countries between 1990 and 2022. For the empirical analysis, this study used the Dynamic Common Correlated Effects (DCCE) because it provides precise cointegration results and immediately solves the problem of cross-sectional dependency. The quantitative results of the study demonstrate that food availability is negatively impacted by climate change and population growth, which raises the incidence of food insecurity in West Africa. On the other hand, the utilization of green energy sources improves food security temporarily but not permanently, and farmers' access to credit improves food security. According to the study's results, West African countries may lessen the detrimental effects of climate change on food security by making investments in infrastructure and agricultural methods that are climate resilient. In addition, enhancing long-term food security in the area depends on controlling population increase through sustainable policies like empowering women and promoting family planning.

Climate Resilience - Ecosystems

Microbially-mediated biogeochemical cycling during a Major Baltic Inflow Event in the Baltic Sea

Katherine Lane (she/her), MIT / Woods Hole Oceanographic Institution

As our climate rapidly changes, oxygen minimum zones around the world's oceans are expanding with impacts on productivity, greenhouse gases, and food supplies. The Baltic Sea is a restricted basin with large freshwater surplus from rivers, and seawater exchange with the North Sea through the Danish Straits. This strong salinity gradient in the waters of the Baltic Sea leads to a halocline which prevents vertical mixing and results in permanent stratification. The deep basins of the Baltic Sea are characterized by a surface oxygenated mixed layer above a sharp oxycline. Below the oxycline, H2S concentrations increase steadily leading to the precipitation of metal-bearing sulfides. As oxygen depletion increases in the central Baltic Sea, geoengineering solutions such as pumping oxygen into the deep are being considered, with potential implications to water chemistry and food webs. The introduction of oxygen to the euxinic bottom waters will lead to a pulse of metals in the water column, as the metal-bearing sulfide minerals oxidize and dissolve. Major Baltic Inflows (MBIs) bring saline, oxygenated waters from the North Sea to the central Baltic Sea's deep sulfidic waters, impacting metal concentrations and microbes, which this research aims to investigate. The last MBI occurred in 2014, and before that in 2003. In early 2024, the Baltic Sea experienced a MBI and our team had the opportunity to explore the biogeochemistry of waters along a transect from the front of the inflow into Gotland Deep, one of the deepest points in the Baltic Sea. This presentation will show how microbial community composition (metagenome) and activity (metatranscriptome) shift in response to the mixing of oxygen-bearing inflow waters with deep euxinic metal-sulfide rich waters. These data are linked with high resolution CTD data (e.g., O2, pH, turbidity, etc.) and discrete samples later analyzed for a suite of elements (e.g., nutrients, aqueous sulfur and nitrogen species, dissolved and particulate metals). By coupling geochemical data with corresponding genes related to metabolic, physiological, and stress response processes, we reveal potential biogeochemical mechanisms and impacts of oxygen intrusion during this natural oxygenation event with implications for understanding the effects of proposed geoengineering activities in the Baltic Sea.

Oral Session 5

Morning (9:00am), Sunday, November 3, 2024

Air-Sea Interactions

Understanding SST Patterns' Effects on Regional Precipitation and Extreme Temperature Trends

Jay Pillai (he/him/his), University of Washington

Over the last 40 years, the evolution of SSTs in the tropical Pacific has taken a peculiar trajectory. Weak cooling in the East Pacific and warming in the West Pacific, resembling a La-Nina like state, has dominated the recent warming trend. Climate models, unable to reproduce the magnitude of this warming pattern, struggle to reproduce the patterns of other observables such as precipitation and extreme temperature. We investigate the impact the recent warming record has had on precipitation and extreme temperature trends through the use of climate model ensembles and atmosphere-only simulations. We find that coupled models are able to reproduce the patterns of precipitation and extreme temperature, but not the right magnitude. Further, with prescribed SST patterns in atmosphere-only simulations, we are able to reproduce a significant portion of observed trends in precipitation and temperature, suggesting that coupled models' atmospheric teleconnections are wrong, and are modulated by the wrong response to historical forcing and/or circulation variability.

Atmospheric Chemistry

Quantifying carbon dioxide emissions from powerplants using remote sensing and deep learning

Hikari Murayama (she/her), University of California - Berkeley

Global emissions of carbon dioxide (CO_2) are currently estimated using ”bottom-up” accounting from national greenhouse gas inventories, which largely rely on self-reporting. However, different inventories can disagree, and the coarse resolution of emissions reporting makes it difficult to target reduction strategies. Remote sensing of greenhouse gases has the potential to address existing gaps by providing ”top-down” measurements that are high resolution, objective, and transparent. Multiple satellites highlight carbon sources and sinks that fulfill this objective, with additional missions launching in the near future. However, CO_2 enhancements from anthropogenic sources tend to be small compared to background levels, making it difficult to attribute emissions to specific emitters. Meteorological attributes further obscure observable signals— data taken in conditions with moderate wind, flat terrain, and an absence of clouds are suitable for current methods. Despite these setbacks, several studies have demonstrated the ability of satellite data to observe and quantify both point source and city-level emissions, albeit only for a small sample. This work explores the feasibility of scalable CO_2 emissions monitoring using a deep learning approach, starting with electricity-generating facilities. Focusing on simulated and remote sensing data from current-day satellite missions, we examine how different satellite mission parameters, such as spatial resolution, sensors, and meteorological conditions, impact our performance. Our method circumvents the need for a chemical transport model. We compare our results with other emissions databases, discuss uncertainty estimations, examine strengths and limitations in our approach, and provide a road map for non-point source emissions mapping in the future.

A Tale of Two Biogenic Emissions: microbial soil nitrogen oxide emissions modulate isoprene oxidation chemistry in Indonesia

James (Young Suk) Yoon, University of Washington

Isoprene is a biogenic volatile organic compound (BVOC) emitted by trees and is the most significant non-methane hydrocarbon by total emissions. Once in the atmosphere, isoprene is quickly oxidized by the hydroxyl (OH) radical to form smog and secondary organic aerosols in the presence of nitrogen oxides (NOx). Isoprene also impacts global warming: my previous work investigated how changes in isoprene emissions can deplete global OH, which decreases methane's chemical loss and increases global temperatures. However, isoprene's impact on OH, aerosols, and climate change is sensitive to its chemistry, particularly its interactions with NOx. With satellite isoprene measurements from the Cross-track infrared sounder (CrIS) instrument, we can investigate how isoprene emissions, chemistry, and meteorology interact over areas with few in-situ observations. With these retrievals, we observe a positive correlation between isoprene columns and precipitation in Indonesia, which is governed largely by the Madden-Julian Oscillation (MJO) and ENSO. This correlation is unique to Indonesia and overshadows isoprene's exponential increase with temperature, which may be due to changes in emissions or changes in isoprene oxidation by OH. Using the chemical transport model GEOS-Chem, we suggest that the variations in isoprene columns with precipitation are modulated by changes in soil NO fluxes, which increases OH and isoprene/methane losses. Since both isoprene emissions and microbial soil NO fluxes are sensitive to changes in temperature, precipitation, and climate oscillations (e.g. ENSO), this study highlights the importance of atmospheric chemistry and accurate biogenic emissions into climate models, which may affect future aerosol forcing and methane lifetimes.

Vegetation and Carbon Cycle

The Future Carbon Sequestration Potential of Chihuahuan Desert Ecosystems

Jacob Blais (he/him/his), Northern Arizona University

The southwest U.S. is largely comprised of dryland ecosystems, making it inherently water-limited, and is warming faster than most regions across the globe (Seager & Vecchi, 2010). At the same time, precipitation in this region is declining and becoming more variable both within and across years (Maurer et al., 2020; Zhang et al., 2021). Such changes in weather and climate will reshape the structure and function of these ecosystems because water is their primary limiting resource (Huxman, Smith, et al., 2004). In comparison to other ecosystem types, drylands strongly influence the carbon sequestration capacity of the biosphere due to their high degree of interannual variability in precipitation and plant productivity (Gherardi & Sala, 2019). Previous work in this region has focused on the impacts of increasing frequency and magnitude of drought and within-season variability in precipitation on various ecosystem processes (Jentsch et al., 2007; Munson et al., 2022). However, less is known regarding the simultaneous effects of increasing drought and interannual precipitation variability on the relationship between water availability and plant productivity. I present results from a precipitation manipulation experiment nestled into the northern edge of the Chihuahuan desert in New Mexico. By systematically altering precipitation that reaches experimental plots, I investigate the effects of these dual changes in precipitation on the carbon sequestration potential of common desert plants. Preliminary results reveal that reduced and more variable precipitation has a negative synergistic effect on blue grama grass productivity, but what about other widespread species? Find out during this presentation!

Clouds and Radiation

Impacts of wind speed driven coarse mode sea spray aerosol on precipitation in marine boundary layer clouds

Katherine Mifsud (she/they/them), University of Washington

Precipitation in low clouds strongly affects cloud response to aerosol perturbations, thereby impacting aerosol-forcing of climate; a significant but uncertain response. Drizzle formation in marine low clouds depends on cloud-aerosol interactions in the cloud layer. Sea salt aerosols, due to their chemical composition, are large and more likely to promote hygroscopic growth in a saturated environment and drive collision and coalescence, leading to precipitation formation. Larger droplets are also more likely to undergo collision and coalescence. Evidence suggests that sea salt aerosol concentration can be controlled by low-level wind speed across the ocean surface and that an increase in wind speed may lead to an increase in the aerosol size and the concentration of sea salt aerosols that travel to the cloud base through updrafts in the tropics and subtropics. Giant cloud condensation nuclei (GCCN), which in this study, have a diameter larger than 1 um, may be generated as wind speed increases. Adding a few GCCN to stratocumuli could have a direct influence on collision-coalescence efficiency, thus increasing the probability of drizzle formation. This study utilizes datasets from the 2020-2023 Aerosol-Cloud-Meteorology Interactions over the

Western Atlantic Experiment (ACTIVATE) to assess the dependence of coarse mode sea spray aerosol size on wind speed over the Western Atlantic by characterizing GCCN size distributions. Results explore the number and size distribution of GCCN and their dependence on wind speed. It is necessary to understand whether wind speed – coarse mode concentration relationships are universal, or if significant differences exist in different meteorological regimes.

Oral Session 6

Morning (10:20am), Sunday, November 3, 2024

Climate at the Poles - Arctic Warming

Sources of Predictability in Skillful Summer Arctic Sea Ice Forecasts

Jacob Cohen (he/him/his), University of Washington

The recent reduction of Arctic sea ice extent has led to more area and time with ice-free conditions and more access to the Arctic. Understanding the predictability of summertime Arctic sea ice conditions, especially sea ice minima, is therefore becoming increasingly important. Previous studies have demonstrated the influence of local and remote processes on Arctic sea ice variability. Here, we extend those analyses by assessing prediction skill in a global climate model simulation and interrogating how the predictive skill of JAS (July, August, September mean) Arctic sea ice extent (SIE) is impacted by local and remote atmospheric and oceanic processes. We evaluate prediction skill of the Arctic SIE in the Seasonal-to-Multiyear Large Ensemble (SMYLE) Experiment, a set of initialized hindcasts using the Community Earth System Model that contains 20-member ensembles of 24-month simulations initialized quarterly from 1970 to 2019. We verify predictions from SMYLE against satellite observations from the National Snow and Ice Data Center (NSIDC). We decompose the SIE prediction skill into the interannual contribution to the overall correlation to investigate which years exhibit high predictive skill and find that years with sea ice minima contribute the most to predictive skill. For the years with the highest skill contributions, we examine patterns of sea ice concentration, sea ice thickness, and local atmospheric and oceanic variables to understand the processes that contribute the most to Arctic SIE prediction skill. This work demonstrates how atmospheric and oceanic processes affect Arctic sea ice predictability on seasonal timescales.

Climate at the Poles - Glaciers

Attributing Glacier Mass Loss Using Minimally Calibrated Physics-Based Melt Models and Neural Networks

Christina Draeger (she/her), University of British Columbia

Current state-of-the-art glacier models predominantly rely on temperature-index methods, which estimate melt rates based solely on temperature data and require empirical calibration from well-studied glaciers. These calibrated parameters are then extrapolated to unmeasured glaciers. However, the limited transferability of these parameters across space and time introduces significant uncertainties in projections of glacier mass changes, particularly at local scales where glacier retreat has the most critical impact on communities' freshwater resources. This study evaluates the performance of a minimally calibrated glacier evolution model that incorporates a physics-based surface energy balance melt model to reconstruct glacier mass changes for 18,787 glaciers in Western Canada from 1979 to 2022. Additionally, we present a novel method for simulating glacier albedo evolution using deep learning models. In addition to temperature, our glacier evolution model attributes glacier melt responses to a range of climatic forcings, moving beyond the limitations of traditional temperature-index models. The model outputs are evaluated at regional, sub-regional, and local scales against observed glacier thinning and area changes, derived from remote sensing data and in-situ observations. The goal of this study is to advance our process-based understanding of glacier responses to climate change and reduce uncertainties in glacier projections across varying spatial scales.

Oceans - Biogeochemical

Dynamical shifts in the California Current System as drivers of biogeochemical variability in a semi-enclosed coastal sea

Becca Beutel (she/her), University of British Columbia

The Salish Sea is a semi-enclosed coastal sea between Vancouver Island and the coast of British Columbia and Washington State, invaluable from both an economic and ecologic perspective. Pacific inflow to the Sea, strongly influenced by the California Current System (CCS), is the main contributor of many biologically important constituents. Climate change induced changes to CCS dynamics, such as alterations in California Undercurrent depth, upwelling and downwelling strength and timing, and Pacific Subarctic Upper Water intrusion, have direct implications for Salish Sea inflow. However, the extent of this connection and the Salish Sea's vulnerability to specific changes remain unknown. This study explores the contribution of Pacific water masses to Salish Sea inflow in relation to variability of CCS dynamics. We conducted quantitative Lagrangian particle tracking experiments using a 3D physical-biogeochemical ocean model of the Salish Sea and surrounding coastal waters. Water parcels were integrated backwards in time to assess water mass path from the shelf region to the Salish Sea, and paths were connected to modelled and observed biogeochemical properties and trace metals. This study aims to identify the main drivers of Salish Sea biogeochemical variability in the context of CCS changes. By doing so, we contribute valuable insights to the understanding of the intricate interplay between physical and biogeochemical processes in this coastal sea, with implications for upwelling systems worldwide.

Oceans - Dynamics

Estuarine exchange and tidally mixed flows through inter-connected pathways in the Salish Sea

Camryn Stang (she/her), University of British Columbia

The Salish Sea is a coastal ocean whose largest basin (Strait of Georgia) is connected to the north-eastern Pacific Ocean through regions with tight constructions and sills that cause intense tidal mixing. The Fraser River supplies substantial freshwater to the Salish Sea and flows into the Strait of Georgia, driving an estuarine circulation. The southward estuarine surface flow and northward deep flow are complicated through the tidally mixed region around then San Juan and Gulf Islands (SJGI), causing considerable reflux back into the Strait of Georgia. Thus, the dynamics in the SJGI region strongly influence the water properties and the transport of nutrients, carbon, etc. Understanding the dynamics through this region is important in light of the changing climate conditions. The SJGI region consists of three different straits, Haro Strait, Rosario Strait, and San Juan Channel. Haro Strait is the largest and deepest of the channels and as such, more exchange occurs through this Strait than the others. To examine the differences in water transport through the different channels, Lagrangian particle tracking simulations were performed for a 4-year hindcast (from 2018-2022) using 3-dimensional numerical model SalishSeaCast. The density difference between the two sides of the region is the most dominant factor driving water transport, accounting for ~ 80% of the variance in water flux. The tides are the next most prominent factor, accounting for 15% of variance, and as expected are negatively correlated with the baroclinic and barotropic water fluxes. While there is 2-layer flow through Haro Strait, water flow through the shallower Rosario Strait and San Juan Channel is typically only southward. However, the proportion of the southward flow carried by these straits is significant. The relative proportion of the southward flow through Rosario Strait increases at the onset of the Fraser River freshet, from ~ 20% in the winter to 30% in the summer.

Paleoclimate

Reconstructing the demise of the Patagonian Ice Sheet

Matias Romero (he/him/él), University of Wisconsin-Madison

Currently, the Antarctic and the Greenland ice sheets are undergoing rapid and widespread changes, posing major societal and economic consequences due to sea level rise. Yet, forcings and feedbacks behind ice sheet melting remain uncertain, hindering our ability to inform models working on predicting future ice sheet evolution. Therefore, reconstructing past ice sheets can illuminate how these ice masses grew and decayed over time, and how they responded to climate forcings. During the Last Glacial Maximum, the Patagonian Ice Sheet (PIS) formed a contiguous cap over the southern Andes from 38° to 55° S, with a sea level equivalent to approximately 1.5 m. Despite recent progress in reconstructing ice sheet geometry and configuration during the last 35000 years, constraints on the timing of ice sheet retreat and thinning during the last deglaciation remain limited. We employed cosmogenic nuclide surface exposure dating on exposed bedrock surfaces at different elevations across the Southern Volcanic Zone, providing new ages to document the timing of ice sheet thinning. Using these results as constraints, we then perform transient simulations of the PIS during the last deglaciation with the Ice Sheet and Sea-level System Model (ISMM) to test ice sheet sensitivity of the northern PIS to changing climatological inputs driven by the Community Climate System Model Trace-21ka experiment. Our new data and model simulations provide a comprehensive data-model comparison to investigate both the timing and drivers of ice sheet change following the last glacial period in the southern mid-latitudes.

POSTER PRESENTATION ABSTRACTS

Poster Session A
(A01-A21)
Evening (5:00pm), Friday, November 1, 2024

Poster Session B
(B22-B49)
Evening (7:00pm), Friday, November 1, 2024

Poster Session C
(C43-C66)
Evening (5:15pm), Saturday, November 2, 2024

Poster Session D
(D65-D85)
Evening (7:45pm), Saturday, November 2, 2024

Oceans - Biogeochemical

(A01) Does small-scale ocean physics and biology matter to global climate? Lessons learned from NASA's Sub-mesoscale Ocean Dynamics Experiment (S-MODE)

Sarah Lang (they/she), University of Rhode Island

As oceanic uptake of carbon dioxide continues to increase with rising atmospheric concentrations, advancing our understanding of the ocean's role in climate is crucial to accurately predicting future climate. Recent studies suggest that submesoscale (small-scale: 0.1-10 km in size, time scales of hours-days) biological and physical processes in the ocean play an important role in the climate system, yet the impacts are still being uncovered. For example, submesoscale vertical velocities can induce significant fluxes of heat, oxygen, nutrients, and carbon, resulting in biological and climatological impacts such as enhanced phytoplankton production or carbon export. These processes are challenging to observe due to their small and fast spatiotemporal scales, so our ability to model these scales has outpaced our ability to observe them. As part of NASA's Sub-mesoscale Ocean Dynamics Experiment (S-MODE), my work involves uncovering how submesoscale dynamics structure phytoplankton ecosystems and carbon export using airborne remote sensing, in situ observations, and high resolution ocean modeling. I developed airborne models for biological parameters (e.g.

chlorophyll-a and particulate organic carbon), explored relationships between biological parameters and concurrent surface physics, and characterized the submesoscale processes leading to those distributions. This work seeks to improve the understanding of how submesoscale physics impact ocean phytoplankton ecosystems and carbon export.

(B22) Variability of oxygen in Denmark Strait Overflow Water (DSOW) as revealed by novel oxygen sensors in the Irminger Basin

Hiroki Nagao (he/him/his), Woods Hole Oceanographic Institution

The Subpolar North Atlantic plays a key role in the regulation of the greenhouse effect and oxygenation of the deep ocean because deep convection in this region enhances the oceanic uptake of atmospheric CO_2 and oxygen. Climate models predict that deep convection will weaken over the 21st century, potentially lowering the uptake of both gases. One important pathway through which oxygen-enriched waters enter the deep ocean is the Denmark Strait Overflow Water (DSOW). DSOW flows across the Denmark Strait sill, located between Iceland and Greenland, before descending to the Irminger Basin and spreading to the rest of the North Atlantic. However, variability in the oxygen concentration of DSOW remains uncertain because year-round measurements of oxygen are lacking. Here, we document changes in the oxygen concentration of DSOW, using new time series data from oxygen sensors deployed in the Western Irminger Basin. These data, which are the first year-round oxygen measurements in the deep North Atlantic, reveal a seasonality in the oxygen concentration of DSOW, increasing over winter/spring and decreasing over summer/fall. We hypothesize that this seasonality is related to (i) variations in the oxygen concentration at the Denmark Strait sill or (ii) variations in the water masses that mix into DSOW upon spreading from the sill to the Irminger Basin. This work has key implications for understanding how the oxygen content of dense overflow waters may respond to changes in the ocean circulation and climate of the Subpolar North Atlantic.

(C43) Tracking Hydrothermal Metal Transport Across the Pacific Basin Via Sedimentary Metal Deposits

Katherine Squires (she/her), Massachusetts Institute of Technology-Woods Hole Oceanographic Institution Joint Program

Hydrothermal vent fluids are a large but enigmatic source of many metals to the ocean. These metals, particularly iron (Fe), exert a substantial impact on ocean chemistry and serve as important nutrients for chemosynthesis and photosynthesis. Historically, the scientific community has assumed that most hydrothermal Fe is precipitated as polymetallic sulfide minerals and oxyhydroxides, then rapidly removed to the seafloor (i.e. close to a vent source). However, recent GEOTRACES studies have demonstrated that hydrothermal Fe may actually persist in the water column for thousands of kilometers. Therefore, it is possible that hydrothermal Fe may travel far enough to be upwelled in the Southern Ocean, thereby impacting primary productivity and CO2 drawdown in this Fe-limited region. Currently, there exist major gaps in knowledge regarding the spatial extent to which hydrothermal metals persist in the water column and in understanding the element-specific removal of these metals to the sediments. In this project, we use the elemental composition of 800+ modern coretop sediment samples from across the Pacific Basin to track where hydrothermal material travels in the water column before it is deposited on the seafloor. The maps and figures produced in this study, coupled with knowledge of vent locations and water column data, allow us to better constrain the distances that various metals travel after being discharged from a vent. A detailed understanding of hydrothermal metal transport is essential for accurate reconstruction of hydrothermal fluxes and for understanding the role that vent fluids play in elemental cycling, primary productivity, and global climate.

(D65) Evaluating variability of interior ocean regenerated carbon using observationally constrained data products

Stevie Walker (they/she), University of Washington

The biological carbon pump (BCP) plays a key role in transporting carbon from the surface to the deep ocean, sequestering a fraction of the organic carbon produced by photosynthesis in the mesopelagic. Many studies assess changes in the BCP in terms of export flux, the amount of organic carbon transported to depth. However, investigating regenerated carbon (Creg) – inorganic carbon originating from organic biological material – integrates both the gain and loss terms for ocean interior organic carbon and more directly relates the BCP to the reservoir of atmospheric CO2. The expanding global array of biogeochemical (BGC) Argo floats and the development of algorithm-driven observational data products is enabling exploration of BGC changes at high spatiotemporal scales. I use the GOBAI-O2 data product to assess changes in mesopelagic oxygen content, apparent oxygen utilization (AOU), and Creg at global and regional scales from 2004-2023. Globally, Creg is increasing by about 2.2 Gt/decade in the mesopelagic (200 m - 1000 m). The increase in AOU accounts for the majority (~82%) of the oxygen decrease in the mesopelagic, with warming-induced solubility changes accounting for the remaining 18%. High-Creg water masses are characterized by some combination of old age, which allows more time for respiration to occur, and high overlying production, which provides more organic material to be respired. Evaluating seasonal and interannual Creg changes across different depth ranges and regions will allow us to better constrain changes in the BCP and to evaluate the effect that these changes have on the ocean carbon sink.

Oceans - Dynamics

(A02) 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. ATOMIC deployed three saildrones—uncrewed surface vehicles powered by wind and solar energy and equipped with several oceanographic and atmospheric sensors. Saildrones collected upper-ocean velocity measurements with an acoustic doppler current profiler, sampling in a tight line or triangular formation, separated by 3-5 km, so along-track and across-track submesoscale gradients could be estimated. We investigate statistics of vertical vorticity, horizontal divergence, lateral strain rate, surface horizontal frontogenetic tendency, and vertical velocity in the sampling area. We find that vorticity and divergence distributions are more symmetric compared to mid-latitude regions and there is a prevalence of anticyclonic vorticities, reaching -10f in extreme cases. Statistics are also computed and compared for frontal transects, 10 km in length, which were identified via an along-track density gradient threshold associated with the 90th percentile range. 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. An analysis of vorticity and divergence suggests the presence of a secondary circulation in the cross-frontal plane. The analysis provides insights on tropical submesoscale dynamics, an important step towards understanding the role of these small-scale processes on Earth's climate.

(B23) Model versus observation showdown: How well do global ocean models represent North Atlantic thermohaline processes?

Taydra Low (she/her), University of Wisconsin-Madison

Subpolar North Atlantic currents are a key part of the Atlantic meridional overturning circulation (AMOC), which affects the climate through its transport of heat, carbon, and freshwater. It is in this region where heat and carbon are sequestered to the deep ocean through deep convection. Subpolar North Atlantic thermohaline processes control AMOC variability and strength. However, AMOC strength has declined in recent in situ observations. While it is unknown how much of the observed decline is due to greenhouse gases versus natural variability, global ocean models show AMOC decline starting at this time. Global ocean models, however, suffer from long-standing biases and inadequate process representation, which degrades their credibility. Our goal here is to evaluate subpolar North Atlantic thermohaline biases using surface-forced water mass transformation as a method to compare North Atlantic circulation in several ocean models that participated in the Ocean Model Intercomparison Project (OMIP). To evaluate biases, we use a set of observation-based water mass transformation benchmarks. Our analysis focuses on how well OMIP water mass transformation fits within the observational range. Assessing ocean model biases aids in improving thermohaline processes, which will increase our fidelity in climate predictions.

(C44) Insights into AMOC Stability: How Critical Slowing Down Fails in a 3-Box Model

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

Understanding Atlantic Meridional Overturning Circulation (AMOC) stability is immensely important for predicting future climate. While comprehensive climate models typically do not simulate a collapse under global warming, recent observational studies have argued that a collapse is imminent. Here we investigate the potential multistability of the AMOC and the concept of Critical Slowing Down (CSD). Changes in certain statistical indicators can reveal CSD due to the slowed relaxation from external perturbations associated with a loss of stability. To explore their performance, we calculate such indicators for a 3-box model of the AMOC over widely varying parameter regimes, investigating the underlying dynamical structure of the system over gradual climate forcing. While the 3-box model can exhibit bistability, it contains no bifurcations in much of the explored parameter space. CSD indicators accurately warn of a critical transition only when the salinity transport via Atlantic gyres is relatively small, which gives rise to a bifurcation in the modeled AMOC strength. The indicators raise a false alarm in runs where this transport is strengthened, and the bifurcations are lost. It follows that the underlying structure of the potential landscape determines whether this type of indicator can be confidently used as a predictor of critical transitions; we argue that it is not a priori clear whether the AMOC is in a multistable regime or not.

Air-Sea Interactions

(A03) Role of Stratospheric Aerosols in Modulating Tropical Cyclone Intensity through Upper Tropospheric cooling

Paul Adigun (he/him/his), University of Tsukuba

Environmental factors like upper-level temperatures that modulate outflow and ventilation heavily influence tropical cyclone intensification. Stratospheric aerosols from volcanic eruptions can cool the upper troposphere, potentially providing more favorable conditions for intensification. However, the magnitude of this effect and underlying physical mechanisms still need to be better quantified. Using an ensemble of CMIP6 models, we investigate how stratospheric aerosol loadings impact tropical cyclone intensity through induced upper-level temperature changes. In multiple models, we composite thousands of synthetic tropical cyclones from aerosol-rich and aerosol-poor periods. Aerosol-rich periods exhibit significantly cooler upper tropospheric temperatures throughout the tropics and subtropics. Composite analyses reveal this upper-level cooling enhances tropical cyclone outflow, ventilating hot tower cores more efficiently. Coupled with modestly warmer sea surface temperatures, the improved ventilation allows for higher sustainable intensity as predicted by potential intensity theory. Lagrangian air parcel trajectories trace the sources of cooler outflow air to the lower stratosphere. We quantify the outflow temperature-intensity relationship using the potential intensity framework. The observed outflow temperature differences in aerosol-rich versus aerosol-poor composites can explain 20-40% of the simulated intensity changes. Our results highlight stratospheric aerosol geoengineering as a possible approach to regionally modulating tropical cyclone behavior through favorable upper-level temperature modulations.

(B24) Atmospheric and Oceanic Responses to Ocean Thermal Energy Conversion

Leslie Moffat (she/her), University of Victoria

As the effects of the unprecedented rate global warming are intensifying around the globe, governments and communities are searching for ways to minimize human stress on the climate system. Power consumption is expected to increase and there is growing demand for renewable energy sources to replace fossil fuels. Ocean Thermal Energy Conversion (OTEC) is a promising form of marine renewable energy which harnesses solar energy stored in the vertical thermal water column by using the thermal gradient between the surface and deep ocean to drive a heat engine. OTEC is non-polluting and independent of season or time of day, rendering it a consistent and safe form of electricity generation. Current research aims to determine the potential magnitude of energy that can be drawn from OTEC along with its corresponding reduction in atmospheric carbon dioxide concentration and global mean surface air temperature. OTEC involves redistributing large water masses within the vertical water column, which results in cooling of sea surface temperatures in regions of OTEC implementation. This unprecedented ocean surface cooling has the potential to influence oceanic and atmospheric dynamics. The presented research includes using the UVic Earth System Climate Model to investigate the effects of OTEC on global mean surface air temperature, localized ocean surface cooling, and large-scale ocean circulation changes which is required before widespread OTEC implementation can be considered viable.

(C45) Evaluating the use of simple climate models for global warming projections

Manali Nayak (she/her), University of Washington

Climate change assessment reports such as the IPCC AR6 use simple energy balance models (EBMs) to generate future climate projections for policymakers as comprehensive global climate models (GCMs) tend to overestimate key metrics such as Effective Climate Sensitivity (ECS). These simple models lack the full physics of GCMs, and their parameters are empirically constrained by observed values to produce the expected global temperature and top-of-atmosphere (TOA) energy imbalance. However, the warming projections of these simple models have been assumed to be accurate on the basis of this historical fitting with no verification provided. In this study, we explore whether a simple EBM tuned to the historical record of a GCM can accurately predict the future warming of that GCM. Specifically, we fit a two-layer EBM to output from the CESM Large Ensemble (LE) for the period 1850-2020. We then obtain the calibrated parameters and run the model for the entire period of the CESM-LE simulation (1850-2100) under a high emission scenario (RCP 8.5) and find that the two-layer EBM overestimates warming in the future. Current work is aimed at investigating missing physical mechanisms in the two-layer model, particularly time-varying ocean heat uptake efficiency, as this may inform modifications necessary in the simple model to produce more accurate warming projections in future assessment reports.

(D66) Extra-tropical radiative response driven by equatorial warming

Pappu Paul (he/him/his), University of Illinois Urbana Champaign

Variations in sea surface temperature (SST) patterns significantly modulate radiative fluxes at the top of the atmosphere (TOA). In this work, we explore the sensitivity of radiative feedback to SST patterns in idealized aquaplanet simulations using Community Atmospheric Model version 5 (CAM5), part of Community Earth System Model (CESM 1.2.1). We use a green's function approach where we prescribe delta function-like perturbations of SST in latitude bands, with SSTs kept fixed at climatological values everywhere else. For this study we design 37 equidistant '2K' warming 1D latitude bands. We find that while the radiative response is primarily driven by warming at the equator, the strongest radiative fluxes out of the top of the atmosphere occur in the extratropics. These results suggest a need for altering the classic view of zonal mean radiative feedbacks - such as those used in diffusive energy balance models - where the feedbacks are most negative in the subtropics. Our results show that these ostensibly extra-tropical feedbacks are actually driven by equatorial warming. An important limitation of the results is that Green's function responses in the model are strongly non-linear outside of the Intertropical Convergence Zone (ITCZ).

(B25) Scale-Dependent Drivers of Gulf Stream Variability

Noah Rosenberg (he/him/his), University of Washington

The strength and position of the Gulf Stream is a key driver for extratropical weather and climate in the Northern Hemisphere, and is not represented well in low-resolution climate models. Variability in the system is a function of both atmospheric and ocean dynamics, with atmospheric drivers setting some large-scale properties and ocean dynamics driving mesoscale and submesoscale features. The relative importance of the atmosphere and ocean, and the mechanisms by which each modulates the Gulf Stream, are not well understood at all spatial scales. In this work, we investigate drivers of variability in the system using a high-resolution regional model ensemble with four different boundary conditions to highlight differences in ocean-driven versus atmosphere-driven regimes.

(A04) The impact of biological and physical process timing on CO2 air-sea gas exchange

Meg Yoder (she/her), Boston College

The ocean acts as a major control on the amount of carbon dioxide (CO_2) in the atmosphere, which in turn impacts our changing climate. CO_2 moves between the ocean and the atmosphere via air-sea gas exchange, which is largely controlled by the concentration of CO_2 in the atmosphere relative to the ocean beneath it. CO_2 in the atmosphere is relatively homogenous, however the concentration in the ocean varies regionally and locally, driven by physical properties such as temperature, salinity, wind speed, wave state, and depth of the mixed layer. Biological processes, primarily photosynthesis and respiration, also govern surface ocean CO_2 concentration by reducing and increasing surface inorganic carbon, respectively. These forces act together, and on each other, to control the rate of air-sea CO_2 exchange. To isolate how changes in individual drivers may influence air-sea CO_2 exchange in the notably active subpolar North Atlantic, we utilize a modeling approach. We have successfully validated the use of an adapted 1-dimensional vertical mixing model using observational mixed layer depth and carbonate chemistry time series data from the Irminger Sea. We will run a series of experiments including baselines and alterations of the timing and intensity of key events, like storms and phytoplankton blooms, in order to identify their impact on seasonal and annual air-sea CO_2 exchange. In doing so, we aim to better understand potential change in the ocean's role in mitigating the accumulation of CO_2 in the atmosphere.

Paleoclimate

(A05) Quantifying the State Dependency of Climate Sensitivity Across Cenozoic Warm Intervals

Mary Grace Albright (she/her), University of Connecticut

Equilibrium climate sensitivity (ECS) quantifies the amount of warming resulting from a doubling of the atmospheric CO2 forcing. Despite recent computational advancements, there remains large uncertainty on the degree of future warming. To help alleviate this uncertainty, past climates provide a valuable insight into how the Earth will respond to elevated atmospheric CO2. However, there is evidence to suggest that ECS is dependent on background climate warmth, which may interfere with the direct utilization of paleo-ECS to understand present-day ECS. Thus, it is important that a range of different climate states are considered to better understand the factors modulating the relationship between CO2 and temperature. Here, we focus on three time intervals: the mid-Pliocene Warm Period (3.3 – 3.0 Ma), the mid-Miocene (16.75 – 14.5 Ma), and the early Eocene (~50 Ma). We constrain the ECS and its uncertainty using several published methods to estimate the global mean surface temperature (GMST) from sparse proxy records. This framework utilizes an emergent constraint between the simulated GMST changes and climate sensitivities across model ensembles. For each, we employ a combination of parametric and non-parametric functions, coupled with a probabilistic approach to derive a refined estimate. Preliminary results for the Pliocene indicate a GMST reconstruction of approximately 19.3°C, which is higher than previous estimates that were derived using only marine records. Using this estimate, we calculate an ECS than is also higher than previously published values, especially due to the inclusion of high-latitude terrestrial temperature records into our estimates. Intriguingly, using the consistent methodology, our calculated ECS for the early Eocene and mid-Miocene is lower than that of the mid-Pliocene. This result does not support an amplified ECS in hothouse climate, and points to a potentially important role of ice albedo feedback in amplifying the ECS in coolhouse climate.

(B26) Deciphering mechanisms of persistent low oxygen in the Northeast Pacific Ocean over the last 20,000 years

Jonas Donnenfield (he/him/his), Oregon State University

Global oceans show a 2% loss in oxygen content over the last 50 years because of anthropogenic CO2 emissions, leading to expanded low-oxygen mid-depth regions of coastal oceans. These can disrupt marine ecosystem stability, biogeochemical cycling, and fishing economies, the effects of which have been observed in the Pacific Northwest (PNW) during enhanced seasonal upwelling of oxygen-poor waters. Given the short time series of modern observations, it is unclear whether these PNW low-oxygen events are a short-term perturbation or part of a long-term trend. Studies

reconstructing past ocean conditions can shed light on this, suggesting oxygen loss in the Northeast Pacific Ocean can be driven by increased low-oxygen source waters, limited re-oxygenation of intermediate waters, and greater oxygen utilization. However, the contribution of each mechanism in driving low oxygen to become persistent in the geologic record remains uncertain. In this study, we use a suite of new marine sediment cores offshore of the PNW to establish the timing, extent, and causes of regionally persistent low oxygen in the Northeast Pacific over the last 20,000 years. Preliminary results from sedimentary features and microfossil (foraminifera) assemblages suggest persistent low oxygen periods spanning several centuries in the past 20,000 years. The origin and magnitude of these episodes will be evaluated using bulk-sedimentary geochemistry, foraminiferal stable isotopes and trace elements, and low-oxygen tolerant foraminifera morphology. With oxygen loss projected to continue with global warming, this research is crucial in constraining uncertainty in the spatial distribution and mechanisms of persistent low oxygen.

(C46) Mid-Pliocene climate forcing, sea surface temperature patterns, and implications for climate sensitivity

Michelle Dvorak, University of Washington

Characterized by similar-to-today CO levels (~400ppm) and surface temperatures 2 approximately 3-4°C warmer than the preindustrial, the mid-Pliocene Warm Period (mPWP) has often been used as an analog for modern CO2-driven climate change, and as a constraint on the equilibrium climate sensitivity (ECS). However, model intercomparison studies suggest that non-CO2 boundary conditions – such as changes in ice sheets – contribute around half of the global mean warming and strongly shape the pattern of sea-surface warming during the mPWP. Here, we employ a hierarchy of CESM2 simulations to quantify mPWP effective radiative forcings, study the role of ocean circulation changes in shaping the patterns sea-surface temperature response. We find that the non-CO2 boundary conditions of the mPWP, enhanced by changes in ocean circulation, contributed to larger high-latitude warming and less-stabilizing feedbacks relative to changes induced by CO2 alone. Accounting for such differences in feedbacks between the mPWP and the modern (greenhouse-gas driven) climate provides stronger constraints on the high-end of modern-day ECS. However, a quantification of forcing from non-CO2 boundary condition changes combined with the distinct radiative feedbacks that they induce suggests that Earth System Sensitivity may be higher than previously estimated.

(D67) Using clumped isotopes to make new connections on Cretaceous paleohydrology at low latitudes

Carina Kentish (shey/they), Brigham Young University

Deep time climate reconstructions are key to improving our predictions of future climate change due to anthropogenic activities. Greenhouse periods like the Cretaceous (145 -66 Ma) are characterized by high global temperatures compared to the modern and can be used as case studies for studying Earth's climate system during warm phases. An enhanced hydrologic cycle (EHC) is one of the proposed mechanisms for explaining the severity of high-latitude greenhouse warming during the Cretaceous; however, unambiguous evidence of enhanced precipitation and evaporation during the Cretaceous is still lacking, especially at low latitudes. Previous paleohydrology studies have focused on reconstructing Cretaceous hydrologic conditions for the mid- to high latitudes. The lack of studies surrounding the hydrologic cycle at low latitudes has created a gap in our understanding. To test the EHC hypothesis, this study investigates low-latitude paleohydrology in the middle Cretaceous Tlayúa Formation (Puebla, MX). Shallow marine carbonates and terrestrial paleosols from the same stratigraphic section will be sampled and analyzed using clumped and triple-oxygen isotope geochemistry and Bt-horizon elemental geochemistry in order to quantitatively reconstruct key paleoclimate parameters such as temperature and precipitation, and to constrain paleoevaporation for the middle Cretaceous. The results of this study will provide new constraints on the EHC hypothesis and the differences between greenhouse and icehouse hydrologic systems.

(C47) A deep learning approach to the taxonomic classification of grass silica short cell phytoliths: implications for paleoclimatic and paleoecological reconstructions

Benjamin Lloyd (he/him/his), University of Washington

Poaceae, the grass family, contains over 12,000 species that occupy ecological niches across a wide variety of temperature and precipitation regimes, from rainforest understories, to deserts, to tundra. With adequate taxonomic specificity, reconstructions of ancient grass communities can be used to make robust paleoclimatic and paleoecological inferences. Phytoliths, microscopic silica bodies that infill plant tissues, have proven especially useful in this pursuit, due to the distinct morphologies of Grass Silica Short Cell Phytoliths (GSSCPs) affording more taxonomic specificity than largely non-diagnostic grass pollen and leaf fossils. However, the precision with which GSSCPs can be identified in the fossil record is limited by the difficulty and subjectivity of phytolith morphotype classification. Deep learning approaches to image classification offer new tools to standardize and streamline phytolith classification. We have adapted newly developed pollen classification methods to phytoliths with a robust training set of 7,023 GSSCP images obtained from vouchered herbarium specimens of 111 species spanning all twelve Poaceae subfamilies. Trained convolutional neural networks (CNNs) achieve ~75% accuracy in species classification, significantly above the 0.9% expected by chance. We next transform CNN classification features using a second machine learning model (multilayer perceptron, MLP) trained on known phylogenetic distances. The MLP-transformed features are then used to place fossil phytoliths on the Poaceae phylogeny using Bayesian inference. These methods have the potential to uncover previously unrecognized connections between morphology and phylogeny, expanding researchers' ability to draw paleoecological and paleoclimatic conclusions from fossil phytolith assemblages.

(B27) Reconstructing the Tropical Pacific Upper Ocean using Online Data Assimilation with a Deep Learning model

Zilu Meng, University of Washington

A deep learning (DL) model, based on a transformer architecture, is trained on a climate-model dataset and compared with a standard linear inverse model (LIM) in the tropical Pacific. We show that the DL model produces more accurate forecasts compared to the LIM when tested on a reanalysis dataset. We then assess the ability of an ensemble Kalman filter to reconstruct the monthly-averaged upper ocean from a noisy set of 24 sea-surface temperature observations designed to mimic existing coral proxy measurements, and compare results for the DL model and LIM. Due to signal damping in the DL model, we implement a novel inflation technique by adding noise from hindcast experiments. Results show that assimilating observations with the DL model yields better reconstructions than the LIM for observation averaging times ranging from one month to one year. The improved reconstruction is due to the enhanced predictive capabilities of the DL model, which map the memory of past observations to future assimilation times. This success highlights the significant potential of deep learning to improve our understanding and prediction of climate change through reconstructing climate variables from sparse information such as from coral proxies.

(D68) Attributing the Impacts of Last Millennium Land Use and Greenhouse Gas Emissions on Mississippi River Basin Hydroclimate

Kelsey Murphy (she/her), Rice University

The Mississippi River basin generates billions of dollars each year for the United States and has been heavily engineered to withstand extreme events in the last century. A key challenge to predicting future hydroclimate conditions across the Lower Mississippi River basin is determining whether river discharge will increase or decrease during the 21st century. Specifically, climate model studies disagree on how greenhouse gas forcing will influence river discharge, as both precipitation and evaporation are predicted to increase, while hydrologic contributions due to snowmelt are expected to decrease. Using single- and full-forcing simulations from NCAR's Community Earth System Model - Last Millennium Ensemble (CESM-LME), we evaluate changes in key hydroclimate variables on monthly-to-centennial time scales. Anthropogenic (greenhouse gas, land-use/land-cover) and natural (volcanic) forcing simulations are used to identify the hydrological responses to each climate forcing individually. Our results suggest 1) the Mississippi River basin is wetter during the 20th century compared to the pre-industrial period, but shifts again towards drier conditions in the 21st century, and 2) land-use/land-cover changes exert a more dominant control on Mississippi River basin runoff and discharge compared to greenhouse gas forcing. Understanding what drives past hydroclimate conditions will help supply resources for water managers to use and build upon, and also inform the development of future flood mitigation strategies and climate-resilient infrastructure.

(A06) Inferred Late Holocene Chilean Climate and Environmental trends from Trace elements distribution (Gotten from Core-Scanning X-Ray Fluorescence) in Lago NN Tantanuco, Chile

Godspower Ubit (he/him/his), 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 the region's winter rains and providing snowpack and fresh water to the entire west coast of southern South America. 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. I propose to understand Chile climate and environmental has changed over the last 2500 years using trace elements data gotten from Core Scanning X-ray Florescence analysis of Lago NN Tantauco sediment core. The analyzed Lago NN Tantauco sediment core is pristine without intrusion from volcanic materials and allows understanding of these variability at a high resolution of 0.5cm (equal to 70–80-year interval) over the last 2500 years. Robust statistical and time series analytical methods will be applied to the dataset to understand their relationship with SWW movements in the past. The result serves as a preliminary investigative tool prior to my biomarker/isotope analyses and will provide more accurate data to our climate models to make better climate projections and arm relevant stakeholders with the right information so they can make the right policies in response to the drought.

Clouds and Radiation

(D83) Light-Absorbing Aerosol-Cloud Interactions

Shreya Joshi, Michigan Technological University

Light-absorbing aerosols, particularly black carbon (BC) particles, significantly influence Earth's climate system by absorbing and scattering sunlight and altering cloud formation and properties. BC is one of the most influential species in the atmosphere in terms of positive climate forcing, comparable to carbon dioxide. Additionally, these aerosols act as cloud condensation nuclei or ice-nucleating particles. However, not all clouds precipitate; some evaporate, reintroducing the aerosols into the atmosphere where they undergo further interactions with clouds. These interactions can modify the particles' properties, affecting their role in climate processes.The Light-Absorbing Aerosol-Cloud Interactions (LAACI) project was designed to study these interactions in a controlled setting utilizing Michigan Tech's turbulent cloud Pi-chamber. We used BC surrogates (cab-o-jet) and coating materials (liquid smoke) to produce particles that mimic coated BC. These particles underwent cloud interactions in the Pi-chamber. We investigated three types of particles: (1) uncoated BC, (2) BC coated with liquid smoke and (3) liquid smoke particles alone. Using a pumped counterflow virtual impactor, we isolated and dried cloud droplets to analyze the residuals, while unactivated aerosols were collected separately. We found that a significant fraction of the coated BC residuals were more compact than the injected particles, indicating complex interactions between aerosol activation and morphology. We also observed a decrease in the real part of the refractive index in the residual particles and an increase in the mean size of the particle distribution. These findings provide insights into the atmospheric aging of BC-containing particles and should allow the development of more accurate parametrizations for atmospheric models to improve the predictions of future climates.

(B28) A Regional Comparison of CERES Downward Shortwave Surface Irradiances with the Oklahoma Mesonet from 2019-2021

Bradley Lamkin (he/him/his), University of Oklahoma

Clouds affect different components of Earth's climate system by reflecting some of the incoming solar radiation back to space, preventing some from reaching Earth's surface. Accurate radiative flux retrievals from spaceborne sensors are prone to different error sources than surface observations because they are derived from top-of-the-atmosphere (TOA) radiance measurements and estimates of atmospheric transmittances, with many errors being associated with clouds. The surface radiation budget plays a major role in global and regional climate change. Thus, a thorough understanding of the influence of clouds on satellite-based surface flux data is needed to improve our assessment of Earth's radiation budget. We compared two Clouds and the Earth's Radiant Energy System (CERES) surface radiation algorithms, Single Scanner Footprint (SSF) and Cloud and Radiative Swath (CRS), with the Oklahoma Mesonet total incoming solar radiation observations. We found that the CERES-CRS product had significantly lower mean bias error than the CERES-SSF product. We also find weaker agreement in CERES-Mesonet comparisons in the Spring and Summer. We speculate that the biases are possibly due to isolated cumulus clouds, which block the direct component of solar radiation and are difficult to account for in cloud transmittance modeling when they exist at low cloud fractions or complex spatial patterns. We also compare CERES-SSF and CERES-CRS across all nine Oklahoma climate divisions, to determine where biases are largest. The improvements in the surface irradiance retrievals in the CRS product will help assess trends in Earth's surface radiative budget and may improve global climate models.

(C48) Observing the truth? Challenges and advances in recording Earth's flow of energy

Hamish Prince (he/him/his), University of Wisconsin-Madison

The exchange and flow of energy in the Earth system is the most fundamental driver of the climate. From the absorption of sunlight, to the emission of thermal radiation from the Earth, the flow of energy around the planet can take numerous pathways through atmospheric and oceanic circulation paired with the exchange of energy between these reservoirs. In fact, the weather we experience can be viewed solely as a response to flows of energy in the atmosphere. Through this perspective, it becomes apparent that understanding the current state of Earth's energy flows is of utmost importance along with understanding how it may change in the future. We critically evaluate the current observations of Earth's energy balance, highlighting the heavy dependence on reanalysis for quantifying the movement of energy through the atmosphere. Satellite observations of Earth's energy balance will be assessed, examining some emerging trends in the record. The ability to observe the full global surface energy balance from space is also examined, discussing the discrepancies and highlighting the value of accurately measuring quantities such as evaporation and sensible heat fluxes for defining the current state of our climate. Finally, I will introduce the recently launched NASA PREFIRE mission which will measure Earth's spectrally resolved thermal emission in the far-infrared, a part of Earth's thermal emission that has never before been measured globally.

(C49) Advancing Our Understanding: Exploring the Influence of Galactic Cosmic Rays on Cloud Formation and Climate Dynamics

Ayesha Saeed (she/her), University of Michigan - Ann Arbor

Galactic cosmic rays (GCRs) have garnered significant attention in climate science for their potential influence on cloud formation and climate variability. This abstract presents a comprehensive analysis of recent advancements in understanding the intricate interplay between GCRs, cloud nucleation, and climate dynamics. Leveraging state-of-the-art observational datasets and sophisticated modeling techniques, this study elucidates the underlying mechanisms driving GCR-induced atmospheric processes. Our results provide strong evidence that ionization caused by GCRs acts as a catalyst to accelerate the formation of cloud condensation nuclei (CCNs), especially in areas where aerosol concentrations are low. We show the spatial and temporal variability of GCR-induced cloud cover modulation through detailed analysis of satellite observations, atmospheric measurements, and model simulations, emphasizing the importance of regional climatic conditions in mediating these effects. Moreover, this research elucidates the intricate interplay between solar variability, atmospheric dynamics, and GCR-induced ionization, elucidating the relative contributions of each factor to observed cloud and climate variations. By integrating multi-disciplinary approaches, including atmospheric physics, radiation chemistry, and climate modeling, our study provides a comprehensive framework for understanding the complex interactions driving Earth's climate system. Implications of our research extend beyond fundamental atmospheric science, with potential implications for climate modeling, solar-terrestrial interactions, and climate change attribution. Through rigorous analysis and innovative methodologies, this study contributes to the ongoing dialogue surrounding the role of GCRs in shaping Earth's climate, paving the way for future advancements in climate science and policy formulation.

Climate Adaptation - Policy and Perceptions

(A08) Effect of Air masses on Electricity Consumption in Europe

Oluwaferanmi Akinyemi (he/him/his), Kent State University

The European climate is diverse, dominated by the interaction of several air masses, each with its own distinct meteorological characteristics, all of which can impact the region's energy resources. Outdoor conditions play a large role in indoor human thermal comfort, and in many countries, energy consumption for heating and air conditioning are therefore responsible for substantial variability in electricity demand. Thermal comfort, however, is not only a function of temperature, but also humidity, wind speed, and cloud cover – which are best captured holistically as an air mass. Thus, enhanced understanding of the impact of air masses on power demand can

provide valuable insights for energy planning, grid management, and the creation of environmentally friendly energy systems. This research utilizes version 2 of the Gridded Weather Typing Classification System (GWTC) to examine the complex association between air masses and power consumption in Europe. The GWTC is a global-scale dataset that classifies air masses based upon six meteorological factors, into one of 11 different categories. The research indicates strong relationships between distinct air masses and energy demand. For instance, times of intense heat or cold caused by specific air mass types can result in higher demand for heating or cooling, hence impacting energy usage. Furthermore, the correlation between air masses and electricity demand varies both seasonally and regionally, since different parts of Europe have different baseline 'comfort' levels depending largely on latitude. Future research will explore whether these GWTC air masses are better predictors of electricity demand than air temperature alone.

(C50) Assessing the value in and the use of climate change communication curriculum in atmospheric science undergraduate programs

Kierstin Blomberg (she/her), University of Nebraska-Lincoln

It's been proven there is a Science Communication Gap that exists between scientists and the public when trying to relay scientific information. Even though Science Communication has been studied, little work has been done within the Atmospheric Sciences, especially as it pertains to students. Students will become the future researchers, scientists, and experts. If students are better trained to communicate with others, they will learn how to effectively translate information and methods to make the information relatable, useful, and actionable to each individual audience. In particular, this is critical in the context of climate change, where communicating accurate and impactful information is essential. A survey is being developed to assess the state of climate change science communication curriculum within undergraduate Atmospheric Science programs in the U.S. Survey respondents will include faculty and students, and the survey will collect data to answer the following: (1) Is there a gap between how educators value climate science communication and its weight in curriculum (i.e., a climate change science communication "teaching" gap)? (2) Is there a gap between how students value climate science communication and what they are being taught (i.e., a "learning" gap)? This presentation will share the methods of survey design and a sample of the survey questions. This research serves as a foundation to develop and implement education and outreach materials to ensure that Atmospheric Science students are learning effective climate change communication methods.

(D69) Examining Public Financial Mechanisms in British Columbia's Transition to a Post-Carbon Economy

Leif Douglass (he/him/his), University of Victoria

The urgency of transitioning to a post-carbon economy is already generally accepted by the British Columbia (BC) Government and a majority of the public. Transitioning away from fossil fuels will require not only a shift in energy sources but also a fundamental transformation of the provincial economy. While the Clean BC plan outlines the province's goals for emissions looking to 2030 and beyond, and the Climate Change Accountability Reports provide mandatory annual progress updates, they don't explore the financial mechanisms that may have a significant role in determining the pace of this transition. Understanding how public priorities are communicated and budgeted for within government Ministries is important for identifying potential roadblocks and inefficiencies hindering progress towards a post-carbon economy. By examining these practices, my research will specifically examine how public financial levers within the provincial budgeting process influence BC's progress towards a post-carbon economy, with the aim of identifying areas for improvement and suggesting ways to accelerate BC's transition. My research is rooted in the idea that making progress towards solving the climate crisis will require not just a diverse range of programs and initiatives, but also a deep integration of climate considerations into how the government makes all financial decisions. The goal of this research is to provide actionable insights that can be used by the provincial government in the future to improve their decision-making processes.

(A09) Visualizing Change: Digital Storytelling as a Catalyst for Public Engagement and Awareness about Climate Change, the Case of Brunei Darussalam

Silas Emovwodo, Universiti Brunei Darussalam

This research examines the role of digital storytelling in promoting public engagement and awareness within the context of Brunei's National Climate Change Policy, Agenda 2030, and Brunei Wawasan (vision) 2035. Examining how digital narratives may successfully convey the seriousness and consequences of climate change, encouraging a more thoughtful and proactive reaction from the public, is the main goal. By qualitatively analysing selected Instagram posts of the Brunei Climate Change Office (@bcco.bn), the Department of Environment (@jastre.bn), and the Brunei Vision 2035 office (@wawasanbrunei2035) this study investigates how these organisations utilise the platform to display initiatives, projects, and advancements in line with the nation's long-term development strategies. Employing the Agenda-Setting and Visual Framing theories of communication, and an adaptation of Russman & Svensson's (2016) studying organizations on Instagram (SOI) methodological framework, the study analyses the efficacy of digital storytelling as a tool for disseminating information, encouraging civic participation, and nurturing a sense of collective responsibility among Bruneians. Findings reveal that user-generated content by the selected Instagram profiles, such as images, captions, and hashtags, uncovers patterns and trends in public discourse related to sustainable development. It concludes that visual storytelling shapes public perceptions and attitudes toward Brunei's commitment to sustainable development. It recommends continued use of and attention to social media, as it offers insights to inform communication strategies for governments and organisations working towards sustainable development goals.

(C51) A Climate Change Informed Decision Making Framework for Mono Lake Diversions and Recovery

Sara Graves (she/her), University of California - Los Angeles

Mono Lake is a saline lake located in California's Sierra Nevada that is incredibly important ecologically and culturally. In the 1940s, LADWP began diverting water from Mono Lake as part of the Los Angeles Aqueduct system that provides crucial water resources to Los Angeles. These diversions caused the lake level to decline substantially, which has imperiled the lakes wildlife, harmed indigenous communities and caused influxes of toxic dust (PM10) into the surrounding air. Various water stakeholders and managers have been working towards implementing a new diversion policy which will balance the recovery of Mono Lake levels with the water needs of LADWP. This incredibly difficult task is even further complicated by the uncertainty surrounding what California's future hydroclimate will look like under climate change. Here, we produce a model to predict future Mono Lake level based on the atmospheric conditions from a suit of downscaled GCMs, and then implement this model to evaluate and optimize potential policies. We use single realizations from 11 GCMs under SSP245, SSP370 and SSP585 to capture a wide range of possible future conditions. This model allows for flexible diversions which we use to analyze over 100,000 different policies with various combinations of diversion limits based on different lake levels and hydrological conditions. Through on-going collaboration with various stakeholders, we collected a list of important metrics and objectives to evaluate different outcomes and policy characteristics with the goal of providing decision makers with a flexible framework for policy optimization based on their constraints and priorities.

(B29) Realizing the clean energy transition: Large-scale surveys of citizen and organizations' perceptions of energy transition technologies and policies in small and medium communities of Western Canada

Rowan Hargreaves (he/him/his), University of Victoria - British Columbia

Advancing clean energy transitions can come with multiple benefits for the planet as well as harms for people and organizations who are most impacted. Small and medium-sized communities of Western Canada are deeply dependent on fossil fuels, making the clean energy transition especially salient to them. At present, there are no representative survey-based studies of energy transition visions of entire communities and organizations. Likewise, there are no large-scale surveys about these communities' and organizations' support and drivers of support for policy instruments and associated clean technology that could both accelerate the transition and reduce economic harms on the most affected citizens and organizations. Policymakers lack understanding of perceived transition risks and opportunities in small and medium-sized communities, businesses, and organizations. This knowledge would support the design of policies that could advance both climate and justice goals in an effective, acceptable and inclusive manner. The proposed study represents the first attempt to conduct large representative and longitudinal surveys of citizens and organizations in small and medium communities in British Columbia, Alberta, Saskatchewan, and Manitoba to address the following research objectives:

1) Explore community members' visions for the energy transition and assess the risks and opportunities they perceive
2) Assess awareness and sources of information regarding just transition policies, technologies, and associated perceived risks
3) Assess levels of support for different types of transitions technologies and climate-justice policies including supports for the most marginalized populations including Indigenous communities
4) Identify drivers of support and opposition to different transitions technologies and policies.

(D70) Discussing Public Understanding and Interpretation of Heat-Related Information

Bruce Pollock (he/him/his), University of Albany

Due to climate change, extreme heat events will increase in severity and frequency worldwide; thus, it is critically important to have clear and effective heat messages that help the public, including heat vulnerable populations. protect themselves. Many different organizations, such as the National Weather Service (NWS), issue messages about heat which notify the public of impending extreme heat conditions. However, we argue terms like Heat Advisory, Extreme Heat Warning, Heat Index, and Apparent Temperature are and contain jargon—or specialized terms that have meaning to experts but may not be readily understood by the public (Olson et al., 2023; Sutton et al., 2022). Jargon can negatively impact message understanding, which limits the public's ability to take protective action (Mileti & Sorensen, 1990). Yet, we do not know how members of the public understand and interpret heat jargon. Additionally, we do not know how the public interprets impact and vulnerability information, both of which are essential to encourage action. To fill this gap, we will share results of study that aims to determine how members of the public interpret NWS heat information. Specifically, we will share results of 16 focus groups we conducted in 16 metropolitan regions in the CONUS United States that are demographically and climatologically diverse. We will discuss how messaging may or may not need to change to encourage action against extreme heat.

(C52) The Impact of Heat Index and Heat Waves on Active Transportation Usage in 200 US Cities

Ahmad Ilderim Tokey, Ohio State University

Due to climate change and urbanization, cities are becoming increasingly hotter. People using active transportation (AT) face heightened risks during extreme heat events. Exposure to heat has become a demotivating factor for adopting various forms of sustainable transportation that require physical activity due to a wide range of health hazards and discomfort. Previous research has identified that temperature adversely affects AT usage. However, the sensitivity of AT users to temperature in the presence of different geographical and geophysical elements is less known. Additionally, while temperature has received much attention, the impact of the heat index, which comprises temperature, humidity, and wind, and heat waves are less studied. This study attempts to understand the impacts of a high heat index and the presence of heat waves on AT usage frequency in 200 US cities. We are using NextGen NHTS National OD Data, which provides zone-to-zone AT mobility frequencies for every month of 2022. In addition, we combine Parameter-elevation Regressions on Independent Slopes Model (PRISM) temperature data, from which we derive the heat index and heat waves for every city each month. To control for city-level variables, we introduce a wide range of socioeconomic data from the American Community Survey, built environment data from the Smart Location Database, and satellite-derived elevation data. We will use a machine learning model that can handle the time-series component of the data, spatial autocorrelation, and non-linearity. The expected findings include insights into the worst timing for AT usage in different regions, the resiliency of cities to temperature, the mediating effect of the built environment, and the interaction effects of socioeconomic characteristics on heat impact.

(B30) Exploring social media as a way to communicate about key food security topics in the Inuvialuit Settlement Region (ISR)

Bryan Woodward (he/him/his), University of Victoria

Northern communities in Canada face numerous threats to their food security. Climate change, food web disturbances and declines in key species affect wild-caught "country food" opportunities. Additionally, the remoteness of the communities and their short-to-nonexistent growing seasons mean that market-based and imported foods can be prohibitively expensive. As a result, many people are undernourished and rely on cheap calories which lead to micronutrient and caloric deficiencies. Food sharing networks across the Arctic and in the Inuvialuit Settlement Region (ISR) have existed as an important cultural practice for millennia. Now, these food trading networks are often organized by posts in Facebook groups, which have the potential to connect people across larger areas, reconnect families who have been forcibly displaced, and facilitate new food trading opportunities. However, there has been little effort to document the various uses and community perceptions regarding how social media may support and/or threaten food security and food sovereignty through its impact on retail and country food access, affordability, sharing, preparation, and safety in the ISR. Such information may be important for community and regional organizations supporting and addressing food security in the region. Using community-based semi-structured interviews, my MA research asks three central questions: 1) How is social media used to discuss key food security topics (food prices, food sharing networks) in the ISR? 2) Has social media changed the way food is shared, traded, and sold? If so, how?, and 3) Is social media useful for supporting food security in communities? If so, how? The findings of this work will be used to inform the development of the regional food security strategy through a long-term research collaboration with the Inuvialuit Regional Corporation (IRC). Interviews will be coded in collaboration with local/regional Inuit organizations, and results will be compiled into a research manuscript and a plain language report to be shared back with community members.

(D71) Plans to Action: Do Climate Action Plans Matter for Climate Investments? [Withdrawn]

Haoyu Yue, University of Washington

Climate-related public investments are pivotal in reducing greenhouse gas emissions, exposure, and vulnerability to climate change. California Climate Investments (CCI) supports various climate-related state-led programs in California. The engagements of local governments and agencies are associated with the climate commitments and roadmaps within local climate action plans (CAP). However, previous studies suggest that CAPs have limited impacts on action outcomes, even sometimes with regressive outcomes. Therefore, a more detailed investigation into the range of strategies and policies under CAPs and their variance across different locales is needed. This research intends to examine the effectiveness of CAPs by assessing the impact of municipal and

county CAPs on the received investment from CCI. We analyze 237 CAP documents for municipal incorporations and unincorporated regions. We evaluate their comprehensiveness and quality in climate pledges, addressing mitigation, resilience, adaptation, social equity, implementation, and finance. Meanwhile, we construct a spatial distribution index of the investments between 2015 and 2022 and examine the relationship between climate investments and CAPs as well as other key determinants of climate investment, such as natural hazards and pollution exposure. Our preliminary results show whether adopting a CAP is not statistically significantly associated with the allocation of climate investments, though some key components, such as the carbon-neutral target and local fiscal policy, do influence the funding distribution. Also, the inequity mismatch between community needs and climate investments exists. These results suggest the need for more targeted and substantive commitment and actions in local climate action plans.

Climate Resilience - Ecosystems

(A10) Deep Learning-Based Spatio-temporal Prediction of Suspended Sediment Concentration in Coastal Wetlands

Xin Yan (she/her), University of Georgia

Suspended sediment concentration (SSC) is a crucial indicator of water quality, sediment dynamics (accretion and elevation), and marsh growth, reflecting both natural processes and anthropogenic impacts, while no spatial time series products are currently available for creeks and waterways in coastal wetlands. Unlike Total Suspended Solids (TSS) and turbidity, which are also common measures of particles suspended in water, SSC often closely approximates the true sediment concentration. This study aims to unify these three indicators and conduct a detailed correlation analysis between SSC, Landsat series images, and various water quality parameters, including nitrogen, pH, salinity, and chlorophyll-a. Utilizing 193,859 ground truth data points from the National Estuarine Research Reserve (NERR), United States Geological Survey (USGS), and field trips, we focused on predicting SSC in coastal wetlands of the US through time series analysis. To capture both temporal and spatial dependencies, we employed four Long Short-Term Memory (LSTM) architectures—Vanilla LSTM, Convolutional Neural Network LSTM (CNN LSTM), Stacked LSTM, and Bidirectional LSTM—and Transformer networks, all with hyperparameter tuning, to evaluate their predictive performance on SSC time series data. Additionally, we tested the models using higher-resolution Planet imagery to explore the effects of resolution on prediction accuracy. The final product is the optimized model with the best performance and the creation of the first spatial SSC product covering the entire US, capable of near real-time monitoring. This study underscores the significance of deep learning models in environmental monitoring, providing valuable insights for more effective management and conservation strategies.

Climate Adaptation - Technology

(B31) Potential of Nuisance Seaweed to Enhance Crop Growth and Replenish Soil Carbon

Nicole Capizzi (she/her), Washington State University

Earth's soils hold more carbon (C) than the atmosphere and vegetation combined, potentially drawing down excess levels of carbon dioxide (CO2) which contribute to climate change. Fast-growing Ulva seaweed hinders shellfish farms, smothering beds and degrading water quality when it decomposes. This study will evaluate the potential dual solution of removing nuisance Ulva seaweed from aquatic farms to provide crop nutrients and replenish soil C on terrestrial farms. Modern agriculture depletes instead of builds soil C by losing more as CO2 than it gains through sequestration. Organic inputs with low carbon to nitrogen (C:N) ratios, such as seaweed, help stabilize soil C by feeding microbes that bind soil minerals to organic matter and protect it from further decomposition (Castellano et al., 2015). C stability in soil can be examined through a framework of "active" particulate organic matter (POM) and "stable" mineral-associated organic matter (MAOM) pools (Wander, 2004; Lavallee et al., 2020). The distribution of these pools helps indicate soil C storage capacity and persistence (Cotrufo et al., 2019). This randomized, replicated research design will apply seaweed at 5 rates and sample soil from 0-30 cm over 3 years. Through soil physical fractionation and analysis of soil nutrients and harvested Ulva and crop biomass, we will evaluate seaweed's effect on soil C formation and its value as a crop input. This collaborative study with University of Washington will generate soil, water, and greenhouse gas data that can be applied in coastal areas worldwide and inform CO2 removal frameworks and modeling tools.

(D72) "Down to Earth": Design Considerations for Sustainable AI Developers from the Environmental and Climate Movement

Amelia Dogan (they/she), University of Washington

Climate change, with its long-term impact on temperature and weather patterns, presents a critical global challenge. Recent interest from both corporate and academic circles has focused on leveraging artificial intelligence and machine learning (AI/ML) for sustainability and climate solutions. Building upon a rich history of climate and environmental activism, my study investigates the design and technical barriers associated with creating effective AI/ML tools for climate and environmental organizing. We conducted 19 semi-structured interviews, engaging both AI developers in the sustainability field and environmental advocates. Through these interviews, we identified three central themes: (1) the actual usage of digital and AI tools, (2) perceptions and values related to AI, and (3) care for people and the planet. Additionally, we explore where the desires of environmental and climate advocates align or diverge from those of AI developers working on climate change solutions. Our findings contribute valuable design recommendations for AI/ML tools that better address the needs of environmental activists. Moreover, this research underscores the urgency of bridging the gap between technological innovation and environmental justice, emphasizing how AI can be used for a more just and sustainable future.

(C53) Understanding and harnessing microbes for climate change mitigation

Zachary Flinkstrom (he/him/his), University of Washington

Microorganisms serve as the engines of Earth's biogeochemical cycles, turning carbon, nitrogen, and other minerals through their various forms and enabling ecological function. While microbes perform vital roles in nutrient recycling, their activities naturally produce globally significant quantities of carbon dioxide, methane, and nitrous oxide. Consequently, it is imperative that we understand what controls microbial greenhouse gas emissions in natural and engineered settings so that we can develop strategies for climate change mitigation and reversal. This talk will focus on the relevant microbial processes in wetland and agricultural soils, with an emphasis on soil carbon sequestration and methane and nitrous oxide emissions. It will explain the techniques used to investigate the soil microbiome and its function in soil carbon formation and greenhouse gas emission. Data from our field work in a freshwater wetland connected to Lake Washington in Seattle will serve as a case study. Finally, we will explore the ways in which microbial systems could be harnessed for climate change mitigation by enhancing soil organic matter formation or by modifying practices within waste management to reduce emissions and sequester carbon.

(D73) Machine learning-based time series forecasting for distributed energy resources in power grids to enhance resilience

Vineet Jagadeesan Nair (he/him/his), Massachusetts Institute of Technology

Rapid power system decarbonization is crucial to reduce emissions and meet climate goals. Clean power is also key to electrifying and decarbonizing other sectors like transportation and heavy industry. However, the transition from coal and natural gas to renewables like wind and solar introduces system reliability and resilience challenges due to the variability and intermittency of such resources. Therefore, highly accurate forecasts of renewable generation and electricity demand will be essential to manage the future grid. We apply machine learning methods based on privacy-preserving federated learning to predict solar photovoltaic output and load in a probabilistic. Through the custom federated learning framework, we use neural network models to obtain accurate probabilistic forecasts. We then utilize these short-term forecasts for the real-time operation of grids and electricity markets. In particular, we show how operators can detect cyber-physical attacks on the grid and mitigate these using distributed, market-based coordination of flexible resources.

Climate Resilience - Built Environments

(A11) Examination of Climatic Controls on Seasonal Patterns of Groundwater Elevation in Unconfined Aquifers Within The Piedmont

Mubarak Bakare, Georgia State University

This study developed a statistical model that uses multiple linear regression to predict groundwater levels in the Piedmont region. The model's primary predictor variables for groundwater levels at four monitoring wells in the Metropolitan Atlanta area include short- and long-term antecedent rainfall and temperature data. The examination of the dataset, which covers the years 2019 to 2023, shows a significant correlation between these climate elements and variations in groundwater levels. R2 values of the models are consistently above than 0.9, indicating a well-fitting model. This study shows how climate variables affect groundwater dynamics, especially in urban settings, and it also shows how the model may be used to improve groundwater management techniques. The findings have implications for mitigating groundwater inundation following significant precipitation occurrences in metropolitan areas and can inform studies in similar regions.

(B32) Surging seas and saline soils: a novel approach to modeling the drivers and effects of saltwater intrusion

Hanne Borstlap (she/hers), University of Virginia

The rural coastal communities on the Eastern Shore of Virginia (ESVA) are highly dependent on natural resources that are increasingly being threatened by the effects of climate change. One of the main areas of concern has been damage to croplands resulting from saltwater intrusion (SWI), which is being exacerbated by the combination of rising sea levels and increased storm intensities. The extent and magnitude of this SWI caused by storm surge overwash and subsequent vertical infiltration is influenced by several factors: the height of the storm surge (which itself depends on storm intensity, wind direction, tide levels, and local hydrological conditions), the local topography and drainage infrastructure, and the anteceding soil moisture conditions. However, although the processes driving vertical SWI are well understood, there have been few modeling efforts that have accounted for both storm surge specifics and local hydrologic conditions. This research addresses this information gap by coupling

ADCIRC, a coastal storm surge model ran for storms along the entire ESVA, with RHESSYs, a small-scale ecohydrological model designed to simulate interactions between ecological and hydrological processes on the land surface. This integration of models provides an estimation for the spatial extent and magnitude of saltwater infiltrated during past storms, as well as the post-surge freshwater flushing rates that ultimately determine the long-term impacts. Furthermore, future vulnerable areas on the ESVA were identified by running the models for different scenarios accounting for sea level rise, as well as changes in wind speeds and local hydrological conditions.

(C54) Mapping the Spatial Variation of Climate Change in the Ganga-Brahmaputra Basin

Bikram Parajuli, University of Oklahoma

The Ganga-Brahmaputra (GB) river basin, one of the world's largest and most densely populated river basins, traverses India, China, Nepal, Bangladesh, and Bhutan in South Asia. It stretches from the Indian Ocean and fertile plains in the south to the inhospitable terrain of the towering Himalayas in the north, featuring diverse bioclimatic regimes and complex orography. This study aims to delineate the GB river basin into different spatial regions with homogeneous bioclimatic characteristics based on 40 years of annual and seasonal gridded precipitation and temperature anomalies, vegetation cover, and topography data. The analysis uses k-means and hierarchical clustering techniques along with a regionalization approach to identify regions having similar bioclimatic characteristics. The quality of the generated regions is evaluated using the silhouette coefficient, Calinski-Harabasz score, and geographic coherence. In general, the basin can be divided into four to six meaningful bioclimatic zones. These divisions highlight colder, low-rainfall areas in the upper basin along the Himalayas, warmer, drier regions in the southwestern basin, and wetter areas in the southeastern basin along the Bay of Bengal. Clustering methods effectively identify regions with homogeneous bioclimatic characteristics, while the regionalization approach produces spatially contiguous clusters that are less geographically coherent. These findings enhance the understanding of climate dynamics in this critical geographical area and provide valuable guidance for regional planning and environmental management. Improved regional planning can significantly aid the adaptation of vulnerable communities to climate change.

(D74) Salt Marsh Channel Metabolism Alterations Due to Dredged Sediment Placements

John (Jake) Supino (he/him/his), Boston College

Key to designing effective marsh restoration projects is minimizing short-term ecosystem impacts. As many marshes around the world change through climate-related drivers and coastal development, there is ongoing debate about whether marshes can keep pace with accelerated sea level rise, or whether they will cease to sequester new carbon and instead outgas and export their carbon stores to the atmosphere or coastal ocean. Since the start of the 20th century, over half of global coastal wetlands have been lost due to natural processes and anthropogenic activities, but there are increasingly new approaches being tested to prevent further degradation. One important habitat restoration method currently in use is the placement of dredged sediment on the marsh platform to build marsh elevation. In 2019, the Seven Mile Island Innovation Laboratory (SMIIL) was established as a testbed to advance marsh restoration techniques using sediment dredged from the New Jersey Intracoastal Waterway. Since then, a number of sediment placements have occurred at the SMIIL to increase elevation and protect existing marshland, but the spatial and temporal extent to which these placements affect the surrounding channel biogeochemistry is unknown. Over 2022-2023, we monitored two placements for their biogeochemical impacts to the surrounding water column, and calculated metabolic rates before, during, and after placement to assess recovery rate and ecosystem function. Preliminary results suggest that sediment placements alter ecosystem metabolism at similar rates to serious storms, but the system recovers soon after. This work will help gauge these restoration projects for stakeholders and quantify short-term impacts.

(D75) Integrating Urban Planning, Climate Adaptation, and Sustainable Transportation through Advanced Spatial Analysis Techniques

Tiansheng Tan (she/her), University of Minnesota - Twin Cities

This research explores the intersection of spatial urban planning, climate change, and transportation, emphasizing the relevance to climate adaptation and mitigation through the utilization of machine learning, Geographic Information Science and spatio-temporal modeling techniques. Cities, housing over 60% of the global population, are significant contributors to greenhouse gas emissions and are increasingly vulnerable to climate impacts. Effective urban planning is critical for both mitigation—reducing carbon emissions, and adaptation—enhancing resilience to climate impacts. The study employs a combination of time series analysis, spatio-temporal modeling, and advanced machine learning techniques, including Random Forest and K-Nearest Neighbors (KNN), to analyze urban data. Using OpenStreetMap data, we examine the spatial distribution of urban features and their impact on climate metrics. We incorporate Moran's I to assess the spatial autocorrelation of climate variables, providing insights into patterns of urban heat islands and areas of high carbon emissions. The integration of these methods allows us to identify key urban planning interventions that can mitigate climate change effects and promote sustainable development. Our findings offer broader implications for policymakers and urban planners, advocating for the adoption of comprehensive planning frameworks that align with global climate goals. By bridging the gap between urban and global climate studies, our research provides a holistic approach to sustainable urban development, ensuring livable conditions for future generations. The clarity of our findings underscores the necessity of coordinated efforts in urban planning and climate action to foster resilient, sustainable cities.

Climate Resilience - Croplands

(A12) Microbially Induced Carbonate Precipitation: A Versatile Tool for Soil Restoration and Carbon Sequestration

Augusta Finzel (she/her), Washington State University
Soil acidity and metal contamination are two of the most widespread forms of soil degradation and can lead to high levels of soil carbon loss. Soil pH is the most important parameter determining metal availability, and most metals are more bioavailable, and thus more toxic, at a lower pH. The proposed work aims to provide long-term solutions to increase the pH of acidified croplands and decrease the metal availability within contaminated soils through microbially induced calcium carbonate precipitation (MICP). MICP is a common phenomenon among soil microorganisms and occurs when organisms produce metabolic products that react with calcium ions in the soil and form calcium carbonate. This process can raise the pH of the soil and sequester carbon dioxide. MICP has been demonstrated as an effective approach to stabilize highly erodible soils, but there is little literature exploring plant interactions with microorganisms capable of MICP. The proposed work will target plant growth promoting microorganisms capable of MICP within the rhizosphere and determine their viability as effective inoculants to increase the pH of acidic soil, decrease metal availability, increase soil carbon, and increase plant vigor. Research exploring restoration of degraded soils and ecosystems through MICP and plant interactions presents an opportunity to address a suite of issues including enhancing metal phytoremediation, increasing carbon sequestration in degraded soils, creating healthier and more resilient soils less susceptible to extreme weather events, and creating a food supply chain able to better adapt to climate extremes.

(C55) Assessing the adaptability of quinoa and millet in two agroecological zones of Rwanda

Olivier Ndayiramije, Washington State University
Quinoa (Chenopodium quinoa Willd.) and millet species (including Eleusine coracana,

Panicum miliaceum, and Setaria italica) are nutritionally valuable seed crops with versatile applications in food production and consumption. Both quinoa and millet have the potential to provide drought-tolerant, nutritious complementary crops to maize which is predominantly cultivated in Rwanda. This study evaluated quinoa and millet genotypes and assessed their agronomic performance in two agroecological zones of Rwanda. Twenty quinoa and fourteen millet cultivars were evaluated for grain yield, emergence, days to heading, flowering, and maturity, and plant height in 2016 and 2017 in Musanze, a highland region (2,254 m above sea level), and Kirehe, in the Eastern lowlands of Rwanda (1,478 m above sea level). The results suggest that quinoa and millet have potential as regional crops for inclusion in the traditional dryland cropping rotations in Rwanda, thereby contributing to increased cropping system diversity and food security.

(D76) Monitoring Crop Responses to Climate Change in India using Evapotranspiration and Climate Data

Afshin Shayeghi (he/him/his), University of Oklahoma

Understanding crop responses to climate change is key to sustainable agricultural water management. However, there is limited understanding of how cropping systems are adapting to changing weather patterns and climate in data-scare regions like India, a major cereal producer of the world. This is due to unavailability of high-resolution data on crop conditions and potentially underutilization of remotely sensed and climate data. Integrating remotely sensed evapotranspiration (ET) data with field and meteorological data can offer crucial insights into how agricultural systems are responding to climate change and water scarcity. This study integrates Standardized Precipitation Evapotranspiration Index (SPEI) and Evaporative Stress Index (ESI) to assess agricultural drought and yield anomalies across diverse agroecological systems and growing seasons in India. Utilizing potential ET (PET) data from Global Land Evaporation Amsterdam Model (GLEAM) and the Penman-Monteith method using global reanalysis data, in conjunction with precipitation data from Multi-Source Weighted-Ensemble Precipitation, we calculated SPEI at varying scales (e.g., 1-month, 4-month, and 12-month) for India. We derived ESI using both GLEAM and Ensemble ET products and studied the spatiotemporal patterns of water stress across agricultural regions during kharif and rabi seasons in India. District-level yield and yield anomaly for India's primary crops are being analyzed across different seasons to study the linkages between climate-induced stresses and crop production. Our findings can provide useful insights into how ET products can be utilized to monitor climate change impacts, thereby informing agricultural and water resource management strategies and supporting the resiliency of Indian agricultural systems to changing climate.

(C56) Climate Change Impacts on Mountain Ecosystems and Andean Agropastoral Communities

Melody Zarria Samanamud, Colorado State University

Mountain ecosystems cover about 27% of the world's land surface and support 1.1 billion people worldwide, about 15% of the global population. The interaction between humans and ecosystems in mountain regions has created complex and multifunctional landscapes. In the Peruvian Andes, rangelands cover approximately 22 million ha and play a critical role in livestock production. Although it is anticipated that the effects of climate change will be significant in the Andes, the extent of these impacts is still not well understood. We use a social-ecological system approach to explore climate change's potential ecological and land management impacts on two valleys of Huascarán National Park in the Peruvian Andes. We built the Agent-based model of laNd management Dynamics and Ecosystem Services (ANDES) linked to L-Range, an ecosystem-process model. ANDES is a spatially explicit model of livestock grazing behavior, land and livestock management, and households' economies. L-Range simulates biogeochemical processes and vegetation dynamics, e.g., monthly primary production and plant population dynamics. The land management scenarios under analysis include potential responses implemented at the family and park service level, e.g., rotational grazing schemes and livestock population reduction. We used climate data from four global circulation models to explore climate change's potential impacts on ecosystems, e.g., vegetation production and cover changes. Our research is in the data analysis phase. Thus, I will present the methodology of building the coupled ANDES/L-Range model and preliminary findings. Information from our study can serve as a basis for policy development aimed at increasing the resilience of mountain social-ecological systems.

Extreme Events - Drivers and Observations

(A13) Impact of Temperature Extremes on Drought Severity in Georgia's Climate Divisions

Olalekan Alamoh (he/him/his), Georgia State University

Droughts, exacerbated by climate change, pose significant challenges to ecosystems. While precipitation deficits in droughts are well-known, the influence of temperature extremes remains understudied. This study examines the impact of temperature extremes on drought severity in three of Georgia’s climate divisions: Northeast (903), Central (905), and Southwest (907). These divisions were chosen due to their experiences of exceptional drought during significant dry spells in Georgia's recent history, specifically in 2006-2008, 2010-2012, and 2015-2016. These periods exemplify extreme climatic adversities, making them relevant for investigating the impacts of

temperature extremes on drought dynamics and ecological resilience. The results show a statistically significant relationship between the Palmer Drought Severity Index (PDSI) and temperature extremes. In the Central climate division, 10.7% of the variability in PDSI is affected by temperature anomalies, while in the Southwest and Northeast divisions, it is 10.4% and 7.9%, respectively. The influence of temperature extremes is strongest in the southern regions of Georgia, decreasing towards the north. High temperature extremes in southern Georgia precede exceptional droughts in all the considered drought years. This ongoing research will utilize the Normalized Difference Vegetation Index (NDVI) to assess the differential response of vegetation to drought events associated with temperature extremes versus those unrelated to temperature extremes. The study will analyze the spatio-temporal connections between temperature extremes and vegetation health in Georgia, aiming to provide insights into the underlying drivers of severe drought events and inform strategies for ecological resilience.

(D77) Atmospheric drivers of marine heatwaves in the North Pacific Ocean in the CESM2 Large Ensemble

Cassia Cai (she/her), University of Washington

Marine heatwaves (MHWs) are periods of extreme warm ocean temperature events and can be 3-dimensional in space. We investigate their manifestation at the ocean surface, identifying surface MHWs as prolonged discrete 2-dimensional objects from sea surface temperature anomaly (SSTa) fields. MHWs can be forced locally through processes affecting the mixed layer temperature budget and can be modulated by large-scale climate modes and their teleconnections. MHWs can have significant physical, biogeochemical, and ecological impacts, including biodiversity loss, community structure changes, and increases in occurrence and intensity of ocean acidification events. The Northeast Pacific has emerged as a hot spot for extremely persistent and large-scale events that are forced by anomalous air-sea heat flux driven by remote forcing from the tropics as described by El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) in addition to the long-term anthropogenic warming. To examine these relationships, we identify, track, compare and characterize MHWs with a footprint in the North Pacific Ocean in the 100 historical simulation ensemble members of the CESM2 Large Ensemble Community Project, identifying 7 spatially distinct types of MHWs. To study the influence of local atmospheric processes to the development of the MHWs, we examine the anomalies of net heat flux, wind stress curl, sea level pressure, and mixed layer depth leading to the maximum spatial extent of each MHW. We examine the relationship between MHW occurrence and the PDO indices and the Niño-3.4 indices. Understanding the driver processes of MHWs can advance our ability to predict them.

(B33) Understanding the influence of El Niño Southern Oscillation on co-occurring heat conditions across global croplands

Madhulika Gurazada, University of California Merced

El Niño Southern Oscillation (ENSO) is the dominant mode of interannual global climate variability and impacts cropland areas worldwide. While previous studies have identified ENSO teleconnections for individual temperature or precipitation events and co-occurring hot and dry (HD) events, this study examines the influence of ENSO on both co-occurring hot and dry (HD) and hot and wet (HW) events across global croplands. Such co-occurring events can reduce yields due to either drought and heat stress or excessive humidity that creates conditions conducive to pest outbreaks and post-harvest losses, respectively. ENSO teleconnections have the most widespread impacts on global croplands during boreal summer. For example, during El Niño both co-occurring HD and HW are more likely relative to baseline conditions in several food-insecure regions in tropical and sub-tropical parts of Asia, Africa and Latin America. This includes over 10,000 km2 and over 4,000 km2 of croplands in South Asia exposed to HD and HW conditions during El Niño years, respectively. Improved ENSO event forecasts offer insights into the upcoming climate patterns, allowing for more proactive preparation to mitigate risks to global croplands. By anticipating the occurrence and severity of ENSO events, stakeholders can implement targeted adaptation measures and resource allocation strategies, reducing the vulnerability of agricultural systems to adverse climatic conditions.

(C57) Connecting land heatwaves and marine heatwaves through a large-scale atmospheric stationary wave pattern in observations and climate models

Yanjun Hu, Purdue University

Heat waves over land can exacerbate droughts and wildfires, and have significant negative impacts on a number of issues such as health, infrastructure performance, and causing problems in the agriculture sector. Marine heat waves are prolonged periods of anomalously high sea surface temperatures, leading to severe consequences for marine ecosystems. Due to different stakeholders, land and marine heatwaves are studied in distinct research communities. However, they exhibit significant similar spatiotemporal features and there may potentially exist a shared physical process connecting them. We propose and demonstrate that a significant amount of marine and land heatwaves are co-driven by a large-scale quasi-stationary atmospheric pattern with wavenumber-5, leading to surface warming through downward control. Using reanalysis data and climate model outputs, we first identified and analyzed the correlations between marine heat waves in the northern Pacific and the land heat waves over continental United States. Subsequently, through statistical and causal inference methods, both these extreme events were attributed to the wavenumber five planetary wave patterns. Further, we propose a methodology to predict land heat waves on subseasonal timescale using information from marine heat waves.

(A14) Understanding the response of wave extremes in a future warmer climate

Zhaoyu Liu (he/him/his), Purdue University

Every year extreme weather events such as heat waves, cold spells and extreme precipitation can pose severe damage and loss over the midlatitude regions where most of the people live. Previous studies have suggested that those extreme weather events are usually related to the extreme (Rossby) wave activity in the atmosphere, e.g. those large-amplitude ridges, troughs and even multiple waves. Although many efforts have been made to investigate the dynamic contribution of wave extremes to a variety of weather extremes, it remains an open question that how such wave extremes can respond to the future climate, and subsequently how such dynamical contribution to weather extremes will be altered with warming. Filling this gap of knowledge has important implications for helping the community better assess and predict the future response of extreme weather events under climate change. Motivated by this, specifically, my research is to answer: does extreme wave activity get more extreme or less extreme in a future warmer climate? By adopting local wave activity (LWA) framework to quantify the wave, we find that extreme local wave activity becomes less extreme in the future warming scenario based on an ensemble of CMIP6 climate models and our idealized aquaplanet simulations. We will explain such a response from the perspective of the eddy-mean flow interaction and the role of diabatic heating.

(D78) Evaluating Data-Driven Forecasts of Extreme Weather

Ankur Mahesh (he/him/his), University of California - Berkeley

FourCastNet (FCN) is a data-driven weather forecasting model that offers a 5,000x computational speedup over traditional numerical weather prediction (NWP) models. Trained on forty years of reanalysis data, FCN uses neural operators and spherical harmonic transforms to generate 0.25-degree horizontal resolution weather forecasts. In terms of annual global mean anomaly correlation coefficient, FCN matches the performance of the Integrated Forecasting System (IFS), a physics-based NWP model. Because this metric is averaged in space and time, it is unsuitable for assessing the accuracy and quality of extreme weather forecasts. Furthermore, a known challenge with machine learning models is that they produce smoothed forecasts. To evaluate the fidelity of FCN's extreme weather forecasts, we present a comprehensive suite of extreme weather diagnostics. First, we evaluate deterministic forecasts from FCN and

IFS. We assess these models' ability to successfully predict rare events, such as those greater than the 95th percentile of historical climate. We compare FCN's and IFS's performance on the tails of the distribution. Second, we evaluate perturbed ensemble forecasts from these two models. We show how our suite of metrics evaluates key features of an ensemble weather forecast: reliability, resolution, sharpness, skill, spread, and discrimination between extreme and typical weather. Finally, we compare FCN and IFS on case studies of extreme weather events with return periods greater than 10 years. As machine learning is rapidly adopted in weather forecasting, we present ways to apply our open-source extreme diagnostics to other data-driven weather models.

Drivers of Persistent Marine Heatwave Predictions in the Northeast Pacific
Evan Meeker (he/him), University of Wisconsin-Madison
Marine heatwaves (MHWs)–periods of anomalously warm sea surface temperatures–often lead to significant negative ecological and socioeconomic impacts. The largest and most persistent MHWs stretch across ocean basins and last for many months or years. The mechanistic drivers of MHWs are numerous, and their relative importance varies across both location and individual events. As such, the prediction of MHWs at seasonal and longer timescales is a difficult yet societally relevant challenge. In this study we perform a heat budget analysis on Community Earth System Model (CESM) simulations and predictions of the 2013-2015 Northeast Pacific MHW to assess the atmospheric and oceanic drivers of this extreme event. We first assess the representation of this event using CESM's ocean model forced with atmospheric reanalysis. We find that this MHW is primarily driven by both anomalous wind-driven turbulent surface heat fluxes and Ekman-driven oceanic heat advection, in agreement with observational studies. The spatial pattern and temporal evolution of this event in the model also closely matches observations. We next assess predictions of the 2013-2015 Northeast Pacific MHW using the CESM Seasonal to Multi-Year Large Ensemble (SMYLE) prediction system. Intensity and spatial evolution of the MHW is not well predicted at lead times as short as 3 months prior to the peak of the event, though predictions initialized after the MHW's peak are skillful for more than a year. An equivalent heat budget analysis is performed on SMYLE ensemble members to compare mechanisms in the poor and skillful predictions to those in the forced simulation. Because this MHW is driven primarily by atmospheric processes prior to its peak, the predictability of the near-surface atmospheric circulation at the seasonal timescale is key to the prediction of the MHW during different stages of its evolution.

(C56) The Implications of Data Poverty for Measuring Climate Extremes
Margaret O'Shea (she/her), Dartmouth College

Station-based meteorological observations are essential to diagnose the pace, magnitude, and impacts from anthropogenic warming. These datasets serve as inputs for widely used gridded products such as Berkeley Earth or HadCRUT datasets and supply observations for reanalyses. Such data then become the basis for analyses on climate dynamics, impacts, risks, and damages. Crucially, these weather stations are not evenly distributed across time or space, as gaps scale with wider socioeconomic vulnerabilities. Here, using a perfect model framework, we systematically evaluate the role that variation in meteorological station densities play in biasing estimates of temperature extremes. By assessing how the accuracy of extreme heat varies as a function of the number of meteorological stations undergirding the estimate, we can better understand if and how data poverty influences the measurement of climate extremes. In doing so, this work reveals how data poverty, as a form of systematic measurement error, limits our ability to effectively estimate climate impacts in the regions most vulnerable to and least culpable for global warming.

(B34) Future trends of association between atmospheric waviness and extreme temperature events

Eliott Roocroft (he/him/his), University of British Columbia

With increasing global temperatures, there has been an observed increase in the quantity and intensity of extreme weather events, particularly heat extremes in the mid-latitude regions. Some recent studies have attributed this increase at least partially to an amplification in the waviness of the upper tropospheric jet stream. However, the causes of frequency and intensity change are still unsure, with both thermodynamical and dynamical changes having an impact. Whereas the thermodynamical impacts are well understood, with rising temperatures due to global warming leading to more heat extremes and less cold extremes, there is lower confidence in the dynamical impacts, such as atmospheric waviness, on the future change of frequency of extreme events. Whilst there is significant scientific uncertainty over causes of recent trends in jet stream waviness, the impact atmospheric waves have on extreme events is clear. Using the CESM2 LENS2 large ensemble, we analyse trends in association between waviness and surface temperature extremes between the historical period (1980-2015) and the future (2065-2100). By calculating projected changes in both the waviness and its association with surface temperature extremes, we analyse the effect that forced dynamical changes to the waviness of the jet stream will have on the changing nature of extreme temperature events by the end of the century.

(A15) Madden-Julian Oscillation and Atmospheric Rivers: S2S Forecast of High-Impact Weather Extremes

Chad Small (he/him/his), University of Washington

Atmospheric rivers transport vast quantities of water vapor globally, some of which translates into tremendous rainfall and potential flooding. For atmospheric rivers that make landfall on the West Coast of the U.S., much of that water vapor is sourced from tropical reservoirs in the Pacific Ocean like the Intertropical Convergence Zone. One such source, the Madden Julian Oscillation, has been studied in connection with atmospheric rivers either statistically (its presence increasing the likelihood of intense rainfall) or through its modulation of jet streams in Pacific Basin altering atmospheric rivers' trajectories. The Madden Julian Oscillation's impact as a direct water vapor source on atmospheric river intensity and potential rainfall has been relatively unexplored, however. These research findings show that atmospheric rivers with the Madden Julian Oscillation as a direct water vapor source are characteristically different, and notably more intense than atmospheric rivers not using the Madden Julian Oscillation as a direct water vapor reservoir. In particular, these atmospheric rivers are larger, carry more water, and move that water vapor more intensely. These results highlight the Madden Julian Oscillation's importance in atmospheric river intensification, and as an essential part of our seasonal-to-subseasonal forecasting repertoire. This work is of particular importance as it also shows how the Madden Julian Oscillation can bridge climatological and meteorological concerns which take place on different time scales.

Hydrological Cycle - Groundwater and Streamflow

(A16) Comparison of Land Use/Land Cover on streamflow variation in the piedmont and coastal plain physiographical provinces in the southeast United States

Mayowa Jimoh (she/her), Georgia State University

This study investigates the impact of land use and land cover (LULC) changes on streamflow variations in the Piedmont and Coastal Plain physiographical provinces in the Southeast United States. Rapid urbanization and changes in land use from agricultural to industrial and residential areas have led to significant modifications in hydrologic responses, affecting evapotranspiration rates, sediment transport, flood peaks, and water quality. By analyzing streamflow records and landcover data from 9 watersheds across South Carolina, North Carolina, Georgia, and Virginia. This research aims to quantify the type and magnitude of streamflow variations resulting from LULC changes. Key findings indicate that urban development, characterized by increased impervious surfaces, significantly raises peak flow rates and discharge volumes, while reducing baseflow due to decreased infiltration. These alterations in streamflow patterns have broader implications for water resource management, urban planning, and ecosystem sustainability in the context of climate change. The study emphasizes the need for effective environmental management practices to mitigate the adverse effects of urbanization on hydrological cycles. This research is highly relevant to climate-related studies as it addresses the intricate relationship between human activities, land cover changes, and their impact on hydrological processes. It contributes original insights into how regional physiographic characteristics influence streamflow responses to urban development, offering valuable data for policymakers and environmental managers. The findings are presented in an accessible manner to engage participants from diverse fields, including environmental management, urban planning, and public policy, making it a significant contribution to the discourse on climate change adaptation and mitigation strategies.

Hydrological Cycle - Hydrometeorology

(B35) The global hydrologic response to evapotranspiration-driven warming

Benjamin Buchovecky (he/him/his), University of Washington

Both canonical theory and climate model simulations predict an increase in globally averaged precipitation with radiatively-driven warming. However, terrestrial processes control surface water and energy fluxes, with potential impacts on surface temperatures and hydrologic cycling, yet their contribution to the global hydrologic cycle is often not considered. Leveraging perturbed parameter ensembles of land surface parameters in two climate models, we examine the hydrologic response to evapotranspiration perturbations within the range of terrestrial parametric uncertainty. We find that the land-driven precipitation response to temperature is the opposite sign of the precipitation response to radiatively-driven warming. Warming driven by terrestrial evapotranspiration decreases precipitation over land and induces a shortwave cloud response that amplifies warming which is consistent with previous idealized experiments using very large evapotranspiration perturbations. Our results highlight the influence of terrestrial processes, which are not well-represented in common theoretical temperature scalings of the global mean hydrologic cycle, and indicate the potential significance of future terrestrial ecosystem response to climate change and land use change which may alter terrestrial evapotranspiration.

(C59) Exploring Intra-Annual Variations in Urban Effects on Precipitation in the Atlanta, GA, USA Region

Olamiposi Fagunloye (he/him/his), Georgia State University

Urbanization profoundly impacts local climates, notably by altering precipitation patterns. This study investigates the intra-annual variations in urban effects on precipitation in the Atlanta-Sandy Springs-Gainesville combined statistical area (CSA), a rapidly urbanizing region in the southeastern United States. Using a comprehensive dataset spanning over two decades (2014-2023), which includes daily precipitation records from 70 meteorological stations, lower-troposphere wind data, and high-resolution land-cover data, this research aims to elucidate the seasonal differences and spatial variability in urban-induced precipitation modifications. The study leverages advanced statistical analyses and geospatial techniques to assess how urbanization influences total precipitation, precipitation days, and heavy-precipitation days across different seasons. Preliminary findings indicate a significant enhancement of summer precipitation in urban areas, likely driven by the Urban Heat Island effect and increased atmospheric instability. Additionally, urban surfaces contribute to increased surface roughness, disrupting wind patterns and enhancing convective precipitation processes. This research addresses gaps in existing literature by focusing on all seasons and employing a larger number of observation stations over a longer temporal scale, providing robust evidence of urban effects on precipitation. The broader implications of this study are critical for urban planning, water resource management, and mitigating flood risks in rapidly urbanizing regions globally. By improving our understanding of urban-climate interactions, this study contributes to the development of more resilient urban environments in the face of climate change.

(C60) Are Mesoscale Convective System Initiation Dynamics Changing?

Stella Heflin (she/her), University of Washington

Both GCM and cloud-resolving model simulations have shown persistent dry and warm biases as compared to observations in the summer over the Great Plains region of CONUS. These biases are in part attributable to failure of these models to capture the frequency and intensity of mesoscale convective systems (MCSs), especially under conditions with weak synoptic forcing. There is evidence that under such conditions, mid-tropospheric vorticity perturbations (MPs) generated by orography might play an important role in initiating MCSs that then tend to produce more frequent and intense precipitation. This analysis first examines outgoing longwave radiation (OLR) and precipitation as proxy variables to detect MCS environments in ERA5 and compares the results with 20 years of MCS observations to confirm that ERA5 is able to accurately capture MCS statistics. The MCS environments are then examined in ERA5 data from 1950 - present by creating a long-term record of MCS patterns and determining their temporal variability and trends, to investigate the MCS initiation mechanisms and the impact of climate change on these mechanisms. The model simulations are compared with the observations and ERA5 reanalysis. We address scientific questions on what mechanisms initiate MCS events, especially under weak synoptic forcing conditions; whether the dynamics of MCS initiation are properly captured in models, and whether a failure to capture them might be responsible for the model warm and dry biases; and how the dynamics of MCS initiation may change with climate. This analysis has implications for the accurate modeling of future rainfall patterns.

(A17) Enhancing the Representation of Hydrological Processes in an Urban Canopy Model: A Multi-parameterization Approach

Yuqi Huang (he/him/his), University of Oklahoma

Accurately representing urban hydrological processes is essential for understanding energy and water exchanges in cities, improving weather and climate simulations across scales, and informing effective flood and water resource management. Despite notable advancements in urban land surface models since the last international urban model intercomparison project, several challenges persist. Notably, many models still struggle to achieve a closed water balance, and the representation of hydrological processes often remains oversimplified. These issues primarily stem from the inherent complexity and heterogeneity of the urban hydrologic cycle. In this study, we integrated multiple hydrological parameterization schemes into a single-layer urban canopy model to better capture key processes such as canopy interception by urban grass and trees, surface runoff, soil moisture dynamics, and groundwater runoff. These new schemes complement the model's existing capabilities of resolving root water uptake and evapotranspiration. We evaluated the performance of these new schemes with observations from different sites across a wide range of background climates and site characteristics. Results demonstrate that employing these new schemes enhances the accuracy of surface energy and water partitioning and improves the characterization of urban hydrological behavior. Additionally, our findings highlight the dependence of model accuracy on specific parameterization schemes in different climate regions. Our approach has important implications for urban planners and policymakers, especially in enhancing urban water management and resilience under extreme weather and climate conditions. Furthermore, these multi parameterization schemes can be coupled into the urban canopy models in mesoscale and global models such as WRF, MPAS, and CESM to improve the representation of urban hydrological processes, ultimately leading to better predictive capabilities and more informed decision-making.

(C61) Moisture Transport Dynamics within the Convective Boundary Layer: Insights from the Southern Great Plains ARM Site

Leia Otterstatter (she/her), University of Oklahoma

Increasing our understanding of moisture transport within the convective boundary layer (CBL) is crucial for improving weather and climate models. The CBL is vital for transporting moisture, heat, and momentum throughout the atmospheric boundary

layer (ABL). These fluxes impact precipitation, surface energy balance, cloud formation, as well as the exchange of energy between land-atmosphere interactions. While previous CBL research has made advancements in our understanding of this complex fraction of our atmosphere, these intricate interactions between the surface and atmosphere continue to remain poorly understood. This study aims to address this knowledge gap by examining high-resolution observational data from the Southern Great Plains (SGP) Atmospheric Radiation Measurement (ARM) site. We analyzed data from Lamont, Oklahoma, collected during the summer of 2018. The cases were examined and filtered with specific criteria, looking at solar radiation, cloud cover, ABL depth (zi), Obukhov length (L), and the convective velocity scale (w*). Using data from Doppler lidar, Raman lidar, and eddy correlation measurements (ECOR), we investigated how moisture, humidity, and buoyancy are transported within the CBL via entrainment and large-scale motions. The insights from this research are expected to enhance the accuracy of atmospheric models, improving our ability to predict weather and climate patterns.

(B36) Quantifying the spatial scaling of precipitation in GPM-IMERG

Akshay Rajeev (he/him/his), Cornell University

Global climate models have been used to assess the risk associated with climate change and one way these models have been improved was by increasing the spatial resolution. Recently, there has been a drive to develop kilometer-scale global climate model (with horizontal resolution of <10 km) with aim of improving the representation of the hydrological cycle. Considering that such high-resolution models would require immense computational resources, it is necessary to be able to quantify the changes in the representation of the hydrological cycle changes with spatial resolution. Considering the importance and challenges of simulating precipitation, we aim to address this knowledge gap by developing a framework to quantify the effect of horizontal resolution on precipitation amount distributions. For this, we will use GPM (IMERG) data product at 0.1° spatial resolution from 2000 to 2022. We will then regrid this into 0.25° and 1° spatial resolutions to understand how the rain amount distribution varies at each resolution. Such a framework is crucial, as considerable resources are concentrated on developing kilometer-scale GCMs.

(D79) Soil Moisture Teleconnections in the Western US

Lily Zhang (she/her), University of Washington

Year-to-year variability in summertime temperature has a large impact on drought, wildfire, and extreme heat across the Western United States. A recent study has linked the leading pattern of Western US summertime temperature variability to soil moisture anomalies in the preceding spring. We test the hypothesis that antecedent soil moisture conditions and subsequent land–atmosphere interactions can cause distal temperature anomalies by imposing a springtime soil moisture anomaly (depletion) in the CESM2 climate model. Our results suggest that soil moisture anomalies can produce teleconnection-like patterns in Western US climate.

Atmospheric Chemistry

(A18) Stratosphere-Troposphere Exchange of Air Mass and Ozone Concentrations Derived from Observations

Anna Hall (she/her), University of Washington

The stratosphere-troposphere exchanges (STEs) of air mass and ozone concentrations have important implications for the global tropospheric ozone budget, atmospheric oxidation capacity, and surface ozone concentrations. However, modern reanalyses have considerable uncertainty in their quantification of ozone STEs. This uncertainty has been attributed to the diabatic heating, isentropic density associated with temperatures, and ozone mixing ratio at the isentropic surface fitted to the tropical tropopause. Here we derive the STEs of air mass and ozone by using observational datasets include temperatures from the Constellation Observing System for Meteorology, Ionosphere, and Climate-2 (COSMIC-2), ozone and water vapor concentrations from the Aura Microwave Limb Sounder (MLS), and the cloud radiative effects based on CALIPSO and CloudSat measurements. The derived air mass and ozone STEs are compared against the Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA2) and the European Center for Medium-range Weather Forecasts (ECMWF) ERA5 STEs of ozone and air masses. We present results in three distinct regions, the northern hemisphere extratropics, southern hemisphere extratropics, and tropics, along with global averages. We will further quantify the uncertainties in STEs from ERA5 and MERRA2 using observed temperatures, ozone concentrations, and clear-sky radiative heating rates derived from observations for 2006-2022.

(B37) Predicting Air Quality under Climate Change using a Surrogate Model of Internal Variability

Emmie Le Roy (she/her), Massachusetts Institute of Technology

The impact of climate change on air quality is uncertain. This uncertainty arises due to uncertainty in how human activities will change over time, how accurately models represent real-world processes, as well as internal climate variability (natural fluctuations in the climate system). Internal variability can confound trends in atmospheric composition arising from climate change because internal variability adds natural fluctuations that mask or mimic the effects of these trends. One method of quantifying internal variability is to generate enough "ensemble members which are multiple simulations of a model each starting with slightly different initial conditions. However, generating enough ensemble members to account for internal variability requires prohibitive computational resources and there is a need to develop alternative tools for estimating internal variability. Here, we develop a method of generating surrogate realizations of ozone (O_3) to quantify internal variability using fewer ensemble members and shorter simulation lengths. We use a chemical transport model driven by a global climate model to relate unforced variability in seasonal-mean O_3 and $PM_{2.5}$ to meteorological variables using simple regression analysis. Since anthropogenic emissions are held constant in our framework, our simulations are uniquely suited for exploring the drivers of unforced O_3 and $PM_{2.5}$ variability. Our initial results confirm that summertime (JJA) climate-induced O_3 variability is a strong linear function of local temperature in certain regions, particularly over North America and Europe (median $R = 0.81$). We then leverage this relationship to estimate the internal variability of surface O_3 as a function of a local temperature variability term.

(D80) Assessing the effectiveness of ocean alkalinity enhancement on carbon sequestration and ocean acidification

Katherine Martin (she/her), University of Victoria

As atmospheric carbon dioxide (CO_2) levels continue to rise, increasing attention is being given to exploring mitigation techniques that could potentially enhance the natural draw down of CO_2. One such mitigative intervention is Ocean Alkalinity Enhancement (OAE). OAE involves dissolving alkaline materials into ocean surface waters to increase its natural CO_2 buffering capacity. Limestone and lime have received the most attention given their widespread availability. Here I address the order one policy-relevant question of whether OAE represents a viable CO_2 removal solution to global warming. I use the UVic Earth System Climate Model to explore the potential of OAE interventions under representative concentration pathways (RCPs) 2.6, 4.5, 6.0, and 8.5. For each RCP, I undertook three OAE interventions. First, I assumed that the global annual production of limestone is crushed and uniformly distributed across, and immediately disassociates in the surface waters of the global ocean. Second, I assumed that the global production of limestone is converted to lime with the CO_2 released in this process being added to the atmosphere. In the third intervention, I repeat the second intervention but sequester the CO_2 arising from lime production. My results suggest that OAE interventions have little potential for mitigating global warming.

(C62) Methane lifetimes in the chemistry-climate system: links between physical and chemical climate variability

Eric Mei (he/him/his), University of Washington

Atmospheric methane (CH_4) is the second-most important anthropogenic greenhouse gas after CO_2. Unlike CO_2, variability in methane trends is modulated by methane's removal rate via oxidation by the hydroxyl radical (OH). Global mean OH abundance is poorly constrained due to the short atmospheric lifetime of OH (~1s) and the nonlinear dependence of OH concentrations on chemical precursors and physical variables (e.g., temperature and humidity). Uncertainty in OH variability challenges our attribution of atmospheric methane trends to anthropogenic methane emissions. Here, we present a linear inverse model (LIM) that emulates key physical and chemical dynamics that drive variability in OH and methane concentrations. Eigen-analysis of the trained LIM uncovers the dominant dynamics of the chemistry-climate system. This analysis reveals how physical modes of internal climate variability like the El Niño Southern Oscillation (ENSO) modulate variability in concentrations of chemical species (OH and methane). We investigate the impact of ENSO on variability in methane trends in long simulations of the chemistry-climate system generated by the trained LIM. These simulations are enabled by the LIM's reduced computational needs (~2 minutes of wall time for ~1,000 years of simulation) compared to a traditional chemistry-climate model (~1 year of wall time). We use the LIM's computational efficiency and reduced dimensionality to investigate dynamical links between physical and chemical climate variability.

(D38) Nitrous oxide dynamics and fluxes in the Southern Benguela Upwelling System (SBUS)

Anagha Payyambally (she/her), University of Connecticut

Nitrous oxide (N_2O) is a potent greenhouse gas, with a global warming potential 300 times greater than that of CO_2, over a 100-year timescale. The ocean is estimated to contribute a third of all natural N_2O emissions to the atmosphere. However, significant gaps remain in our understanding of N_2O distribution and emission across vast ocean regions. N_2O in the ocean is produced through biological reactions associated with organic matter processing and its production can increase as the amount of oxygen in the ocean declines. Since low-oxygen areas may harbor high concentrations of N_2O, upwelling events in these regions will bring them to the surface and potentially release this gas into the atmosphere. To investigate this, we studied N_2O concentration and fluxes within the Southern Benguela Upwelling System (SBUS), a prominent eastern boundary upwelling system. Water samples from this region were collected in August 2023 and analyzed using gas chromatography. The resulting concentration ranged from 8 to 25 nmol/kg, with an excess of 12% compared to surface saturation levels. This supersaturation drives a sea-to-air flux of N_2O between 1-2 μmol/m2/day. The fluxes from the SBUS are lower (0.01% of global marine N_2O emissions). Our future studies will focus on seasonal monitoring of N_2O distribution and fluxes from SBUS and other regions to assess how seasonal upwelling impacts N_2O fluxes. To better understand N_2O dynamics and fluxes in the ocean, we will employ isotopic analysis to pinpoint N_2O sources and deploy a continuous analyzer for real-time monitoring.

(D81) Subannual measurements of methane sulfonic acid and dimethyl sulfide from 1995 to 2023

Drew Pronovost, University of Washington

Marine phytoplankton directly emit dimethyl sulfide (DMS) to the atmosphere. DMS oxidizes to form biogenic sulfate, which is one of the largest sources of uncertainty found in global climate models. DMS is not well preserved in paleoclimate proxies, so methane sulfonic acid (MSA), an intermediate product of this oxidation, is typically used as a proxy for historical DMS emissions. MSA is well preserved in ice cores, and in older cores, it is typically in a constant ratio with biogenic sulfate. Ice cores show a decline in MSA over the industrial period, suggesting that DMS emissions are declining. However, as anthropogenic emissions of common oxidants change, the ratio of DMS to MSA found in ice cores has changed, making MSA a less ideal proxy. To better explore DMS emissions and their changing relationship with MSA records, we will share a record of both MSA and biogenic sulfate concentrations over the last thirty years with subannual resolution. This will provide information about not only the changing DMS to MSA ratio, but also the shifting seasonality of total sulfate emissions.

(B39) Investigating Hydrogen Peroxide Trends from 1950-2014

Vanessa Sun (she/her), University of Utah

The oxidizing capacity of the atmosphere, or the ability of the atmosphere to clean itself of pollutants in the troposphere, is determined by the abundance of oxidants such as the hydroxyl radical (OH), ozone (O_3), and hydrogen peroxide (H_2O_2). O_3 is the primary source of OH while H_2O_2 is a key sink for HOx radicals, OH and HO_2. To better understand changes in OH and the lifetime of pollutant gases in the atmosphere over recent decades, it is essential to also understand how H_2O_2 has changed, as it informs us about changes in HOx budget. We quantify the global H_2O_2 burden and its rate of increase between 1950 and 2014 from the Community Earth System Model - Whole Atmosphere Community Climate Model (CESM2-WACCM6). This time period features decades of climate warming and increases in tropospheric ozone. The rise of H_2O_2 begins in the 1970's, growing from 14% in the 1970's to 34% in the 2000's, in comparison to the 1950's. The largest relative increases occur in the Southern Hemisphere and over Antarctica. Changes in globally averaged annual mean H_2O_2 show strong associations with changes in tropospheric ozone, whereas changes in ozone photolysis rates were a stronger variable in Antarctica. We also find evidence of stratospheric ozone depletion having no discernible impact on global H_2O_2 burden changes using additional parallel simulations holding ozone depleting substances at 1950 levels. These results improve our understanding of the drivers of increased hydrogen peroxide in the modern era marked by significant changes in climate.

Ecosystem Monitoring

(B40) Spatial and Temporal Variations in Whooping Crane Stopover Habitat Preferences along the Kansas Migratory Flyway.

Ifeoma Okonye (she/her), Kansas State University

The whooping crane (Grus americana) is an endangered species that faces critical challenges during migration, making the identification of suitable stopover habitats for their survival and recovery necessary. This research models habitat suitability within the Kansas segment of the Aransas-Wood Buffalo Population migratory corridor, an area impacted by wind energy developments and climate change. First, I reconstructed The Watershed Institute's Habitat Suitability Index (HSI) model, which is currently used by the State of Kansas for decision making, to assess the accuracy of the model. ArcGIS Pro 3.x software was used for the model reconstruction, and validation was done against telemetered crane locations. This model initially screened out habitats near human disturbances and scored wetlands on criteria such as density, size, type, regime, and proximity to food sources. Statistical analysis showed the model lacked validity, performing no better than random. Advancing this work, I developed a habitat suitability model inspired by Belaire et al. (2014) using a random forest machine learning approach. This model estimates the relationship between environmental characteristics and stopover site suitability, incorporating six predictor variables: agricultural land, roads, urban areas, wetlands, ecotone, and bearing. Next, I will be addressing key research questions to determine whether habitat preferences change spatially during migration and temporally over time, considering climate change impacts. This research will inform conservation strategies, aiding development avoidance within these suitable habitats, thereby improving them and supporting whooping crane recovery. Additionally, this research advances habitat suitability modeling methodologies, contributing valuable insights for broader wildlife conservation efforts. Understanding habitat preferences in the context of changing climate conditions is crucial for developing adaptive management strategies based on informed decisions, which highlights this study's relevance to ongoing climate change challenges.

(A19) Foraging in the aftermath: the impacts of wildfire and restoration on a threatened species searching for high-quality food

Maria Ospina (they/them), University of California - Davis

The increasing frequency and severity of wildfires in the sagebrush ecosystem is a threat to sagebrush-obligate species, many that are already imperiled by habitat loss. Post-fire restoration efforts have focused on regrowth of plant communities, but we know little about the effectiveness of these efforts in mitigating fire impacts on wildlife. Here we investigated the foraging decisions of Greater Sage-grouse (Centrocercus urophasianus), a species of conservation concern, in the Santa Rosa Mountains, NV, which lost 440,000 acres to wildfire in 2018. Sagebrush is high in protein, but chemically defended to deter herbivory. Sage-grouse are known to reduce the costs of detoxification by selectively foraging for lower-toxin patches and plants. However, we know little about how diet quality and foraging behaviors change in post-fire landscapes. Plants deter herbivory by producing plant secondary metabolites (PSM). Including monoterpenes, PSMs help exhibit their insecticidal activities depending on the compound produced, which tend to be inversely proportional to plant protein ratios: the overall plant benefit potential for herbivores. We compared sagebrush and sage-grouse fecal monoterpene chemotypes across 5 burned and 4 unburned leks to understand what chemotypes sage-grouse are relying on post-restoration efforts, and where these chemotypes might be found. Combined with data from GPS-tagged birds, we will also test the hypothesis that sagebrush toxicity changes post-fire, changing the foraging effort required by Sage-grouse to find a high-quality diet. As wildfire becomes more common, it is increasingly critical to understand and effectively mitigate wildfire impacts on sensitive species, like Sage-grouse.

Climate at the Poles - Arctic Warming

(D82) Using CNNs to Partition Seasonal Internal Variability and Sea Ice Variability in Arctic Amplification

Sky Gale (she/her), University of Washington

Since 1980 the Arctic (defined as north of 70°N) has warmed more than four times faster than the rate of global warming. This phenomenon of faster Arctic warming than the global mean is called Arctic Amplification (AA). Climate models cannot capture this magnitude of warming, leading to concerns that models may not accurately capture Arctic response to increased greenhouse gas forcings. Internal variability, referring to natural variability inherent to the Earth’s climate system, may also be responsible. A less investigated aspect of the simulated versus observed discrepancy in AA is seasonality. While the annual mean observed AA is about four for 1980-2022, it varies significantly throughout the year due to the strong seasonal dependencies of physical processes that contribute to AA, e.g., the sea ice albedo feedback. In addition, certain internal atmospheric processes have been shown to significantly impact summertime sea ice, but not during other seasons Using a convolutional neural network (CNN), the attributed seasonal temperature increases of external forcings and internal variability are extracted from multi-decadal trend maps of surface air temperature and sea level pressure. This allows for direct comparison of externally forced changes based on observations with those based on simulations to evaluate various feedback processes. Quantifying the role of internal variability for both the Arctic and the globe for different seasons will help identify biases in the simulated forced responses of the Arctic and global warming and allow for constrained predictions of temperature and sea ice loss.

(B41) A Breakdown of Controls on Observed Arctic Warming Using CESM2

Ash Gilbert (they/them/theirs), University of Colorado-Boulder

The Arctic is warming at more than twice the global rate. What controls the observed warming trend and interannual variability is not fully understood. Previous work has shown that nudging winds from a historical hindcast to observed winds can reproduce both the trend and interannual variability in Arctic temperature and sea ice area. Here, we further attribute the controls on the warming trend and variability. Specifically, we breakdown the individual contribution of the winds, mean state, and forcing. Initial results show that the winds alone can explain most of the interannual variability but not the trend. We anticipate including the mean state change, i.e. sea ice thinning, ocean warming, etc., will help explain more of the trend. Although not completely independent of the winds and mean state, we also want to test if the forcing contributes to trend. Overall, we are excited this work will provide new insights into the controls on Arctic warming.

(A07) Projection of sea conditions in Nunatsiavut (Labrador) using climate models and in-situ observations

Thomas Kyeimiah (he/him/his), McGill University

The ongoing changes in global climate patterns significantly impact sea ice conditions, affecting local Inuit communities in Nunatsiavut, Labrador. This study forecasts future sea ice conditions along the Labrador coast by examining historical and projected changes in sea ice extent and thickness. We used observed data from the Canadian Ice Service with a 10 km resolution covering 1990-2020, climate data records (CDR) on a 25 km grid from the same period, and Pan-Arctic Ice Ocean Modeling and Assimilation System (PIOMAS) data from 1979-2023. Additionally, simulated data from the High-Resolution Community Earth System Model (HR-CESM) with a 0.1-degree spatial resolution from 1850-2100 were analyzed. Results indicate a slow decline in maximum

sea ice extent in March, followed by a rapid transition to ice-free conditions by 2060, when the Arctic Ocean becomes seasonally ice-free. This change is expected to stop the southward advection of sea ice through the Nares Strait along the Labrador coastline. There is also a gradual decline in the sea ice season's length and maximum thickness projected until the end of the 21st century. The expected later freeze-up and faster breakup of sea ice will likely affect the marine ecosystem and wildlife, increasing open water areas along the coast. These changes pose significant socio-cultural and economic challenges for Inuit communities, impacting traditional practices and livelihoods. The findings underscore the urgent need for proactive mitigation and adaptation strategies to ensure the sustainability and resilience of Inuit communities in the face of changing sea ice conditions.

(C63) Leveraging Data Assimilation for Accurate Sea Ice State Prediction

Joseph Rotondo (he/him/his), University of Washington

A "perfect model" experiment within the Community Earth System Model (CESM) has been employed to investigate how different atmospheric and albedo observations, including surface air temperature and albedo, can be utilized to better predict the mean sea ice state. This research involves taking one model ensemble member as 'truth' and then assimilating the aforementioned atmospheric and sea ice-based variables into other ensemble members to better match the mean sea ice state of the first model. The data assimilation was conducted using the Data Assimilation Research Testbed (DART). This approach has been applied to an 80-member ensemble starting in July 2020. The goal is to better understand which surface and airborne observations may best guide the model towards an accurate sea ice state. The study found that 2-meter air temperature and albedo are the most crucial atmospheric variables for predicting future sea ice states. Consequently, it is essential to increase the frequency and spatial distribution of these observations in the Arctic to improve predictions of the mean sea ice state under increased GHG forcing scenarios. Enhanced observation networks will provide more accurate data, enabling better forecasting and understanding of sea ice dynamics in a changing climate.

(C64) Local Climate Change and Wind Gusts in Utqiagvik, Alaska: An Analysis of Wind Speed, Temperature, and Variability

Hannah Wolf (she/they), Vanderbilt University

As global climate change accelerates, the temperatures in the Arctic have risen much faster than temperatures in the mid- and lower-latitudes. Arctic climate change is also of increasing concern to local Arctic communities, especially rural populations. One community directly impacted by climate change is Utqiagvik, Alaska, where wind storms threaten traditional hunting practices of its Inupiaq inhabitants (Rolph et al., 2018).

Meteorological data suggests that winds depend heavily on temperature conditions, but there is no consensus as to how rising temperatures will affect the frequency or intensity of wind gusts– brief increases in wind speed– in the Arctic. In this study, we evaluate the variability of wind gusts between 1994 and 2022 in Utqiagvik, Alaska and assess the parameters that influence wind conditions using Bayesian regression models. We also visualize changes in temperature and the mean and variability of wind speed, characterizing variability as the standard deviation of hourly mean values. Results demonstrate a significant increase in the variability of the average wind speed over the study period for 11 of the 12 months, while temperatures have increased for all months and mean wind speeds have not experienced any statistically significant change. Winter temperatures in Utqiagvik have increased more significantly than summer temperatures, indicating a seasonal disparity in regional warming that is supported by previous studies. Our findings suggest that variability in wind speed is more strongly affected by temperature than by mean wind speeds, but temperature changes alone cannot fully explain why the variability has increased in summer.

Climate at the Poles - Glaciers

(A20) Climate Signals Captured by State-of-the-Art Englacial Temperature Measurements in the Allan Hills, Antarctica

John-Morgan Manos (he/him/his), University of Washington

The Allan Hills Blue Ice Area in Antarctica contains ice dating to more than 2 million years before present (see Higgins et al., 2015; Yan et al., 2019), far older than most ice on Earth. This ancient ice provides an entirely new opportunity to study past climates, for example during the Mid-Pleistocene Transition. To understand the physical context of ancient ice, we carried out opportunistic distributed temperature sensing (DTS) measurements in the ALHIC1901 borehole during the 22/23 field season. In the 23/24 field season, ALHIC1901 was reoccupied in addition to measuring englacial temperatures in 4 more nearby shallow boreholes. Observed temperature measurements reflect the heat diffusion from past ground surface temperatures, the geothermal heat flux from the bed, and the advection of ice due to steep basal topography. Here, we utilize both forward and inverse modeling techniques to reconstruct past surface temperatures and better understand the glaciological context in the Allan Hills. Our findings suggest that both diffusion and advection may play an important role in the evolution of the ice temperature profile to its current state in this location. Additionally. Blue ice areas may be more dynamic, particularly in areas with steep basal topography, than previously considered.

(D84) A physical model for katabatic winds on glaciers

Hannah Phelps (she/her), University of British Columbia

Glaciers are rapidly retreating due to climate change; between 2015 and 2100, a 1.5˚C global temperature increase is projected to result in the loss of 49 ±9% of global glacier mass, excluding the Antarctic and Greenland ice sheets. Most current state-of-the-art regional glacier melt models rely on an empirical relationship between temperature and glacier melt. These models are simple but highly dependent on calibration to glacier mass balance observations, which are available for less than 1% of the world's glaciers. For glaciers without observations, these models have large associated uncertainties. There is a need to shift from empirical models to surface energy balance models, which close the energy budget at the glacier surface. These physics-based models are more reliable for glaciers without mass balance observations but require extensive meteorological inputs, making them difficult to apply regionally or globally. Global climate models provide these inputs, but their coarse resolution necessitates downscaling, especially for wind speed, which affects turbulent heat fluxes. Katabatic winds, which are prevalent at glaciers in summer, are poorly resolved in these models, leading to relative errors in turbulent heat fluxes and simulated seasonal melt that can exceed 50%. This study uses wind speed and temperature profiles collected on a large mountain glacier over summer to test a physical model of katabatic winds. The aim of this model is to downscale winds and temperatures from global climate models to the local glacier scale, improving the accuracy of future glacier melt predictions.

Vegetation and Carbon Cycle

(A21) Quantifying the Anthropogenic Impact on Rapid Increases in Atmospheric Moisture Demand over the Southeast Amazonia in the 21st Century

Alex Chang (he/him/his), University of California - Los Angeles

The Amazon rainforest plays a crucial role in the global water and carbon cycles, and in recent decades, it has experienced frequent droughts and heatwaves. Vapor pressure deficit (VPD), an indicator of atmospheric moisture demand, has shown significant increases across large portions of the Amazon, especially its southeastern region. Previously, climate model simulations have attributed this phenomenon mainly to natural variability. We show that increasing surface temperatures are responsible for about two-thirds of the observed VPD increases, whereas reduced surface humidity is responsible for the other third. Our observation-based attribution method shows that natural climate variability explains only 27\% of the observed VPD increases in the Amazon. The other 73\% of VPD increases are attributable to anthropogenic forcings. Changes in land use and precipitation appear to have minor contributions to the observed increases in VPD. VPD increases during drought years are also substantially greater than during non-drought years, which have amplified the extremity of some of the Amazon's droughts in recent decades. Ensemble projections of climate models show VPD increasing at current-day rates until at least 2050 under the "sustainability" scenario (SSP 1-2.6) and at rates double the currently observed rate under the high emission scenario (SSP 5-8.5) in the future. These findings show the impacts of climate change on both the water cycle and ecosystem, and they highlight the urgent need for a sustainable emissions pathway to avoid a much hotter and dryer Amazon, and the resulting loss of its ecosystem impacts regionally and globally.

(B42) Contrasting response of vegetation to elevated atmospheric CO2: the impact on flash drought

Ali Fallahmaraghi (he/him/his), University of Massachusetts - Lowell

Vegetation plays a crucial role in soil moisture regulation and the development of rapid onset drought events known as flash droughts. We analyze soil moisture outputs from CMIP6 climate models to understand how vegetation impacts future flash drought characteristics such as frequency, duration, and percentage of time. Using a set of climate model experiments from the Community Earth System Model (CESM2), we investigate how vegetation responses to rising CO2, which include CO2 fertilization effects and CO2 stomal conductance effects, influence flash droughts. Our findings reveal that the combined radiative and vegetation effects of elevated CO2 shift flash drought hotspots towards higher latitudes, impacting flash drought characteristics significantly. However, the influence of elevated CO2 on flash drought characteristics via vegetation forcing varies regionally, depending on whether CO2 fertilization or stomatal conductance effects dominate. In water-limited regions where CO2 fertilization dominates and surface vegetation strongly controls water availability, elevated leaf area offsets reductions in stomatal conductance and transpiration, increasing the likelihood of future flash droughts. Similar effects are also found in some energy-limited regions like eastern Canada and Siberia. Conversely, in more energy limited regions like western Canada and East Asia, preserved soil moisture from reduced stomatal conductance and transpiration suppresses flash droughts. We use Coupled Climate-Carbon Cycle Model Intercomparison Project (C4MIP) models to examine the robustness of the CESM2 vegetation response to elevated CO2, helping to understand projected flash drought changes across models. This study elucidates the physical processes behind flash drought development, improving predictive capabilities and mitigation strategies.

(D85) Photosynthetic responses to intrinsic water-use efficiency depend on atmospheric feedbacks and modify the magnitude of response to elevated CO2

Amy Liu (she/her), University of Washington

Plant stomata mediate the fluxes of both carbon and water between the land and the atmosphere. The ratio between photosynthesis and stomatal conductance (g_s), or intrinsic water-use efficiency (iWUE), can be directly inferred from leaf or tree-ring carbon isotope composition. In many Earth system models, iWUE is inversely proportional and controlled by a parameter (g1M) in the calculation of g_s. Here we examine how iWUE perturbations, setting g1M to the 5th (low) and 95th (high) percentile for each plant type based on observations, influence photosynthesis using coupled Earth System model simulations. We find that while lower iWUE leads to reductions in photosynthesis nearly everywhere, higher iWUE had a photosynthetic response that is surprisingly regionally dependent. Higher iWUE increases photosynthesis in the Amazon and central North America, but decreases photosynthesis in boreal Canada under fixed atmospheric conditions. However, the photosynthetic response to higher iWUE in these regions unexpectedly reverses when the atmosphere dynamically responds due to spatially differing sensitivity to increases in temperature and vapor pressure deficit. iWUE also influences the photosynthetic response to atmospheric CO2, with higher and lower iWUE modifying the total global response to elevated 2x preindustrial CO2 by 6.4% and -9.6%, respectively. Our work demonstrates that assumptions about iWUE in Earth system models significantly affect photosynthesis and its response to climate. Further, the response of photosynthesis to iWUE depends on which components of the model are included, therefore studies of iWUE impacts on historical or future photosynthesis can not be generalized across model configurations.