20th Annual Graduate Climate Conference



Conference Program and Abstract Book

Table of Contents

- Co-Chairs' Welcome
- History
- Schedule & Map
- Conference Format
  - Public Sessions
    - Public Poster Session
    - Lightning Talks
  - Oral Sessions
  - Poster Sessions
- Keynote Speakers
  - Dr. David (Roo) Nicholson
  - Dr. Joan Casey
- Workshops
  - Student-Led
  - Community Partner
- Posters and Presentations
  - Public Posters and Lightning Talks
    - Public Posters
    - Lightning 1 - Atmospheric Dynamics and Paleoclimate
    - Lightning 2 - Environmental Risk, Resilience, and Clean Energy
    - Lightning 3 - Hydrology and Ecology in a Warming World
  - Oral Sessions
    - Session 1 - Climate and Atmospheric Modeling
    - Session 2 - Coastal Ecosystems, Soil Dynamics, and Carbon Fluxes
    - Session 3 - Decision-Making and Risk in Climate Adaptation
    - Session 4 - Climate Impacts: Ice, Ocean, and Species!
  - Private Posters
    - Session A
    - Session B
    - Session C
- Organizing Committee

Code of Conduct
Acknowledgements
Sponsors

Co-Chairs' Welcome

Welcome to the 20th Annual Graduate Climate Conference, an interdisciplinary climate conference run by graduate students, for graduate students. Over the last twenty years, graduate students representing hundreds of academic institutions have come together to present research and share ideas on climate and climate change in an array of disciplines. We are especially excited to welcome everybody to Pack Forest, the same location as the inaugural GCC twenty years ago!

Over the next few days, we'll hear presentations on topics ranging from polar ice dynamics and ocean biogeochemistry to urban resilience, climate communication, and environmental justice. We are honored to welcome two keynote speakers: Dr. David (Roo) Nicholson from Woods Hole Oceanographic Institute and Dr. Joan Casey from the University of Washington. Dr. Nicholson will deliver the Research and Education Keynote. He is an Associate Scientist in the Marine Chemistry and Geochemistry Department and one of the conference's original founders, so we are especially excited to welcome him back to Pack Forest. Our Career Development and Advocacy Keynote speaker, Dr. Casey, is an Associate Professor in the Department of Environmental and Occupational Health Sciences. She does incredible work connecting climate, human health, and environmental justice and we're really looking forward to having her. Both speakers will be available for informal chats with students during the conference.

In addition to the oral and poster presentations offered by all of you, there will be two pairs of workshops. The first pair will be led by graduate students. In "Improv for scientists," led by Rudra Thaker from the University of Wisconsin Madison, participants will practice communicating science in real-time. Leah Van Dyke from University of California Santa Cruz, "Building interdisciplinary research networks in climate science." We will also have three workshops led by community partners that address topics applicable to many of the modern challenges we face outside of research. Julia Pinnix with the US Department of Fish and Wildlife located locally in Nisqually will present a workshop titled "Emotional resilience in working with tough topics" in which participants explore the emotional challenges of working in difficult fields. In addition, "Climate journalism in an age of misinformation" will be led by Claire Thompson and Kate Yoder, Data Journalists at Grist. Finally, Claire Zarakas, a

research scientist with CarbonPlan, and former GCC alum will present a workshop entitled “Pursuing applied climate science research outside of academia.”

Just as important as the formal schedule are the conversations that happen over coffee breaks, meals, and social activities. These are chances to connect with people from different parts of the continent and across different fields, and these conversations may lead to unexpected future collaborations and increase interdisciplinary understanding of climate-related issues. We also encourage you to join office hours with our keynote lectures and our community partners!

Thank you for being a part of this year’s conference, and a BIG thank you to everyone who has volunteered as an organizer, committee chair, driver, and/or Thursday or Sunday night host.

Please don’t hesitate to reach out anytime during the conference if you have any questions or concerns. We are excited for the opportunity to spend this weekend with you, and hope you are able to make the most of every minute of it.

Sincerely,
Lilac Hong and Katie Webb
2026 Graduate Climate Conference Co-Chairs

History

The 2026 GCC marks its 20th anniversary, having started in 2006 when students in the Program on Climate Change at the University of Washington (UW) hosted the first ever graduate student climate conference. The conference is planned, organized, and attended entirely by graduate students. The GCC has been partially funded by a grant from NSF since 2010, with other funding coming from a mix of sources including participating university departments and non-profits.

In 2011, the GCC transitioned to a traveling format, alternating location each year between Woods Hole, Massachusetts (hosted by students from the Massachusetts Institute of Technology (MIT) Program on Earth, Atmospheric, and Planetary Sciences and the Woods Hole Oceanographic Institution) and Pack Forest, at the base of Mount Rainier in Eatonville, Washington (hosted by students from University of Washington).

Due to safety concerns during the COVID-19 pandemic, the GCC was not held in-person in 2020 and 2021. During this time, the organizing committee expanded its membership and invited graduate students from institutions other than UW and MIT to participate, a practice which has continued since in-person conferences resumed in 2022.

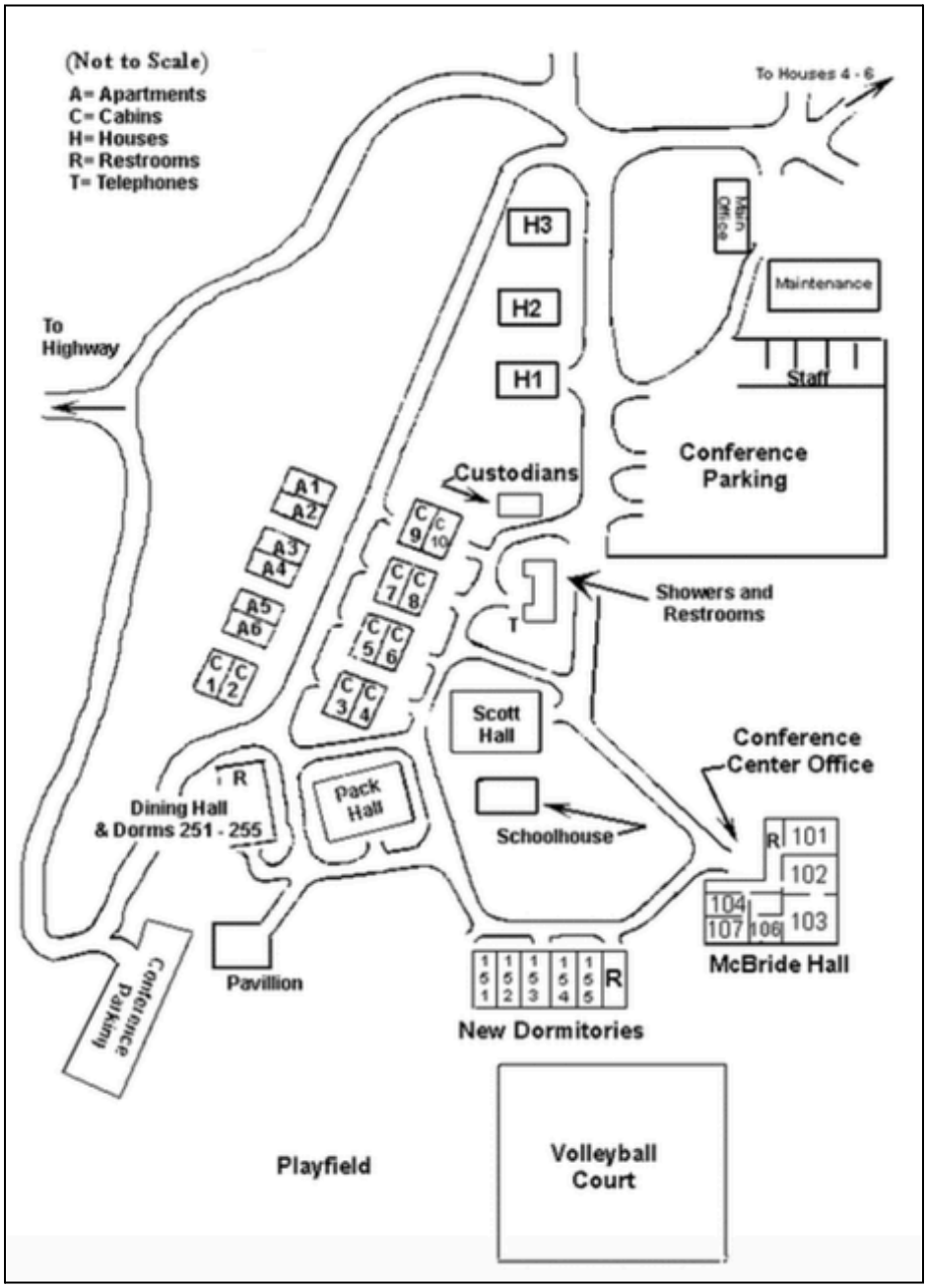
Schedule & Map

Time	*Session*	*Location*
Friday, November 6th		
11:00 AM - 12:00 PM	Lunch at UW	FSH Atrium / FSH 102
12:00 - 2:30 PM	Public Poster & Lightning Talk Session	
2:30 - 4:45 PM	Buses to Pack Forest (one stops at Sea Tac)	
4:45 - 5:00 PM	Coffee Break	
5:00 - 5:30 PM	Introduction and Welcomes	Scott Hall
5:30 - 6:30 PM	Keynote 1: Dr. Roo Nicholson	Scott Hall
6:30 - 7:30 PM	Dinner	Dining Hall
7:30 - 8:30 PM	Oral Session 1	Scott Hall
8:30 PM - Whenever	Social Activity 1: Movie Night (Halloweentown)	Scott Hall
	Social Activity 2: Speed Peering/Game Night	Pack Hall

Saturday, November 7th		
5:15 - 8:00 AM	Social Activity: Morning Hike to Mashel Falls	Meet at Dining Hall
8:00 - 9:00 AM	Breakfast	Dining Hall
9:00 - 9:15 AM	Opening Remarks	Scott Hall
9:15 - 10:15 AM	Keynote 2: Dr. Joan Casey	Scott Hall
10:15 - 10:30 AM	Coffee Break	School House
10:30 AM - 12:15 PM	Poster Session A	Pack Hall / McBride Hall
12:15 - 1:15 PM	Lunch	Dining Hall
1:15 - 2:15 PM	Oral Session 2	Scott Hall
2:15 - 3:15 PM	Student-Led Workshops	Scott Hall / Pack Hall
3:15 - 4:15 PM	Oral Session 3	Scott Hall
4:15 - 4:30 PM	Coffee Break	School House
4:30 - 6:15 PM	Poster Session B	Pack Hall / McBride Hall
6:15 - 7:15 PM	Dinner	Dining Hall
7:15 - 9:15 PM	Poster Session C	Pack Hall / McBride Hall
9:15 PM - Whenever	Social Activity: Trivia Night/Halloween Party (Costume Contest!)	Pack Hall

Sunday, November 8th		
7:45 - 8:15 AM	Pack up & remove belongings from housing	
8:00 - 9:00 AM	Breakfast	Dining Hall

9:00 - 10:30 AM	Oral Session 4	Scott Hall
10:30 - 10:45 AM	Coffee Break	School House
10:45 - 11:45 AM	Community Partner Workshops	Scott Hall / Pack Hall / School House
11:45 AM - 12:00 PM	Concluding Remarks	Scott Hall
12:00 - 12:15 PM	Packaged Lunch (grab on the way out)	Dining Hall
Promptly 12:30 PM	Buses to UW (one stops at SeaTac)	
2:30 - 6:00 PM	Social Activities	
6:00 - 7:00 PM	Dinner (own cost)	



Conference Format

Public Sessions

Friday, Nov 6th | 12:00 - 2:30pm | Fishery Sciences Building (FSH), UW

Lightning talks and poster sessions will be open to preregistered members of the greater Seattle community. The public poster session will take place concurrently with lightning talks, and guests are encouraged to flow between both. Talks and posters in this session will be delivered to a public audience that includes both scientists and members of the broader community, and should be accessible to a wide range of familiarity levels, ensuring clarity for those with little or no prior knowledge while remaining engaging to scientific audiences.

Public Poster Session

Public posters will be presented during the public session in the FSH Atrium. See Posters and Presentations for poster descriptions.

Lightning Talks

All lightning talks will be in FSH 102. Lightning talks are grouped into three sessions, covering different topics. Each lightning talk will be 3 minutes followed by 2 minutes for questions. Speakers and presentation titles are below along with longer descriptions in Posters and Presentations.

Session	Title and Speaker (Presenting Order)
Lightning 1 - Atmospheric Dynamics and Paleoclimate *Chairs: Ashley Lasinsky and Cassandra Bartels*	1. **Joey Rotondo** | Satellite Sea Ice Concentration Observation Uncertainty Is State-Dependent and Varies Seasonally 2. **Bradley Lamkin** | Arctic Goldilocks Clouds: An Important Driver of Arctic Sea Ice Melt 3. **Akarsh Ralhan** | How the Land Reflects: Physics-Informed Machine Learning for Global Land Surface Albedo Parameterization 4. **Miles Epstein** | Forecasting Severe Thunderstorms up to a Week in Advance with Machine Learning 5. **Dora Shlosberg** | Exploring future spatial patterns and trends

	of sea surface salinity using multi-model large ensemble simulations 6. **Emily Nigro** | Triple Oxygen Isotope Record From Ferricrete Deposits Shows Holocene Moisture Source Shift in the Rocky Mountains 7. **Maggie Scholer** | Using high-resolution δ15N and δ18O measurements of nitrate in the GISP2 core to investigate seasonal variations in atmospheric oxidative chemistry since the preindustrial 8. **Kaetlyn Rodriguez** | A multi-proxy investigation on the Gulf of California Oxygenation during the Last Interglacial 9. **Brianna Hoegler** | Alkenones, Calcite, and Community Composition: Untangling Coccolithophores' Roles in the Global Carbon Cycle
Lightning 2 - Environmental Risk, Resilience, and Clean Energy *Chairs: Sky Gale and Hanne Borstlap*	1. **Junxiang Du** | Climate Risk and Renewable Energy Markets: Evidence from Wholesale Electricity Price Volatility 2. **Ruixuan Ding** | Do Corporate Climate-Risk Disclosures Reflect Physical Flood Exposure? Evidence from Companies in the U.S. 3. **Calen Randall** | Quantifying Heatwaves: Exploring the Drivers of Heatwaves Across the Continental USA 4. **Anna Oehlerking** | From Loading Docks to Lungs: An Emissions Inventory for Illinois Warehouses and Evaluation of the Warehouse Pollution Reduction Act 5. **Hannah McKinley** | Got Green Air? An evaluation of 14 low-cost sensors for indoor air quality monitoring 6. **Jack Boyle** | Post-Wildfire Hydrological Recovery in a Changing Climate: Implications for Downstream Water Security in the Northern Rockies and Pacific Northwest 7. **Cat Odendahl** | Soil Lead Distributions Following Urban Wildfires: Insights from a Community-Driven Study in Los Angeles 8. **Katelin Teigen** | Household Perceptions and Preparedness for Wildfire Smoke: Findings from a Community Assessment for Public Health Emergency Response in Spokane, Washington
Lightning 3 -	1. **Madeleine Burns** | The value of snow to water availability 2. **Emerald Goldbaum** | Long-Term Impact of Drought on

Hydrology and Ecology in a Warming World *Chairs: Katelin Teigen and Hanne Borstlap*	Stream Geochemistry in Urban, Agricultural, and Forested Watersheds, Ohio 3. **Mst Proma Sultana Borsha** | Assessing the Influence of Climate Variability on Arsenic Occurrence in Ohio Groundwater 4. **Kerry Mundy** | Climate-Driven Shifts in Soil Hydraulic Properties Across Long-Term Warming Experiments 5. **Stella Potemkin** | Diagnosing Long-Term Aridity Across Atmospheric, Land-Surface, and Biosphere Domains 6. **Grace Callahan** | Turf Wars: Green Urchin Feeding Ecology in a Changing Gulf of Maine 7. **Cameron Dow** | A New Frontier in Drought-Induced Tree Mortality Research: How the Anatomy of a Tree Can Inform Climate Smart Forest Management 8. **Leah Van Dyke** | Tracking Active Microbial Taxa in Restored and Reference Wetland Sites 9. **Rae Fadlovich** | How climatological definition influences the perceived ecological impacts of marine heatwaves

Oral Sessions

All oral sessions will be in Scott Hall. There will be four oral sessions, split up by topic. Each topic will have a brief introduction given by the session chairs. Speakers will have 10 minutes to present, followed by 3 minutes of questions. To make sure that everyone gets a fair share of time, GCC reserves the right to cut off a presentation that goes too long. For detailed descriptions of talks, please see Posters and Presentations.

Session and Time	Title and Speaker (Presenting Order)
Session 1 - Climate and Atmospheric Modeling Friday, Nov 6th 7:30 - 8:30pm *Chairs: Annabel Wade and Dominik Stiller*	1. **Ben Lloyd** | Deep learning provides new insights into earliest C4 grasslands in Early Miocene East Africa 2. **Leo Balcer** | Multi-Model Insights on the Changing Internal Variability of the Upper Arctic Ocean 3. **Jingya Han** | Can station observations tell us how much precipitation intensity distribution is really changing? 4. **Dhwanit Mise** | Aerosol and Meteorological Controls on Deep Convective Cloud Lifecycles: Insights from Observations and Large-Eddy Simulations
Session 2 - Coastal Ecosystems, Soil Dynamics, and Carbon Fluxes Saturday, Nov 7th 1:15 - 2:15pm *Chairs: Sky Gale and Miles Epstein*	1. **Savannah Atchley** | Evaluating Marsh Vulnerability at the Virginia Coast Reserve LTER Site Through UVVR Analysis and Field-Based Ground Truthing 2. **Meilun Zhang** | Seasonal variability in primary productivity at a coastal equatorial time-series station: Roles of terrestrial carbon, nutrients and light attenuation 3. **Aliya Khan** | Anthropogenic Drivers of Carbon Export in California Salt Marshes: Implications for Restoration and Climate Mitigation 4. **Mahmoud Rady** | Cover Cropping and Reduced Tillage Alter Soil Carbon Emissions and Weed Pressure in Collard Production
Session 3 - Decision-Making	1. **Emily Cole** | Whose role is it? Interpreting national climate and biodiversity policy in local government

and Risk in Climate Adaptation Saturday, Nov 7th 3:15 - 4:15pm *Chairs: Hannah McKinley and Bradley Lamkin*	2. **Abrielle Mannino** | Quantifying the Role of Land Fraction in Precipitation Biases over Pacific Small Island Developing States (PSIDS) 3. **Bryn Anderson** | Models in context: best practices for engaging expert stakeholders to build a technical model
Session 4 - Climate Impacts: Ice, Ocean, and Species! Sunday, Nov 8th 9:00 - 10:00am *Chairs: Joey Rotondo and Rudra Thaker*	1. **Arielle "Lu" Nogueira** | Tropical cyclones in a changing climate: A study of high-latitude paleostorms over the past several millennia using sediment cores from Newfoundland, Canada 2. **Lilac Hong** | Climate-Driven Population Trends Align with Species Distribution Model Predictions 3. **Josie Baker** | Temperature rising: what does it mean to be resilient to extreme heat? 4. **Olivia Doty** | Notch Your Average Melt: Wave-Induced Erosion of Ice 5. **Hanne Borstlap** | Unequal Risks Followed by Unequal Costs: Integrating Hydrologic Risk and Social Vulnerability across Coastal Communities

Poster Sessions

All poster sessions will be in McBride and Pack Halls. Posters have been assigned a letter corresponding to session, and a number corresponding to poster location. Posters should be hung up at the start of or slightly prior to the assigned session, but not before any other session (i.e., Session B posters should not be up until after Session A is done). A detailed description of each poster can be found in Posters and Presentations.

★★★ Poster Voting Competition ★★★

In the spirit of friendly competition and encouragement, GCC annually hosts a poster competition. Votes will be aggregated across all poster sessions. The categories are:

- **Most Visually Appealing**: Recognizing the poster with the best organization, layout, and design, including the effective use of graphics and figures.
- **Best Presented**: Honoring the poster accompanied by a high-quality oral presentation and thoughtful responses to questions.
- **Most Creative**: Recognizing posters that use unconventional or inventive approaches, such as metaphors to improve accessibility, additional media (e.g., videos), or exceptionally creative figure design.

Keynote Speakers

Dr. David (Roo) Nicholson

Adventures in Ocean Observing



Dr. David (Roo) Nicholson is an Associate Scientist in the Marine Chemistry and Geochemistry Department at the Woods Hole Oceanographic Institution. His research has the broad goal of understanding global biogeochemical cycles in the context of a changing climate. Towards this challenge, his research uses observations from autonomous platforms, such as underwater gliders, floats and surface vehicles and numerical models of varying complexity. Recent research focuses include growing the global Biogeochemical Argo array, developing chip-based multiparameter sensors and designing monitoring strategies for ocean alkalinity enhancement.

Dr. Joan Casey

Before the Pie Burns — Time, Burnout, and Science in a Warming World



Joan A. Casey is an Associate Professor of Environmental and Occupational Health Sciences and Epidemiology at the University of Washington School of Public Health in Seattle. Dr. Casey uses large secondary spatial data sources to investigate a range of emerging environmental exposures, including wildfires, power outages, fossil fuel infrastructure, and the energy transition, with a focus on health disparities and policy-relevant climate justice work.

If you'd like to speak with the keynote speakers, consider signing up for 'Office Hours' with them during lunch here.

Workshops

Starting in 2018, the GCC added workshops to the program! One workshop session is hosted by GCC's own graduate student participants and the other by invited Community Partners. During each session, participants will select one workshop to attend. Please share your feedback after the workshops to help us improve future sessions!

Student-Led

Workshop #1: Improv for Scientists
Rudra Thaker, he/him, University of Wisconsin-Madison
Saturday, Nov 7th | 2:15 - 3:15pm | Pack Hall

This workshop will be based on a 6 week university credit course Rudra took earlier in the Spring. The workshop, following the course, is about different improv techniques for effective science communication. There is no material to be taught in the workshop but rather different group activities. This includes the "yes and" method of communication, trusting your team games, and then finally a fun exercise of describing your research in 3 minutes, 1 minute, 30 seconds, and 10 seconds. Improv in general has been considered to be a great tool to improvise science communication. This was first done in the field of medical sciences to navigate conversations with patients coming from different beliefs about medicine and was found super successful.

Workshop #2: Building Interdisciplinary Research Networks in Climate Science
Leah Van Dyke, she/her, University of California Santa Cruz
Saturday, Nov 7th | 2:15 - 3:15pm | Scott Hall

Research questions are often inherently interdisciplinary, yet many students feel uncomfortable reaching out to potential collaborators outside of their primary field or may not know how to find researchers whose goals align with their own. This workshop discusses strategies and opportunities for graduate students to connect and work with researchers across disciplines, improve communication across fields, and identify opportunities for collaboration. Participants will discuss common challenges in interdisciplinary research, including differences in terminology, methods, and scientific perspectives, as well as strategies for overcoming barriers to communication and collaboration. Participants will also be encouraged to share organizations, scholarship opportunities, programs, and professional networks that

have helped them connect with researchers, institutions, or collaborators outside of their primary field. The goal of the workshop is to emphasize how interdisciplinary approaches can strengthen climate research and help students identify both barriers and opportunities in building collaborative research networks.

Community Partner

Workshop #1: Finding Emotional Resilience in Working with Tough Topics

Julia Pinnix, Visitor Services Manager at U.S. Fish and Wildlife Service (Nisqually)

Sunday, Nov 8th | 10:45 - 11:45am | School House



Julia Pinnix was carried into now-vanished glacial ice caves on Mount Rainier as a baby. Her path accordingly led to glaciers in Alaska and the Pacific Northwest and a career helping visitors to our public lands understand climate change. She is currently the Visitor Services Manager for Nisqually National Wildlife Refuge Complex, U.S. Fish and Wildlife Service, in Olympia, Washington.

Workshop #2: Pursuing Applied Climate Science Research Outside Academia

Claire Zarakas, Research Scientist at CarbonPlan

Sunday, Nov 8th | 10:45 - 11:45am | Scott Hall



Claire Zarakas is a research scientist at CarbonPlan, a research nonprofit. She received her BA in Geosciences from Princeton University and her PhD in Atmospheric Sciences from the University of Washington, where she was a DOE Computational Science Graduate Fellow. She then joined CarbonPlan as a Schmidt Sciences fellow with a joint appointment at the University of California, Irvine. Previously, she worked at a public sector consulting firm where she conducted research to inform climate mitigation and adaptation policies.

Workshop #3: Climate Journalist in an Age of Misinformation

Claire Thompson and Clayton Aldern, Data Journalists at Grist

Sunday, Nov 8th | 10:45 - 11:45am | Pack Hall



Claire Elise Thompson is an associate editor at *Grist*, and the writer of the weekly solutions newsletter, *Looking Forward*. She has been at *Grist* since 2018, focusing on telling stories about climate solutions and the people leading them. She was a 2022 MJ Bear fellow with the Online News Association and participated in the inaugural Climate Beacons Newsroom Initiative with the Solutions Journalism Network. She is based in Seattle.



Kate Yoder is a senior staff writer covering climate change through the lens of language, culture, and history. Her work has received a FOLIO: Eddie & Ozzie Award and a SEAL Environmental Journalism Award for bringing fresh perspective and social relevance to environmental issues. She has been at Grist since 2015 and is based in Seattle.

Posters and Presentations

Posters (public and private), lightning talks, and oral talks are listed in presentation order for each session.

Public Posters and Lightning Talks

Public Posters

[P1] Observed Structure, Propagation, and Air–Sea Coupling of Sharp Fronts Embedded Within Tropical Instability Waves | *Katie Kohlman, University of Washington*

The tropical oceans play a central role in regulating global climate, weather, nutrient cycling, oxygen minimum zones, and biologically productive marine ecosystems. In the equatorial Pacific, warm surface waters and strong ocean–atmosphere coupling influence global climate variability, including ENSO. Traditionally, this region has been studied primarily through the lens of large-scale circulation, but recent advances in remote sensing now reveal energetic small-scale processes that were previously unresolved. In this project, we investigate upper-ocean fronts on scales of 1–10 km using a combination of satellite and in situ observations. These sharp fronts, embedded within Tropical Instability Waves (TIWs), may play an important role in ocean mixing, air–sea exchange, and tropical ecosystem dynamics. We use observations from the Surface Water and Ocean Topography mission satellite to resolve centimeter-scale sea surface height anomalies associated with convergent frontal structures. High-resolution sea surface temperature observations from MODIS and Visible Infrared Imaging Radiometer Suite are combined with hourly imagery from GOES-18 to identify and track the evolution of these fronts over time. To provide physical context for the satellite observations, we incorporate measurements from Saildrone uncrewed surface vehicles, including salinity, surface meteorology, air–sea fluxes, and upper-ocean structure. Together, these observations suggest that sharp TIW fronts are coherent and persistent features that may play an underappreciated role in tropical air–sea coupling, ocean energetics, and ecosystem variability.

[P2] Impact of Equatorial Winds on the Meridional Heat Transport in the Atlantic Ocean | *Sanjana Satish, University of Wisconsin-Madison*

Atlantic ocean heat transport impacts multiple aspects of the Earth's climate, affecting tropical precipitation, surface temperatures and Arctic sea ice concentration. Tropical wind patterns are known to be a primary driver of heat uptake in the tropics, but their impact on Atlantic ocean heat transport is not well understood because of interactions with the Atlantic Meridional Overturning Circulation. In this presentation, we explore the role of the equatorial winds in setting the meridional heat transport in the Atlantic using an idealized single basin model with a zonally re-entrant channel near the southern boundary. We find that increasing the westward wind stress symmetrically at the equator increases equatorial heat uptake. These symmetric wind changes cause an asymmetric heat transport response, with more heat transported into the Northern Hemisphere than into the Southern Hemisphere. The volume transport of the subtropical cells changes symmetrically, and the meridional heat transport (MHT) response extends well into the subtropics due to increased temperatures in the western boundary current of the subtropical gyre. Temperature changes on the western boundary extend deeper in the North Atlantic than in the South Atlantic, and this results in an asymmetric heat transport response. The latitudinal extent of MHT changes is limited by the separation latitudes of the western boundary currents of the subtropical gyres, poleward of which the MHT anomaly is dramatically reduced due to exposure to colder subpolar atmospheric temperatures.

[P3] Beyond the NAO: Synoptic Drivers of Water Mass Transformation | *Rudra Thaker, University of Wisconsin-Madison*

In the subpolar North Atlantic, regions such as the Labrador and Irminger Seas play an important role in variability of the Atlantic Meridional Overturning Circulation (AMOC) through water mass transformation. These changes are often linked to large-scale atmospheric variability, commonly described by the North Atlantic Oscillation (NAO), but the underlying physical drivers remain unclear. Here, we ask: to what extent do synoptic-scale systems, specifically cyclones and cold air outbreaks (CAOs), contribute to surface density fluxes, water mass transformation (WMT), and water mass formation (WMF) in these regions? We address this

question using daily output from the Community Earth System Model (CESM) forced ocean–sea ice (FOSI) simulations at two resolutions: an eddy-resolving (0.1°) and a standard low-resolution (1°). We compute daily density fluxes, WMT, and WMF during winter and quantify the contributions from cyclones and CAOs using event masks derived from TempestExtremes applied to JRA55 reanalysis. We find that CAOs contribute disproportionately to density flux, WMT, and WMF across all regions. In the Labrador Sea, CAOs occur on approximately 35–40% of winter days but account for nearly 80% of total WMT and WMF. Cyclones also contribute to these processes, but their contributions are closer to their frequency of occurrence. These results are based on the high-resolution simulation, and ongoing analysis with the low-resolution simulation will assess whether these contributions and underlying mechanisms differ across model resolutions.

[P4] Recent increase in ocean heat uptake efficiency: mechanisms, future evolution and implications for global warming | *Manali Nayak, University of Washington*

The ocean is the largest heat sink in the climate system, regulating warming experienced at the surface. As anthropogenic greenhouse gas emissions increase Earth's energy imbalance, the processes that move heat from the surface to the deep ocean become increasingly important in determining the trajectory of climate change. On global scales, this is quantified by the ocean heat uptake efficiency (OHUE), defined as the rate of ocean heat uptake per degree of surface warming. Observations indicate that OHUE has increased in recent decades, temporarily reducing the rate of global warming, although this trend is expected to reverse in the future. In this study, we investigate the mechanisms underlying the recent increase in OHUE using the ocean-only configuration of MITgcm and a Green's function approach. To isolate the contributions of different forcing agents to historical OHUE evolution, the model is subjected to idealized perturbations representing individual dynamic drivers of OHUE, and the resulting temperature responses are convolved with realistic historical forcing trajectories derived from the FaIR climate emulator. We find that greenhouse gas forcing governs the long-term trend in OHUE, with aerosols and natural forcing emerging as the dominant contributors to the recent multi-decadal increase. Strengthening trade winds over the Pacific further amplify the magnitude of OHUE by increasing

equatorial upwelling and cooling sea surface temperatures. We further examine OHUE under a suite of future radiative and wind forcing scenarios to assess how changes in heat uptake influence the rates of future global warming and sea level rise.

[P5] The Role of Sea Surface Temperature Trends in Regional Precipitation Change | *Flora Perlmutter, Dartmouth College*

Predicting how regional precipitation will change is one of the central challenges in climate science. Accurate regional precipitation projections are essential for communities to make informed decisions about water, food, and climate adaptation. A key source of uncertainty in precipitation projections is sea surface temperatures (SSTs). The ocean is a powerful driver of precipitation over land, but climate models have historically struggled to simulate SSTs accurately, failing to reproduce the observed cooling trends in the eastern Pacific and Southern Ocean. Therefore, knowing how ocean temperatures influence terrestrial precipitation is essential for understanding climate variability and predicting and projecting water resources. Here, we develop a regression framework that quantifies the sensitivity of river basin-scale precipitation to observed global SST patterns. We find that SSTs account for 2 to 29% of observed precipitation variability - a substantial fraction with direct implications for water resource planning, agriculture, and flood and drought risk. SSTs also contribute to significant multidecadal precipitation trends in 78 river basins. These results advance our understanding of SST-precipitation relationships and offer a pathway toward more reliable regional precipitation forecasts on the timescales relevant to decision-makers.

[P6] Sensitivity of MPAS Rainfall Forecasts for Tropical Cyclone Kenneth (2019) | *Dessydery Mngao, University at Albany*

Landfalling tropical cyclones bring extreme winds, storm surge and prolonged heavy rainfall, causing flooding, loss of life and widespread damage, yet their rainfall remains among the most difficult quantities to forecast. At the grid spacings typical of global and regional forecast models, much of the rainfall comes from the cumulus scheme, which represents the net impact of thunderstorms too small for

the model grid to resolve, so the choice of physics schemes can strongly shape the forecast. In this study, we examine how the choice of cumulus and microphysics schemes affects rainfall forecasts for Tropical Cyclone Kenneth, the strongest cyclone on record to make landfall in Mozambique (25 April 2019). The Model for Prediction Across Scales – Atmosphere (MPAS-A) was run on a 60-km mesh from ERA5 initial conditions in four configurations that differ by the cumulus scheme (New Tiedtke or Grell-Freitas) and the microphysics scheme (WSM6 or Thompson). Over the landfall region, swapping the cumulus scheme reduced three-day rainfall by 62%, while swapping the microphysics scheme reduced it by only 12%. In all configurations, inland rainfall came mostly from the cumulus scheme rather than the microphysics scheme, and Grell-Freitas produced more of it. Near the coast, the two cumulus schemes placed the storm differently: with New Tiedtke the cyclone and its heaviest rain stayed over land along the coast, while with Grell-Freitas the main region of precipitation remained offshore after 26 April. Microphysics changed rainfall amounts but not their pattern. All configurations underestimated the observed storm intensity. Future work will test finer grid spacing and additional physics combinations.

[P7] Mid-Tropospheric Circulation and Compound Weather Extremes in Western North America | *Amanda Laverty, Washington State University*

Extreme weather and climate events pose significant threats to society, including adverse impacts on human health, increased food and water insecurity, damage to infrastructure, and extensive economic loss. Compound or co-occurring extremes can produce disproportionately greater impacts than isolated events. Globally, changes in the frequency, intensity, and duration of such extremes are influenced by changes in atmospheric circulation patterns and thermodynamic changes in the Earth system, including warming and increasing humidity. In western North America, synoptic-scale weather features such as atmospheric high-pressure systems drive the occurrence of co-occurring extremes such as concurrent heat and precipitation deficits. Advancing our understanding of the relationship between various atmospheric circulation patterns and extreme events is important for enhancing predictability and societal preparedness. In this study, we investigate how different large-scale atmospheric circulation patterns influence daily-scale

compound weather extremes across all four seasons in western North America. Using k-means clustering of daily 500hPa geopotential height anomalies, we identify recurrent circulation patterns and quantify their associated temperature and precipitation impacts. For each season and their cluster patterns, we then quantify the frequency and spatial extent of four types of compound extremes: wet-cold, dry-cold, wet-hot, and dry-hot. By evaluating how large-scale atmospheric patterns drive these events, this work aims to advance understanding of high-impact climate hazards and inform forecasting, emergency preparedness, and adaptation. The framework developed here will be extensible to other regions and types of compound extremes influenced by large-scale circulation, offering a broadly applicable tool for climate risk assessment.

[P8] A Preliminary Investigation of Heatwave–Drought Conditions and Wildfire Occurrence in Canada | *Susanna Hutsul, University of Victoria*

Wildfire activity in Canada is influenced by multiple environmental factors, including extreme temperatures and moisture availability. Although heatwaves and droughts have individually been associated with wildfire activity, their combined relationship with wildfire occurrence remains less well understood, particularly across different Canadian regions. This study investigates associations between heatwaves, surface soil moisture droughts, compound heatwave–drought conditions and large-fire occurrence (≥1,000 ha) across six Canadian regions during April–September, 1991–2025. Preliminary results indicate that compound heatwave–drought conditions were associated with the highest large-fire occurrence rates across all six regions.

[P9] Evaluation of Burned Area, Fire-Related Variables, and Lightning for Improvement of the Canadian Earth System Model version 5.1c| *Sophie Kiley, University of Victoria*

As fire weather becomes increasingly extreme, it is essential to improve the accuracy of wildfire modelling for effective climate adaptation. The Canadian Earth System Model (CanESM5.1c), incorporating recently formulated parameterizations for lightning and wildfires, is used here to evaluate how wildfire activity is

represented across Canada. Fire-related variables are calculated using model-simulated precipitation, relative humidity, noon temperature, and surface wind output. These variables along with burned area and lightning data from the model are then compared to observational datasets from the Canadian Lightning Detection Network (CLDN) and Natural Resources Canada (NRCan) in order to seek improvements in CanESM5.1c. By determining disparities between the model and observed data, biases within CanESM5.1c can be identified. Overall, this project provides insight into how wildfire risk can be better assessed under a warming climate.

[P10] Wildfire smoke and extreme heat disease risks in California prison workers from 2000 to 2100 | *Cecilia Martindale, University of Washington*

Prisons face unique occupational health challenges as many workers are incarcerated and these workplaces cannot readily close or evacuate during extreme weather. Many facilities already fail to handle hazards like wildfire smoke and extreme heat, two hazards expected to worsen with climate change. Using historic and projected climate and wildfire smoke projections, I conducted a risk assessment of extreme heat and wildfire smoke health risks for California prison workers in the mid-century and late-century. Diseases of interest were cardiovascular disease and lung cancer (wildfire smoke) and heat-stress illness (extreme heat). To estimate indoor temperatures, I combined state prison facility information on cooling equipment, observed maximum indoor temperatures, and ERA-5 Land maximum outdoor temperatures to model cooling-specific relationships between daily outdoor and indoor temperature. I predicted indoor temperature by applying these relationships to LOCA-2 data for all California carceral facilities (n=396) based on their probable cooling equipment. I obtained odds ratios comparing odds of heat-stress illness associated with the 95th percentile predicted indoor temperature to the odds of heat-stress illness at 31°C using an existing dose-response model. To estimate indoor wildfire smoke, I used cooling-specific infiltration rates from previously published estimates to obtain indoor concentrations from data provided by Qiu et al. 2025. I calculated inhaled dose of wildfire smoke using varying combinations of worker sex, age, and activity level. Using these inhaled doses and an existing dose-response model, I obtained

relative risks of lung cancer and cardiovascular disease associated with occupational wildfire smoke exposure in this population.

[P11] Heavy Metal Deposition and Post-Remediation Persistence from the 2025 Eaton Fire | *Amelie Sharples, California Institute of Technology*

The January 2025 Eaton Fire burned through 14,000 acres and thousands of residential and industrial structures across Altadena and the San Gabriel Mountains, generating a dust plume across the greater Los Angeles area. Burning urban infrastructure mobilizes heavy metals as fine particulates, raising serious concerns about toxic contamination dispersed at regional scales. One month after the fire, we collected dust wipe samples from 52 affected homes to quantify heavy metal surface concentrations and assess public health risks associated with returning and remediating post-fire. Samples were analyzed by Q-ICPMS for over 60 elements at each location. Lead concentrations frequently exceeded EPA action thresholds, particularly on east-facing windowsills, consistent with the prevailing wind direction during the fire. A preliminary Principal Component Analysis reveals distinct elemental signatures co-deposited across sampling locations, including one consistent with anthropogenic building materials (Pb, Cu, Cr, Ni, Zn) and one with natural crustal and soil sources (Fe, Al, Mg, Ti, Ca), suggesting the fire mobilized both urban infrastructure debris and disturbed soil simultaneously. At the conference, we will present a more in depth analysis and extend it to post-remediation samples recently collected ~1 year after the fire, assessing longer-term contamination persistence across varying remediation statuses. This analysis emphasizes the importance of post-fire sampling to understand the rising issue of urban wildfires.

[P12] Modeling Long-Term Trends in Urban Expansion to Evaluate Land Cover Effects on the Surface Urban Heat Island | *Bright Andoh, University of Oklahoma*

Globally, more than half of the world's population reside in urban areas, a proportion projected to increase to 68% by 2050. This unprecedented urbanization is driven by the concentration of economic opportunities, infrastructure, and social amenities within cities. Ahmedabad, one of India's fastest-growing cities, has

experienced rapid population growth and extensive urban expansion over the past two decades, resulting in significant alterations to its land cover and the city's thermal profile. While previous studies have examined trends in land surface temperature (LST) and urban growth in the region independently, this study integrated long-term urban land cover trends with LST to explore the evolution of Ahmedabad's thermal footprint and disentangle the influences of climate and land cover on these changes. This study used multi-temporal satellite observations to predict the long-term evolution of urban land cover using random forest and temporal segmentation algorithms to process the time series data. We then analyzed the relationships between urban expansion trends on land surface temperature dynamics. We used the Landsat Collection 2 Level 2 Surface Reflectance and Surface Temperature Science Products, including Landsat 5 TM, Landsat 7 ETM+ and Landsat 8/9 OLI/TIRS imagery from 2000 through 2025. Urban expansion was quantified using spatial indices to characterize its magnitude, direction and spatial configuration. The thermal impacts of urban expansion were evaluated using correlation and regression analysis to examine the spatial and temporal relationship between urban expansion and LST in the context of climate trends. To further identify neighborhoods experiencing elevated thermal stress and the ecological quality of the urban thermal environment, estimates of the surface urban heat island (SUHI) and urban thermal field variance index (UTFVI) were estimated. The results provided critical insights into how urban expansion has reshaped Ahmedabad's thermal landscape to support evidence-based urban planning and climate adaptation strategies. These include the relative effects of impervious surfaces and vegetation in heterogeneous landscapes and evidence that urban expansion has exacerbated the influences of climate change on the potential for extreme heat in Ahmedabad.

[P13] Climate Change Influence on the Flash Flood Hazard and Vulnerability Assessment in Tahirpur Upazila, Sunamganj District, Bangladesh | *Rajib Kumar Saha, Washington State University*

Bangladesh has been experiencing changes in precipitation patterns, resulting in more frequent and intense rainfall events. The north-eastern Haor basin is particularly vulnerable to flash floods due to heavy rainfall and water flowing from

the Meghalayan hills in India. Major flash floods occurred in 2007, 2014, 2016, 2017, and 2019. Despite these shifts, no effective solutions have been implemented to reduce future risks. Tahirpur Upazila, situated in Sunamganj District, is characterized by a densely populated, compact, and unplanned area, yet it holds significant potential as a growth center. The study aimed to assess flood susceptibility using a geographic information system (GIS), local geological data, historical rainfall data, and flood records. A flood hazard map was created, and a spatial database was compiled with information on topography (slope, elevation, and watershed), drainage, water extent, soil permeability, geology, land type, and flood inundation. The analysis identified flooded zones and categorized flood hazards as high, medium, or low. The results indicated that 47% of Tahirpur's northern area is susceptible to severe flash floods. Generally, no flooding occurs in the northeastern highland areas. However, flooding depths ranging from 1.83m to over 3.05m are observed in the middle and south-western part of Tahirpur. During each monsoon, low-lying areas are the first to be inundated, and increased rainfall leads to deeper inundation. These findings can benefit policymakers, development agencies, and urban planners by developing appropriate preparedness guidelines to prevent property damage and protect assets in Tahirpur Upazila.

[P14] Hidden Water Costs of Digital Infrastructure: Energy Efficiency, Cooling Demand, and Hydrologic Impacts of Data Centers in a Potomac River Tributary Watershed | *Tejendra Kandel, University of Virginia*

The rapid expansion of data centers, driven by cloud computing and artificial intelligence, has placed unprecedented demands on energy and water resources. While public and scientific attention has concentrated on electricity consumption, the freshwater required for cooling and the watersheds that supply it remain critically underexamined in research and policy. This gap is starkest in the Broadrun watershed of Northern Virginia, which hosts the world's densest concentration of data centers and drains into the Potomac River, a drinking water source for millions. This study presents the first quantitative assessment of how data center clustering affects local water availability within the Broadrun watershed. We evaluated facility-level power usage effectiveness (PUE), cooling water demand, and the hydrologic performance of on-site best management practices (BMPs) under

varying seasonal conditions. Results reveal a pronounced generational divide in infrastructure efficiency: newly constructed facilities achieve PUE values of 1.1-1.4, whereas legacy facilities approach 2.0, reflecting substantial energy and water inefficiencies. Seasonal analysis exposes an acute vulnerability: cooling withdrawals during dry periods compete directly with the county drinking water supply and environmental flows. Although BMPs partially moderate the flow regime by augmenting low flows and attenuating high flows, they cannot offset consumptive cooling demand under drought. These findings indicate that unchecked data center growth threatens community water security and watershed ecosystem integrity; efficiency gains in new construction alone cannot safeguard water availability. Urgent, watershed-specific planning and regulation are essential to prevent continued expansion from depleting critical water resources.

[P15] Investigating Seasonal Drying in Hangman Creek and the Historical Relationship of the Coeur d'Alene People to the Watershed | *Hermosa Otero, Washington State University*

This study aims to investigate the seasonal drying patterns of Hangman Creek and examine the environmental and cultural significance within the historical relationship of the Coeur d'Alene people to the watershed. By exploring hydrological changes alongside Indigenous perspectives and historical land use, the project aims to better understand how shifts in water availability have affected the creek ecosystem and the communities connected to it. The research integrates environmental observations, historical records, and cultural context to highlight the long-standing relationship between the Coeur d'Alene people and Hangman Creek, while also considering the broader impacts of seasonal drying on watershed health and regional sustainability. A long-term goal of this project is to support restoration efforts that increase the Coeur d'Alene Tribe's access to First Foods, particularly salmonids that are culturally, nutritionally, and spiritually significant to the community.

[P16] A cloud journey from the Amazon to the Andean sky islands: Empowering Aquatic Sciences and Climate Education in Colombia | *Alejandra Rodriguez-Abaunza, Indiana University Indianapolis*

Colombia, in northern South America, harbors highly diverse ecosystems connected by the regional water cycle, from the Amazon rainforest to the Andean páramos and tropical glaciers. This hydroclimatic connectivity is increasingly threatened by climate change, deforestation, and land-use transformation, with direct implications for water security and ecosystem resilience. We developed and implemented a virtual education program that translated our palaeoclimatological research on Colombian lake sediments into an accessible learning experience for 20 school educators from rural areas around the Lago de Tota, the study area of my research. I used sediment records from Lago de Tota, the largest high-altitude lake in Colombia, to reconstruct long-term hydroclimate variability in the Northern Andes during the late Quaternary. Lake sediments act as natural archives, recording evidence of past climate and environmental change in Andean watersheds. Paleoclimatic records place current and future hydroclimate variability in a longer-term context. However, this knowledge is most meaningful when shared with communities living in these watersheds, who are directly experiencing changes in climate and water availability. Six interactive virtual workshops in Spanish, combining interactive lectures, hands-on activities, and classroom Science Kits have allowed educators to explore key concepts of the water cycle, climate change, and tropical ecosystems connectivity using the 'Explore, Understand, and Act' framework. This educational program connected local ecosystems with global climate processes to understand climate variability and its impacts in Colombia, emphasizing the Andes–Amazon–Atlantic hydrological connectivity. Integrating research into climate education can empower communities and promote sustainable water management practices.

[P17] Observational Characterization of Offshore Internal Boundary Layer Growth Following Land-to-Ocean Flow Transitions Using Scanning Doppler LiDAR | *Mojtaba Shams Soulari, The University of Texas at Dallas*

Coastal land–ocean transitions create sharp changes in surface roughness and heat fluxes that alter atmospheric boundary-layer structure, turbulence, and air–sea exchange. These adjustments lead to the formation of an internal boundary layer (IBL), a near-surface layer that plays an important role in coastal weather, climate processes, and marine atmospheric dynamics. Despite its significance,

observational studies of offshore IBL evolution remain limited because long-term, high-resolution measurements over coastal oceans are scarce. This study investigates offshore IBL development using nearly one year of observations collected during the Third Wind Forecast Improvement Project (WFIP3) near Nantucket Island, Massachusetts. Measurements from scanning Doppler LiDARs and meteorological instruments were used to characterize wind speed and turbulence evolution following rough-to-smooth surface transitions from land to ocean. A dedicated quality-control framework was developed for continuous-scan LiDAR observations, enabling retrieval of high-resolution spatial fields of mean wind speed and turbulence intensity across multiple offshore fetch distances. Results reveal systematic acceleration of wind speed and substantial changes in turbulence structure as the marine boundary layer adjusts to the smoother ocean surface. Analysis identifies a turbulence-intensity maximum associated with the growing IBL and demonstrates a progressive increase in IBL height with offshore fetch distance. These observations provide new insight into the mechanisms governing boundary-layer adjustment in coastal environments and highlight the value of scanning Doppler LiDAR measurements for studying atmosphere–ocean interactions. The findings contribute to a better understanding of coastal boundary-layer processes that influence weather prediction, climate modeling, and environmental conditions in rapidly developing offshore regions.

Lightning Talks

All lightning talks also have a corresponding private poster. Abstracts are repeated in this session and the assigned private poster session.

Lightning 1 - Atmospheric Dynamics and Paleoclimate

Satellite Sea Ice Concentration Observation Uncertainty Is State-Dependent and Varies Seasonally | *Joey Rotondo, University of Washington*

Earth system data assimilation systems commonly assimilate satellite retrievals of sea ice concentration (SIC). How much weight each retrieval receives relative to the model is set by its observation uncertainty, which is poorly constrained and is almost always prescribed as a constant, typically 0.10 to 0.15. We instead measure this uncertainty from the assimilation system itself. An iterated Desroziers diagnostic, computed in a bounded framework that keeps SIC between 0 and 1, gives the observation uncertainty for two passive microwave products and one optical product in both hemispheres. That uncertainty is far from constant: for passive microwaves it is near zero to 0.1 for a retrieval of open water (0) or complete cover (1) and 0.12 to 0.15 for a retrieval of one half. A limitation of Desrozier's diagnostic emerges under complete cover in the melt season; the model rarely simulates this condition and thus the method cannot constrain the bounded uncertainty properly. A similar uncertainty curve emerges from three collocated satellite products, with no model involved, and from the uncertainty one product publishes with its retrievals, which is biased high. Most of the uncertainty is not instrument noise; its pattern is consistent with known passive microwave retrieval errors over thin and ponded ice. A constant error prescription therefore often gives mid-range retrievals too much weight and often retrievals near 0 and 1 too little.

Arctic Goldilocks Clouds: An Important Driver of Arctic Sea Ice Melt | *Bradley Lamkin, University of Oklahoma*

There are large uncertainties in the life cycle of Arctic, low-level, optically thin clouds (hereafter referred to as goldilocks clouds) because these clouds are difficult to detect by remote sensors over sea ice and due to the scarcity of upper-air and

surface observations. These clouds affect sea ice melt by trapping outgoing radiation, preventing radiational cooling, and accelerating melting. Given their potentially significant impact on sea ice melt and climate change, a thorough understanding of the thermodynamics and dynamics of goldilocks clouds is needed. This work studies the thermodynamics and dynamics of the goldilocks clouds over sea ice using observations collected in the Arctic Radiation-Cloud-Aerosol-Surface Interaction Experiment (ARCSIX) field campaign. The campaign consisted of two deployment periods: Spring 2024 (pre- sea ice melt onset) and Summer 2024 (peak sea ice melt). We identify flights that encountered goldilocks clouds using the G-III (high-altitude aircraft) aircraft outfitted with the High-Altitude Lidar Observatory (HALO), a combined high spectral resolution and differential absorption lidar, and the Advanced Vertical Atmospheric Profiling System (AVAPS, dropsondes). Low-level inversions are a key ingredient in goldilocks cloud formation, which reanalysis products have historically struggled to resolve. We compare vertical profiles from G-III dropsondes with ERA-5 reanalysis to assess how accurately ERA-5 represents the associated thermodynamics and dynamics. We find that, in goldilocks cases, ERA-5 underestimates the boundary layer inversion strength and overestimates the surface wind speed. Taken together, satellite observations, ARCSIX in-situ measurements, and reanalysis data enable a deeper understanding of Arctic goldilocks clouds and climate change.

How the Land Reflects: Physics-Informed Machine Learning for Global Land Surface Albedo Parameterization | *Akarsh Ralhan, University of Maryland, College Park*

The amount of sunlight reflected by Earth's land surface, its albedo, is a fundamental control on global climate. By determining how much solar energy is absorbed versus reflected, albedo governs surface temperature, soil moisture, and the exchange of heat and water vapor between the land and atmosphere. Errors in albedo as small as 0.02–0.05 can produce substantial biases in surface energy budgets, cascading into errors in temperature, precipitation, and atmospheric circulation in climate model simulations. Despite this importance, most models rely on static lookup tables or simple empirical formulas to represent albedo, yet they fail to capture how albedo varies across seasons, landscapes, or changing sunlight conditions. This study develops a new global albedo parameterization that

addresses these limitations by leveraging two decades of satellite observations and a physical understanding of land-surface processes. An ensemble of machine learning models, trained separately for 15 land cover types, predicts how albedo responds to vegetation state, soil moisture, solar angle, topography, and climate across the globe. A spatially explicit statistical correction accounts for fine-scale surface variability that no global model can directly resolve. Together, these components achieve strong agreement with satellite-observed albedo ($R^2 = 0.88$, mean error 7.5%) across diverse ecosystems, including forests, grasslands, croplands, and challenging desert regions where existing methods fail. The result is a physically grounded, scalable tool ready for integration into Earth system models, improving how climate models represent the land surface and, in turn, how reliably they simulate climate across regional to global scales.

Forecasting Severe Thunderstorms up to a Week in Advance with Machine Learning | *Miles Epstein, University of Washington*

In the United States, a thunderstorm is considered severe if it produces straight-line winds of at least 58 mph, hail of at least one inch diameter, or a tornado. Accurate forecasting of these storms is essential to protect people and property. Severe thunderstorms and their associated hazards often occur on too small a scale to be directly resolved in numerical weather prediction (NWP) models; however, we can statistically post-process NWP model output to produce probabilistic forecasts of severe thunderstorm hazards. We develop a decoder-only transformer (DOT) model that predicts daily probabilities of severe hazards in the medium-range (up to eight days) from NWP and AI-based NWP emulator model output by treating each lead time as a token. Previous work has shown such a model to be skillful; in this work, we expand model capability and improve model skill by increasing temporal resolution and incorporating user-desired target variables such as lightning, heavy rainfall, and hazard intensity.

Exploring future spatial patterns and trends of sea surface salinity using multi-model large ensemble simulations | *Dora Shlosberg, University of Colorado Boulder*

Sea surface salinity (SSS) is a widely-used indicator of the hydrologic cycle, as the surface ocean is at the interface of atmospheric and oceanic freshwater fluxes. Since the mid-20th century, the hydrologic cycle has broadly intensified, characterized as “wet get wetter, dry get drier”, resulting from increased greenhouse gas (GHG) concentrations and global warming. Meanwhile, impacts of human-emitted aerosols on the hydrologic cycle vary based on spatial distribution and concentration, opposing the GHG pattern in some places while reinforcing it in others. Understanding future changes in the hydrologic cycle and how they relate to the past can provide crucial information to coastal and island nations adapting to water resource changes. While SSS provides insights into the hydrologic cycle, its observational record is relatively short. Here we use 6 single-model initial-condition large ensemble experiments to investigate changes in SSS, evaporation (E) and precipitation (P) from 1950-2024 and 2025-2100. To glean aerosol and GHG contributions separately, we examine two different future emission scenarios within MPI and UKESM and look at single-forcing experiments from the CESM models. We quantify how representative historical SSS changes are of future trends using pattern correlations between the two periods. Across the 6 models, mean pattern correlations over the ensemble members range from 0.200-0.499. Regional analysis suggests that the North Atlantic has relatively high pattern correlations, while the Indo-Pacific exhibits more variability. The relationship between E-P and SSS is weakest in the South Atlantic, suggesting SSS changes there are dominated by ocean circulation over atmospheric fluxes.

Triple Oxygen Isotope Record From Ferricrete Deposits Shows Holocene Moisture Source Shift in the Rocky Mountains | *Emily Nigro, Stanford University*

Holocene hydroclimate changes in the western US are poorly constrained, in part because the region's complex topography and seasonally distinct circulation patterns can generate heterogeneous responses over small spatial scales. To better understand regional precipitation patterns over the Holocene, we measured the triple oxygen isotopes of goethite from high-elevation ferricrete deposits across a latitudinal gradient in the Rocky Mountains. Ferricretes form in stream water that reflects the isotopic composition of local precipitation, providing a record of past hydroclimate changes. We also used a 1-dimensional vapor transport model to

simulate precipitation δ18O and Δ′17O along a hypothetical storm track, given varying moisture recycling amounts and evaporation versus transpiration contributions. We find that both northern (central Montana) and southern (southwest Colorado) sites exhibit similar increases in goethite δ18O over time, accompanied by declines in goethite Δ′17O. To interpret these trends, we considered three potential drivers: temperature, moisture recycling and evapotranspiration partitioning, and moisture source. Δ′17O is largely insensitive to temperature, and our model shows that changes in moisture recycling and evapotranspiration partitioning along the storm track cannot account for the observed Δ′17O decreases. Instead, we conclude that the isotopic trends primarily reflect an increased contribution of southerly-sourced precipitation, since moisture from the Gulf of Mexico—the dominant source of interior western US summer precipitation—is characterized by high δ18O and low Δ′17O relative to Pacific moisture. More generally, this work demonstrates how triple oxygen isotopes can be used to disentangle changes in temperature, atmospheric moisture dynamics, and moisture source in semiarid to arid regions.

Using high-resolution δ15N and δ18O measurements of nitrate in the GISP2 core to investigate seasonal variations in atmospheric oxidative chemistry since the preindustrial | *Maggie Scholer, University of Colorado Boulder*

Nitrate (HNO3) is a key component of the global nitrogen cycle, playing an essential role in many biological, chemical, and geological processes that regulate atmospheric composition and climate. In the atmosphere, nitrate is the final oxidation product of nitrogen oxides (NOx = NO + NO2), a critical air pollutant that drives tropospheric chemistry through its reactions with ozone (O3) and the hydroxyl radical (OH). Since these oxidants dictate greenhouse gas lifetimes, understanding their historical variations is vital for climate modeling. In polar snow and ice, nitrate is well-preserved and abundant, providing critical insights into past atmospheric chemistry. Nitrate stable isotopes (δ15N and δ18O) are powerful tools for investigating the chemical processing and source variability of atmospheric NOx. δ15N largely reflects different sources of NOx, whereas δ18O reveals the oxidative pathways NOx undergoes to form HNO3. Here, we present preliminary measurements of nitrate concentration and isotopes in the GISP2-E ice core. Our

study utilizes high-resolution (weekly–biweekly) sampling to investigate the evolution of atmospheric oxidative chemistry from 1750 to 1990. Our measurements show a clear decrease in δ15N-NO3- values from the 1760s to the 1970s, associated with increasing industrial NOx emissions. Critically, our high-resolution measurements allow us to capture seasonal signals in δ15N-NO3- and δ18O-NO3- for the first time. By analyzing these variations, we can distinguish between OH and O3 reaction pathways, providing the first high-resolution look at how the seasonality of oxidative chemistry has evolved from the preindustrial to the 1990s, offering crucial constraints for historical climate simulations.

A multi-proxy investigation on the Gulf of California Oxygenation during the Last Interglacial | *Kaetlyn Rodriguez, Tulane University*

Observed ocean oxygen is declining in both shallow-intermediate waters and the deep ocean, but models fall short in capturing trends and projections. The presence of low-oxygen waters are critical in defining the habitable range of many marine organisms and provide meaningful feedbacks to global climate, thus, we must look at the Last interglacial (MIS5e) which was 1-2°C warmer than pre-industrial sea surface temperature in the Pacific and had a global sea level of 6-9 m higher than present conditions, making MIS5e particularly useful as an analogue for ocean oxygen responses to climate change. The multi-proxy approach sensitive to in situ oxygenation will allow us to contribute to a complete picture of marine oxygen sensitivity to climate perturbations while addressing the limitations of individual proxies. Here we present an age model constrained by benthic oxygen isotopes as well as bulk sediment sensitive-trace metals from the IODP Site U1545 in the Gulf of California (GoC) to reconstruct local bottom water oxygenation. Bulk elemental analyses show an increase in uranium (U), molybdenum (Mo), and a decrease in manganese (Mn) enrichment factors (EF) at depths consistent with the Last Interglacial. Minimal Mn EF, elevated U EF, and very high Mo EF indicate much lower oxygenation during the MIS 5e, whereas an increase in Mn EF coincident with lower Mo EF and U EF suggest a more oxygenated ocean in the glaciation period after MIS5e.

Alkenones, Calcite, and Community Composition: Untangling Coccolithophores'

Roles in the Global Carbon Cycle | *Brianna Hoegler, Brown University*

Coccolithophores, calcifying marine algae, play dual roles in the marine carbon cycle: simultaneously exporting particulate organic carbon (POC) and producing particulate inorganic carbon (PIC), which releases CO2. This contrasts with non-calcifying phytoplankton, making coccolithophores a unique lever in regulating air-sea CO2 exchange. As climate change alters marine ecosystems, shifting phytoplankton community dynamics may impact PIC:POC production and burial, ultimately impacting the ocean's efficacy as a carbon sink. Alkenones, lipid biomarkers produced by certain coccolithophore species, are widely used as export productivity proxies, yet their relationship to carbon export and community structure remains uncertain. Here, we combine this geochemical proxy with satellite observations and nannofossil assemblage data from globally distributed core-top sediments to evaluate how coccolithophore community structure mediates carbon export pathways. Our results indicate that alkenone concentrations are more closely associated with total coccolith mass than with the mass of alkenone-producing species, supporting the use of C37 alkenones as a total export productivity proxy. Surface POC and PIC do not show a uniform relationship with alkenones. Instead, alkenones track chlorophyll-a and estimated POC production, while PIC varies independently, indicating a decoupling of organic and inorganic carbon productivity. These findings suggest that coccolithophores cannot be treated as a single functional group in carbon cycle models. Rather, shifts in coccolithophore community composition may alter the balance between carbon sequestration and CO2 release, even under similar productivity regimes. This distinction has important implications for interpreting past ocean carbon cycling and for predicting how biological carbon pumps will respond to future climate change.

Lightning 2 - Environmental Risk, Resilience, and Clean Energy

Climate Risk and Renewable Energy Markets: Evidence from Wholesale Electricity Price Volatility | *Junxiang Du, Liverpool John Moores University*

The decarbonization of electricity systems increasingly depends on renewable energy, but this transition also makes power markets more exposed to weather-driven climate risk. Wind speed, solar irradiance, and temperature directly affect renewable electricity supply and demand, yet the mechanisms through which short-run weather variability contributes to market instability remain insufficiently understood. This paper examines how physical climate risk is transmitted into wholesale electricity price volatility through renewable generation and electricity demand channels. Using 30-minute settlement-period data from the Great Britain electricity market between 2015 and 2025, the study develops a two-stage empirical framework to distinguish predictable weather-related variation from unexpected system disturbances. First, a recursive structural equation model estimates the links from wind speed to wind generation, solar irradiance to solar generation, and temperature-driven heating and cooling degree days to electricity demand. Renewable generation and demand are then connected to wholesale electricity prices, allowing residual supply, demand, and price innovations to be identified. Second, these innovations are modelled within a multivariate volatility framework to test whether unexpected deviations in wind generation, solar generation, and electricity demand amplify wholesale electricity price volatility. The analysis also examines whether these shocks become more dynamically connected with price innovations during periods of system stress. By tracing the pathway from weather variability to renewable supply-demand imbalances and electricity price volatility, this paper contributes to understanding the climate resilience of renewable power systems. The findings have implications for electricity market design, balancing mechanisms, and adaptation planning as electricity systems become increasingly dependent on weather-sensitive renewable energy.

Do Corporate Climate-Risk Disclosures Reflect Physical Flood Exposure? Evidence from Companies in the U.S. | *Ruixuan Ding, The Ohio State University*

Climate-related flood risks show increasing challenges to corporate infrastructure, supply chains, and long-term economic resilience. At the same time, companies are under growing pressure to disclose physical climate risks through voluntary reporting frameworks such as the Carbon Disclosure Project (CDP). However, it remains unclear whether corporate climate-risk disclosures align with the actual spatial distribution of physical flood exposure. In this study, we investigate the relationship between corporate climate risk attention and flood exposure across the United States, using CDP disclosures from 2013 to 2024. We apply Latent Dirichlet Allocation (LDA) topic modeling to quantify the proportion of disclosure text related to physical climate risks and combine these results with facility-level flood exposure assessments derived from reported corporate site locations and flood hazard layers. We then evaluate temporal and spatial patterns of alignment and mismatch between disclosure attention and physical flood exposure. Our preliminary results indicate that reported corporate flood exposure increased substantially over time, largely driven by expanding participation in CDP reporting and increased disclosure of facility locations. In contrast, climate-risk attention exhibited strong temporal variability, with elevated disclosure attention during 2017–2020 followed by declining attention after 2020. Spatial evaluations indicate persistent regions where companies have relatively high flood exposure but low attention to climate risk, particularly in coastal and metropolitan areas. These findings indicate that the company's attention to physical climate risks is only partially aligned with actual flood exposure patterns. The study highlights potential blind spots in corporate climate-risk awareness and adaptation planning.

Quantifying Heatwaves: Exploring the Drivers of Heatwaves Across the Continental USA | *Calen Randall, University of California Davis*

The intensity, duration, and frequency of heatwaves globally continue to increase, necessitating a strong understanding of current and future heatwave impacts and dynamics. Despite our qualitative understanding of how heatwaves form, persist, and terminate, our quantitative understanding of the relative importance of heatwave drivers remains low, particularly in the continental USA (CONUS). This presentation focuses on bridging these heatwave driver quantification gaps and addresses the questions: (1) What is the relative importance of individual heatwave

drivers regionally? (2) Do regional heatwave driver characteristics align with regions of similar heatwave characteristics? (3) Can climate dataset biases in heatwave metrics be explained through biases in their heatwave drivers? Three components directly impact the temperature of heatwaves, temperature advection (warming via the wind blowing warmer air into a region), adiabatic components (warming via the compression of air as it descends to the surface), and diabatic components (Warming via incoming solar radiation, longwave radiation, and contributions from surface heat fluxes like latent and sensible heating). These components are influenced by high pressure synoptic systems referred to as “blocking highs” or “heat domes” and surface characteristics like dry soil moisture. To explore these questions, the three main components are quantified using ERA5 data and the temperature budget equation to identify large temperature anomaly contributions during the creation, termination, and persistence of heatwaves. Large differences in relative driver importance are found between the western, southeastern, and midwest CONUS and generally correspond to regions sharing unique heatwave characteristics.

From Loading Docks to Lungs: An Emissions Inventory for Illinois Warehouses and Evaluation of the Warehouse Pollution Reduction Act | *Anna Oehlerking, Northwestern University*

Nearly one in five Americans live in close proximity to a warehouse. In Cook County, home to Chicago, Illinois, this metric jumps to 42%. These facilities, often located near racially-diverse and low-income communities, aggregate an array of emissions sources: medium- and heavy-duty trucks, transport refrigeration units, on-site vehicles, building-level fuel use, and more. As climate change intensifies cumulative environmental burdens on vulnerable communities, the disproportionate air quality impacts of freight infrastructure represent an urgent and understudied dimension of environmental justice. The proposed Warehouse Pollution Reduction Act (WPRA) addresses these climate-adjacent burdens through a flexible, points-based emissions reduction framework for facility operators. Here, we develop a baseline emissions inventory for Illinois warehouses to analyze the emissions implications of these facilities and assess the possible utility of the WPRA. We construct a database of 1,000 Illinois warehouses by integrating industry

reports, telematic truck data, and federal agency records. These analyses provide the first emissions inventory for warehouse-attributable emissions outside of southern California, estimating health-harming primary emissions at community-relevant scales. Preliminary estimates indicate that on-site idling contributes the majority of warehouse-related volatile organics, whereas the majority of particulate emissions are related to on-road activity, suggesting that warehouses contribute differentially harmful emissions in neighboring communities and near truck corridors. This work establishes the foundation for evaluating the air quality and health implications of Illinois warehousing operations and the WPRA. By quantifying warehouse emissions, this inventory promoted the development of community-oriented policies that can reduce the cumulative impacts of environmental risks in freight-adjacent communities.

Got Green Air? An evaluation of 14 low-cost sensors for indoor air quality monitoring | *Hannah McKinley, University of Washington*

As climate change intensifies the frequency and severity of wildfires, communities face growing risks from wildfire smoke, particularly through its impact on indoor air quality (IAQ). Few studies have evaluated the effectiveness of low-cost IAQ sensors for household-level monitoring and decision-making. Public Health–Seattle and King County in collaboration with the University of Washington CEER Lab have conducted a project evaluating 14 low-cost air quality sensors commonly cited in scientific literature and consumer reports. This evaluation used laboratory-based performance testing to identify the precision and accuracy of a variety of low-cost sensors and assessed facilitators and barriers to the overall accessibility of these sensors for the general public. These findings will help inform the development of guidance on household-level IAQ monitoring and support strategies to reduce the health impacts of air pollution in wildfire-prone regions.

Post-Wildfire Hydrological Recovery in a Changing Climate: Implications for Downstream Water Security in the Northern Rockies and Pacific Northwest | *Jack Boyle, University of Virginia*

Wildfire is devastating. Communities which suffer through the flames are nowhere

close to recovering after the smoke dissipates; the fire leaves scars that harm the landscape for decades to come. Across the Northern Rockies and Pacific Northwest, snowpack has collapsed to levels unseen in 40 years. The wildfires coming this summer will not just burn landscapes; they will compromise the freshwater that communities depend on. Forested watersheds are the primary source of clean drinking water for millions of Americans, yet wildfire fundamentally disrupts the hydrological processes that make this possible. Using remote sensing estimates of evapotranspiration (ET) and post-fire forest loss, our research demonstrates that watershed recovery following wildfire is governed primarily by the rate at which ET recovers—a process that takes decades in many catchments, and in some cases never fully occurs. Rising vapor pressure deficit under projected climate scenarios further suppresses vegetation recovery, prolonging hydrological vulnerability and extending periods of elevated streamflow, flood risk, and pollutant transport to downstream waters. Yet the consequences for communities within the wildland-urban interface remain poorly quantified. To address this gap, we employ the ecohydrological model EcH_2O to simulate post-fire restoration scenarios, evaluating the capacity of targeted revegetation to accelerate ET recovery, attenuate extreme streamflow, and promote watershed retention of nitrogen and phosphorus, reducing eutrophication risk before nutrients reach the riparian zone. As wildfire seasons grow longer and more severe, this research offers actionable guidance for the land and water managers on the front lines of protecting freshwater security after fire.

Soil Lead Distributions Following Urban Wildfires: Insights from a Community-Driven Study in Los Angeles | *Cat Odendahl, University of Southern California*

Los Angeles experienced destructive wildfires in January 2025, with the Palisades and Eaton fires burning over 57,000 acres and destroying more than 15,000 structures. In the aftermath, communities raised concerns about potential contamination from fire-derived ash, particularly lead (Pb). In response, we established a community-based soil testing initiative, the Contaminant Level Evaluation and Analysis for Neighborhoods (CLEAN) project, to assess total Pb in residential soils. Residents submitted soil samples through a network of local

drop-off locations, including libraries and community centers. Samples were analyzed using X-ray fluorescence (XRF) spectrometry, generating elemental data from magnesium to uranium. Results are shared directly with participants and used to produce anonymized, neighborhood-scale maps identifying areas of elevated contamination risk. Statistical analyses reveal significant differences in Pb concentrations between burn zones, with samples from the Eaton Fire region exhibiting a broader and higher overall distribution of Pb compared to the Palisades region. In contrast, no significant differences were observed within burn zones as a function of distance (0–1 km, 1–5 km, 5–10 km) from burn boundaries. Ongoing work aims to explain observed variability through factors such as housing age, urban infrastructure, and traffic patterns. The most recent investigation of variability shows that overall the more older homes surrounding a sample, the higher the Pb concentration. Within the Palisades region, high Pb is also associated with increased pollution. This project demonstrates the utility of community-engaged, rapid-response environmental monitoring for assessing post-wildfire contamination and informing public health awareness.

Household Perceptions and Preparedness for Wildfire Smoke: Findings from a Community Assessment for Public Health Emergency Response in Spokane, Washington | *Katelin Teigen, University of Washington*

Wildfire season has grown in length and severity in the Northwest United States, where increased wildfire smoke (WFS) has worsened air quality and associated public health impacts. The University of Washington and Gonzaga University conducted a Community Assessment for Public Health Emergency Response (CASPER) in Spokane, Washington to assess household perceptions of WFS and other environmental hazards and their health impacts; household strategies to reduce exposure; and preparedness needs. As a rapid needs assessment, CASPER uses a cluster sampling methodology to identify households to survey and, with sampling weights, yields generalizable findings for the entire community. A survey was developed to capture household-level demographics, environmental hazard concerns, household and community WFS impacts, exposure reduction strategies, and air quality information preferences. The Spokane CASPER was conducted in-person in October 2025. Of the 210 target households, 94 completed the survey,

representing a 45% completion rate. When asked about environmental hazards, 92% of households reported recently experiencing WFS in Spokane, with 62% expressing high concern. During WFS events, 90% of households closed windows and doors, 89% reduced outdoor activities, and 76% sought air quality information. The most preferred measures for improving community WFS resilience were cell phone alerts on smoky days (supported by 47% of households), funding for local schools to improve indoor air quality (44%), and financial assistance for portable air cleaners (41%). These results highlight the pervasive impacts of WFS among Spokane households, providing timely information on preparedness and preferences for community climate resilience efforts.

Lightning 3 - Hydrology and Ecology in a Warming World

The value of snow to water availability | *Madeleine Burns, Dartmouth College*

Seasonal snow is an essential component of the hydrologic cycle in the Northern Hemisphere, directly supplying over 2 billion people with water. However, the unique contributions of snow to streamflow remain poorly understood, limiting our ability to quantify the consequences of present-day snow droughts and predict future water availability. Previous research characterizes mountain snowpacks as “water towers” that store water during the winter, release a concentrated pulse of snowmelt in the spring and, through these mechanisms, supply rivers and streams more efficiently than rain. Yet these studies produce mixed conclusions across scales: some demonstrate that less snow corresponds to less streamflow, while others show streamflow remains constant or even increases. These contradictory findings suggest the mechanisms that govern the unique role of snow (relative to an equivalent amount of rain) remain unknown. Here, we hypothesize that the energetic properties of snow—including its high albedo (reflectivity), role as an energy sink during melt, and synchronicity with the seasonal solar radiation cycle – govern the snow-streamflow relationship. We employ causal inference methods and historical observations to quantify the relationship between the energetic properties of snow and streamflow across 169 snow-dominated watersheds in the Northern Hemisphere. Using climate model projections from CMIP6, we apply our derived relationship to predict the impacts of future snow loss on water availability. Our work provides a comprehensive assessment of streamflow changes in a low-snow future, providing a foundation for predicting and ultimately adapting to these changes and their socioeconomic and ecological impacts.

Long-Term Impact of Drought on Stream Geochemistry in Urban, Agricultural, and Forested Watersheds, Ohio | *Emerald Goldbaum, The Ohio State University*

Due to climate change, short-term droughts have become more frequent in the midwestern United States. During drought events, nutrients can accumulate in soils instead of being washed downstream by runoff. When post-drought precipitation occurs, nutrient and ion concentrations spike in draining streams. Currently, it is unclear how the trajectory of this pulse differs depending on the watershed's

physical characteristics (i.e. land-use history, vegetation extent, soil tillage). To assess which characteristics are most influential in a stream's chemical resilience to drought, we will analyze 36 years (1975-2011) of water quality data (pH, major ions) from nine streams of different land-uses at the North Appalachian Experimental Watershed in Coshocton, Ohio. We will create a timeline of each stream's pre- and post-drought nutrient and ion concentrations over that time period, and use this information to create a random forest model that predicts how streams will chemically react to drought events. The model will be validated using summer 2026 dry season water chemistry data from an urban stream, Adena Brook, in Columbus, Ohio. We expect flow in altered urban and agricultural watersheds to experience flashier increases in solute concentrations than forested watersheds. As droughts become more frequent and severe in the Midwest, understanding the factors contributing to chemical stability in streams, and how they vary by region and land-use, can aid agricultural communities in environmental remediation efforts. These results can inform future water quality protection measures in Ohio and beyond, providing a framework to better understand chemical evolution of streams undergoing drought.

Assessing the Influence of Climate Variability on Arsenic Occurrence in Ohio Groundwater | *Mst Proma Sultana Borsha, University of Dayton*

Arsenic contamination in groundwater has been widely reported across many parts of the northern United States. Understanding the sources and mobilization of arsenic is challenging because of the region's complex geology. Climate change may further influence arsenic mobility by altering precipitation patterns, temperature, and hydrological conditions. Changes in precipitation can affect groundwater recharge, which may alter redox conditions and therefore affect arsenic mobilization in aquifer systems. Factors such as redox conditions, pH, aquifer lithology, and groundwater chemistry control arsenic concentrations in groundwater. In Ohio, approximately 42% of the population relies on groundwater as a drinking water source. Long-term exposure to arsenic-contaminated groundwater can increase the risk of cancer, cardiovascular disease, diabetes, and neurological disorders. Therefore, understanding the factors that influence arsenic occurrence is critical for protecting public health and managing water resources.

This study examines the relationship between climate variability and arsenic contamination in Ohio. Precipitation and temperature data from 1980 to 2025 are analyzed to identify climate trends and evaluate their effects on groundwater conditions. Groundwater quality data are obtained from the Ohio Environmental Protection Agency's Ambient Groundwater Monitoring Network. Geographic Information Systems are used to map the distribution of arsenic-contaminated wells in relation to groundwater recharge rates and hydrogeologic characteristics. By linking climate trends, recharge patterns, and groundwater quality, this research seeks to improve understanding of how climate variability may influence arsenic occurrence in Ohio. The findings can support groundwater monitoring, risk assessment, and adaptive water resource management under current and future climate conditions.

Climate-Driven Shifts in Soil Hydraulic Properties Across Long-Term Warming Experiments | *Kerry Mundy, Rutgers University*

Average temperatures across the US are projected to rise 3–6°C by 2100 under continued greenhouse gas emissions, altering soil moisture dynamics, with implications for drought frequency and intensified hydrologic events. Soil plays a critical role in buffering these impacts by regulating water storage and movement; however, links between warming-induced structural changes and hydraulic function remain poorly constrained. Field-based climate manipulation experiments provide an ideal framework to investigate how warming alters soil structure and water movement across ecosystems. In this study, measurements were conducted at warming experiments in MA (Harvard Forest, HF), PR (TRACE), and MN (B4WarmED at Hubachek and Cloquet). Sites differ in warming method, magnitude (+1.4°C to +5°C), and duration (8-35 years). Infiltration rates were measured under varying tensions (-15 to -1 cm), transmitting water through different pore sizes. Analyses of soil aggregation, particle-size distribution, and water repellency were conducted on control and warmed samples, linking hydraulic responses to changes in soil structure. At HF, warming reduced infiltration ~58%, aggregate stability ~5%, mean aggregate diameter ~11%, and hydrophobicity index ~11%. In contrast, B4WarmED showed increased infiltration ~93% under high warming (+3.4°C at Hubachek) and ~11% under moderate warming (+1.7°C at Cloquet). These increases were

accompanied by ~40% greater coarse sand fractions (250–2000 μm) at Hubachek and ~20% at Cloquet relative to controls. TRACE exhibited weaker, variable responses. Together, results indicate that warming effects on soil hydraulic function are mediated by changes in soil structure, highlighting the need to better represent these dynamics in climate and ecosystem models.

Diagnosing Long-Term Aridity Across Atmospheric, Land-Surface, and Biosphere Domains | *Stella Potemkin, Dartmouth College*

As the climate warms, some regions are drying, manifesting as a tendency toward greater drought risks and a reduction in water availability. And yet such long-term drying can be difficult to diagnose, in part owing to the varied aridity metrics in the atmosphere, biosphere, and land surface. At the same time, there are fundamental questions of whether aridity trends manifest as a function of drought changes, or vice versa, intimating at a fundamental gap in our theories linking short- and long-term hydroclimate variability under a changing climate. As a first step in a larger intervention along these lines, we build an observational ensemble of in situ, remotely sensed, and reanalysis data, to reconcile the diverse measures of aridity applied to each of these domains—the atmosphere, biosphere, and land surface. Using transparent empirical approaches, we show where these diverse aridity measures across domains are consilient or decoupled from long term trends indicators of water availability on the land, such as soil moisture, surface runoff, and vegetation greenness. Our findings serve as an important observational foundation to more formally attribute the mechanisms driving divergence in long-term hydroclimate trends, in particular, their linkage to anthropogenic forcing. These results also carry potential value for informing long-term, capital-intensive adaptation investments that may need to be taken by decision makers like farmers, water managers, and drought monitoring agencies navigating changes in expected average water availability.

Turf Wars: Green Urchin Feeding Ecology in a Changing Gulf of Maine | *Grace Callahan, Northeastern University*

Climate change is reshaping the distribution and abundance of habitat-forming

species around the world. In the southwestern Gulf of Maine, a hotspot of ocean warming, cold-adapted kelps have widely collapsed and been replaced by beds of filamentous red "turf" algae, mirroring changes occurring in other temperate marine systems. This dramatic shift in the macroalgal community has the potential to alter the structure and function of nearshore food webs, jeopardizing a range of ecosystem services including fisheries. However, the impacts of kelp-to-turf transitions on many key organisms remain unknown. One such organism is the green sea urchin (Strongylocentrotus droebachiensis), an ecologically important herbivore and the basis of a historically lucrative roe fishery in the Gulf of Maine. Urchin growth, metabolism, and roe quality are known to be influenced by the composition of macroalgae in their diet. Switching from a kelp- to turf-dominated habitat represents a significant change in the nutritional landscape for urchins, but whether a turf-dominated diet is less preferred or of lower quality remains unclear. Furthermore, preferential grazing on kelp or turf may accelerate or stymie the transition to turf dominance where urchins are abundant. This study (underway in summer 2026) will experimentally test green urchin feeding preference for rapidly proliferating turf species versus historically dominant kelp, and evaluate the consequences of a turf-dominated diet on urchin growth, roe quality, and grazing behavior. These data will illuminate how this ongoing habitat transition may impact benthic food webs and the viability of the Maine urchin fishery under future climate change.

A New Frontier in Drought-Induced Tree Mortality Research: How the Anatomy of a Tree Can Inform Climate Smart Forest Management | *Cameron Dow, West Virginia University*

Forests are one of the largest terrestrial carbon sinks on the planet. Unfortunately, tree mortality rates are expected to rise as climate change intensifies, increasing the frequency and intensity of drought. Models of future tree mortality rates are likely woefully under-predicting the climate change-induced increase in mortality rates across the eastern USA because mortality events in the western USA dominate the literature, and are used to parameterize such models. However, the mechanism of mortality differs greatly between eastern and western forests, resulting in incorrect predictions across the east. The fundamental mechanisms

which induce tree mortality during drought are not fully understood, but it is widely accepted that hydraulic failure resulting from embolism of water-conducting tissue greatly contributes. Past studies of tree mortality have neglected to examine the role that the anatomy of the water-conducting xylem tissue plays in determining which individual tree will die following drought. We examined a recent drought-induced mortality event in the eastern USA using a quantitative wood anatomy framework to determine if xylem vessel size could explain individual mortality risk post-drought. Building on these results, we then examined how a typical forest management prescription, forest thinning, may be used to build more climate resilient forests in the eastern USA. Our results showcase the role of xylem anatomy on individual tree mortality, offer insight into how we can manage to reduce future mortality risk in the face of climate change, and greatly add to our understanding of tree mortality in the Eastern USA.

Tracking Active Microbial Taxa in Restored and Reference Wetland Sites | *Leah Van Dyke, University of California Santa Cruz*

The Elkhorn Slough, one of California's largest coastal estuaries, has experienced flooding, vegetation loss, and altered tidal dynamics due to sea-level rise and anthropogenic activity. Two wetland sites, a healthy "Reference" and a "Restored" site, provide insight on the effectiveness of restoration as a nature-based solution to climate change, and how microbial communities impact biogeochemical cycling, especially carbon dynamics. Using quantitative Stable-Isotope Probing (qSIP), soil samples from each site were amended with control (H2^16O) or heavy isotope (H2^18O) water, incubated, and subjected to DNA extraction and density fractionation to account for DNA weight and phylogenetic identity. This method enables identification and linkage of active microbial taxa with changes in carbon sequestration efficiency of wetland soils. Samples were taken in the 2022 dry and 2024 wet seasons, with muddy soil and higher plant cover at the Reference site, and compacted sandy soil and lower plant cover at the Restored site. In 2022, the most active taxa were taxonomically distinct and significantly more ^18O enriched (active) and diverse ($H = 7.47$ vs. 7.19, $p < 0.001$) at the Reference site. Increased algal biomass at the Restored site in 2024 prompted incubations to test community response to reduced autotrophic activity. When light inputs were removed,

opposite responses were observed, with heterotrophic biomass increasing at the Restored site and decreasing at the Reference site. These results suggest that restored wetland microbial communities remain less active and differ from reference wetlands but may change rapidly as restoration progresses.

How climatological definition influences the perceived ecological impacts of marine heatwaves | *Rae Fadlovich, University of California Santa Cruz*

As climate change warms our oceans, we are experiencing an increase in the frequency and intensity of marine heatwaves (MHWs). These periods of anomalously warm ocean temperatures have been linked to negative ecological impacts, but it can be difficult to determine what characteristics of MHW make it impactful. Here, we evaluate how the use of different MHW definitions influences the characteristics of a measured ecosystem response. To do this, we evaluate the chlorophyll response to MHWs in the Chesapeake Bay, the largest estuary in the United States. We determined MHW events from daily NOAA Geo-Polar satellite sea surface temperature using both the classic definition and an adapted definition based on the residuals from a fast Fourier Transform (FFT). We used NASA MODIS satellite chlorophyll data to assess the daily mean chlorophyll concentrations before, during, and after the identified MHW events. We then used linear regression to assess the impacts of MHW definition, season, duration, and event severity on chlorophyll concentrations. We identified 108 MHW events using the classic definition and 78 events with the FFT definition. While both definitions showed a statistically significant chlorophyll reduction, concentrations continued to decline post-MHW under the classic definition but not the FFT definition. MHWs appear to suppress chlorophyll concentrations in the Chesapeake Bay, but how we define MHW events impacts how we characterize this response. These findings suggest that ecologists should consider how definition may impact or obscure ecologically meaningful response patterns and potentially influence our understanding of ecosystem vulnerability to extreme climate events.

Oral Sessions

Session 1 - Climate and Atmospheric Modeling

Session Chairs: Annabel Wade and Dominik Stiller

Deep learning provides new insights into earliest C4 grasslands in Early Miocene East Africa | *Ben Lloyd, University of Washington*

Grasses using the C4 photosynthetic pathway dominate low to mid-latitude grassland and savanna ecosystems globally, where they exert a strong influence on global climate, the carbon cycle, and the silica cycle, while fostering substantial biodiversity and underpinning the livelihoods of millions of people. However, the assembly and proliferation of C4-dominated ecosystems is a geologically recent phenomenon, with isotopic signals of C4 grassland expansion occurring asynchronously across the globe throughout the Neogene, without an obvious global climate forcing. To better resolve the initial assembly of this biome type, we developed a deep learning analysis pipeline to identify microscopic grass fossils (Grass Silica Short Cell Phytoliths, or GSSCP) from the earliest known records of C4 grasslands. These fossils occur in 21-18 Ma Early Miocene volcanically-associated fossil vertebrate sites, deposited in the East African rift within modern-day Kenya and Uganda. The fossil mammals within these sites include some of the earliest records of Hominoidea. The climates, floral compositions, and vegetation structures of these ecosystems all have profound implications for the selective pressures driving early hominoid evolution, as well as the broader evolution and diversification of early Miocene flora and fauna of East Africa. We report new identifications of 300 fossil GSSCP at unprecedented precision, which we use to refine previous estimates of floral composition and generate new coexistence-based paleoclimate reconstructions.

Multi-Model Insights on the Changing Internal Variability of the Upper Arctic Ocean | *Leo Balcer, University of Wisconsin-Madison*

Recent warming and freshening of the upper Arctic Ocean and the decline of its perennial sea ice are among the most robust signals of our changing climate.

Reconstructions and projections of these trends are complicated by internal variability: a critical and irreducible source of uncertainty that can enhance or mask the signal of forcing at all scales. While significant advances have been made in disentangling internal variability from the forced response of the Arctic, less is known about how this form of uncertainty is responding to our warming climate. Here, we diagnose trends in the recent historical (1980-2015) and future-forced (2015-2100) internal variability of regional and pan-Arctic upper ocean temperature (Θ_{sfc}) and salinity (S_{sfc}) across eleven CMIP6 ensembles and the CESM2 Large Ensemble. The internal variability of upper Arctic Ocean temperature is found to increase for all considered models, with seasonality and spatial coherence highly correlated to surface warming, the interannual decline of sea ice, and enhanced turbulent air-sea fluxes. For the same models, surface freshening and sea ice melt are not accompanied by robust trends or trend seasonality in salinity internal variability. The results from this work carry broad implications for the near-future predictability and simulated intrinsic variability of the changing upper Arctic Ocean and climate system.

Can station observations tell us how much precipitation intensity distribution is really changing? | *Jingya Han, Cornell University*

Precipitation, from light drizzle to extreme downpours, affects nearly every aspect of human life, from agriculture and water supply to flooding and infrastructure damage. As the climate warms, the entire precipitation intensity is expected to be amplified, with important consequences for how often and how severely these impacts occur. But how well do climate models actually capture these changes? To answer this, we compared long-term precipitation observations from stations dating back to 1955 with simulations from state-of-the-art climate models. A key challenge in this comparison has been the lack of appropriate methods for extracting meaningful signals from noisy station records. We developed a new smoothing approach and used two simple metrics to summarize how the distribution of precipitation intensity changes over time: one capturing an overall increase in precipitation amounts, and one capturing a shift toward more intense events. Our results show that while climate models correctly capture the direction of these changes, they consistently underestimate their magnitude by a factor of 2

to 3, both globally and at regional scales. In other words, the real world appears to be responding more strongly than models suggest. This matters because climate model projections form the basis of risk assessments and adaptation planning worldwide. If models are systematically underestimating changes in precipitation intensity, we may be underpreparing for the future, particularly for extreme precipitation events that pose the greatest risks to society.

Aerosol and Meteorological Controls on Deep Convective Cloud Lifecycles: Insights from Observations and Large-Eddy Simulations | *Dhwanit Mise, University of Oklahoma*

Deep convective clouds remain a critical source of uncertainty in climate projections, yet their lifecycle and interactions with aerosols and meteorological conditions are poorly constrained in numerical models. The Tracking Convection Interactions Experiment (TRACER; 2021–2022) near Houston investigated these interactions under diverse meteorological and aerosol conditions using the C-Band Scanning ARM Precipitation Radar (CSAPR-2) alongside co-located surface aerosol instruments. Analyzing ~400 deep convective cells during June–September 2022, this study finds that long-lived cells are substantially wider (~13.2 km) and deeper (~11.4 km) than short-lived counterparts (~6.4 km wide, ~7.3 km deep). Random Forest modeling identifies precipitable water vapor (PWV) as the dominant predictor of cell lifetime, followed by the 2–6 km temperature lapse rate (LR_26km), 0–8 km bulk wind shear (BS_08km), and surface fine aerosol mass concentration (Mass_f). Higher PWV is associated with significantly longer convective cell lifetimes compared to the low-PWV group, particularly within low LR_26km, moderate-to-high BS_08km and low-to-moderate Mass_f environments. To understand the underlying mechanisms, pre-convective soundings were clustered into nine meteorological regimes via K-means clustering, with five selected to initialize Weather and Research Forecasting (WRF) large-eddy simulations using a bin microphysics scheme. Higher-PWV environments produced deeper, longer-lived convection, whereas high-aerosol environments produced weaker, shallower, shorter-lived convection. Process-rate analysis reveals that enhanced diffusional growth in clean environments intensifies latent heating and drives deeper convection, while high-aerosol conditions promote evaporation and entrainment,

suppressing convective development. These findings offer insight into how moisture (PWV) and aerosol jointly influence storm longevity, with implications for improving storm representation in numerical models.

Session 2 - Coastal Ecosystems, Soil Dynamics, and Carbon Fluxes

Session Chairs: Sky Gale and Miles Epstein

Evaluating Marsh Vulnerability at the Virginia Coast Reserve LTER Site Through UVVR Analysis and Field-Based Ground Truthing | *Savannah Atchley, University of Virginia*

Salt marshes along the Virginia Coast Reserve (VCR) are increasingly vulnerable to accelerated sea level rise (SLR) and sediment deficits that threaten their long-term stability. This study evaluates marsh resilience using the Unvegetated-to-Vegetated Ratio (UVVR) framework, combined with elevation and sediment-based lifespan metrics, to identify areas at risk of degradation. Marshes require sufficient sediment supply to maintain vertical accretion relative to rising sea levels; however, recent SLR estimates (~5.75 mm yr^{-1}) may exceed current accretion rates in the VCR, increasing vulnerability to submergence. Using remotely sensed datasets, this study analyzes over 6,000 marsh units to quantify UVVR, elevation relative to mean sea level, and projected sediment lifespan under future SLR scenarios. Marshes with UVVR values greater than 0.15 are classified as unstable, reflecting increased open-water conversion, vegetation loss, and sediment deficits. Preliminary results indicate that much of the VCR exceeds this threshold, with many marsh areas exhibiting sediment lifespans under 200 years when accounting for projected SLR. To validate and expand upon these findings, Delft3D hydrodynamic modeling is used to simulate sediment transport, shear stress, and flow velocity across the system, while field measurements measuring wave attenuation, vegetation density, and hydrodynamics provide ground-truth data at selected high- and low-risk sites. By integrating remote sensing, numerical modeling, and field observations, this study aims to assess the accuracy of the UVVR framework in predicting marsh vulnerability and to identify the physical processes driving degradation. These results will inform management strategies to enhance marsh resilience under

future climate conditions.

Seasonal variability in primary productivity at a coastal equatorial time-series station: Roles of terrestrial carbon, nutrients and light attenuation | *Meilun Zhang, University of Washington*

Tropical shelf seas play a major role in marine productivity and carbon cycling, yet their ecosystem metabolism remains poorly constrained at high temporal resolution. This gap is especially important in Southeast Asia, where climate change and land-use alteration are increasing terrestrial runoff and coastal "browning" through enhanced delivery of colored dissolved organic matter (CDOM). Here we present the first year-long analysis of primary productivity in the central Sunda Shelf Sea, based on high-frequency dissolved oxygen measurements from an autonomous buoy in the Singapore Strait during 2023. Rates of gross primary production (GPP), net ecosystem production (NEP), and respiration (R) were estimated and related to monsoon-driven hydrography, nutrient concentrations, and optical properties. Mean GPP was 5.7 ± 7.3 mmol O_2 m^{-3} d^{-1} and showed clear seasonal variability. Lowest GPP (1.4 ± 6.9 mmol O_2 m^{-3} d^{-1}) occurred during the early southwest monsoon despite high nutrient concentrations, likely because terrestrial CDOM reduced light penetration and shoaled the euphotic zone, whereas highest GPP (11.5 ± 7.7 mmol O_2 m^{-3} d^{-1}) occurred during intermonsoon 2 when deeper sunlight penetration and residual nutrients supported a phytoplankton bloom. NEP fluctuated near 0 year-round, indicating tight coupling between production and respiration. However, persistent dissolved oxygen undersaturation and pCO_2 supersaturation indicate net heterotrophy, and suggest that the Singapore Strait acts as a net source of CO_2 to the atmosphere. GPP estimated from pCO_2 and alkalinity showed a similar seasonal pattern to oxygen-based estimates. These results provide evidence of coastal browning impacts in the tropics and highlight how future climate and land-use change may alter coastal productivity and carbon cycling through changes in terrestrial inputs.

Anthropogenic Drivers of Carbon Export in California Salt Marshes: Implications for Restoration and Climate Mitigation | *Aliya Khan, University of California Santa Cruz*

Coastal wetlands are among the most valuable ecosystems on Earth, providing ecosystem services including carbon sequestration, water filtration, storm surge protection, and habitat provisioning (Adams et al. 2021). These ecosystems serve as nature-based climate solutions, sequestering carbon at rates up to ten times those of terrestrial forests despite covering a fraction of the area. They contribute nearly half of all oceanic carbon burial while occupying only ~2% of the ocean surface making them disproportionately vital to global climate mitigation (Duarte et al. 2005) (McLeod et al. 2011). Lateral carbon fluxes, carbon moved via surface water, represent a significant and often overlooked component of the blue carbon budget. Across blue carbon ecosystems, laterally exported carbon is estimated to match or exceed buried carbon (Santos et al. 2021). If a substantial portion of this exported inorganic carbon is subsequently sequestered downstream, current estimates may significantly underestimate the climate mitigation potential of these systems. Yet the mechanistic drivers of lateral inorganic carbon export, and how anthropogenic disturbance shapes them, remain poorly understood. Land use change, hydrologic alteration, and sea level rise are driving rapid and widespread degradation of coastal wetlands globally, often converting vegetated marshes to unvegetated mudflats, and restoration offers a pathway to reverse these losses. To understand mechanistic drivers and assess restoration viability, we quantified lateral inorganic carbon export across four California saltmarshes spanning a gradient of anthropogenic conditions: impoundment, drowning, and active restoration. We find that anthropogenic change can significantly impact inorganic carbon export and production, with important implications for how we account for and manage the sequestration potential of restored and degraded coastal wetlands.

Cover Cropping and Reduced Tillage Alter Soil Carbon Emissions and Weed Pressure in Collard Production | *Mahmoud Rady, Clemson University*

Soil degradation, greenhouse gas emissions, and increasing weed pressure threaten the sustainability and profitability of vegetable production systems in the southeastern United States. Developing management practices that maintain productivity while reducing environmental impacts is critical. This study evaluated the effects of cover crops and conservation production systems (CPS) on soil carbon emissions, weed suppression, and collard (Brassica oleracea L. var. viridis)

performance during 2025 at CREC (Charleston, SC) and EREC (Blackville, SC). A split-plot randomized complete block design compared four cover crop treatments (sunnhemp, sudex, sunnhemp–sudex mixture, and bare soil) and three CPS practices (conventional tillage, reduced tillage, and plastic mulch). Measurements included soil CO_2 emissions, wild mustard coverage, weed seedbank, and collard yield. Results showed that CPS practices had a greater influence on soil carbon emissions than cover crop treatments. Plastic mulch consistently produced the highest soil CO_2 emissions, whereas reduced tillage maintained the lowest emissions across treatments, highlighting its potential to reduce agriculture's carbon footprint. Weed pressure was substantially reduced under plastic mulch, with wild mustard coverage declining dramatically compared with conventional tillage. Correspondingly, plastic mulch produced the highest marketable collard yield, while conventional tillage resulted in greater unmarketable yield. These findings demonstrate key tradeoffs between productivity and sustainability in collard production. Reduced tillage offers a promising strategy for mitigating soil carbon emissions, while plastic mulch effectively suppresses weeds and enhances yield. Integrating cover crops with conservation practices may help growers balance economic returns with long-term environmental stewardship.

Session 3 - Decision-Making and Risk in Climate Adaptation

Session Chairs: Hannah McKinley and Bradley Lamkin

Whose role is it? Interpreting national climate and biodiversity policy in local government | *Emily Cole, University of Southampton*

National climate and biodiversity targets increasingly depend on local governments for implementation, yet there is no single model of the role local government should play in delivering these objectives. This study uses Q-methodology to examine how 18 local government officers in Hampshire, England interpret and prioritise national land-use policies for climate change and biodiversity. Participants ranked 48 statements derived from national policy documents and previous interviews, followed by semi-structured interviews to support interpretation. Four distinct perspectives reflected different models of local implementation:

place-based stewardship, emphasising local autonomy; partnership governance, prioritising collaboration to overcome capacity constraints; policy integration, calling for coherent national direction; and transformational governance, advocating rapid, large-scale environmental action. While participants broadly supported national climate and biodiversity objectives, the perspectives differed in where responsibility for implementation should sit and what local governments require to act effectively. The findings demonstrate that coherent implementation cannot be achieved through national policy alignment alone. Rather, implementation must accommodate tensions between clear national direction and sufficient local discretion to respond to place, underpinned by relational capacity and communication across governance levels. Recognising these different models of local government implementation can help inform policies that translate national climate and biodiversity ambitions into coordinated local action.

Quantifying the Role of Land Fraction in Precipitation Biases over Pacific Small Island Developing States (PSIDS) | *Abrielle Mannino, Brown University*

Climate change-induced extreme weather poses an ongoing and existential threat to Small Island Developing States (SIDS) due to their tropical location and coastal geography. Uniquely threatened are Pacific Small Island Developing States (PSIDS) because of their extreme geographic isolation and proportion of low-lying atolls. Despite the need for locally accurate climate model projections to assess present and future PSIDS extreme weather risk, even high-resolution regional climate models (RCMs) are too coarse to represent the land fraction of PSIDS. Inaccurate PSIDS representation reduces skill in local-scale precipitation extremes, as local topography, differential heating, and the diurnal cycle are demonstrated drivers of precipitation regimes. Therefore, there is a critical need to evaluate I) how land fraction at various horizontal resolutions affects agreement between simulated and observed precipitation in PSIDS and II) whether observed biases are attributable to the physical representation of islands or underlying model physics. To address these, we compare historical precipitation accumulation median, intensity, and frequency across the South Pacific simulated by the CMIP5 Coordinated Regional Downscaling Experiment (CORDEX) at 0.22° and 0.44° horizontal resolutions with NCEI Global Hourly Integrated Surface Data and Climate Hazards Group InfraRed

Precipitation with Station (CHIRPS) on daily, monthly, and seasonal timescales. Initial results reveal underestimation of precipitation intensity and frequency across models, with 0.44° models showing greater underestimation than 0.22° models, and clear relationships between the representation of small islands and precipitation uncertainty and error.

Models in context: best practices for engaging expert stakeholders to build a technical model | *Bryn Anderson, Northeastern University*

There is a growing recognition, particularly for climate models, that usable, decision-relevant knowledge must be a goal of model development. Scientific models excel at generating high-quality data for research, but without considering the needs of intended users, researchers can struggle to use them to gain public trust and inform policy decisions. Prior research has differentiated between useful and usable knowledge; a model may produce information modelers consider useful, but if that information does not fit the needs of its intended users, the knowledge remains unusable. Fit-for-purpose modeling addresses this idea directly by grounding model development in the needs of its intended users, centering usability, reliability, and feasibility. Using lessons from the development of spatial-statistical tile drainage models in the Upper Mississippi River Basin, we identified best practices for engaging with expert stakeholders and communication of results to support the development of a fit-for-purpose model. We conducted 26 semi-structured interviews spanning academic, government, NGO, and industry sectors. Transcript analysis, thematic coding, and reflection with the modeler revealed best practices for model development and communication of model results. Model development best practices include engaging experts before the modeling begins, integrating the modeler in the stakeholder interviews to eliminate information loss, treating expert knowledge as a source of model inputs, and asking if the model being developed is useful and to whom. For communication of model results, best practices include prioritizing relational over informational communication, collaborating with trusted groups as they will carry more credibility than researchers alone, and knowing your audience and whether they appreciate general results or nuance. We offer these best practices as adaptable to a modeling method that wishes to engage with expert stakeholders to ensure that a model is

fit-for-purpose and communicated appropriately.

Session 4 - Climate Impacts: Ice, Ocean, and Species!

Session Chairs: Joey Rotondo and Rudra Thaker

Tropical cyclones in a changing climate: A study of high-latitude paleostorms over the past several millennia using sediment cores from Newfoundland, Canada | *Arielle "Lu" Nogueira, Old Dominion University*

Tropical cyclones (TCs) are widely known to pose a major threat to human life and infrastructure in the North Atlantic. Despite TC's destructive nature, the impact of anthropogenic climate change on TC frequency is poorly understood due to the brief and biased observational record of TCs (1850 to present). Higher latitudes experience more rapid warming due to climate change than mid and low latitudes, yet very little is known about paleostorm occurrence at high latitudes. Here, we reconstruct TC frequency over the past 7500 years using sediment cores from Holyrood Pond in Newfoundland, Canada. Our goal is to investigate how long-term climate forcing impacts tropical cyclones at high latitudes. Using grain size analysis and loss-on-ignition, we identify coarse-grained event beds in our two 7 meter long sediment cores from Holyrood Pond. The modern events beds in our cores date to historical hurricanes that have struck Newfoundland, including the signature of Hurricane Larry (2021). Using our new paleostorm reconstruction, we examine the frequency of TCs prior to modern instrumentation and TC response to changes in climate on a multi-decadal to centennial time scale. Our reconstruction indicates the presence of three distinct multidecadal to centennial-scale active intervals of storminess in the past 7500 years in Newfoundland, with notably less activity in the last 1000 years. Our new record provides critical insights into long term patterns of TC frequency at high latitudes, which is crucial for informing risk assessments and disaster preparedness efforts.

Climate-Driven Population Trends Align with Species Distribution Model Predictions | *Lilac Hong, University of Washington*

Climate-based species distribution models (SDMs) are widely used in conservation planning to forecast species range shifts under climate change, yet their predictive reliability remains insufficiently evaluated. Assessing their accuracy is critical for determining how effectively SDMs can inform adaptive management strategies. We compared projected range shifts from climate-based SDMs with observed population trends for North American bird species. We used SDMs driven by CMIP5 climate projections to estimate changes in species distributions between 2010 and 2025 under two climate scenarios (RCP4.5 and RCP8.5), identifying areas of projected range contraction and expansion. We then analyzed annual population survey data from the Breeding Bird Survey (2010–2024) using Bayesian hierarchical models to estimate population trends while accounting for the effects of habitat loss, thereby improving inference of climate-associated population responses. Preliminary results for grassland birds showed that, after accounting for grassland change, population declines occurred in both projected contraction and expansion zones over the past decade. However, declines were stronger in contraction zones and weaker in expansion zones. These findings suggest that short-term population trends broadly align with SDM-projected range shifts, providing evidence that climate-based SDMs may capture emerging population responses to climate change.

Temperature rising: what does it mean to be resilient to extreme heat? | *Josie Baker, University of Southampton*

Climate change is increasing the likelihood of longer, hotter and more frequent heatwaves. Evidence has demonstrated that the United Kingdom is underprepared for the rising threat of extreme heat, particularly given the cultural landscape in which hot weather is largely viewed as positive. Quantitative studies on the impacts of these events have emphasised the need for longer-term resilience, but offered little empirical evidence of what it means to be resilient to heat. It has also been acknowledged that women face unique and often overlooked challenges during heatwave events. These gendered challenges have not yet been explored in the UK context; nor has there been sufficient critical engagement with heat resilience narratives to ensure that inequalities are not reinforced. This thesis seeks to address these gaps by exploring women’s lived experience of extreme heat to

reveal the breadth of conceptualisations of resilience and the social and cultural context in which these have been established. By conducting a qualitative study using in-depth, narrative interviews and a diverse range of literary and archival sources, this project will uncover the memories and narratives that exist in relation to past, present and future heat resilience. This will not only contribute to the global literature on the gendered impacts of heat but also offer more nuanced and empirically grounded understandings of heat resilience. The findings will support the development of more effective climate resilience policy and community initiatives, promoting an equitable transition to living well with heat through climate change.

Notch Your Average Melt: Wave-Induced Erosion of Ice | *Olivia Doty, University of Wisconsin-Madison*

Ice loss from icebergs and from the fronts of ice shelves is often driven by waves. The rate of wave-induced erosion is impacted by numerous factors including varying ice and wave conditions, exposure to breaking or standing waves, as well as water temperature and salinity. Here, we assess the still-water and wave-induced melt rates of a vertical ice wall using a cryospheric wave tank. We compare the experimental results to theoretical predictions and melt rate parameterizations used in ice drift/trajectory models. The wave tank features wave-energy absorbing paddles that propagate and maintain standing waves and allow us to explore the melt dependence on wave frequency, amplitude, and water temperature in near-realistic environmental conditions. The still-water melt results closely match a power law scaling proposed previously from theoretical considerations. The experimental wave-induced melt results are broadly consistent with linear predictions of melt rate vs wave amplitude and temperature but also exhibit a lot of variability and highlight the complexity of the wave–ice interactions. The results from these laboratory studies have significant implications on improving large-scale ice and ocean models, which in turn shed light on the dynamics of climate for years to come.

Unequal Risks Followed by Unequal Costs: Integrating Hydrologic Risk and Social Vulnerability across Coastal Communities | *Hanne Borstlap, University of Virginia*

Building coastal resilience under climate change requires understanding not only where environmental risks are increasing, but also who is most affected. This is particularly important on the Delmarva Peninsula (Delaware–Maryland–Virginia), where rural, lower-income communities often face greater environmental exposure while having fewer resources to adapt. For example, rising groundwater tables are causing crop losses and threatening septic systems, with replacement costs often exceeding $10,000 per household. To identify areas of greatest need and better target adaptation funding, I combined high-resolution environmental and socio-economic datasets to quantify disparities in risk exposure. Environmental metrics included the frequency of shallow groundwater exceeding critical thresholds. This data builds on previous work that coupled process-based hydrologic modeling with machine learning to scale predictions from individual watersheds to the entire peninsula. To assess social vulnerability, I collaborated with environmental economists to integrate environmental risk metrics with parcel-level socio-economic information from the Environmental Impacts Frame (EIF), a privacy-protected micro-census dataset. Results indicate that many areas with persistent high groundwater levels may be unsuitable for conventional septic systems in the long term, while also showing a correlation between groundwater exposure and household income. These findings were then shared with state policymakers and the Department of Health to help target septic system assistance and other adaptation resources to communities facing the greatest environmental and economic risks.

Private Posters

Session A

[A1] Beyond the final checkpoint: training dynamics of an AI weather model | *Annabel Wade, Boston University*

In a warming climate with worsening extreme weather events, it is becoming more crucial to have accurate predictive tools that we can trust for forecasting weather. AI weather models have emerged as a way to efficiently make forecasts, with impressive skill but also known limitations, such as spectral biases and problems going out of distribution. As the production of AI weather models skyrockets, it is essential that we understand how these so-called “black box” models learn to make predictions to build trust in them and improve their skill. In this project, we demonstrate that studying an AI weather model as it is learning through training can reveal a deeper understanding of the model than just analyzing the final model checkpoint. We analyze when it develops important cross-variable relationships, how the model learns physical principles such as geostrophic balance, and when it learns - or forgets - how to predict extreme weather events. By watching the model’s predictions evolve throughout its training, we can understand how their errors came to be, and target improvements for crucial forecasts such as extreme weather.

[A2] Forecasting Severe Thunderstorm Probabilities with Transformer Post-Processing of NWP Forecasts | *Miles Epstein, University of Washington*

In the United States, a thunderstorm is considered severe if it produces straight-line winds of at least 58 mph, hail of at least one inch diameter, or a tornado. Accurate forecasting of these storms is essential to protect people and property. Severe thunderstorms and their associated hazards often occur on too small a scale to be directly resolved in numerical weather prediction (NWP) models; however, we can statistically post-process NWP model output to produce probabilistic forecasts of severe thunderstorm hazards. We develop a decoder-only transformer (DOT) model that predicts daily probabilities of severe hazards in the medium-range (up to eight days) from NWP and AI-based NWP emulator model output by treating each lead time as a token. Previous work has shown such a model to be skillful; in this work,

we expand model capability and improve model skill by increasing temporal resolution and incorporating user-desired target variables such as lightning, heavy rainfall, and hazard intensity.

[A3] Destination-Stratified Walking Route Simulation Reveals Income-Based Inequalities in Walking Route LST Across 10 U.S. Cities | *Yazhuo Cao, Northwestern University*

Urban heat significantly affects low-income communities, while most studies measure thermal conditions at the residential tract level rather than along the routes residents actually walk. Based on reliable patterns of income-stratified walking destinations, we assigned necessity-oriented destinations (transit stops, clinics, grocery stores) to low-income tracts and leisure-oriented destinations (parks, cafés, cultural venues) to high-income tracts across 300 census tracts in 10 U.S. cities. We simulated 30 walking routes per tract (9,000 routes total) using OpenStreetMap pedestrian networks. Based on Google Earth Engine, we generated 40-meter street buffers and extracted land surface temperature from walking routes via Landsat 8 composites (2021-2023 summer). Multilevel mixed-effects models reveal that low-income routes are on average 1.08°C hotter than high-income routes, with Sun Belt cities showing larger disparities (up to 2.26°C) than Rust Belt cities. Causal mediation analysis suggests imperviousness and tree canopy account for approximately 62% and 29% of this difference in low-income routes respectively. SHAP-based attribution further indicates that tree canopy is extremely associated with walking route LST in Sun Belt cities than Rust Belt cities. Our results suggest that targeted tree canopy investment along low-income walking routes may offer meaningful thermal equity benefits, particularly in arid climates.

[A4] Household Perceptions and Preparedness for Wildfire Smoke: Findings from a Community Assessment for Public Health Emergency Response in Spokane, Washington | *Katelin Teigen, University of Washington*

Wildfire season has grown in length and severity in the Northwest United States, where increased wildfire smoke (WFS) has worsened air quality and associated public health impacts. The University of Washington and Gonzaga University

conducted a Community Assessment for Public Health Emergency Response (CASPER) in Spokane, Washington to assess household perceptions of WFS and other environmental hazards and their health impacts; household strategies to reduce exposure; and preparedness needs. As a rapid needs assessment, CASPER uses a cluster sampling methodology to identify households to survey and, with sampling weights, yields generalizable findings for the entire community. A survey was developed to capture household-level demographics, environmental hazard concerns, household and community WFS impacts, exposure reduction strategies, and air quality information preferences. The Spokane CASPER was conducted in-person in October 2025. Of the 210 target households, 94 completed the survey, representing a 45% completion rate. When asked about environmental hazards, 92% of households reported recently experiencing WFS in Spokane, with 62% expressing high concern. During WFS events, 90% of households closed windows and doors, 89% reduced outdoor activities, and 76% sought air quality information. The most preferred measures for improving community WFS resilience were cell phone alerts on smoky days (supported by 47% of households), funding for local schools to improve indoor air quality (44%), and financial assistance for portable air cleaners (41%). These results highlight the pervasive impacts of WFS among Spokane households, providing timely information on preparedness and preferences for community climate resilience efforts.

[A5] Got Green Air? An evaluation of 14 low-cost sensors for indoor air quality monitoring | *Hannah McKinley, University of Washington*

As climate change intensifies the frequency and severity of wildfires, communities face growing risks from wildfire smoke, particularly through its impact on indoor air quality (IAQ). Few studies have evaluated the effectiveness of low-cost IAQ sensors for household-level monitoring and decision-making. Public Health–Seattle and King County in collaboration with the University of Washington CEER Lab have conducted a project evaluating 14 low-cost air quality sensors commonly cited in scientific literature and consumer reports. This evaluation used laboratory-based performance testing to identify the precision and accuracy of a variety of low-cost sensors and assessed facilitators and barriers to the overall accessibility of these sensors for the general public. These findings will help inform the development of

guidance on household-level IAQ monitoring and support strategies to reduce the health impacts of air pollution in wildfire-prone regions.

[A6] Atlantic meridional overturning circulation slowdown modulates atmospheric rivers in a warmer climate | *Mohima Sultana Mimi, University of California Riverside*

The slowing of the Atlantic meridional overturning circulation (AMOC) under anthropogenic warming has been suggested to significantly impact Earth's climate. Here, we isolate and quantify the AMOC impact on atmospheric rivers (ARs) across the twenty-first century using coupled climate model simulations. We find that a weakened AMOC promotes AR frequency in mid-latitudes by intensifying the prevailing westerly winds, especially at the west coast of North America, which dramatically enhances AR-induced precipitation in wintertime California. Aside from dynamic processes, the weakened AMOC can also modulate ARs through thermodynamic processes. It reduces AR frequency and related precipitation over the Arctic and Greenland while increasing AR frequency and associated precipitation along the eastern coast of South America and around Antarctica, owing primarily to AMOC-induced moisture decrease and increase in the Northern and Southern Hemispheres, respectively. Our findings highlight the role of the AMOC in future regional hydroclimate and climate extreme shifts.

[A7] The importance of tides in wind-driven coastal upwelling | *Chunyu Ren, Boston University*

Coastal upwelling systems are among the most productive regions of the ocean and play an important role in regional climate, marine ecosystems, and coastal biogeochemistry by regulating the exchange of heat, nutrients, and tracers between the shelf and the open ocean. These systems are primarily driven by winds, but tides are also energetic over continental shelves and can reshape the circulation through turbulent mixing and tidally rectified mean flows. Yet the role of tides in modulating wind-driven upwelling remains poorly constrained, especially in models that cannot resolve shelf-scale tidal processes. In this research we use idealized numerical simulations to investigate how tidal forcing modifies coastal upwelling under different stratification, topographic, and forcing conditions. We examine how

wind–tide interactions affect the strength and vertical structure of the upwelling jet, cross-shore transport pathways, turbulent mixing, and tracer exchange across the shelf. By comparing simulations with and without tides, we identify the dynamical mechanisms by which tidal mixing and tidal rectification alter the coastal response to wind forcing. Our results show how local tidal dynamics can influence the pathways through which cold, nutrient-rich water reaches the surface and how tracers are exchanged between nearshore and offshore regions. This work highlights tides as an important but often underrepresented component of coastal upwelling dynamics, with implications for improving coarse-resolution climate and Earth system models that must parameterize unresolved shelf processes.

[A8] Tracing Phytoplankton Nitrogen Sources in the Gulf of Maine Using Flow-cytometry-sorted Nitrogen Isotopes | *Celia Murphy-Braunstein, Boston College*

The Gulf of Maine (GoM) is a changing continental-shelf ecosystem where rapid warming, altered circulation, and shifting water-mass composition has resulted from anthropogenic climate change and a weakened Atlantic Meridional Overturning Circulation. The physical property changes of the system are expected to affect nutrient supply, primary production, which is the creation of biomass by autotrophs like phytoplankton from inorganic substances, and harmful algal bloom dynamics. Nitrogen availability is a key control on phytoplankton growth in this region, yet it remains difficult to determine which nitrogen sources are actually assimilated by different phytoplankton groups. This project will evaluate the feasibility of using natural-abundance nitrogen isotopes of flow-cytometry-sorted phytoplankton to trace nitrogen source use in the Gulf of Maine. In collaboration with Bigelow Laboratory of Ocean Sciences, water, particulate nitrogen, and phytoplankton samples will be taken monthly in the GoM over the 2026 summer from the R/V Bowditch underway system. Phytoplankton communities will be separated using flow cytometry and undergo isotopic analysis. The resulting data will be used to determine whether different phytoplankton groups show distinct isotopic signatures consistent with reliance on nitrate supplied from deeper water sources versus regenerated nitrogen sources such as ammonium. Ultimately, this research aims to clarify how climate-driven changes in circulation and nutrient supply may restructure the base of the marine food web, with implications for

bloom dynamics, coastal productivity, and carbon cycling in rapidly warming shelf ecosystems.

[A9] Evaluating Transferability of Ocean Model Products for Climate-Informed Stock Assessments for West Coast Groundfish | *Diandre' Richie, University of Florida*

Climate change is driving unprecedented variability in marine ecosystems, creating an urgent need for adaptable decision-making tools to ensure sustainable fisheries. Effective fish stock management relies on accurate assessments, yet these often overlook the influence of climate-driven oceanographic changes. This project addresses a critical gap: managers need tools that reflect changing conditions. Climate-informed stock assessments offer a pathway to account for these shifts. A major challenge is that stock assessment and ecosystem scientists face a wide range of ocean model products but lack clear guidance on which are best suited for specific applications or how that choice impacts assessment outcomes. This project provides essential guidance, evaluating how environmental drivers can be integrated to improve forecasts of fish population dynamics, particularly for Northern Yellowtail, an ecologically and commercially important groundfish species. We assessed two ocean model products: the Global Ocean Reanalysis from Copernicus (GLORYS) and the climate-adaptive Modular Ocean Model 6 (MOM6), supported by NOAA's Changing Ecosystem and Fisheries Initiative (CEFI). The study analyzes (1) agreement between models on climate-relevant ocean variables, (2) temporal consistency, (3) seasonality differences, and (4) recruitment model selection based on the product used. These comparisons will inform the reliability of ocean models in climate-aware stock assessments. This work contributes original research at the intersection of climate science and fisheries management, with implications for sustainable resource use under climate change. It also builds capacity in climate data analysis, reproducible workflows, and science communication key skills for interdisciplinary collaboration.

[A10] Creating a Consistent Volcanic and Layer Count Record for the Bipolar Ice Core Chronology (BICC) | *Quinn Mackay, Oregon State University*

Ice core chronologies are critical for providing accurate depth-age relationships, and are the baseline for much paleoclimate information shared across disciplines, such as providing context for modern exponential greenhouse gas rise. Further, they are necessary for comparing multiple records to identify spatial climate patterns and relative phasing, informing our modern understanding of the global climate and improving climate projections. There currently exist two major chronologies, the Antarctic Ice Core Chronology (AICC) and Greenland Ice Core Chronology (GICC). These records synchronize ice core depths in their respective hemispheres, enabling cross-core analysis. However, these chronologies are incomplete as they do not incorporate all (bipolar) age constraints, nor all deep ice cores. Here, we present work related to the development of the Bipolar Ice Core Chronology (BICC), which utilizes recently identified bipolar volcanic linkages to synchronize all major ice cores between hemispheres for the first time. BICC relies upon accurate volcanic linkages, however; our analysis shows substantial numbers of published volcanic linkages are inconsistent with each other, especially within Antarctica (~5%). We present methodology for discovering and resolving inconsistent linkages, along with a tool for checking the consistency of future identified linkages. Our methodology also automatically expands the number of linkages by 500+, filling in critical gaps. The most accurate ice core records are dated by counting annual layers, however, substantial uncertainty exists between Greenland and Antarctic counts. We present efforts in Holocene synchronization of Bipolar layer counts for the first time, making BICC the most reliable global ice core record available.

[A11] Using high-resolution δ15N and δ18O measurements of nitrate in the GISP2 core to investigate seasonal variations in atmospheric oxidative chemistry since the preindustrial | *Maggie Scholer, University of Colorado Boulder*

Nitrate (HNO_3) is a key component of the global nitrogen cycle, playing an essential role in many biological, chemical, and geological processes that regulate atmospheric composition and climate. In the atmosphere, nitrate is the final oxidation product of nitrogen oxides ($NO_x = NO + NO_2$), a critical air pollutant that drives tropospheric chemistry through its reactions with ozone (O_3) and the hydroxyl radical (OH). Since these oxidants dictate greenhouse gas lifetimes,

understanding their historical variations is vital for climate modeling. In polar snow and ice, nitrate is well-preserved and abundant, providing critical insights into past atmospheric chemistry. Nitrate stable isotopes (δ15N and δ18O) are powerful tools for investigating the chemical processing and source variability of atmospheric NOx. δ15N largely reflects different sources of NOx, whereas δ18O reveals the oxidative pathways NOx undergoes to form HNO3. Here, we present preliminary measurements of nitrate concentration and isotopes in the GISP2-E ice core. Our study utilizes high-resolution (weekly – biweekly) sampling to investigate the evolution of atmospheric oxidative chemistry from 1750 to 1990. Our measurements show a clear decrease in δ15N-NO3- values from the 1760s to the 1970s, associated with increasing industrial NOx emissions. Critically, our high-resolution measurements allow us to capture seasonal signals in δ15N-NO3- and δ18O-NO3- for the first time. By analyzing these variations, we can distinguish between OH and O3 reaction pathways, providing the first high-resolution look at how the seasonality of oxidative chemistry has evolved from the preindustrial to the 1990s, offering crucial constraints for historical climate simulations.

[A12] Contributions of Light Absorbing Particles to Reduced Albedo: Spatial and Temporal Analysis of Black Carbon and Dust Tracers in Svalbard Firn Cores | *Tess Kraics, Central Washington University*

The Arctic is warming at four times the global rate, with Svalbard experiencing rates up to seven times higher, making this the fastest-warming region on Earth. Rising temperatures accelerate snow and ice melt, leading to increased glacier retreat and exposure of local dust sources. Light absorbing particles (LAPs), specifically black carbon and mineral dust, contribute to the process of Arctic amplification by reducing snow albedo. While black carbon has been extensively studied worldwide, dust remains under-researched in Svalbard. For this study, four ~10-meter firn cores were collected from spatially distributed sites in Svalbard in 2025 and analyzed for black carbon using a Single Particle Soot Photometer (SP2) and trace elements via Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The data was utilized to investigate LAP contributions to snow albedo reductions. Furthermore, post depositional melt effects were explored to examine the preservation of trace element signals within the ice core record. Elemental stability was compared to

identify which elements were less impacted by melt. This research provides useful insight into understanding the opportunities and limitations of using ice cores retrieved from sites undergoing rapid melt.

[A13] Climate in the Classroom: Lessons from a Climate Model Tutorial | *Ashley Lasinsky, MIT-WHOI*

Climate science is a highly interdisciplinary field that requires learning a wide array of skills, including scientific and mathematical reasoning, understanding of Earth system processes, and, increasingly, coding. This makes climate science a particular challenge to teach, especially when students enter the classroom with a range of prior knowledge. In the summer of 2026, I taught a series of tutorials for a summer short course on climate models at the Woods Hole Oceanographic Institution. The tutorials provided an introduction to analyzing climate model output in python for students ranging from undergraduates to postdocs. I will share my takeaways on successful strategies and challenges faced, including topics such as teaching coding in the AI era, balancing mixed goals and skill levels in the classroom, utilizing active learning activities, and cultivating an inclusive classroom community. My presentation will be grounded in literature on evidence-based teaching methods, and explore how these can be best applied in a climate classroom context.

[A14] Biophysical mechanisms of forest recovery and reburns in wet PNW forests |*Samuel Hall Watson, Washington State University*

Climatically wet PNW forests, which are highly resistant to ignition in their late-successional state, have been observed to be prone to destructive and costly reburns in the aftermath of an initial severe wildfire. Biophysical processes characteristic of the unique burn scar environment, including feedbacks between vegetation regrowth, soil moisture, and microclimate, can be conducive to elevated fire weather conditions and increased susceptibility to re-burning. However, the mechanisms connecting these feedbacks to reburn risk are poorly understood. We use a combination of original field data, gridded environmental data, and high-resolution numerical modeling to characterize these mechanisms, and to test for correlations between land-atmosphere feedback strength and reburn risk in

post-fire early successional forests. We hypothesize that quantifying the relationship between soil moisture and plant transpiration in a recovering burn scar may serve as a capable indicator of reburn susceptibility.

[A15] Soil Lead Distributions Following Urban Wildfires: Insights from a Community-Driven Study in Los Angeles | *Cat Odendahl, University of Southern California*

Los Angeles experienced destructive wildfires in January 2025, with the Palisades and Eaton fires burning over 57,000 acres and destroying more than 15,000 structures. In the aftermath, communities raised concerns about potential contamination from fire-derived ash, particularly lead (Pb). In response, we established a community-based soil testing initiative, the Contaminant Level Evaluation and Analysis for Neighborhoods (CLEAN) project, to assess total Pb in residential soils. Residents submitted soil samples through a network of local drop-off locations, including libraries and community centers. Samples were analyzed using X-ray fluorescence (XRF) spectrometry, generating elemental data from magnesium to uranium. Results are shared directly with participants and used to produce anonymized, neighborhood-scale maps identifying areas of elevated contamination risk. Statistical analyses reveal significant differences in Pb concentrations between burn zones, with samples from the Eaton Fire region exhibiting a broader and higher overall distribution of Pb compared to the Palisades region. In contrast, no significant differences were observed within burn zones as a function of distance (0–1 km, 1–5 km, 5–10 km) from burn boundaries. Ongoing work aims to explain observed variability through factors such as housing age, urban infrastructure, and traffic patterns. The most recent investigation of variability shows that overall the more older homes surrounding a sample, the higher the Pb concentration. Within the Palisades region, high Pb is also associated with increased pollution. This project demonstrates the utility of community-engaged, rapid-response environmental monitoring for assessing post-wildfire contamination and informing public health awareness.

[A16] Warm-Winter Snowmelt Shifts and Potential Recharge Responses Across Great Lakes Basin | *Fatemeh (Kamelia) Karimi, The University of Texas at Dallas*

Warmer winters are changing how snow-affected watersheds store and release water. In the Great Lakes region, seasonal snowpack has historically acted as temporary storage, holding winter precipitation and releasing it gradually during late winter and spring. As winters warm, snowpacks are becoming less persistent, midwinter melt and rain-on-snow events are becoming more common, and runoff is shifting earlier in the year. What remains less clear is how these changes affect the balance between water that runs off quickly and water that moves into the subsurface as potential recharge. This study examines how warm-winter conditions influence snowpack persistence, runoff timing, and potential recharge across the Great Lakes Basin. It focuses on why some watersheds may respond more strongly than others by considering snow persistence, soil freezing, antecedent wetness, rain-on-snow events, land cover, soil drainage, and watershed setting. The main idea is that meltwater is more likely to become runoff when soils are frozen or already wet, while partially thawed soils with available storage may allow more water to move downward. By connecting winter warming with watershed-scale water partitioning, this work helps clarify how cold-season hydrology is changing in a major freshwater region. The results can improve understanding of future runoff timing, recharge potential, and water availability across Great Lakes watersheds.

[A17] Abrupt transitions from dry to wet extremes in the Contiguous United States: Linkages with Corn Yield | *Tian Yang, Indiana University Bloomington*

Abrupt transitions from dry to wet extremes, also known as weather whiplash, can amplify risks to water security, food production, and human well-being. For example, antecedent dry extremes can reduce water availability for crops, while subsequent wet extremes can cause waterlogging and nutrient loss. Such rapid transitions can exacerbate adverse impacts on agricultural productivity. However, comprehensive research on abrupt transitions in the contiguous United States remains limited. This study addresses this knowledge gap by analyzing spatiotemporal patterns of abrupt transitions and evaluating their impacts on corn yields, a staple crop for U.S. agriculture and global food markets. We use a rolling 30-day Standardized Precipitation Evapotranspiration Index (SPEI) to identify dry-to-wet transitions from 1981 to 2024 and characterize their climatology and trends in frequency, transition time, and intensity. We also assess the relative roles

of precipitation (P) and potential evapotranspiration (PET) in event occurrence. We then apply a copula-based statistical approach to quantify the relationship between corn yield anomalies and dry-to-wet transitions. Event frequency shows no significant nationwide increase, whereas transition times have shortened and event intensity has strengthened across most climate regions. About 71% of dry-to-wet transitions occur within 30 days, and this proportion has increased over time. P anomalies dominate event occurrence, with a relative contribution of 80%. These results provide a basis for evaluating how abrupt hydroclimatic transitions affect corn yield variability. Our work will assist policymakers, agricultural managers, and stakeholders in developing timely adaptation strategies to enhance agricultural resilience to future hydroclimatic extremes.

[A18] Ground-Truthing Climate Resilience: Field Validation of Agrivoltaic Soil Microclimate Dynamics in Semi-Arid South Texas | *Theophilus Adu-Azumah, Texas A&M University–Kingsville*

Agrivoltaic systems, which integrate photovoltaic solar panels with active crop production, represent a promising strategy for addressing the converging pressures of renewable energy demand, agricultural water scarcity, and food security under accelerating extreme weather conditions. By co-locating energy generation with farming, Agrivoltaic systems have demonstrated potential to reduce irrigation demand, moderate heat stress, and improve land-use efficiency in water limited regions. However, widespread implementation remains constrained by uncertainties in soil microclimate response, including altered soil temperature regimes, modified moisture retention, and reduced photosynthetically active radiation parameters that vary significantly by location and are poorly characterized for semi-arid conditions, such as South Texas. Existing agrivoltaic simulation models, including DSSAT-based frameworks, rely on microclimate adjustment assumptions derived from geographically distant field studies, limiting their predictive reliability for region-specific agricultural systems. This study addresses that gap through a controlled pilot field experiment establishing baseline soil microclimate data under agrivoltaic conditions for regional model calibration. Two soil sensor arrays were positioned beneath installed solar panels while the other two placed in open-field control beds, which continuously monitor soil temperature,

volumetric water content, and photosynthetically active radiation throughout a sweet corn (Early Sunglow hybrid) growing season. Time-series comparisons between treatment and control conditions characterize panel-induced microclimate modification across the growing cycle. Results reveal measurable reductions in soil temperature and improved moisture retention under panels, providing locally-validated parameters to improve agrivoltaic simulation accuracy for semi-arid South Texas and analogous climate regions globally.

[A19] Urine nutrient reclamation: a golden opportunity to reimagine climate friendly and enduring agricultural systems | *Madeline DuBois, University of Manitoba*

Conventional fertilizers used in agriculture are a huge contributor to climate change. Approximately 2% of annual global greenhouse gas (GHG) emissions are attributed to synthetic nitrogen (N) fertilizer production[1]. The planetary boundary of N has already been far exceeded[2], and that excess N further contributes to emissions through formation of potent N2O and NO. Phosphorus (P) fertilizer production also contributes to GHGs via mining, transportation, and energy intensive removal during wastewater treatment. Recycling the nutrients we have, as happens in natural ecosystems, would not only reduce emissions but would also conserve finite resources and help move back towards planetary boundaries for N and P. In a pilot project based at The Land Institute in Salina, KS, we reclaimed nutrients from human urine to apply as N and P fertilizer. The project bridged soil and social science to determine both whether urine can provide plant-available nutrients to perennial forage crop alfalfa (Medicago sativa) and to aid future workplace urine collection endeavors. Results showed that urine is a promising source of plant-available N and P with potential to off-set synthetic fertilizer use and reduce GHG emissions associated with agriculture, but further research is needed to explore increases in soil salinity. Significant regulatory challenges highlighted the need for policy that addresses urine separate from wastewater. Staff surveys provided insights that can hopefully be applied in future projects, notably recommendations for effective communication and the need for education on fertilizer and waste management.

1. Menegat, S. (2022) Nature. 2. Steffen, W. (2015) Science.

[A20] Temperature Associated Shifts in Cultivated Areas of Specialty Crops in the US between 2008 and 2025 | *Katie Webb, University of Washington*

Studies on agricultural production and climate change often look at yields but assume that production areas remain constant. Shifts in production areas are a plausible adaptation to climate change – which a few studies have already observed in grains, but no such study has looked at fruits and vegetables. Specialty crops have high economic and nutritional value, so their gain (or loss) from a region could have ramifications for farmer livelihood and local food systems. Using the USDA Cropland Data Layer and PRISM temperature data from Oregon State University I examine changes in the spatial distribution and growing temperatures of 52 fruits and vegetables in the conterminous United States between 2008 and 2025. I compute the cumulative growing degree days for each crop area each year and compare the observed temperatures experienced by each crop each year to temperatures in a counterfactual scenario where cropping areas remain constant to a reference period. Results indicate where temperature-associated shifts in crop-specific cultivated areas have taken place in the US over the past twenty years, and may inform additional modeling to understand the spatial allocation of crops under future climate change scenarios.

[A21] Historical Changes in North American Extratropical Cyclones and associated Winter Storms Since 1950 | *Matthew Lynne, University at Albany, State University of New York*

As air temperatures rise, cold-season snowfall has decreased across many populated regions in North America. Low-pressure systems called extratropical cyclones (ETCs) are responsible for much of the snowfall and its associated infrastructure damage that occurs across North America. Yet it remains unclear how changes in ETCs have contributed to historical snowfall trends. In this study, precipitation and snowfall associated with ETCs are verified and tracked at an hourly temporal resolution across North America from October 1950 through April 2024 with May – September excluded. ETC-associated precipitation has increased across much of North America from 1950-2024, yet only over southern Canada and the northern United States Great Plains have there been corresponding increases in snowfall amounts. Temperatures during precipitating hours are found to be

strongly related to the proportion of ETC precipitation that falls as snow during a cold season. While the preferred locations of ETCs have not significantly changed, temperatures during precipitating hours in ETCs' cold sectors, where snowfall is highly favored, have greatly warmed. This physical mechanism acted to significantly reduce snowfall over the Midwest and northeastern United States. The large warming rates of ETCs' cold sectors are consistent with faster surface warming over higher latitudes than lower latitudes and suggest a possible linkage between global and synoptic (~1000km) scale climate changes. An improved understanding of the mechanisms controlling ETC-associated snowfall on climatic time scales can increase confidence in long-term snowfall projections and aid communities in preparing their infrastructure for future ETC and snowfall related changes.

[A22] Analyzing Nor'easter Impacts in Massachusetts Bay using Sediment Cores and Historical Records | *Noah Crone, Old Dominion University*

Nor'easters constitute major hazards to coastal communities in New England. Recent destructive Nor'easters have raised concerns about how their frequency may vary in response to climate change. However, historical observations are too short to robustly address this question. Here, we combine a 2000-year sedimentary proxy record of overwash events from Massachusetts Bay with extended tide gauge records from Boston, MA to reconstruct the recurrence of intense storms impacting Massachusetts Bay. Intense storms generate strong waves which can suspend and transport coarse beach sands into back-barrier environments dominated by fine-grained sediments. These sand layers can be identified in sediment cores and used to reconstruct past surge events from coastal storms. We reconstruct storm events striking Massachusetts Bay using sediment cores from a back-barrier pond in northeast Massachusetts. We find that Nor'easters are the primary mechanism for storm-induced flooding in this region, not hurricanes. The most modern overwash layers in the cores are attributable to documented historical Nor'easters within age uncertainty, including Nor'easters in February 1978, December 1909, and April 1851. Boston tide gauge records during these events indicate that Palmer Pond is only overtopped during storm tides greater than 3 meters. Consequently, Palmer Pond has only recorded a portion of passing storms compared to the frequency of Nor'easters in historical reanalysis which pass close to the site. This

work provides the first steps towards constraining the types of storms which generate coastal flooding in this region and evaluating how the frequency of Nor'easters striking Massachusetts Bay responds to natural climate variability.

[A23] Arctic Goldilocks Clouds: An Important Driver of Arctic Sea Ice Melt, *Bradley Lamkin, University of Oklahoma*

There are large uncertainties in the life cycle of Arctic, low-level, optically thin clouds (hereafter referred to as goldilocks clouds) because these clouds are difficult to detect by remote sensors over sea ice and due to the scarcity of upper-air and surface observations. These clouds affect sea ice melt by trapping outgoing radiation, preventing radiational cooling, and accelerating melting. Given their potentially significant impact on sea ice melt and climate change, a thorough understanding of the thermodynamics and dynamics of goldilocks clouds is needed. This work studies the thermodynamics and dynamics of the goldilocks clouds over sea ice using observations collected in the Arctic Radiation-Cloud-Aerosol-Surface Interaction Experiment (ARCSIX) field campaign. The campaign consisted of two deployment periods: Spring 2024 (pre- sea ice melt onset) and Summer 2024 (peak sea ice melt). We identify flights that encountered goldilocks clouds using the G-III (high-altitude aircraft) aircraft outfitted with the High-Altitude Lidar Observatory (HALO), a combined high spectral resolution and differential absorption lidar, and the Advanced Vertical Atmospheric Profiling System (AVAPS, dropsondes). Low-level inversions are a key ingredient in goldilocks cloud formation, which reanalysis products have historically struggled to resolve. We compare vertical profiles from G-III dropsondes with ERA-5 reanalysis to assess how accurately ERA-5 represents the associated thermodynamics and dynamics. We find that, in goldilocks cases, ERA-5 underestimates the boundary layer inversion strength and overestimates the surface wind speed. Taken together, satellite observations, ARCSIX in-situ measurements, and reanalysis data enable a deeper understanding of Arctic goldilocks clouds and climate change.

[A24] Examining the health of a sea ice floe and its impact on the floe size distribution and rheology | *Geraint Webb, University of Washington*

The horizontal size of a sea ice floe can moderate climatic feedbacks and sea ice dynamics. The floe size distribution (FSD) quantifies the probability of observing a floe of a given size over a given domain. Within the Community Ice CodE (CICE6) sea ice model, sea ice floes are evolved using a prognostic FSD. The prognostic FSD evolves six processes in time: new ice formation, lateral growth, lateral melt, welding (coagulation), wave fracture, and floe deformation. Recently, we have implemented a metric for floe health (for quantifying the weakness of the cracks in floes) within CICE6. Floe health, in turn, has the ability to feedback onto the FSD and further increase fragmentation if a high density of recently formed cracks is present. Floe health also feedbacks onto ice strength (since sea ice with more/larger cracks will be weaker) and can alter the sea ice's rheology. With this accounting of floe health, we examine the impacts to the FSD and rheology between a CONTROL simulation (without feedbacks enabled) and HEALTH simulation (with feedbacks enabled). We find that including HEALTH increases the FSD's variability compared to CONTROL, while deformation statistics improve too between HEALTH and CONTROL.

[A25] Impacts of Nuclear War on Human Health from Changed Surface Ultraviolet Radiation | *Shu Xu, Rutgers University*

Climate model simulations indicate that surface ultraviolet (UV) radiation would change after soot injection into the stratosphere during a nuclear war, due to the competing effects of ozone depletion and aerosol attenuation. Using climate model simulations, we evaluate UV impacts under two scenarios: a regional India-Pakistan conflict producing 5 Tg of soot and a global U.S.-Russia war producing 150 Tg. UV enhancements due to ozone depletion substantially shorten safe outdoor exposure time, particularly for individuals with lighter skin types. Applying UV dose-response relationships, earlier simulations indicate thousands of additional melanoma and non-melanoma skin cancer deaths within the first 15 years after the war and more than 35,000 cumulative excess deaths over the following century under the 150 Tg scenario. Using the more recent outputs with updated emissions and chemistry, the regional war scenario with 5 Tg soot could result in about 10,000 deaths within the first decade and more than 75,000 cumulative excess mortality during the century after the conflict. These findings demonstrate that nuclear war-induced changes in

surface UV radiation represent a persistent but previously understudied health impact of nuclear war. While skin cancer would not dominate overall mortality following a nuclear war, enhanced cumulative surface UV radiation represents an additional, long-lasting threat to human health that compounds other global impacts such as climate disruption and food insecurity. The excess UV may also pose negative impacts on animals and plants, including those used for agriculture, which remain to be quantified.

[A26] Climate Risk and Renewable Energy Markets: Evidence from Wholesale Electricity Price Volatility | *Junxiang Du, Liverpool John Moores University*

The decarbonization of electricity systems increasingly depends on renewable energy, but this transition also makes power markets more exposed to weather-driven climate risk. Wind speed, solar irradiance, and temperature directly affect renewable electricity supply and demand, yet the mechanisms through which short-run weather variability contributes to market instability remain insufficiently understood. This paper examines how physical climate risk is transmitted into wholesale electricity price volatility through renewable generation and electricity demand channels. Using 30-minute settlement-period data from the Great Britain electricity market between 2015 and 2025, the study develops a two-stage empirical framework to distinguish predictable weather-related variation from unexpected system disturbances. First, a recursive structural equation model estimates the links from wind speed to wind generation, solar irradiance to solar generation, and temperature-driven heating and cooling degree days to electricity demand. Renewable generation and demand are then connected to wholesale electricity prices, allowing residual supply, demand, and price innovations to be identified. Second, these innovations are modelled within a multivariate volatility framework to test whether unexpected deviations in wind generation, solar generation, and electricity demand amplify wholesale electricity price volatility. The analysis also examines whether these shocks become more dynamically connected with price innovations during periods of system stress. By tracing the pathway from weather variability to renewable supply-demand imbalances and electricity price volatility, this paper contributes to understanding the climate resilience of renewable power systems. The findings have implications for electricity market design, balancing

mechanisms, and adaptation planning as electricity systems become increasingly dependent on weather-sensitive renewable energy.

[A27] Do Corporate Climate-Risk Disclosures Reflect Physical Flood Exposure? Evidence from Companies in the U.S. | *Ruixuan Ding, The Ohio State University*

Climate-related flood risks show increasing challenges to corporate infrastructure, supply chains, and long-term economic resilience. At the same time, companies are under growing pressure to disclose physical climate risks through voluntary reporting frameworks such as the Carbon Disclosure Project (CDP). However, it remains unclear whether corporate climate-risk disclosures align with the actual spatial distribution of physical flood exposure. In this study, we investigate the relationship between corporate climate risk attention and flood exposure across the United States, using CDP disclosures from 2013 to 2024. We apply Latent Dirichlet Allocation (LDA) topic modeling to quantify the proportion of disclosure text related to physical climate risks and combine these results with facility-level flood exposure assessments derived from reported corporate site locations and flood hazard layers. We then evaluate temporal and spatial patterns of alignment and mismatch between disclosure attention and physical flood exposure. Our preliminary results indicate that reported corporate flood exposure increased substantially over time, largely driven by expanding participation in CDP reporting and increased disclosure of facility locations. In contrast, climate-risk attention exhibited strong temporal variability, with elevated disclosure attention during 2017–2020 followed by declining attention after 2020. Spatial evaluations indicate persistent regions where companies have relatively high flood exposure but low attention to climate risk, particularly in coastal and metropolitan areas. These findings indicate that the company's attention to physical climate risks is only partially aligned with actual flood exposure patterns. The study highlights potential blind spots in corporate climate-risk awareness and adaptation planning.

[A28] Earth’s energy imbalance in initialized decadal predictions | *Dominik Stiller, University of Washington*

Observations of Earth's energy imbalance indicate strong and accelerating energy

gain over recent decades. Coupled free-running simulations underestimate this energy gain, but the drivers of this discrepancy remain unclear. Here, we evaluate top-of-atmosphere radiation in initialized decadal hindcasts that remove internal-variability mismatch as potential driver. On interannual timescales, outgoing longwave radiation is predictable out to two years and the net imbalance for about one year, primarily through ENSO's radiative response. On decadal timescales, initialization brings the simulated energy-imbalance trend closer to observations in most models, although not significantly, and for reasons that differ between models. Our analysis shows that the simulated climate state explains only a small part of the missing energy gain, and leaves the drivers of the remainder as the open question for model evaluation.

Session B

[B1] Score-Based Data Assimilation for Long-Range Climate Trajectory Reconstruction| *Andrei Medvedev, University of Washington*

Multi-decadal ocean reanalyses are expensive because online data assimilation requires running coupled GCMs, and existing products are poorly constrained before the Argo era. We show that a score-based data assimilation (SDA) framework reconstructs a coupled ocean-atmosphere 4D state in over 1950-2020 without any online model. A diffusion model trained on the MIROC6 large ensemble learns the spatiotemporal prior of the joint state; posterior trajectories are then conditioned on historical observations of sea-surface temperature, sea-level pressure, near-surface air temperature, and temperature–salinity profiles. A three-step validation separates distinct error sources. In a cross-model experiment with CESM2 as an out-of-distribution target, a MIROC6-trained prior recovers the dominant multi-decadal modes of variability, including ENSO and several interior-ocean modes inaccessible to surface-only reconstructions. In the real-world reconstruction, unassimilated sea-surface height tracks satellite altimetry and basin-scale ocean heat content matches gridded products. We also characterize the framework's limits: skill degrades with depth, the ensemble is underdispersed, a pre-1990 South Pacific warm offset persists, and Antarctic sea-ice trends are not recovered because the single-GCM prior never sampled them. SDA offers a

probabilistic, computationally inexpensive route to long-record coupled ocean-atmosphere reconstruction.

[B2] Evaluating a Deep Learning Earth System Model with a Baroclinic Wave Test on an Aquaplanet | *Will Yik, University of Washington*

Deep learning models for weather prediction have recently shown great success, outperforming traditional physics-based models and seeing increasing use for subseasonal-to-seasonal and climate timescale prediction. However, there remain open questions regarding how well these models have internalized fundamental atmospheric physics and their ability to generalize to atmospheric states unseen during training. On the other hand, the dynamical cores underlying traditional weather models undergo rigorous hierarchical testing to ensure that they accurately solve the governing equations of the atmosphere. We evaluate DLESyM, a recent deep learning Earth system model, using a well known idealized test in this hierarchy: a baroclinic wave test on an aquaplanet. Notably, DLESyM is only trained on historical reanalysis data and is not retrained from aquaplanet simulations. Unlike other pure and hybrid deep learning weather prediction models such as ACE and NeuralGCM, which immediately revert back to ERA5-like conditions with continental imprinting, DLESyM is able to generalize to the aquaplanet and produce simulations which qualitatively match that of OpenIFS, a traditional physics-based weather model. Additionally, in this idealized aquaplanet setting, DLESyM is able to propagate a small local perturbation to the zonal wind into a realistic baroclinic wave, again matching the structure of OpenIFS. We believe that the success of DLESyM for this test in comparison to other deep learning weather prediction models is due to its localized convolutional architecture, lack of learned positional embeddings, and constraints based on atmospheric physics.

[B3] Distilling Southwest U.S. Hydroclimate Sensitivity from the Ai2 Climate Emulator (ACE2-ERA5) | *Vlad Munteanu, Boston University*

The Southwest U.S. (SWUS) has recently struggled with maintaining a safe water supply for the millions of people living in the region. This is attributed to a “megadrought” that lasted for over 20 years as a result of significantly reduced

precipitation in the region. However, the exact mechanisms behind the reduced precipitation in the SWUS are not entirely clear. Isolating these mechanisms in observations is an incredibly difficult signal-to-noise problem given the single climate state represented in the observational record. By using climate models, previous work has reduced some of the noise by simulating many climate states, however, there is still disagreement between models on the relative importance of those mechanisms and uncertainty if those mechanisms are actually present in Earth's real climate. Here we introduce a Green's Function method to distill SWUS precipitation sensitivity from the Ai2 Climate Emulator trained on observations/reanalysis (ACE2-ERA5). By comparing this approach to traditional climate models, we successfully identify important and interpretable mechanisms for precipitation variability in the SWUS. This serves to constrain current understanding of these mechanisms by providing an observational basis to compare with past methods. Furthermore, we reproduce a previously-identified yet poorly-understood mechanism tied to sea-surface temperatures in the Caribbean Sea and explore possible explanations for it using ACE2-ERA5. Through the application of Green's Function to SWUS precipitation in ACE2-ERA5, we demonstrate the capability of ACE2 to produce interpretable and physically coherent predictions and we constrain current understanding of SWUS precipitation.

[B4] A Time-Aware Machine Learning Comparison for Long-Term Daily Temperature Prediction: Evidence from Lubbock, Texas (1947–2026) | *Syed Ehsan Ar Rafi, Texas Tech University*

Accurate modeling of daily temperature is important for climate analysis, agriculture, and energy planning. This study evaluates the performance of three predictive approaches—linear regression, random forest, and extreme gradient boosting (XGBoost)—for daily maximum (TMAX) and minimum (TMIN) temperature prediction using long-term observational data from Lubbock, Texas, spanning 1947–2026. A time-aware train–test split is employed to account for temporal dependence and non-stationarity. Results show that machine learning models provide only marginal improvements over linear regression in overall prediction accuracy. Random forest achieves the lowest root mean squared error (RMSE) for

both TMAX and TMIN; however, it underperforms in extreme temperature conditions relative to simpler models. Seasonal analysis reveals higher prediction errors during winter months compared to summer. These findings highlight the strong autocorrelation structure of temperature data and suggest that increased model complexity does not necessarily yield substantial predictive gains, particularly under non-stationary climatic conditions.

[B5] Performance Gaps Between Machine Learning and Process-Based Models for Urban Turbulent Heat Flux Predictions (Across Global Cities) | *Yu Ding, University of Oklahoma*

Urban turbulent heat fluxes are fundamental to urban energy balance and boundary-layer processes. However, accurately predicting sensible and latent heat fluxes remains challenging across cities with diverse climates and urban forms. Here, we evaluate five machine learning (ML) models, Ridge regression, Random Forest, XGBoost, LightGBM, and Support Vector Regression, for predicting turbulent heat fluxes using meteorological data from 21 urban flux tower sites in the Urban-PLUMBER project. Their performance is then compared against simulations from a process-based, vegetated urban canopy model implemented within the High-Resolution Land Data Assimilation System (HRLDAS). All ML models successfully reproduce observed turbulent heat fluxes across global sites, although performance slightly varies among algorithms. LightGBM provides the most consistent and accurate predictions across sites. On average, ML models outperform the process-based model, with the largest improvements occurring during high-flux conditions (>90th percentile). In contrast, process-based simulations can outperform ML models under low-flux conditions (<10th percentile).The performance advantage of ML further increases with impervious fraction, suggesting that data-driven approaches are particularly more effective in dense urban environments. These results demonstrate the potential of ML for urban flux prediction while revealing systematic dependencies of model performance on flux regime and urban form. The findings also provide guidance for selecting and integrating data-driven and process-based approaches for future urban modeling efforts.

[B6] Garlic Breeding: Saving and Creating Diversity | *Eric Cassetta, Montana State University*

Garlic is a globally important vegetable crop, yet production relies on a tiny genetic base. Most of the garlic grown worldwide is just two very closely related commercial varieties, creating a vulnerability similar to the genetic uniformity that contributed to the Irish potato famine. As climate change accelerates shifts in temperature, precipitation, and pathogen pressure, this lack of diversity threatens the long-term resilience of garlic production. My research focuses on rebuilding and widening garlic's genetic diversity through breeding. Although garlic is exclusively clonally propagated and widely assumed to be sterile, past work has identified fertile individuals capable of producing true garlic seed. Sexual reproduction enables recombination, expands genetic variation, and provides a pathway to develop cultivars adapted to new climate stresses. This project will integrate diverse garlic cultivars with known fertile accessions to initiate a breeding program that will expand garlic's adaptive capacity. By preserving and recombining genetic diversity within garlic, this work contributes to climate-resilient agriculture and reduces the risk of catastrophic crop failure in a changing world.

[B7] Decolonial Climate Education: Uplifting Indigenous Knowledges from the Amazon | *Maria Albuquerque, Simon Fraser University*

Amid escalating climate change and its profound impacts in the Global South, efforts to mitigate and adapt are urgent, with climate education (formal and informal) serving as a key mechanism for understanding causes and effects and fostering solutions. However, climate education without a decolonial lens risks excluding non-dominant narratives and knowledges from the debate while not acknowledging the historical contexts of colonialism and its ongoing contribution to greenhouse gas emissions. Despite the ongoing threats of extractive expansion in Brazil, Indigenous communities have preserved 98% of the native vegetation within their legally recognized territories, playing a pivotal role in maintaining climate stability. This paper represents the first phase of my research, where I explore currents of decolonial climate education, highlighting the importance of Indigenous and Quilombola knowledges from Latin America, particularly from Brazil, and their role in informing climate solutions. I argue that centering these perspectives, such

as kinship, confluence, and compartilhamento in climate learning, are critical for reimagining transformative futures. My research examines how these perspectives and knowledge can inform and be intertwined with current mainstream approaches to climate education and communication, also in North America, fostering climate justice. This research is a step toward new pathways to decolonial studies, not only in climate education but also in climate research, collaborating with current efforts in climate adaptation and resilience. In my presentation, I discuss these perspectives and outline the next steps of my community-engaged and participatory action research with the Dessana, an Indigenous community in the Amazon region.

[B8] Climate Risk, Environmental Data, and Community Priorities in Tribal Nations | *Zane Smith, University of Oklahoma*

Climate change and environmental variability produce uneven risks across communities, shaped not only by physical hazards such as extreme weather, water stress, and air quality, but also by differences in infrastructure, monitoring capacity, and resources. This project examines these intersecting climate and environmental risks for Tribal communities across the United States with particular focus on New Mexico and Oklahoma. The study asks: how do air-, water-, and land-related concerns vary across communities, and how do those concerns compare with available environmental observations and monitoring coverage? To address these questions, the project integrates geospatial analysis, environmental observation networks, and multi-wave survey data. Weather, streamflow, and air quality monitoring stations are mapped relative to Tribal boundaries to assess spatial coverage, gaps, and access to environmental information. Survey data from MSIS-Net in Oklahoma are analyzed to evaluate patterns in climatologically related concern, particularly amongst those who self-identify as American Indian or Alaska Native. This combined approach links environmental monitoring capacity with community perceptions of climate-related risk. Preliminary results suggest meaningful spatial variation in both environmental monitoring coverage and reported environmental concerns. Rather than treating these patterns as directly causal, this project uses them together to identify where environmental data, community priorities, and planning needs may overlap. Work from this project is

presently being leveraged by a Tribal Nation to support improved monitoring of locations of cultural significance. Anticipated outcomes include maps, summary statistics, and visualization tools that can support environmental management, climate adaptation planning, and more place-based approaches to resilience for tribal communities.

[B9] Renewing Hydrosocial Relations through Data Sensemaking | *Amelia Dogan, University of Washington*

Water in the past year in Washington State has caused statewide evacuations from flooding and a statewide drought declaration. These extremes, exacerbated by climate change, impact frontline communities first and worst. Through a series of participatory workshops with 40 community members in Washington State, we explore how community members use lived experience and water quality sensors to tell stories of water justice. This includes the community's relationships with water captured through photovoice, as well as the exploration of cultural narratives around water through popular education. Through surveys and follow-up interviews, we demonstrate that community members experienced an increase in their sense of agency, community, and self-efficacy. We also seek to contextualize how community-based research can fit into broader community efforts to address water justice through engagement with government agencies and other partners.

[B11] Reconstructing Deep Ocean Circulation in the Eastern North Atlantic Since the Last Glacial Maximum | *Apollonia Arellano, Columbia University*

As Atlantic Meridional Overturning Circulation (AMOC) plays a vital role in regulating climate, it is imperative to gain a deeper understanding of this system of ocean currents. More specifically, questions about the geometry of AMOC remain unanswered. Intra-basin variability in North Atlantic paleocirculation records has been observed; however, it is unclear whether different sources of Glacial North Atlantic Intermediate Water or different overturning depths caused this variability. Reconstructing deep ocean circulation in the eastern North Atlantic using an assortment of geochemical proxies can provide insight into the future state of AMOC and the evolution of its geometry. Here we present records of benthic

foraminiferal δ18O and δ13C, and sedimentary 231Pa/230Th from IODP expedition 397, site 1586. The optimal location and depth of this site allow for a meaningful comparison to available paleocirculation records to determine whether AMOC strength varies zonally or with depth. We find that the benthic δ13C, export of 231Pa, and inferred strength of AMOC generally increased from the LGM to the Holocene, with significant decreases during Heinrich events 1 and 2. Additionally, the 231Pa/230Th record at this deep site in the eastern basin was found to vary in a similar pattern as that of a western site of a comparable depth, more closely than that of a shallower, proximal site. This indicates that depth differences are more of a determining factor than zonal differences in establishing AMOC strength, revealing that different overturning depths likely influenced the variability observed between eastern and western Atlantic paleocirculation records.

[B12] Can the Arctic Ocean still form dense water under global warming? | *Carlo Mans, University of Bergen*

The Arctic meridional overturning circulation (ArMOC) transforms inflowing Atlantic Water into dense water masses that feed the lower limb of the Atlantic overturning. The Arctic climate is, however, rapidly changing, and it is not known whether the Arctic Ocean will continue to form dense water as it warms, loses sea ice and freshens. Here, we track Atlantic Water entering the Arctic through Fram Strait and the Barents Sea Opening with offline Lagrangian trajectories in HadGEM3-GC3.1-MM from 1850 to 2100 under SSP5-8.5. We define dense water both by a fixed density threshold and relative to the overturning density, diagnosed each year from the pan-Arctic overturning streamfunction across the four major gateways. In the historical period, the Barents Sea branch dominated dense water formation. Its variability is set by inflow volume and salinity and by cold, ice-producing Barents winters, whereas the Fram Strait branch is almost entirely governed by inflow volume. Under warming, the formation of water denser than σ0 = 27.8 kg m−3 largely ceases, yet water mass transformation continues and produces a lighter lower limb. The Barents Sea inflow freshens strongly, and a smaller fraction of it is transformed into the lower limb. Atlantic Water entering through Fram Strait instead cools more strongly and increasingly reaches the Barents shelf, where it is transformed. In the late 21st century, the Fram Strait

branch overtakes the Barents Sea branch as the dominant source of the ArMOC lower limb. The Arctic Ocean thus continues to overturn under strong warming, but no longer produces dense water in the traditional sense, and the relative roles of the Fram Strait and Barents Sea branches may reverse.

[B13] How Do Future Changes in the Amundsen Sea Low Influence West Antarctic Coastal Winds? | *Sophia Ludtke, University of Washington*

The West Antarctic Ice Sheet (WAIS) has been losing mass at an accelerated rate over the past two decades. A definitive anthropogenic attribution statement linking human forcing to mass loss in the Amundsen Sea region of Antarctica, however, has yet to be made. An interconnected chain of processes links greenhouse-gas emissions to (1) high-latitude atmospheric circulation, (2) the intrusion of warm, wind-driven modified circumpolar deep water (CDW), and ultimately (3) ice-shelf retreat. This project investigates Process 1, using both forced and unforced (control) simulations from the CMIP6 archives to isolate and evaluate anthropogenic signals in Amundsen Sea atmospheric dynamics. Specifically, we quantify (i) changes in the magnitude (pressure minimum) and location of the Amundsen Sea Low (ASL) pressure system and (ii) regional wind-stress anomalies that modulate CDW transport pathways. By comparing trends in these metrics across forced and unforced model experiments, we aim to distinguish an externally forced circulation change signal from internal variability. Using a statistical detection and attribution framework, we will establish whether future shifts in the ASL and associated wind patterns exceed the range of natural variability. In doing so, we will clarify the mechanism by which atmospheric forcing drives ocean heat delivery to the West Antarctic, while strengthening the basis for statements linking human forcing to WAIS melt and resultant sea level rise.

[B14] Wave-Tide-Surge Interactions in an Idealized Estuary Shelf System | *Malavika Sudhakaran, University of Maine*

Coastal communities experience growing flood risk from sea level rise, intensifying storms, and changing river discharge patterns under climate change. Estuaries are especially vulnerable, since flooding here results from the combined effects of

tides, storm surge, and waves interacting with one another. Despite this vulnerability, few studies have examined how these forces interact in estuaries with complex shapes and strong river influence, limiting our ability to predict future flood risk in such systems. This study uses a coupled numerical model (Delft3D, combining a hydrodynamic flow module with the SWAN wave model) to investigate wave-tide-surge interactions in an idealized estuary representative of the Kennebec River Estuary, Maine. The domain includes a 20 km, shallow (5 m) estuary connected to a 100 km continental shelf, with a high-resolution grid (25 m in the estuary, 80 m on the shelf) capturing both nearshore and offshore processes. The Kennebec River Estuary is an ideal natural laboratory, combining a wave-exposed barrier beach, tide-dominated marshes and tidal flats, and steep transitions from deep to shallow water, features shared by many mixed-energy estuaries worldwide. Using an idealized setup makes these findings broadly applicable to similar systems facing increasing climate-driven coastal hazards. Preliminary results will examine how tidal currents modify wave heights, how wave-driven forces affect tidal propagation, and how these interactions influence storm surge and total water levels during extreme events. Understanding these interactions is a critical step toward improving coastal flood predictions, a key adaptation strategy for vulnerable estuarine and coastal communities worldwide.

[B15] Divergence in Marsh Elevation Deficits Along the U.S. Atlantic Coast | *Md Asif Hasan, Tulane University*

Marshes along the U.S. Atlantic Coast provide essential ecosystem services but face increasing pressure from accelerating sea-level rise. Assessing their capacity to maintain elevation relative to rising seas requires disentangling surface elevation dynamics from regional sea-level forcing. Here, we synthesize surface elevation table (SET) observations from marsh sites with GNSS-derived vertical land motion corrections and geocentric sea-level rise (SLR) estimates from satellite altimetry to evaluate elevation deficits across the Atlantic seaboard. Corrected surface elevation change (SEC) averages 8.0 ± 7.5 mm yr^{-1}, while regional geocentric SLR averages 3.5 ± 0.9 mm yr^{-1}. More than half of all sites (53%) exhibit an elevation deficit (SEC < SLR), demonstrating widespread vulnerability even after removing deep land motion effects. Strong spatial contrasts emerge when evaluated by region. In the

North Atlantic (Massachusetts to Connecticut), 76% of sites exhibit an elevation surplus, likely supported by their dominant organic nature, lower shallow subsidence, and higher tidal ranges. The South Atlantic (North Carolina to Florida) shows nearly opposite conditions, with only 10% of sites maintaining an elevation surplus against regional forcing. The Mid-Atlantic (New York to Virginia) displays the broadest overlap in trends; 61% of sites in this zone fall behind or struggle to keep pace with sea-level rise as they grapple with the region's variable subsidence and sediment accretion. A sharp gradient in elevation response is observed near Cape Hatteras (~35.2°N), which coincides with a transition from the high-surplus regime of the North Atlantic to the deficit-dominated South Atlantic.

[B16] Satellite Sea Ice Concentration Observation Uncertainty Is State-Dependent and Varies Seasonally | *Joey Rotondo, University of Washington*

Earth system data assimilation systems commonly assimilate satellite retrievals of sea ice concentration (SIC). How much weight each retrieval receives relative to the model is set by its observation uncertainty, which is poorly constrained and is almost always prescribed as a constant, typically 0.10 to 0.15. We instead measure this uncertainty from the assimilation system itself. An iterated Desroziers diagnostic, computed in a bounded framework that keeps SIC between 0 and 1, gives the observation uncertainty for two passive microwave products and one optical product in both hemispheres. That uncertainty is far from constant: for passive microwaves it is near zero to 0.1 for a retrieval of open water (0) or complete cover (1) and 0.12 to 0.15 for a retrieval of one half. A limitation of Desrozier's diagnostic emerges under complete cover in the melt season; the model rarely simulates this condition and thus the method cannot constrain the bounded uncertainty properly. A similar uncertainty curve emerges from three collocated satellite products, with no model involved, and from the uncertainty one product publishes with its retrievals, which is biased high. Most of the uncertainty is not instrument noise; its pattern is consistent with known passive microwave retrieval errors over thin and ponded ice. A constant error prescription therefore often gives mid-range retrievals too much weight and often retrievals near 0 and 1 too little.

[B17] Extensive tree mortality across forested wetlands in the coastal US | *Henry Chi Hang Yeung, University of Virginia*

Forested wetlands are carbon-dense ecosystems providing critical services–including storm protection, water filtration, and timber–to millions of people living in vulnerable coastal regions. However, rising water tables, salinization, and extreme weather are accelerating tree mortality across these habitats. Surprisingly, some mortality hotspots were found in areas beyond sea-level rise hotspots and in high-elevation wetlands. Yet, the heterogeneity of coastal landscapes makes it difficult to determine the 'true' extent, pace and drivers of the die-off pattern. Here, we present a deep learning–based approach for tracking individual tree mortality biennially between 2010 and 2023 using sub-meter aerial imagery across the coastal United States, spanning the Atlantic, Gulf, and Pacific coasts, as well as the Great Lakes region. By tracking over 200 million individual tree mortalities over the past decade, we identified many mortality hotspots not captured by traditional remote sensing approaches or surveys, revealing substantial mortality in forested wetlands across a diverse elevation range (0 to > 50 m). This approach offers a scalable framework for identifying emerging mortality hotspots and understanding how climate and hydrological stressors are reshaping forest resilience. Such insight is crucial for informing adaptive coastal management and anticipating ecosystem transformation under accelerating climate change.

[B18] Forest management results in divergent taxonomic and trait composition in shrub communities of a dry coniferous forest | *Jarrett Dalia, Washington State University*

Forest persistence is currently being threatened by the compounding effects of climate change and fire exclusion history. Forest management treatments, including thinning and prescribed burning, are widely implemented to promote forest resilience to rapid environmental change. While the impacts of prescribed fire on understory communities have been characterized, the effects beyond taxonomic composition are poorly understood. Management treatments are expected to directly alter plant composition; however, whether taxonomic and trait composition show synchronous responses remains a question. We proposed a

trait-based approach to address this knowledge gap, including information on shrub communities at Priest River Experimental Forest (PREF), a dry coniferous forest in northern Idaho. In 1987, the Forest Service applied alternative combinations of thinning treatments that were later burned in the Spring and Fall of 1989, creating a replicated series of temporally distinct prescribed burn treatment groups (spring, fall, control), and thinned stands (80 and 40 remaining basal area). We found that both taxonomic and trait community composition showed similar responses to fire treatments, where fall burns in heavy thinning stands resulted in more compositional dissimilarity. Divergence in community composition was explained by high species turnover and richness differences as well as changes in species rank. Any divergence in community composition is likely to impact the resilience and resistance of managed forests to rapid climate change.

[B19] A New Frontier in Drought-Induced Tree Mortality Research: How the Anatomy of a Tree Can Inform Climate Smart Forest Management | *Cameron Dow, West Virginia University*

Forests are one of the largest terrestrial carbon sinks on the planet. Unfortunately, tree mortality rates are expected to rise as climate change intensifies, increasing the frequency and intensity of drought. Models of future tree mortality rates are likely woefully under-predicting the climate change-induced increase in mortality rates across the eastern USA because mortality events in the western USA dominate the literature, and are used to parameterize such models. However, the mechanism of mortality differs greatly between eastern and western forests, resulting in incorrect predictions across the east. The fundamental mechanisms which induce tree mortality during drought are not fully understood, but it is widely accepted that hydraulic failure resulting from embolism of water-conducting tissue greatly contributes. Past studies of tree mortality have neglected to examine the role that the anatomy of the water-conducting xylem tissue plays in determining which individual tree will die following drought. We examined a recent drought-induced mortality event in the eastern USA using a quantitative wood anatomy framework to determine if xylem vessel size could explain individual mortality risk post-drought. Building on these results, we then examined how a typical forest management prescription, forest thinning, may be used to build more

climate resilient forests in the eastern USA. Our results showcase the role of xylem anatomy on individual tree mortality, offer insight into how we can manage to reduce future mortality risk in the face of climate change, and greatly add to our understanding of tree mortality in the Eastern USA.

[B20] Post-Wildfire Hydrological Recovery in a Changing Climate: Implications for Downstream Water Security in the Northern Rockies and Pacific Northwest | *Jack Boyle, University of Virginia*

Wildfire is devastating. Communities which suffer through the flames are nowhere close to recovering after the smoke dissipates; the fire leaves scars that harm the landscape for decades to come. Across the Northern Rockies and Pacific Northwest, snowpack has collapsed to levels unseen in 40 years. The wildfires coming this summer will not just burn landscapes; they will compromise the freshwater that communities depend on. Forested watersheds are the primary source of clean drinking water for millions of Americans, yet wildfire fundamentally disrupts the hydrological processes that make this possible. Using remote sensing estimates of evapotranspiration (ET) and post-fire forest loss, our research demonstrates that watershed recovery following wildfire is governed primarily by the rate at which ET recovers—a process that takes decades in many catchments, and in some cases never fully occurs. Rising vapor pressure deficit under projected climate scenarios further suppresses vegetation recovery, prolonging hydrological vulnerability and extending periods of elevated streamflow, flood risk, and pollutant transport to downstream waters. Yet the consequences for communities within the wildland-urban interface remain poorly quantified. To address this gap, we employ the ecohydrological model EcH_2O to simulate post-fire restoration scenarios, evaluating the capacity of targeted revegetation to accelerate ET recovery, attenuate extreme streamflow, and promote watershed retention of nitrogen and phosphorus, reducing eutrophication risk before nutrients reach the riparian zone. As wildfire seasons grow longer and more severe, this research offers actionable guidance for the land and water managers on the front lines of protecting freshwater security after fire.

[B21] Climate-Driven Shifts in Soil Hydraulic Properties Across Long-Term Warming

Experiments | *Kerry Mundy, Rutgers University*

Average temperatures across the US are projected to rise 3–6°C by 2100 under continued greenhouse gas emissions, altering soil moisture dynamics, with implications for drought frequency and intensified hydrologic events. Soil plays a critical role in buffering these impacts by regulating water storage and movement; however, links between warming-induced structural changes and hydraulic function remain poorly constrained. Field-based climate manipulation experiments provide an ideal framework to investigate how warming alters soil structure and water movement across ecosystems. In this study, measurements were conducted at warming experiments in MA (Harvard Forest, HF), PR (TRACE), and MN (B4WarmED at Hubachek and Cloquet). Sites differ in warming method, magnitude (+1.4°C to +5°C), and duration (8-35 years). Infiltration rates were measured under varying tensions (-15 to -1 cm), transmitting water through different pore sizes. Analyses of soil aggregation, particle-size distribution, and water repellency were conducted on control and warmed samples, linking hydraulic responses to changes in soil structure. At HF, warming reduced infiltration ~58%, aggregate stability ~5%, mean aggregate diameter ~11%, and hydrophobicity index ~11%. In contrast, B4WarmED showed increased infiltration ~93% under high warming (+3.4°C at Hubachek) and ~11% under moderate warming (+1.7°C at Cloquet). These increases were accompanied by ~40% greater coarse sand fractions (250–2000 μm) at Hubachek and ~20% at Cloquet relative to controls. TRACE exhibited weaker, variable responses. Together, results indicate that warming effects on soil hydraulic function are mediated by changes in soil structure, highlighting the need to better represent these dynamics in climate and ecosystem models.

[B22] Multi-Mode Madden-Julian Oscillation in the CESM2 Large Ensemble Community Project | *Prem Rao, University of Wisconsin-Madison*

The Madden-Julian Oscillation (MJO) drives variability at intraseasonal time scales, impacting both the tropics and mid-latitudes. The MJO has been difficult to model in Global Climate Models (GCMs), with progress made in the Community Earth System Model 2 (CESM2). Recent work has shown the importance of two non-orthogonal modes, obtained through a linear inverse model (LIM), in fully capturing MJO variability. In this study, we use a LIM to investigate the representation of these two

modes in the CESM2 Large Ensemble Community Project (LENS2). We quantify the biases in spatial pattern, frequency, and damping time scales, and use the large ensemble to diagnose internal variability. We also investigate changes to the MJO modes in a warming climate.

[B23] Long-Term Impact of Drought on Stream Geochemistry in Urban, Agricultural, and Forested Watersheds, Ohio | *Emerald Goldbaum, The Ohio State University*

Due to climate change, short-term droughts have become more frequent in the midwestern United States. During drought events, nutrients can accumulate in soils instead of being washed downstream by runoff. When post-drought precipitation occurs, nutrient and ion concentrations spike in draining streams. Currently, it is unclear how the trajectory of this pulse differs depending on the watershed's physical characteristics (i.e. land-use history, vegetation extent, soil tillage). To assess which characteristics are most influential in a stream's chemical resilience to drought, we will analyze 36 years (1975-2011) of water quality data (pH, major ions) from nine streams of different land-uses at the North Appalachian Experimental Watershed in Coshocton, Ohio. We will create a timeline of each stream's pre- and post-drought nutrient and ion concentrations over that time period, and use this information to create a random forest model that predicts how streams will chemically react to drought events. The model will be validated using summer 2026 dry season water chemistry data from an urban stream, Adena Brook, in Columbus, Ohio. We expect flow in altered urban and agricultural watersheds to experience flashier increases in solute concentrations than forested watersheds. As droughts become more frequent and severe in the Midwest, understanding the factors contributing to chemical stability in streams, and how they vary by region and land-use, can aid agricultural communities in environmental remediation efforts. These results can inform future water quality protection measures in Ohio and beyond, providing a framework to better understand chemical evolution of streams undergoing drought.

[B24] Assessing the Influence of Climate Variability on Arsenic Occurrence in Ohio Groundwater | *Mst Proma Sultana Borsha, University of Dayton*

Arsenic contamination in groundwater has been widely reported across many parts of the northern United States. Understanding the sources and mobilization of arsenic is challenging because of the region's complex geology. Climate change may further influence arsenic mobility by altering precipitation patterns, temperature, and hydrological conditions. Changes in precipitation can affect groundwater recharge, which may alter redox conditions and therefore affect arsenic mobilization in aquifer systems. Factors such as redox conditions, pH, aquifer lithology, and groundwater chemistry control arsenic concentrations in groundwater. In Ohio, approximately 42% of the population relies on groundwater as a drinking water source. Long-term exposure to arsenic-contaminated groundwater can increase the risk of cancer, cardiovascular disease, diabetes, and neurological disorders. Therefore, understanding the factors that influence arsenic occurrence is critical for protecting public health and managing water resources. This study examines the relationship between climate variability and arsenic contamination in Ohio. Precipitation and temperature data from 1980 to 2025 are analyzed to identify climate trends and evaluate their effects on groundwater conditions. Groundwater quality data are obtained from the Ohio Environmental Protection Agency's Ambient Groundwater Monitoring Network. Geographic Information Systems are used to map the distribution of arsenic-contaminated wells in relation to groundwater recharge rates and hydrogeologic characteristics. By linking climate trends, recharge patterns, and groundwater quality, this research seeks to improve understanding of how climate variability may influence arsenic occurrence in Ohio. The findings can support groundwater monitoring, risk assessment, and adaptive water resource management under current and future climate conditions.

[B25] Exploring future spatial patterns and trends of sea surface salinity using multi-model large ensemble simulations | *Dora Shlosberg, University of Colorado Boulder*

Sea surface salinity (SSS) is a widely-used indicator of the hydrologic cycle, as the surface ocean is at the interface of atmospheric and oceanic freshwater fluxes. Since the mid-20th century, the hydrologic cycle has broadly intensified, characterized as "wet get wetter, dry get drier", resulting from increased

greenhouse gas (GHG) concentrations and global warming. Meanwhile, impacts of human-emitted aerosols on the hydrologic cycle vary based on spatial distribution and concentration, opposing the GHG pattern in some places while reinforcing it in others. Understanding future changes in the hydrologic cycle and how they relate to the past can provide crucial information to coastal and island nations adapting to water resource changes. While SSS provides insights into the hydrologic cycle, its observational record is relatively short. Here we use 6 single-model initial-condition large ensemble experiments to investigate changes in SSS, evaporation (E) and precipitation (P) from 1950-2024 and 2025-2100. To glean aerosol and GHG contributions separately, we examine two different future emission scenarios within MPI and UKESM and look at single-forcing experiments from the CESM models. We quantify how representative historical SSS changes are of future trends using pattern correlations between the two periods. Across the 6 models, mean pattern correlations over the ensemble members range from 0.200-0.499. Regional analysis suggests that the North Atlantic has relatively high pattern correlations, while the Indo-Pacific exhibits more variability. The relationship between E-P and SSS is weakest in the South Atlantic, suggesting SSS changes there are dominated by ocean circulation over atmospheric fluxes.

[B26] Diagnosing Long-Term Aridity Across Atmospheric, Land-Surface, and Biosphere Domains | *Stella Potemkin, Dartmouth College*

As the climate warms, some regions are drying, manifesting as a tendency toward greater drought risks and a reduction in water availability. And yet such long-term drying can be difficult to diagnose, in part owing to the varied aridity metrics in the atmosphere, biosphere, and land surface. At the same time, there are fundamental questions of whether aridity trends manifest as a function of drought changes, or vice versa, intimating a fundamental gap in our theories linking short- and long-term hydroclimate variability under a changing climate. As a first step in a larger intervention along these lines, we build an observational ensemble of in situ, remotely sensed, and reanalysis data, to reconcile the diverse measures of aridity applied to each of these domains—the atmosphere, biosphere, and land surface. Using transparent empirical approaches, we show where these diverse aridity measures across domains are consilient or decoupled from long term trends

indicators of water availability on the land, such as soil moisture, surface runoff, and vegetation greenness. Our findings serve as an important observational foundation to more formally attribute the mechanisms driving divergence in long-term hydroclimate trends, in particular, their linkage to anthropogenic forcing. These results also carry potential value for informing long-term, capital-intensive adaptation investments that may need to be taken by decision makers like farmers, water managers, and drought monitoring agencies navigating changes in expected average water availability.

[B27] The Role of Environmental Sustainability in Mitigating the Impact of Climate Shocks on Economic Performance | *Zunaira Amin, University of Huddersfield*

Climate-related shocks increasingly affect macro-economic performance across countries by reducing economic productivity, risking human health, and lowering the ecosystem resilience of countries. This study examines whether environmental sustainability practices mitigate the adverse effects of climate shocks on economic performance across countries with different resilience capacities. Using panel data for 140 countries over the period 2000–2021 and employing a dynamic system GMM estimator, we analyse the direct and moderating effects of climate shocks and environmental sustainability on economic performance. The results show that the composite climate index capturing temperature, precipitation, and humidity extremes has a consistently negative and statistically significant effect on economic performance across all resilience groups. The findings further reveal substantial heterogeneity in the effects of individual climate shocks: humidity shocks are most pronounced in high-resilience countries, whereas precipitation shocks are strongest in medium resilience countries, while temperature shocks mainly affect low resilience countries. Additionally, our study highlights that the moderating effect of ESI mitigates the adverse impact of climate shocks on economic performance, however the magnitude of this mitigation effect varies systematically across resilience levels and depends on the severity of specific shocks. Overall, the findings highlight the importance of integrating environmental sustainability strategies to strengthen macro-economic stability in tackling the climate crisis.

[B28] The value of snow to water availability | *Madeleine Burns, Dartmouth College*

Seasonal snow is an essential component of the hydrologic cycle in the Northern Hemisphere, directly supplying over 2 billion people with water. However, the unique contributions of snow to streamflow remain poorly understood, limiting our ability to quantify the consequences of present-day snow droughts and predict future water availability. Previous research characterizes mountain snowpacks as “water towers” that store water during the winter, release a concentrated pulse of snowmelt in the spring and, through these mechanisms, supply rivers and streams more efficiently than rain. Yet these studies produce mixed conclusions across scales: some demonstrate that less snow corresponds to less streamflow, while others show streamflow remains constant or even increases. These contradictory findings suggest the mechanisms that govern the unique role of snow (relative to an equivalent amount of rain) remain unknown. Here, we hypothesize that the energetic properties of snow – including its high albedo (reflectivity), role as an energy sink during melt, and synchronicity with the seasonal solar radiation cycle – govern the snow-streamflow relationship. We employ causal inference methods and historical observations to quantify the relationship between the energetic properties of snow and streamflow across 169 snow-dominated watersheds in the Northern Hemisphere. Using climate model projections from CMIP6, we apply our derived relationship to predict the impacts of future snow loss on water availability. Our work provides a comprehensive assessment of streamflow changes in a low-snow future, providing a foundation for predicting and ultimately adapting to these changes and their socioeconomic and ecological impacts.

[B29] Aerosol Optical Properties of Wildfire Smoke Transported to the Southern Great Plains of the U.S. | *Hayden Webb, University of Oklahoma*

With climate change increasing the risk of wildfires, smoke exposure is a growing health concern. Wildfires emit large quantities of combustion aerosols, which have intense local effects and can be transported thousands of miles. While previous work has studied smoke's physical and chemical properties, changes in properties during long-range transport have been less examined. This is despite transport and aging effects being poorly represented in many atmospheric models. Our investigation aims to improve understanding of aerosol physical properties, including aerosol optical depth (AOD), extinction Ångström exponent (EAE), single

scattering albedo (SSA), and absorption Ångström exponent (AAE) in the Southern Great Plains. A total of twenty-seven smoke events between 2015 and 2022 were identified using a combination of MODIS Deep Blue maps, AERONET data, and HYSPLIT back trajectories. Comparisons of AERONET observations across sites indicated long-range transport, with AOD, EAE, and SSA decreasing and AAE increasing during transport to Oklahoma. Mean AOD decreased during transport by ~0.21, ~0.38, ~1.69, ~1.43, and ~0.1, while mean EAE decreased by ~0.14, ~0.2, ~0.24, ~0.17, and ~0.19 for zero (<24 hours) through four-day transport time, respectively. Mean SSA decreased by ~0.02, ~0.02, <0.01, ~0.02, and ~0.01, while mean AAE increased by ~1.26, ~0.16, ~0.04, ~0.34, and ~0.32. While lower arrival height may correspond with shorter transport times, underlying synoptic-scale wind patterns appear to be the primary determinant of the plume path. Our findings highlight the need for further research on how meteorology and fuel type influence smoke aerosol optical properties and their evolution during transport.

Session C

[C1] PM2.5 Modeling for Underobserved Areas | *Jeffrey Lee, University of Oklahoma*

The increasing contribution of natural aerosol emissions, coupled with variability in anthropogenic sources, has intensified the need for robust methods to model the spatiotemporal distribution of atmospheric particulate matter. Chemical transport models (CTMs), such as CMAQ, remain the primary tool for this task but exhibit persistent biases in reproducing surface-level PM2.5 concentrations. In this study, we present a data-driven framework for estimating historical PM2.5 distributions that integrates satellite retrievals with statistical modeling. The approach first applies a deep learning-based gap-filling method to satellite-derived aerosol optical depth (AOD) (Lee et al., 2025) to address missingness and improve spatial continuity. The reconstructed AOD fields are then combined with meteorological and land-use predictors within a statistical data-fusion model to infer surface-level PM2.5 concentrations. Preliminary results indicate that this workflow produces spatially coherent and physically plausible PM2.5 fields, capturing fine-scale structure that is often underrepresented in traditional CTM outputs. These findings suggest that hybrid, data-driven approaches offer a viable complement to

process-based models for retrospective air quality estimation, particularly for areas with limited monitors and emissions inventories needed for traditional models.

[C2] Developing a Deep Learning Approach for Downscaling Arctic Sea Ice Thickness using MESACLIP | *Sky Gale, University of Washington*

High-resolution Arctic sea ice thickness (SIT) is critical for community-based safety and prediction, but coarse CESM output hinders this, particularly along coastlines. Here, we develop a physically informed deep learning network to downscale SIT from coarse-resolution using a residual super-resolution approach that preserves large-scale structure while learning subgrid-scale variability. CNN and U-Net architectures both substantially outperform baseline bilinear interpolation, improving spatial coherence and representation of ice edges. However, the deep learning deterministic models smooth fine-scale features, including narrow leads and sharp coastlines. This highlights a fundamental limitation of deterministic downscaling and motivates our shift toward an ensemble, diffusion-based framework that captures uncertainty and fine-scale variability. Ongoing work focuses on fine-tuning an ensemble, diffusion-based framework to generate physically consistent, high-resolution SIT fields for CESM applications.

[C3] How the Land Reflects: Physics-Informed Machine Learning for Global Land Surface Albedo Parameterization | *Akarsh Ralhan, University of Maryland, College Park*

The amount of sunlight reflected by Earth's land surface, its albedo, is a fundamental control on global climate. By determining how much solar energy is absorbed versus reflected, albedo governs surface temperature, soil moisture, and the exchange of heat and water vapor between the land and atmosphere. Errors in albedo as small as 0.02–0.05 can produce substantial biases in surface energy budgets, cascading into errors in temperature, precipitation, and atmospheric circulation in climate model simulations. Despite this importance, most models rely on static lookup tables or simple empirical formulas to represent albedo, yet they fail to capture how albedo varies across seasons, landscapes, or changing sunlight conditions. This study develops a new global albedo parameterization that

addresses these limitations by leveraging two decades of satellite observations and a physical understanding of land-surface processes. An ensemble of machine learning models, trained separately for 15 land cover types, predicts how albedo responds to vegetation state, soil moisture, solar angle, topography, and climate across the globe. A spatially explicit statistical correction accounts for fine-scale surface variability that no global model can directly resolve. Together, these components achieve strong agreement with satellite-observed albedo (R^2 = 0.88, mean error 7.5%) across diverse ecosystems, including forests, grasslands, croplands, and challenging desert regions where existing methods fail. The result is a physically grounded, scalable tool ready for integration into Earth system models, improving how climate models represent the land surface and, in turn, how reliably they simulate climate across regional to global scales.

[C4] Environment-Aware Machine Learning Ensemble Estimation for Capturing Crop Water Demand Across Climatic Gradients and Management Systems in the Conterminous U.S. | *Rajsree Das Tuli, University of Oklahoma*

Evapotranspiration (ET) is the primary mechanism through which terrestrial ecosystems, including croplands, respond to shifting climatic conditions. As precipitation variability intensifies and atmospheric demand rises under climate change, accurately capturing how crop water use changes across diverse hydroclimatic settings and management systems becomes increasingly critical for food security and water resource planning. Existing satellite-based ET models rely on different biophysical constraints, making each model more accurate under specific environmental conditions. Conventional ensemble methods assign fixed weights across all conditions, failing to capture how model performance shifts with changing environment and land surface states. This study develops an intelligent ML-based ensemble ET framework that dynamically integrates six OpenET models (geeSEBAL, PT-JPL, SSEBop, SIMS, eeMETRIC, DisALEXI) across 59 flux tower at crop sites spanning diverse climatic zones of the contiguous United States. Six ML classifiers learn which model best captures observed ET under prevailing environmental gradient and vegetation conditions. Model probabilities then become dynamic weights, producing ensemble ET estimates that adapt to environmental variability rather than applying rigid assumptions. The framework is

evaluated under random and leave-one-site-out cross-validation strategies, ensuring generalizability across unseen climates and crop types. The six ML-based EEMs yielded test R2 within 0.85 to 0.87 and RMSE within 0.91 to 0.97 mm/day, outperforming the simple mean ensemble (R2=0.81, RMSE=1.08 mm/day) and individual OpenET models. SHAP analysis reveals that recent precipitation, water availability, VPD, and vegetation state are the dominant drivers of model selection, directly reflecting how changing climatic conditions shape ET estimation across varied crop types and management systems.

[C5] The Impact of Tropical Modes of Variability on Mesoscale Convective System-Associated Precipitation over CONUS | *Stella Heflin, University of Washington*

Mesoscale convective systems (MCSs) are defined as large thunderstorms containing both a convective and stratiform component and organized via deep convection. MCSs are an important precipitation phenomena over the continental United States (CONUS), where they are responsible for over 50% of annual precipitation in many regions, and have been linked with flooding and severe wind events. There is evidence that the frequency of other related convective phenomena, including tornadoes and lightning, are modulated over CONUS by teleconnections with tropical oscillatory modes such as El Nino Southern Oscillation (ENSO), the Madden Julian Oscillation (MJO), and the Boreal Summer Intraseasonal Oscillation (BSISO). However, this key source of potential predictability has not yet been studied in relation to MCSs. We address this knowledge gap by tracking MCSs in CONUS404 (1979-2021), a hydroclimate dataset created by initializing and nudging a 4-km high resolution weather model run with ECMWF reanalysis version 5 (ERA5) data. We combine this MCS dataset with ENSO, MJO, and BSISO phase data, calculated from brightness temperature, wind anomalies, and sea surface temperature using ERA5 and satellite data. Using a probability ratio metric, we determine the extent to which a given phase of an oscillation modulates MCS initialization frequency and MCS precipitation volume over each CONUS sub-region (Northern/Southern Great Plains, Midwest, Southeast, Northeast) and season. To validate these findings, we compare with results calculated similarly but using an observational MCSs dataset. The results of this work will help increase the predictability of MCS occurrence and MCS-associated precipitation over CONUS.

[C6] Investigating Tropical-Extratropical Interactions Associated with Convectively Coupled Equatorial Waves | *Jessica Davis, University of Oklahoma*

Equatorially trapped waves coupled with convection, called convectively coupled equatorial waves (CCEWs), are known to influence the variability of atmospheric circulation, convection, and associated cloud and precipitation dynamics in the tropics. However, there is a need to expand knowledge of the teleconnection influences CCEWs might have on the extratropics. It is known that other tropical phenomena, such as the Madden-Julian Oscillation, can have significant tropical to extratropical teleconnections. Yet, potential CCEW teleconnective influences on the extratropics have not been frequently studied. This is largely because compared to these other tropical phenomena, CCEWs do not persist in an area for as long, and thus have less time to generate teleconnections. This presentation will focus on understanding if there are notable tropical to extratropical teleconnections associated with CCEWs, and how these relationships might differ based on the location of CCEW, and El Niño–Southern Oscillation phase. In particular, we study whether equatorial Rossby, Kelvin, and mixed Rossby-gravity CCEW types have statistically significant geopotential height teleconnections globally. Through empirical orthogonal function and regression, compositing, and Monte Carlo Bootstrapping methods, we find that when the convectively coupled equatorial Rossby waves are present, geopotential heights in select areas of the extratropics are significantly different than the climatology. The preliminary findings of our research imply that Kelvin, and mixed Rossby-gravity CCEWs may not have as significant of an influence on the atmosphere beyond the tropics. This work demonstrates the importance of future studies in discovering the extent in which CCEWs may influence atmospheric dynamics and climate in the extratropics.

[C7] The Effects of Tropical-Extratropical Interactions on Central United States Snowfall in a Changing Climate | *Stephen Foskey, University of Oklahoma*

Snowstorms are impactful events that can cause loss of life and property damage, and they influence the hydrology of a region. Furthermore, snowstorms are increasing in intensity and decreasing in frequency in the Central United States,

likely due to increasing intensity of precipitation events and increasing temperatures associated with global climate change. Thus, some of the hazards associated with heavy snow could increase despite the climate warming overall. Preparing for these hazards more than a week in advance is difficult, as snowstorms are challenging to predict at long range. However, the El Niño-Southern Oscillation (ENSO) and Madden-Julian Oscillation (MJO) have been found to affect the frequency of snowfall in the Central US. The cool phase of ENSO, La Niña, is associated with an increase in snowfall in the Central US, and MJO-induced convection over the Maritime Continent is associated with an increase in snowstorm frequency in this region. In this work, we study these relationships and their trends over time, to determine if climate change is affecting these tropical-extratropical interactions. Furthermore, we consider the frequency and intensity of events, as well as event characteristics, such as maximum accumulation, mean accumulation, area covered, volume, and location of maximum accumulation. In this way, we can study snowstorms based on their characteristics that impact people and the natural environment. By determining if ENSO and the MJO will continue to have the same effects on snowfall, we seek to make forecasters and planners aware of possible future changes needed to long-range snowfall forecasts.

[C8] Quantifying Heatwaves: Exploring the Drivers of Heatwaves Across the Continental USA | *Calen Randall, University of California Davis*

The intensity, duration, and frequency of heatwaves globally continue to increase, necessitating a strong understanding of current and future heatwave impacts and dynamics. Despite our qualitative understanding of how heatwaves form, persist, and terminate, our quantitative understanding of the relative importance of heatwave drivers remains low, particularly in the continental USA (CONUS). This presentation focuses on bridging these heatwave driver quantification gaps and addresses the questions: (1) What is the relative importance of individual heatwave drivers regionally? (2) Do regional heatwave driver characteristics align with regions of similar heatwave characteristics? (3) Can climate dataset biases in heatwave metrics be explained through biases in their heatwave drivers? Three components directly impact the temperature of heatwaves, temperature advection (warming via

the wind blowing warmer air into a region), adiabatic components (warming via the compression of air as it descends to the surface), and diabatic components (Warming via incoming solar radiation, longwave radiation, and contributions from surface heat fluxes like latent and sensible heating). These components are influenced by high pressure synoptic systems referred to as “blocking highs” or “heat domes” and surface characteristics like dry soil moisture. To explore these questions, the three main components are quantified using ERA5 data and the temperature budget equation to identify large temperature anomaly contributions during the creation, termination, and persistence of heatwaves. Large differences in relative driver importance are found between the western, southeastern, and midwest CONUS and generally correspond to regions sharing unique heatwave characteristics.

[C9] Safe to play? Modeling Children's Heat Load and Safe Activity Levels in Schoolyards | *Kendra Rentz, Arizona State University*

Physical activity is essential for children’s well-being, yet increasingly hot conditions in schoolyards are rendering outdoor play potentially unsafe. Children are particularly vulnerable to high temperatures due to their physiological and behavioral characteristics (Vanos, 2015). Despite this vulnerability, limited child-specific heat modeling and district- or state-level guidance exist to inform when and where outdoor play is safe. To address this gap, we adapted Heat-Lim—a biophysical model that simulates human-environment heat exchange—to account for pre-pubertal child physiology and body morphology and applied it to 2025 schoolyard microclimate and weather data in Phoenix, Los Angeles, and the Bay Area. As part of the HeatReady Schools Initiative, we integrated this model into an online decision-support tool, Play-Safe, to help elementary school teachers determine safe levels of recess play and necessary water intake. Play-Safe will be launched during the 2026–2027 school year and co-produced with teachers to reflect community needs. Preliminary results suggest that light play can be safely sustained during a 30-minute recess on nearly every school day in Los Angeles and the Bay Area. Phoenix was more constrained, with the lowest average maximum safe recess intensities due to its extreme temperatures and July start date. On hot days, shade and rescheduling afternoon recess to earlier hours substantially

increased children's ability to carry out moderate to intense play. Initial feedback on Play-Safe will also be presented. Such results demonstrate how child-specific heat modeling and co-produced tools can support teachers' decision-making and children's play opportunities in a warming world. References: Vanos 2015. Environ. Int.

[C10] Place Matters: Ecological Context and the Predictors of Climate Change Distress in Indonesia | *Anita Novianty, Northeastern University*

Climate change distress is an emerging mental health concern shaped not just by direct exposure to climate impacts, but by how people relate to and experience nature. This study examines predictors of climate change distress in Indonesia using data from 325 participants (ages 18 to 65) across three ecologically distinct regions: urban Jakarta, natural resources dependent South Kalimantan, and forest dependent Central Kalimantan. Participants were recruited in person and completed QR linked survey questionnaires. We tested how demographical factors, nature reliance and exposure, and three human-nature relationship variables (nature connectedness, zero-sum belief on nature and humanity, and human exceptionalism) predict climate change distress. Nature connectedness and human exceptionalism predicted distress consistently across all three regions, while zero-sum belief on nature and humanity, nature exposure, and nature reliance varied significantly by regional context, with South Kalimantan showing the most distinct pattern. These results indicate that climate change distress cannot be explained by individual-level psychological factors alone; ecological context, livelihood, and place also meaningfully shape how this distress is experienced. Theorizing the human-nature relationship, and climate change distress more broadly, may therefore need to move beyond purely individual psychological accounts to incorporate place and livelihood. These findings carry both theoretical and practical implications on designing climate communication and intervention effort across diverse ecological settings.

[C11] From Loading Docks to Lungs: An Emissions Inventory for Illinois Warehouses and Evaluation of the Warehouse Pollution Reduction Act | *Anna Oehlerking, Northwestern University*

Nearly one in five Americans live in close proximity to a warehouse. In Cook County, home to Chicago, Illinois, this metric jumps to 42%. These facilities, often located near racially-diverse and low-income communities, aggregate an array of emissions sources: medium- and heavy-duty trucks, transport refrigeration units, on-site vehicles, building-level fuel use, and more. As climate change intensifies cumulative environmental burdens on vulnerable communities, the disproportionate air quality impacts of freight infrastructure represent an urgent and understudied dimension of environmental justice. The proposed Warehouse Pollution Reduction Act (WPRA) addresses these climate-adjacent burdens through a flexible, points-based emissions reduction framework for facility operators. Here, we develop a baseline emissions inventory for Illinois warehouses to analyze the emissions implications of these facilities and assess the possible utility of the WPRA. We construct a database of 1,000 Illinois warehouses by integrating industry reports, telematic truck data, and federal agency records. These analyses provide the first emissions inventory for warehouse-attributable emissions outside of southern California, estimating health-harming primary emissions at community-relevant scales. Preliminary estimates indicate that on-site idling contributes the majority of warehouse-related volatile organics, whereas the majority of particulate emissions are related to on-road activity, suggesting that warehouses contribute differentially harmful emissions in neighboring communities and near truck corridors. This work establishes the foundation for evaluating the air quality and health implications of Illinois warehousing operations and the WPRA. By quantifying warehouse emissions, this inventory promoted the development of community-oriented policies that can reduce the cumulative impacts of environmental risks in freight-adjacent communities.

[C12] What The Satellites Can't See: Quantifying Primary Productivity in the Subpolar North Atlantic Ocean | *Ilana Jacobs, Boston College*

The subpolar North Atlantic Ocean plays an outsized role in the marine carbon cycle. Deep winter mixing and large spring phytoplankton blooms are the two key drivers of carbon cycling in this region. Gross Primary Productivity (GPP) is a measure of carbon assimilation into biomass via photosynthesis, the starting point for the biological carbon pump, the biologically mediated process of sequestering

CO_2 in the ocean. The Ocean Observatories Initiative, OOI, maintains an array of fixed and mobile assets in the Irminger Sea between Iceland and Greenland enabling the continuous observation of this region. Here, I used high temporal resolution dissolved oxygen measurements from the OOI Irminger Sea Array to determine rates of GPP over a 7-year time series (2018-2024). Depth-integrated GPP peaks in March, prior to mixed layer shoaling and the satellite-evident chlorophyll peak generally associated with the spring bloom. I will compare the in-situ GPP to validate widely-used satellite algorithms for estimating primary productivity and assess how well satellite based algorithms perform in this region. Satellite remote sensing is used to estimate the strength of the biological pump, however, current in-situ validation is limited, especially in the high latitudes. By leveraging high temporal resolution data from the OOI, I am able to assess the sampling resolution needed to accurately quantify GPP at this site, which provides broader insights relevant to future ocean monitoring programs and other autonomous sampling platforms.

[C13] How the Strength of Vertical Mixing on Ocean Worlds Impacts Physical and Chemical Ocean Properties | *Marissa Tripus, University of Wisconsin-Madison*

Previous studies of modern Earth, paleoclimate periods, and ocean worlds have tested various parameters that influence the ocean's physical environment, including salinity, planetary rotation rate, obliquity, incoming stellar radiation, and more. Only recently has vertical mixing in the ocean been explored within these parameter sensitivity studies. The absence of vertical mixing can result in enhanced ocean stratification and stagnant deep water, while strong vertical mixing strengthens ocean overturning and weakens the stratification. Both extremes likely produce different responses for the ocean's chemical properties, as the physical behavior of the ocean strongly influences nutrient cycling and chemical distributions throughout the ocean. This study investigates how changes in vertical mixing influence the physical and chemical properties of Earth-like ocean worlds using cGENIE, an intermediate-complexity ocean–atmosphere–sea-ice model coupled with biogeochemistry. Simulations are performed with modern Earth forcings while varying vertical mixing strength across multiple ocean basin configurations, including an aquaplanet and Earth-like continental configurations.

These configurations are used to test whether the chemical responses to vertical mixing change with different circulation patterns. We hypothesize that stronger vertical mixing will enhance the overturning circulation, therefore increasing the nutrient transport into the surface waters and altering the atmosphere-ocean exchange. Weaker mixing will increase stratification of the ocean, resulting in the potential for a nutrient-depleted surface ocean. Overall, this work aims to address how vertical mixing impacts the ocean's physical and chemical properties on Earth-like ocean worlds, with implications for paleoclimate studies and planetary habitability.

[C14] Alkenones, Calcite, and Community Composition: Untangling Coccolithophores' Roles in the Global Carbon Cycle | *Brianna Hoegler, Brown University*

Coccolithophores, calcifying marine algae, play dual roles in the marine carbon cycle: simultaneously exporting particulate organic carbon (POC) and producing particulate inorganic carbon (PIC), which releases CO2. This contrasts with non-calcifying phytoplankton, making coccolithophores a unique lever in regulating air-sea CO2 exchange. As climate change alters marine ecosystems, shifting phytoplankton community dynamics may impact PIC:POC production and burial, ultimately impacting the ocean's efficacy as a carbon sink. Alkenones, lipid biomarkers produced by certain coccolithophore species, are widely used as export productivity proxies, yet their relationship to carbon export and community structure remains uncertain. Here, we combine this geochemical proxy with satellite observations and nannofossil assemblage data from globally distributed core-top sediments to evaluate how coccolithophore community structure mediates carbon export pathways. Our results indicate that alkenone concentrations are more closely associated with total coccolith mass than with the mass of alkenone-producing species, supporting the use of C37 alkenones as a total export productivity proxy. Surface POC and PIC do not show a uniform relationship with alkenones. Instead, alkenones track chlorophyll-a and estimated POC production, while PIC varies independently, indicating a decoupling of organic and inorganic carbon productivity. These findings suggest that coccolithophores cannot be treated as a single functional group in carbon cycle models. Rather, shifts in

coccolithophore community composition may alter the balance between carbon sequestration and CO2 release, even under similar productivity regimes. This distinction has important implications for interpreting past ocean carbon cycling and for predicting how biological carbon pumps will respond to future climate change.

[C15] A multi-proxy investigation on the Gulf of California Oxygenation during the Last Interglacial | *Kaetlyn Rodriguez, Tulane University*

Observed ocean oxygen is declining in both shallow-intermediate waters and the deep ocean, but models fall short in capturing trends and projections. The presence of low-oxygen waters are critical in defining the habitable range of many marine organisms and provide meaningful feedbacks to global climate, thus, we must look at the Last interglacial (MIS5e) which was 1-2°C warmer than pre-industrial sea surface temperature in the Pacific and had a global sea level of 6-9 m higher than present conditions, making MIS5e particularly useful as an analogue for ocean oxygen responses to climate change. The multi-proxy approach sensitive to in situ oxygenation will allow us to contribute to a complete picture of marine oxygen sensitivity to climate perturbations while addressing the limitations of individual proxies. Here we present an age model constrained by benthic oxygen isotopes as well as bulk sediment sensitive-trace metals from the IODP Site U1545 in the Gulf of California (GoC) to reconstruct local bottom water oxygenation. Bulk elemental analyses show an increase in uranium (U), molybdenum (Mo), and a decrease in manganese (Mn) enrichment factors (EF) at depths consistent with the Last Interglacial. Minimal Mn EF, elevated U EF, and very high Mo EF indicate much lower oxygenation during the MIS 5e, whereas an increase in Mn EF coincident with lower Mo EF and U EF suggest a more oxygenated ocean in the glaciation period after MIS5e.

[C16] Exploring Shifting Controls on Northeast Pacific Export Productivity throughout the Deglaciation | *Cassandra Bartels, MIT-WHOI*

The biological pump is one of the central mechanisms by which the concentration of CO2 in the atmosphere is modulated over glacial-interglacial cycles. This occurs

as CO2 is removed from the atmosphere through enhanced surface export productivity which transfers carbon into the deep ocean or sediments. Constraining when export productivity may have increased or decreased, then, is critical to balancing the deglacial carbon budget. However, for many sites in the North Pacific for which multiple paleo-productivity proxy reconstructions exist, discrepancies between records have resulted in large uncertainties of the timing of deglacial export productivity increases. In this study, we present a new, high resolution record of 230Thxs-normalized mass fluxes, productivity proxies (opal, Corg, and Baxs), and G. bulloides δ18O from core W8709A-8TC/PC (3111m, 42.17°N, 127.58°W) in the northeast Pacific. Results from all export productivity proxies demonstrate an increase in export from the Last Glacial Maximum to the Holocene, although they disagree in the timing of this increase throughout the deglaciation. Informed by local surface seawater δ18O reconstruction and radiolarian assemblages, we identify dynamic open ocean and coastal phenomena that may have played a key role in decoupling export productivity proxy responses throughout the deglaciation. This case study provides key insights into how changes in physical phenomena may produce variable export productivity records, as each responds to different impulses in the system. This serves as a warning for future studies to consider the physical mechanisms that could give rise to the nature of the export productivity responses observed.

[C17] Triple Oxygen Isotope Record From Ferricrete Deposits Shows Holocene Moisture Source Shift in the Rocky Mountains | *Emily Nigro, Stanford University*

Holocene hydroclimate changes in the western US are poorly constrained, in part because the region's complex topography and seasonally distinct circulation patterns can generate heterogeneous responses over small spatial scales. To better understand regional precipitation patterns over the Holocene, we measured the triple oxygen isotopes of goethite from high-elevation ferricrete deposits across a latitudinal gradient in the Rocky Mountains. Ferricretes form in stream water that reflects the isotopic composition of local precipitation, providing a record of past hydroclimate changes. We also used a 1-dimensional vapor transport model to simulate precipitation δ18O and Δ′17O along a hypothetical storm track, given varying moisture recycling amounts and evaporation versus transpiration

contributions. We find that both northern (central Montana) and southern (southwest Colorado) sites exhibit similar increases in goethite δ18O over time, accompanied by declines in goethite Δ′17O. To interpret these trends, we considered three potential drivers: temperature, moisture recycling and evapotranspiration partitioning, and moisture source. Δ′17O is largely insensitive to temperature, and our model shows that changes in moisture recycling and evapotranspiration partitioning along the storm track cannot account for the observed Δ′17O decreases. Instead, we conclude that the isotopic trends primarily reflect an increased contribution of southerly-sourced precipitation, since moisture from the Gulf of Mexico—the dominant source of interior western US summer precipitation—is characterized by high δ18O and low Δ′17O relative to Pacific moisture. More generally, this work demonstrates how triple oxygen isotopes can be used to disentangle changes in temperature, atmospheric moisture dynamics, and moisture source in semiarid to arid regions.

[C18] American Estuaries: An Assessment of Characteristics & Climate Risk | *Mark Nepf, University of Washington*

Estuaries are not just critical ecosystems but also economic juggernauts—eight of the ten largest U.S. cities, with aggregate economic output accounting for 47% of national GDP, are located within estuarine regions. Estuaries are also cultural spaces of great significance, both for the diverse communities that surround them and to Indigenous nations that have held deep connections to these bodies of water for millennia. Geographically complicated and containing overlapping political jurisdictions with complex public management regimes, American estuaries present an ideal landscape for mixed methods research to answer important policy questions. This study focuses on the National Estuary Program (NEP), administered by the Environmental Protection Agency (EPA). While the EPA provides funding and technical assistance, management plans are designed collaboratively by local governing bodies and stakeholders. Spatial models are employed to characterize climate risk within each regional NEP. Climate risk was measured using FEMA's National Risk Index, which represents a Census tract's relative risk to natural hazards. Executive Directors from each NEP were then interviewed to explore whether variation in stakeholder engagement is observed

relative to climate risk. For instance, do NEPs with higher risk values correspond with greater engagement and more robust community collaboration? Does climate risk shape the approaches to collaboration and the use of scientific knowledge in collaborative processes? Thematic analysis will provide insights on the role of administrative infrastructure and community engagement in shaping the use of scientific evidence in estuary governance.

[C19] Regional Pattern and Drivers of Coastal Forest Resilience Loss under Saltwater Intrusion | *Shenyi (Elsie) Liu, University of Virginia*

Coastal forests along the eastern United States are increasingly affected by sea-level rise and saltwater intrusion, resulting in widespread tree mortality and the emergence of “ghost forests.” Assessing how these ecosystems respond to disturbance, and what drives shifts in their resilience, has become an urgent priority. Temporal autocorrelation (TAC) provides a useful indicator of ecosystem recovery rates and thus serves as a proxy for resilience. Rising TAC values indicate slower recovery from perturbations and may signal that a system is approaching a threshold of regime shift. This study assembled a multi-decadal Landsat EVI time series and a suite of environmental datasets to quantify resilience using TAC and evaluate how biophysical gradients shape spatial patterns of resilience decline. We characterized regional gradients in resilience decline, identified hotspots in estuarine and low-lying settings, and evaluated how elevation, soil properties, forest structure, drought history, hydrology, and disturbance exposure shape spatial variability in lag-1 autocorrelation (AR1). NACP Coastal forests show clear spatial patterns of resilience loss over the past two decades. High-TAC pixels cluster at low elevations, with TAC trends peaking near 5 m, indicating long-disturbed low zones and ongoing transitions at mid elevations. Median AR1 increases from north to south, aligning with stronger drought, storm, and salinity stress in southeastern and Gulf regions. Random forest models highlight salinity, hurricane exposure, and multi-year drought (SPEI) as leading predictors, with importance varying by HUC2 basin. Residuals suggest additional fine-scale hydrologic and land-use influences.

[C20] Shallow methanogenesis in tidal salt marsh soils | *Susan Pit, University of California Santa Cruz*

Wetlands are important natural climate solutions because they store large amounts of carbon in their soils, helping mitigate climate change. However, wetlands can also emit greenhouse gases during organic matter decomposition, potentially offsetting some of their carbon storage benefits. Methane is especially important because its global warming potential over 20 years is 81-85 times greater than carbon dioxide (IPCC, 2021). As a result, even relatively small methane emissions can substantially reduce a wetland's net climate benefit. Methane emissions are generally much lower in saline wetlands than in freshwater wetlands because sulfate-rich conditions inhibit methane production through bacterial sulfate reduction. Despite this, measurable methane emissions still occur in saline wetlands, and the sources and controls of this methane remain poorly understood. This limits our ability to accurately assess the climate benefits of salt marsh conservation and restoration. This study investigates environmental controls on methane production and consumption in a salt marsh within Elkhorn Slough. Push cores to 25 cm depth were collected across two wet seasons and two dry seasons, and porewater was analyzed for a suite of geochemical tracers. Preliminary results show the highest dissolved methane concentrations occur just below the sediment surface, despite high sulfate availability that would typically inhibit methane production. These findings suggest methane cycling in saline wetlands is more complex than previously understood and can help inform restoration strategies to maximize carbon storage while minimizing greenhouse gas emissions.

[C21] Tracking Active Microbial Taxa in Restored and Reference Wetland Sites | *Leah Van Dyke, University of California Santa Cruz*

The Elkhorn Slough, one of California's largest coastal estuaries, has experienced flooding, vegetation loss, and altered tidal dynamics due to sea-level rise and anthropogenic activity. Two wetland sites, a healthy "Reference" and a "Restored" site, provide insight on the effectiveness of restoration as a nature-based solution to climate change, and how microbial communities impact biogeochemical cycling, especially carbon dynamics. Using quantitative Stable-Isotope Probing (qSIP), soil samples from each site were amended with control (H2^16O) or heavy isotope (H2^18O) water, incubated, and subjected to DNA extraction and density fractionation to account for DNA weight and phylogenetic identity. This method

enables identification and linkage of active microbial taxa with changes in carbon sequestration efficiency of wetland soils. Samples were taken in the 2022 dry and 2024 wet seasons, with muddy soil and higher plant cover at the Reference site, and compacted sandy soil and lower plant cover at the Restored site. In 2022, the most active taxa were taxonomically distinct and significantly more ^18O enriched (active) and diverse ($H = 7.47$ vs. 7.19, $p < 0.001$) at the Reference site. Increased algal biomass at the Restored site in 2024 prompted incubations to test community response to reduced autotrophic activity. When light inputs were removed, opposite responses were observed, with heterotrophic biomass increasing at the Restored site and decreasing at the Reference site. These results suggest that restored wetland microbial communities remain less active and differ from reference wetlands but may change rapidly as restoration progresses.

[C22] Turf Wars: Green Urchin Feeding Ecology in a Changing Gulf of Maine |*Grace Callahan, Northeastern University*

Climate change is reshaping the distribution and abundance of habitat-forming species around the world. In the southwestern Gulf of Maine, a hotspot of ocean warming, cold-adapted kelps have widely collapsed and been replaced by beds of filamentous red "turf" algae, mirroring changes occurring in other temperate marine systems. This dramatic shift in the macroalgal community has the potential to alter the structure and function of nearshore food webs, jeopardizing a range of ecosystem services including fisheries. However, the impacts of kelp-to-turf transitions on many key organisms remain unknown. One such organism is the green sea urchin (Strongylocentrotus droebachiensis), an ecologically important herbivore and the basis of a historically lucrative roe fishery in the Gulf of Maine. Urchin growth, metabolism, and roe quality are known to be influenced by the composition of macroalgae in their diet. Switching from a kelp- to turf-dominated habitat represents a significant change in the nutritional landscape for urchins, but whether a turf-dominated diet is less preferred or of lower quality remains unclear. Furthermore, preferential grazing on kelp or turf may accelerate or stymie the transition to turf dominance where urchins are abundant. This study (underway in summer 2026) will experimentally test green urchin feeding preference for rapidly proliferating turf species versus historically dominant kelp, and evaluate the

consequences of a turf-dominated diet on urchin growth, roe quality, and grazing behavior. These data will illuminate how this ongoing habitat transition may impact benthic food webs and the viability of the Maine urchin fishery under future climate change.

[C23] How climatological definition influences the perceived ecological impacts of marine heatwaves | *Rae Fadlovich, University of California Santa Cruz*

As climate change warms our oceans, we are experiencing an increase in the frequency and intensity of marine heatwaves (MHWs). These periods of anomalously warm ocean temperatures have been linked to negative ecological impacts, but it can be difficult to determine what characteristics of MHW make it impactful. Here, we evaluate how the use of different MHW definitions influences the characteristics of a measured ecosystem response. To do this, we evaluate the chlorophyll response to MHWs in the Chesapeake Bay, the largest estuary in the United States. We determined MHW events from daily NOAA Geo-Polar satellite sea surface temperature using both the classic definition and an adapted definition based on the residuals from a fast Fourier Transform (FFT). We used NASA MODIS satellite chlorophyll data to assess the daily mean chlorophyll concentrations before, during, and after the identified MHW events. We then used linear regression to assess the impacts of MHW definition, season, duration, and event severity on chlorophyll concentrations. We identified 108 MHW events using the classic definition and 78 events with the FFT definition. While both definitions showed a statistically significant chlorophyll reduction, concentrations continued to decline post-MHW under the classic definition but not the FFT definition. MHWs appear to suppress chlorophyll concentrations in the Chesapeake Bay, but how we define MHW events impacts how we characterize this response. These findings suggest that ecologists should consider how definition may impact or obscure ecologically meaningful response patterns and potentially influence our understanding of ecosystem vulnerability to extreme climate events.

[C24] Using a turf transplant experiment to investigate the demographic drivers of alpine plant responses to changes in climate | *Katie Bardsley, University of Colorado Boulder*

One of today's most pressing challenges is predicting the impacts of a changing climate on natural communities. For many species, not only do we lack insight into future population dynamics, but we know even less about the processes that mediate responses to environmental stressors. This gap is especially critical for alpine plant species, which may be uniquely vulnerable to the impacts of a warmer climate, having adapted to extreme environmental conditions characterized by long, cold winters and short growing seasons. Here, I leverage a turf transplant experiment – where intact plots of plant and soil were relocated between sites of the same community type but with different temperature conditions – to investigate the impacts of a novel temperature regime on the demographic[KB1.1] dynamics of two alpine plant species. After an additional field season of data collection, I will explore the effects of microclimatic variation on vital rates (survival, growth, reproduction) in Bistorta vivipara and Bistorta bistortoides from dry and moist habitats at Niwot Ridge (CO), and test if and how genetic and environmental factors influence any observed variation in vital rates and impact the relationships between them. This study evaluates population responses to the environment using individuals transplanted with their original plant and soil communities, making it possible to infer population responses to climate variation within a community context.

[C25] Observing the Seasonality of Amazon Forest Greenness at a Fixed Sun-Sensor Angle Using a Geostationary Satellite | *Qiren Wang, California Institute of Technology*

Amazon forests are a major component of the land carbon cycle and are increasingly exposed to a drying climate. However, how Amazon forests change during drought or the dry season remains debated. Despite observational evidence showing greening of Amazon forests during drought or the dry season, previous studies have raised concerns that the small changes observed by satellites could be artifacts. Changes in the relative positions of the sun and satellite, namely the sun-sensor geometry, can lead to artificial greenness change signals. Currently, most sun-sensor geometry corrections for the Amazon rely on observations from sun-synchronous sensors, which may be limited by the number of clear-sky observations over the persistently cloudy Amazon. Geostationary satellites have much higher temporal resolution, providing more observations across a wide range

of sun-sensor geometry. Here, we leverage data from a geostationary satellite to correct the seasonality of Amazon forest greenness to a fixed sun-sensor angle. We first show that, before the correction, two commonly used vegetation indices of greenness, EVI and NDVI, display opposite seasonality. We attribute the opposite seasonality to the sun-sensor geometry effect using both observational and theoretical evidence. After applying our correction, the consistency between EVI and NDVI seasonality improves. We also compare our corrected dry season changes with existing corrected datasets and demonstrate several differences. We emphasize that opposing changes between EVI and NDVI can serve as an indicator of sun-sensor geometry effects and highlight the need for caution when interpreting the small satellite-derived changes in Amazon forest greenness.

[C26] Trace Metal Dynamics in the Discontinuous Permafrost Floodplain of the Yukon River Basin | *Rubye Strickland, University of Southern California*

Arctic environments are changing rapidly, driving coupled hydrological and biogeochemical changes such as the alarming “rusting rivers” observed in Alaska. The associated mobilization of trace metals from thawing permafrost can contaminate local water sources, posing threats to human and ecosystem health, and alter metal fluxes to the high-latitude oceans. At the same time, accelerated erosion releases sediments that can clog water filtration systems and also carry the metals released from permafrost. Metals released into aquatic systems can also bioaccumulate, affecting food sources for Arctic residents who rely on subsistence fishing and hunting. Despite the potential risks to ecosystem and human health, little is known about when and where metals are being released from thawing Arctic permafrost. To begin addressing this problem, this study focused on assessing trace metal dynamics across three floodplain areas of the Yukon River basin, all in discontinuous permafrost. Over 300 water samples were collected from a range of floodplain aquatic environments (rivers, sloughs, oxbow lakes, thaw ponds, pore waters) near the villages of Huslia, Beaver, and Alakanuk, Alaska. Metal concentrations were universally below US water quality regulatory standards, except for notable exceedances in Mn and Fe in over 100 of the samples. These metals could present challenges for treatment facilities and lead to other negative health impacts over time. Ongoing geospatial analysis is exploring the potential

floodplain controls on metal biogeochemistry, along with further planned analyses of sediment-bound metal concentrations.

[C27] Wind tunnel insights into cloud droplet dynamics: implications for climate models | *Julian Reis, University of Washington*

Our understanding of the physical processes in clouds plays an important role in accurate climate modeling, and they currently contribute significantly to uncertainties in current models. There are a variety of complex interactions between physical processes within clouds; for example, turbulence can affect precipitation dynamics by altering the droplet size distribution. These microphysical processes can cause complex changes in the radiative cooling effects of clouds. To narrow this gap in our understanding, our research focuses on the dynamics of cloud droplets under different turbulence conditions within and at the edges of clouds. Clouds are characterized by a wide range of turbulent scales, from large scales on the order of hundreds of meters, causing large-scale entrainment of ambient air, down to scales of a couple of millimeters, at which we observe complex interactions with cloud droplets. Cloud droplets generally interact differently at those scales, changing important properties such as settling behavior and spatial distribution. At the small turbulent scales, cloud droplets start to cluster, making coalescence more likely and thereby altering droplet growth. Since processes at those small scales are impossible to resolve in full-scale cloud simulations, we need to model them using knowledge from scaled experiments. We will share observations of droplet dynamics from wind tunnel experiments that are representative of turbulence conditions found in clouds. We show how particle settling and clustering vary under different local turbulent conditions within and at the edges of clouds, and how these observations could inform current models of those microphysical processes.

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I. Expected Behavior

- Treat all GCC participants and individuals associated with GCC with respect and consideration. Recognize value in diversity of backgrounds and perspectives.
- Interact in a considerate, respectful, and collaborative manner. Communicate openly and with respect for others, critiquing ideas rather than individuals.
- Present your research findings accurately and objectively, acknowledging those who made significant contributions to your research. Respect others' requests for confidentiality of new or unpublished research.
- Meet new people! Consider reaching out to people you don't know whose talk, poster and/or workshop you enjoyed.

II. Unacceptable Behavior

- Harassment (including sexual and gender harassment), bullying, physical or verbal abuse, or discrimination in any form will not be tolerated.
- Examples of unacceptable behavior include, but are not limited to:
    - Verbal comments related to gender, sexual orientation, disability, physical appearance, body size, race, religion, national origin, or socioeconomic class;
    - Harassment or intimidation by words, gestures, body language, or any menacing behavior;
    - Inappropriate use of nudity and/or sexual images in public spaces or in presentations;
    - Threatening or stalking any GCC participant, student host, staff member, or other individual associated with the GCC.

III. Consequences

- Anyone requested to stop unacceptable behavior is expected to comply immediately.
- The GCC organizing team may take any action deemed appropriate, including immediate removal.
- We reserve the right to prohibit attendance at any future GCC.

IV. Reporting

- If you are the subject of unacceptable behavior or have witnessed any such behavior, please immediately notify the GCC organizing team at gradclimateconference@gmail.com or any of the GCC co-chairs individually:
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Charles L. Pack Experimental Forest Conference Center

We would also like to offer our thanks to Terri McCauley and the team at the Charles L. Pack Experimental Forest Conference Center for allowing us to host the GCC. A total of nine conferences have been hosted by UW at this beautiful location at the base of Mount Rainier in Eatonville, Washington, and we are grateful we were able to return again this year.

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Out-of-town graduate students attending the conference who arrive Friday/leave Monday are hosted by volunteer graduate students from climate-related departments at UW. We're thankful to all our volunteer hosts this year for offering up their couches to visitors!

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