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Abstracts Booklet

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ORAL PRESENTATION ABSTRACTS

Oral Session 1
Morning, Saturday, October 29, 2022

Carbon cycle

Assessing climate and land use impacts on the soil methane sink
Hannah Dion-Kirschner (she/her/hers)
Most soils on Earth consume methane from the atmosphere through the activity of microorganisms called methanotrophs. This process is the only terrestrial sink for atmospheric methane, and today it accounts for 5-10% of the total sink. However, this sink size is certain to change in response to future changes in climate, land use, and atmospheric methane levels. To help predict the future of the soil methane sink, we have developed a method for field-based measurements of soil methane consumption rates. We are collecting two years' worth of seasonal data at three California locations with varying climate and land use. These sites also represent arid biomes where soil methane consumption is understudied. Initial findings reveal that the spatial variability in methane consumption across individual landscapes is similar in amplitude to the variability among landscapes with very different climate and land use characteristics. Ongoing measurements of the physical, chemical, and biological properties of soil from each sample site will clarify the mechanistic controls on methane consumption rates. This study will support more accurate predictions of future soil methane consumption, and will clarify land management practices that can improve soil methane uptake.

Examining the air-sea CO2 exchange in the Gulf Stream Region using autonomous observations
Sarah Nickford (she/her/hers)
Carbon dioxide is a byproduct of the burning of fossil fuels and is the greenhouse gas primarily responsible for climate change. The oceans have absorbed more than 25% of these emissions with a large fraction absorbed in the North Atlantic. Global estimates of the ocean uptake of carbon dioxide differ depending on the method used to calculate it, resulting in a large uncertainty. This uncertainty motivates my work to understand and more precisely quantify the ocean's role in the global carbon cycle. CO2 uptake by the ocean occurs through the process of air-sea exchange and is coupled with intense heat loss to the atmosphere. This exchange is maximized in western boundary current regions where subtropical mode waters (STMW) are also formed. STMW is exposed to the atmosphere in winter but is capped by a warm surface layer in spring and may be subducted into the main thermocline taking its temperature, salinity, carbon properties with it. This research aims to quantify the wintertime air-sea CO2 fluxes in the Gulf Stream and STMW formation region. Recent observations from Saildrones are used to

examine the mechanisms that lead to wintertime ocean pCO2 variability. This work also evaluates the biases introduced when estimating air-sea CO2 fluxes using a reanalysis product in place of contemporaneous measurements. Most of the water in the northward flowing Gulf Stream recirculates in the subtropical gyre for >20 years, where it must increase in density, through air-sea exchange and internal mixing, before continuing north as part of the Atlantic Meridional Overturning Circulation (AMOC).

Mixotrophic protists: sinks or sources of CO2 across the ocean?
Elaina Thomas (she/her/hers)
The ocean is teeming with single-cell eukaryotes, known as protists. By photosynthesizing (fixing CO2) or eating prey (respiring CO2), protists modulate the atmosphere-ocean flux of carbon and the marine food web. While some protist species only photosynthesize or feed on prey, many protists are mixotrophs, able to switch between these two trophic modes in response to environmental conditions. Whether mixotrophic protists rely more on photosynthesis or prey ingestion likely varies with region, depth, and time, but marine productivity models assume that mixotrophic protists are always photosynthesizing, potentially overestimating CO2 fixation. In response to limited understanding of mixotrophic protists across the ocean, Lambert et al. (PNAS, 2022) developed a machine learning model that predicts the in-situ trophic mode of protists based upon community-wide sequencing of RNA (metatranscriptomes). Application of this machine learning model to metatranscriptomes across the North Pacific showed that mixotrophic protists at 5 m depth rely primarily on heterotrophy in the warm, nutrient-poor subtropical gyre, and photosynthesis in the nutrient-rich subpolar gyre (Lambert et al. PNAS, 2022). To determine whether mixotrophic protists also shift trophic mode in response to light and nutrients with depth, I apply this machine learning model to metatranscriptomes collected throughout the water column at multiple North Pacific sites. This work will develop a two-dimensional (latitude and depth) distribution of the dominant trophic mode of mixotrophic protists that can be incorporated into models of marine productivity. This improvement of marine productivity models will enable more accurate predictions of the future climate.

<u>Ocean heat content & large-scale circulation</u>

Quantifying multidecadal variability in the North Atlantic ocean state in observations and climate models
Noah Rosenberg (he/him/his)
Variability of water properties in the North Atlantic Ocean is poorly constrained on multi-decadal time scales and can be inconsistent between models and reconstructions. The magnitude and characteristic time scales of variability are crucial for understanding the drivers of the Atlantic Multidecadal Variability (AMV) as well as changes in the Atlantic Meridional Overturning Circulation (AMOC), which in turn affects climate in the Northern Hemisphere, carbon sequestration, and sea level rise. Previous work has attempted quantify the variability of

sea surface temperature (SST) on decadal-to-centennial time scales using the spectral slope, which defines a power-law fit to the power spectrum of a time series, and use this quantity to compare observations to climate models as a measure of the relative strength of low- versus high-frequency variability. While good agreement has been found on a global scale between the spectral slopes of proxy data and model output, this agreement has not held up locally in different regions, suggesting that models may be underestimating low-frequency variance in the climate system. In this work, we analyze the spectral slope of output from the CESM Last Millennium Ensemble (LME), a 13-member, 1156-year coupled model ensemble which approximates historical climate conditions. By decomposing the SST into leading spatial modes weighted by the ratio of low- to high-frequency variance, we explore how spatial patterns of internal variability dominate the regional distribution of spectral slope. This gives us a dynamical understanding of the discrepancy between regional and global scale slope, as well as a measure of the robustness of spectral slope as a single quantity for proxy-model comparison.

Controls On Salinity Variability In The Eastern Sub-Polar North Atlantic

Ali Siddiqui (he/him/his)

The eastern sub-polar north Atlantic experienced an unprecedented upper ocean freshening event during 2014-2017. Recent hypotheses attribute this to re-routing of Arctic-origin freshwater anomalies via the North Atlantic Current as a consequence of anomalous wind stress curl in the subpolar region. These Arctic anomalies propagate primarily via the East and West Greenland Currents or the Baffin Island Current into the Labrador Sea. They enter the Labrador Current and subsequently merge with the North Atlantic Current off Newfoundland. They then retroflect and propagate into the eastern sub-polar gyre. Using the ECCO (Estimating the Circulation and Climate of the ocean) and ASTE (Arctic Subpolar Gyre State Estimate) state estimates, we extend the hypothesis that Arctic freshwater re-routed through the Labrador current is responsible for the 2014-2017 freshening event in the Iceland basin and explore the role of the AMOC in setting these salinity anomalies. We investigate the strength of the overturning circulation in the state estimates and the freshwater and heat transports associated with it into the Iceland basin. We find that the gyre circulation dominates the overturning in setting upper ocean salinity anomlies in the eastern subpolar north Atlantic. Based on our results, we hypothesize that the freshening of the eastern sub-polar North Atlantic is primarily a balance between the freshwater export from the Arctic and transport of subtropical salinity anomalies as modulated by the interannual atmospheric forcing in the two basins, with only a minor role of the AMOC.

Biogeochemical cycling

Hydrodynamic forcings and causal drivers of saltmarsh biomass in the Altamaha River estuary

Kadir Bice

Salt marshes play a critical role in coastal biogeochemical cycles and provide unique ecosystem services. The functioning of these systems depends on climatic and hydrological conditions. Here we analyze the temporal patterns of temperature, precipitation, river discharge, sea level and drought index for a salt marsh in the SE US using monthly time series between 1984-2018. We employ gap filling approaches to have a complete dataset; continuous wavelet transforms and empirical mode decomposition to detect temporal patterns in each environmental variable; wavelet coherence to reveal coherent patterns with salt marsh biomass. We then employ empirical dynamic modeling to identify potential causal connections. Results demonstrated that 2D kriging separating seasonal and interannual trends was successful in gap filling larger gaps in our highly seasonal biomass timeseries. Along with strongly seasonal temperature signal, biomass, river discharge and sea level were partially persistent in seasonal frequencies. Further analyses show the long term increases in biomass, temperature, and sea level; and shifts in drought patterns around early 2000s. We also detect the coherence of the salt marsh biomass mostly in annual frequencies with temperature (in phase), river discharge (6 month out of phase) and sea level (in phase) respectively. Causality analyses showed that temperature, river discharge, drought and sea level were causally connected to the salt marsh biomass. Surrogate tests to investigate the impact of seasonality as a confounding factor revealed that the causal connections from these variables were significant.

Reduced sea surface temperature and stable productivity gradients across the eastern equatorial Pacific during the Pliocene

Kristin Kimble (she/her/hers)

The mid-Pliocene Warm Period (3.3-3.0 Ma) is an ideal reference for investigating potential climate change by the end of the 21st century. Globally warmer conditions in the Pliocene likely influenced patterns of sea surface temperature (SST) and biological productivity in the tropical Pacific Ocean. Upwelled cool nutrient-rich waters characterize the modern eastern equatorial Pacific (EEP), which generate strong gradients in SST and productivity between the eastern and western EEP. However, the strength of SST and productivity gradients is uncertain during the warmer and wetter Pliocene. We present new Pliocene alkenone paleotemperature and organic biomarker productivity records from Ocean Drilling Program (ODP) cores that span an east-west transect across the modern EEP upwelling zone. Additionally, we present estimates of sediment composition calculated from calibrated X-ray fluorescence (XRF) elemental concentrations and fluxes along the same transect. The temperature and productivity records suggest climate variability on glacial-interglacial scales over the late Pliocene. The SST gradient between ~90°W and ~120°W was reduced to 0.5°C in the late Pliocene, compared to the >2.5°C gradient observed today. Contrary to modern El Niño SST and productivity patterns across the equatorial Pacific, there was no reduction in surface productivity based on alkenone C37 total and XRF fluxes. The high biogenic opal composition in the eastern EEP suggests that upwelling velocity was not greatly diminished, and more nutrient-rich waters may have upwelled during the Pliocene relative to today. Therefore, reductions in the SST gradient suggest warmer waters at the base of the mixed layer upwelled in the Pliocene EEP.

Oral Session 2
Afternoon, Saturday, October 29, 2022

Environmental management & agriculture

A review and analysis of scenario planning as a decision support tool for climate change adaptation and uncertainty management

Lunia Oriol (she/her/hers)

As decision-makers and communities prepare for future impacts of climate change, they rely on climate knowledge that is usable, relevant, and fits decision needs. However, gaps in delivering usable climate knowledge and managing its uncertainty hamper one's ability to make decisions for the future. Scenario planning, one tool to bridge these gaps, explores a set of plausible and uncertain futures. In the general literature, scenario planning has been increasingly applied to climate change adaptation contexts, but with varying methodological approaches and consequently varying degrees of success for users. Evaluations of scenario planning can review outcomes, synthesize gathered knowledge and guide potential users who are interested in using this tool. We first conduct an umbrella review of scenario planning from 2015-2021 to identify emerging practices and gaps in scenario planning. Next, we explore the usage of scenario planning as done by the Great Lakes Integrated Sciences and Assessments program (GLISA), a boundary organization helping decision-makers prepare for and adapt to climate change. We conclude with a comparative analysis of GLISA's scenario planning approach and the literature's in order to analyze GLISA's place in the general methodology. Through this study, we offer a comprehensive analysis of the state of scenario planning for climate change adaptation, its success toward creating usable climate knowledge for end-users, and where boundary organizations such as GLISA may offer improvements to the practice.

Global Crop Failures as explained by Agroclimate Conditions and Implications for Future Climate

Tayler Schillerberg (she/her/hers)

Shifts of local-scale climate in crop production regions may threaten global food security. While consensus results have been reached regarding the impacts of mean climate on crop yields over different crop production regions, little is known about how agroclimate conditions, based on daily weather, are changing and how these changes impact crop failure risks. In this study, we analyze the variability and trends of global crop failure of four staple crops (maize, rice, soy, and wheat) as well as their linkages with agriculture-significant climate conditions from 1982 to 2016 using satellite-based data, climate reanalysis data, and machine learning methods. We derive twelve agroclimate indices as indicators of agriculture-significant climate conditions for each crop growing season over global croplands. To different extents, agroclimate indices can well predict and explain crop failure events over the past decades depending on regions and crop types. Using the most influential agroclimate indices, we explore future probabilities of crop failures at the end of the century if current agroclimate trends were to continue. The findings of this study will be helpful for understanding the impacts of agroclimatic conditions on crop failures and can potentially inform global climate adaptation strategies for agriculture and food security.

Ecoclimate & biological responses to climate change

Corals' metabolic responses to future climatic conditions: insights from the natural laboratory of Bouraké, New Caledonia

Juliette Jacquemont (she/her/hers)

Coral reefs are among the most sensitive ecosystems to climate change, and insight into how coral reefs could persist in tomorrow's climate is urgent. However, laboratory experiments are limited by both their duration in time and their ability to reproduce environmental complexity. To overcome these limitations, natural extreme reef environments are being used as natural laboratories to investigate the specificities of corals chronically exposed to future-like conditions. Among these natural laboratories, the lagoon of Bouraké in New Caledonia is one of the only sites in the world where coral reefs have been identified despite temperatures, pH and dissolved oxygen chronically fluctuating between present-day and future-like conditions. In March 2020, I participated in a field trip during which I studied the metabolic rates and endosymbiont specificities of seven coral species of this lagoon in order to better understand why these corals could withstand conditions predicted to decimate typical coral colonies. We found significant differences in the symbiont and chlorophyll content of these extreme corals compared to reference corals, as well as species-specific changes of metabolic rates. These metabolic changes could explain how corals from Bouraké can cope with conditions outside of corals' usual environmental niche. The diversity of metabolic responses that we observed in Bouraké corals suggest that no unique response can explain corals' tolerance to sub-optimal conditions and that a variety of mechanisms will be at play for corals in a changing world.

Decadal-scale changes in the Georges Bank ecosystem: evidence from bulk and compound-specific stable isotope analyses of fish scales

Ciara Willis (she/her/hers)

The impacts of climate change are increasingly apparent in the physical oceanographic environment of the global ocean, with cascading effects through ecosystem structure to individual species. We can examine these ecosystem linkages from multiple angles, including via compound-specific stable isotope analysis of carbon and nitrogen focused on individual amino acids. This analysis can provide individual-level information (e.g. dietary sources, trophic position) as well as ecosystem-level information (e.g. variability at the base of the food web, nutrient regimes, food web structure). In this study, we used almost a century of haddock scale stable isotopes from Georges Bank (northeast US) to investigate changes in the diet and trophic status of the haddock population driven by climate change and fisheries exploitation, and to draw larger conclusions about the entire ecosystem. Specifically, we used nitrogen isotopes to identify the signal of a large-scale nutrient regime shift driven by increasing input of warm, nutrient rich water from the Gulf Stream. In contrast to this physical change, carbon isotopes indicate a relatively stable food web during the study period. Here we examine the climatic and ecological factors altering the Georges Bank system, and consider the possibility of future ecosystem regime shifts.

Hydrology and geomorphology

Nitrate Variability due to Heavy Rain Events in the North Alouette Watershed, British Columbia

Ariel Greenblat (she/her/hers)

In the northern mid-latitudes, extreme precipitation events are projected to become more frequent and intense over the next century, largely due to the Earth's warming climate. The occurrence of precipitation extremes has been extensively studied because of the potential impacts to human society and ecosystems; however, the relationship between extreme precipitation events and the potential impacts on nitrate transport have not been well documented. Nitrate is the most common groundwater contaminant, typically sourced from synthetic fertilizer and livestock manure in agricultural areas. Changes in precipitation intensity affect runoff and infiltration rates, and therefore potentially the transport of nitrate and nitrogen species within the hydrological system. The purpose of this research is to better understand how extreme precipitation affects the variability of nitrate in groundwater. Water samples collected from the North Alouette River, as well cranberry and blueberry field ditches within proximity of the river, are analyzed for nitrate to determine the relationship between nitrate sources and receiving waters and possible pathways of transport. Nitrogen isotopic signatures are also used to determine sources of nitrate. In addition, oxygen, and hydrogen isotopic signatures of extreme precipitation events, specifically Atmospheric River storms, and river and field ditch water will be used to determine the proportion of groundwater recharge from Atmospheric River events. This research may be used for improving agricultural management practices, for example, by defining more suitable timing of fertilizer application with respect to heavy rain events.

Oral Session 3
Afternoon, Saturday, October 29, 2022

Polar climate

Characteristics and Drivers of Arctic and Antarctic Sea Ice Extent Variability in a Warmer Climate

Zachary Espinosa (he/him/his)

Surface temperatures in the Arctic are warming at about twice the rate of global surface temperatures - a phenomenon known as Arctic amplification. Dramatic positive trends in surface temperature have been accompanied by equally dramatic declines in the annual Arctic sea ice area minimum (SIA), a measure of perennial sea-ice. The majority of recent studies on SIA have investigated the characteristics and drivers of SIA decline in a warming climate. Far fewer studies have focused on understanding trends in the amplitude and seasonality of the interannual variability of SIA (IVSIA). Trends in IVSIA can modify the relative importance of natural climate fluctuations to anthropogenic climate trends in the Arctic. A change in this "signal-to-noise" ratio may have important implications for how we interpret future observations and for our ability to predict the annual ice edge. Using a thermodynamic, mathematical model of sea-ice growth and a simple geometric argument we demonstrate that trends in the IVSIA are controlled by 1) the geometry of the Arctic basin and Antarctic continent and 2) the strength of temperature dependent radiative feedbacks. Simulations of a latitudinally and seasonally varying diffusive energy balance model (EBM) and an analysis of various models in the CMIP6-Large Ensemble support the proposed theoretical framework. The framework is then seasonally extended, suggesting that negative trends in the IVSIA are enhanced in the summer compared with the winter in the Arctic.

Facing Arctic Climate Change: Developing Understanding in a Community-focused Framework

Ellen Koukel (she/her/hers)

The Arctic is warming at a much faster rate than the global average, a process that significantly and disproportionately affects the wellbeing of Arctic Indigenous communities who derive livelihoods and cultural significance from land and ocean resources in remote coastal locations. Historically, climate scientists have not prioritized metrics directly relevant to Arctic Indigenous communities, particularly at such local scales. Kivalina, Alaska, an Iñupiaq town located on the Chukchi Sea, is one such community. My research focuses on the timing, changes, and mechanisms regarding sea ice freeze-up at Kivalina. Here, I find significant shifts towards later ice advance dates from 1980 - 2019, leading to unsafe sea ice conditions for local travel and subsistence activities. Using simple linear regression models, I find that Chukchi Sea surface temperatures alone are not solely responsible for the timing of sea ice freeze at Kivalina. Then, utilizing ERA5 reanalysis data, I look into the atmospheric components primarily responsible for sea ice freeze-up to occur and determine that short-term anomalies in winds, temperatures at 500 and 850 hPa, and pressures at sea level and 500 hPa are necessary for the sea ice at Kivalina to freeze. The methodology used here is expected to be useful for similar local-scale sea ice forecasting applications in Arctic regions.

Climate change in sensitive regions

Advanced shoreline-change modeling of Hawaii's beaches

Richelle Moskvichev (she/her/hers)

As the climate changes, we are experiencing rising ocean levels that lead to erosion and flooding in coastal communities. Coastal erosion is mainly driven by wave action, rising sea levels, geology, and beach shape. The state of Hawaii is known for its sandy beaches, as well as for its diverse geologic coastline structure and powerful wave climate. Hawaii will experience rising sea levels, but of the state's more than 900 miles (1440 km) of unique coastline, only select areas have been well-studied with it in mind. There is a need for a comprehensive coastline-change study as a part of the state's climate mitigation plans. Here we present a process-driven model that can project shoreline change on nearly all of Hawaii's beaches. The model will be informed by historical imagery via automated high-resolution satellite shoreline detection, as well as extensive wave hindcasting and forecasting. Different types of beaches will have different model regimes, such as fully sandy beaches versus mixed sediment beaches. When completed, our model will show how Hawaii's coasts will grow or diminish with different future sea level rise, wave behavior, and climate mitigation scenarios. We anticipate that this model will be the starting point for advanced shoreline modeling in Hawaii and a crucial step towards helping to develop policies that benefit the state's future.

Oral Session 4
Afternoon, Saturday, October 29, 2022

Climate variability, from seasonal to orbital timescales

Antarctic Subglacial Precipitates Record Ice Sheet Response to Suborbital Southern Ocean Warming

Jessica Gagliardi (she/her/hers)

The response of the Antarctic ice sheet (AIS) to orbitally forced climate change on hundred thousand-year time scales is well characterized by offshore sediment records and model simulations. What remains poorly understood is how the AIS is affected by smaller changes in Southern Ocean temperature occurring on millennial to centennial timescales. This study presents a compilation of U-Th age and isotopic compositional data (87Sr/86Sr, δ18O, δ13C) from both new and previously reported calcite and opal subglacial precipitates that formed beneath the periphery of the Antarctic ice sheet. These U-Th dates from over 30 samples span 1 to ~500 ka and include locations across the continent with a focus on the Transantarctic

Mountains and the Ross Sea. Carbonate precipitation from subglacial waters records the time at which water was present beneath the cold-based glaciers at the ice sheet margins, and isotopic characterization of these waters suggests they originated from beneath the polar plateau (δ18O <-50‰) where elevated 87Sr/86Sr and [234U/238U] water compositions indicate prolonged periods of rock-water contact, likely in subglacial lakes located up-glacier from the precipitates. Comparison between the U-Th dates in this study and Antarctic climate records reveals a strong correlation between the timing of precipitate formation and Antarctic Isotopic Maxima (AIMs). We hypothesize that this correlation suggests that Southern Ocean warming drives grounding line migration and the acceleration in outlet glacier velocity, which in turn dilates subglacial hydrologic systems, permitting infiltration of meltwater from the wet-based ice sheet interior and matching the observed isotopic traits of the precipitates. Such a hypothesis would require that ocean forcing on millennial time scales strongly influences the Antarctic ice sheet, which will have implications for projections of future ice sheet behavior as ocean temperatures continue to rise.

Quantifying Antarctic Iceberg Rafted Debris Through the Pleistocene Using Artificial Intelligence

Claire Jasper (she/her/hers)

In the early Pleistocene the 41-kyr obliquity period dominates major climate proxy records. This observation is difficult to reconcile with the classic Milankovitch model that predicts global ice volume is controlled by summer insolation, which is dominated by both the 23-ky precession period and obliquity. This contradiction is the basis for the “41-kyr problem,” and a number of hypotheses have been formulated to explain the perplexing lack of precession in the global record of ice volume through the early Pleistocene. To better understand this apparent contradiction, we can use Antarctic Ice Sheet proximal records of mass loss, such as iceberg rafted debris (IRD). As large ice sheets grow and flow across a rocky landscape, they erode and incorporate basal continental rock into their mass. When icebergs calve from marine-terminating glaciers and float out to sea, they transport terrigenous material to distal marine locations. As the icebergs melt, the IRD grains are deposited into deep ocean sediments. These IRD grains are distinctly different from the silty clays typically found in deep sea sediments. The International Ocean Discovery Program (IODP) Expedition 382 recovered two high-resolution records of Pleistocene sedimentation with abundant IRD in the Scotia Sea. IRD is identifiable within X-ray images as granule- to pebble-sized black shapes with sharp edges and we have developed a computer vision approach using convolutional neural networks to identify and quantify these IRD grains. With this new approach, we present a new, high-resolution record of the distribution and flux of Pleistocene Antarctic IRD on orbital timescales.

Land-Ocean interactions over Western North Africa following the Middle Miocene (13.8 Ma) climate transition

Ray Zammit

The hydrological regime over North Africa and the Mediterranean is subject to abrupt changes from arid to humid and vice versa over geological timescales. The 6th IPCC report highlights great uncertainty in predicting future precipitation and drought over the region. The Miocene (23 to 5.5 Ma) represents a time of great environmental variability and can act as a natural laboratory where we can explore hydrology, carbon cycling, and depositional processes. During the Mid-Miocene climate transition (13.8 Ma) the Antarctic Ice-Sheet expanded significantly and the Earth System accelerated in its decent towards the Icehouse. This global cooling event also coincided with the final and complete disconnection between the Indian and Atlantic Oceans through the Tethys Sea-way. Here we present benthic and planktic foraminiferal geochemical data from the Island of Malta (Central Mediterranean) in order to investigate the response of North-African climate to these events. The following paleoproxies were measured, δ18O and δ13C of Trilobatus Trilobus (planktic) and Heterlopea Dutemplei (benthic), foraminiferal Mg/Ca Trilobatus Trilobus (planktic) and Uvigerina spp. (benthic). This allowed us to determine surface and bottom water temperatures (using the Mg/Ca paleothermometer) and the δ18O of sea water. The differences measured between bottom water and surface water δ18O allows to differentiate between the ice-volume signal and the precipitation/evaporation signal in the seawater δ18O record. Through this we were able to confirm that the West African Monson intensified following the Mid-Miocene.We suggest that this transition to a super-humid interval reflects a regional response to global cooling, gateway changes and astronomical forcing.

Proxy development

n-alkane Chainlength Distributions as a Paleo-Vegetation Proxy in eastern Africa

Ruth Tweedy (she/her/hers)

Understanding how the climate and ecology of eastern Africa have changed throughout the last 15 million years is an important part of human origins research, as vegetation structures (e.g. the proportion of trees to grasses on a landscape) contribute to evolutionary trait selection. Plant wax produced n-alkanes are a widely utilized and well preserved biomarker for terrestrial plants. While alkanes have long been used as stable isotope archives for hydrological or plant photosynthetic type reconstructions, we investigate their ability to archive information about the plant functional types (e.g. tree vs grass) they are produced by. Using a collection of over 400 modern plant samples, the relative distribution of odd chainlength homologues (i.e. 25-carbon chains through to 35-carbon chains) within each sample was measured. Binning these distributions by photosynthetic pathway and plant functional type, diagnostic qualities of certain plant types were identified. For example, C4 photosynthetic grasses are demonstrated to have more abundant long chain alkanes than other plant types. Chainlength distribution “fingerprinting” of plant functional types may provide a new proxy for the types of plants which existed at a site. By “unmixing” n-alkanes within a sediment archive using Bayesian analysis in future work, a time series of vegetational shifts at a site could be produced. Such a record would not only provide information about the habitats of early human evolution, but could also indicate climate changes on a local (e.g. site specific paleosol record) and regional/continental (e.g. lake or deep-sea ocean core) scale.

Oral Session 5
Morning, Sunday, October 30, 2022

<u>Atmospheric chemistry</u>

Hydrogen Sulfide Emission Properties from Two Large Landfills in New York State
Alexandra Catena (she/her/hers)
Landfills are a source of malodors, greenhouse gases, harmful pollutants, pests, noise, and litter. To reduce their impact on neighboring communities, landfill facilities and the policies they follow must reduce emissions of trace gases such as hydrogen sulfide and methane. However, a comprehensive understanding of the spatial variability of both pollutants at landfills should first be established to obtain a clear picture of emissions at landfills. This presentation will summarize a paper on this study, which measured the mixing ratios of hydrogen sulfide and methane at two landfills in New York State (Fresh Kills Landfill and Seneca Meadows Landfill) in November 2021 using laser-based methods deployed in a mobile lab. Hydrogen sulfide emission fluxes were also estimated based on a mass balance calculation using the methane flux from simultaneous airborne measurements and the ratio between the two pollutants. The fluxes were also compared to the self-reported EPA Greenhouse Gas Reporting Program Inventory. There was variability in mixing ratios, pollutant ratios, and hydrogen sulfide fluxes between the landfills, which can be attributed to various factors, including facility operations and design, landfill age, meteorology, types of waste, and pH levels, but further multiday measurements are needed at each landfill to improve emission estimates and determine a more accurate and resolute reasoning behind these variations.

<u>Clouds, radiation, and climate sensitivity</u>

ClimART: Emulating Atmospheric Radiative Transfer with Machine Learning
Salva Rühling Cachay (he/his)
Climate and weather prediction models are essential tools for providing crucial information to society, policymakers, and the public. The involved numerical simulations of Earth's weather and climate require substantial amounts of computation. This has led to a growing interest in replacing subroutines that explicitly compute physical processes with approximate machine learning (ML) methods that are fast at inference time. Within weather and climate models, atmospheric radiative transfer (RT) calculations are especially expensive. This has made them a popular target for neural network-based emulators. However, prior work is hard to compare due to the lack of a comprehensive dataset and standardized best practices for ML benchmarking. To

fill this gap, we introduce the ClimART dataset, which is based on the Canadian Earth System Model, and comes with more than 10 million samples from present, pre-industrial, and future climate conditions. ClimART poses several methodological challenges for the ML community, such as multiple out-of-distribution test sets, underlying domain physics, and a trade-off between accuracy and inference speed. We discuss our progress in tackling these challenges - e.g., how to incorporate physics into the ML models - and present several novel baselines that indicate shortcomings of the datasets and network architectures used in prior work.

Cloud-Radiative Feedbacks Within the Madden-Julian Oscillation

Hrag Najarian (he/him/his)

The Madden-Julian Oscillation (MJO) affects weather and climate globally; however, it has been challenging to accurately represent the MJO in Global Circulation Models (GCMs), which can lead to uncertainties when forecasting on the subseasonal-to-seasonal and climate time scales. However, the inclusion of cloud-radiative feedbacks in GCMs has been shown to improve MJO representation. Previous studies theorizing the MJO to be a moisture mode suggest cloud radiative feedbacks are an important process that leads to moistening and thereafter, enhanced convection. Furthermore, the MJO is known to have stronger cloud-radiative feedbacks compared to higher frequency convectively coupled equatorial waves, suggesting greater radiatively-driven moistening with lower frequency waves. Utilizing data from and during the Dynamics of the MJO/Atmospheric Radiation Measurement (ARM) MJO Investigation Experiment (DYNAMO/AMIE) field campaign, the MJOs cloud type evolution starts shallow, deepens, and then stratifies, while the higher frequency (Kelvin and Westward Interio Gravity) waves saw a less organized evolution. Furthermore, most cloud types (precipitating and non-precipitating) maximize in frequency after the enhanced phase (maximum precipitation) of the MJO, not seen for the higher frequency waves. Similarly, the MJOs cloud-radiative forcing (CRF) maximized after the enhanced phase and had the largest CRF amplitude compared to the higher frequency waves. After decomposing cloud-radiative moistening per cloud type frequency through a linear relationship between cloud type frequency and CRF, it was found that simultaneous moistening by all cloud types is responsible for maintaining the enhanced phase of the MJO. This analysis demonstrates the importance of capturing the correct evolution of different cloud types and their radiative effects to better understand the thermodynamics that govern the MJO.

Oral Session 6
Morning, Sunday, October 30, 2022

Extreme events

A Statistical Heat Wave Definition Employed from 1980 through 2020 across the Southern Great Plains

Taylor Grace (she/her/hers)

Model predictions have signaled an increase in frequency, longevity, and intensity of future extreme heat events due to global climate change. Heat waves continue to be defined by a variety of methods. This study aims to use a statistical methodology to generate a heat wave definition specific for the Southern Great Plains (SGP; 106.646W to 93.508W and 25.837N to 39.999N) to allow for climate variability, with respect to time and space. The heat wave methodology proposed in this study connects previous heat wave definitions, but incorporates a statistical standpoint compared to others. This study utilizes two reanalyses (ERA-5 and MERRA-2) and one re-gridded observational (Daymet) dataset from 1980 through 2020. The derived daily maximum and minimum standardized temperature anomalies are fitted to gamma, normal, and skewed normal distributions. This process is done for each grid point split into seasonal (i.e., Winter, Spring, Summer, and Fall) time periods from 1980 through 2020. By executing the KS-test, each grid point distribution is examined for goodness of fit, before assigning a percentile threshold for SGP heat wave events. Our results suggest that the skewed normal distribution is sufficient for both variables across most of the SGP. Further separation of the dataset into two primary time periods (i.e., 1980-2000 and 2001-2020) illustrated a shift in the best fit distribution function. This heat wave definition proposed in this study aids toward the progress of increasing the predictability and impacts of extreme heat events.

Changes in Hail and Associated Processes in a Future Climate

Holly Mallinson (she/her/hers)

Severe thunderstorms and their hazards (i.e., hail, tornadoes, damaging winds, flooding) present a significant socio-economic risk and the impacts of a warming climate on these hazards is unclear. Specifically, hail formation is dependent on numerous processes and interactions that span kilometers to millimeters, all of which are expected to change in the future and affect hail differently. Previous work concluded that thunderstorms will be stronger and in turn, hail will be larger in a future climate. However, these studies focused on changes in regional processes which have been shown to be poor predictors of hazard specifics (for example, hail size) because they do not provide information on small-scale processes necessary for hail formation and how these may change in the future. This study uses a high-resolution, pseudo-global warming modeling approach where five historical severe weather events are simulated in current conditions and in conditions modified by anthropogenic climate change to investigate how these events differ in a warmer climate. Preliminary results show that contrary to prior work, there is a shift towards smaller hail sizes despite stronger updrafts (which would act to support larger hail), in future climate scenarios. Future storms have more hailstones within the area of the storm responsible for hail growth, thus increasing competition for available supercooled liquid water necessary for hailstone growth. This increase in competition in tandem with warmer temperatures, leading to more hail melt, is hypothesized to be a key factor in shifting the size distribution.

Tropical dynamics and convection

Understanding the Land Surface Influence on Precipitation using Drydown Convective Available Potential Energy (CAPE)

Lily Zhang (she/her/hers)

Land-atmosphere coupling is a long-standing topic with growing interest within the climate and modeling communities. Understanding how land surface processes modulate the lower atmosphere has important implications for weather and climate prediction. One component of land-atmosphere coupling not yet fully understood is the soil moisture-precipitation relationship. This work quantifies the land influence on one pathway for precipitation, convection, by examining its development in the lower atmosphere during periods of soil moisture drydown. Using global satellite observations, we find clear spatial and temporal trends that link convective development to soil moisture content and evaporation. These observational results provide a basis of comparison for future work to evaluate how well weather and climate models capture the complex coupling between land and atmosphere.

Oral Session 7
Morning, Sunday, October 30, 2022

Urban design and climate policy & solutions

Where there's an (oil) well, there's a way: how energy sector involvement and political ideology impact support of climate change policy

Claire Burch (she/her)

As climate change adaptation and mitigation strategies make their way into policy, it is important to understand what shapes public opinion of these policies. In particular, when considering the success of climate change policy in more hostile state environments, understanding the nuances of support can help to inform policy design and implementation. My research looks at the impact of employment in the oil and gas sector and political ideology on climate change policy support in Oklahoma. Oklahoma represents a valuable case study for climate change policy support because its energy economy represents a unique environment for policy implementation. My results indicate that working in the oil and gas industry does not always negatively impact support for climate change policy. While I found that political conservatism did negatively impact support for climate change policy, my results present a nuanced trend where the probability of support was lower for policies that could be perceived as posing a threat to the fossil fuel industry. This research emphasizes that context for policy implementation is important and that the framing of climate policy can lead to a difference in support when communicated appropriately. My research contributes to considerations of a just energy transition, where we must consider the industries being phased out and how those workers fit into climate change policy and sector changes. It serves as an important reminder for those of us working in the field, that we should strive to not leave anyone behind.

Data-Efficient Machine Learning for Smart and Sustainable Buildings

Hari Prasanna Das (he/him/his)

In the United States, buildings are responsible for approximately 40% of primary energy consumption, 73% of electrical use and 40% of greenhouse gas emissions, a major contributor for climate change, and such high levels are now rapidly spreading across the rest of the world. At the same time, buildings are integral to our lives, as we spend most of our time in them which substantially affects our health, well-being, and productivity. My research aims to improve the energy efficiency of buildings, reduce their environmental impact, and at the same time, improve the way they function for the people who work and dwell inside them. I focus on developing Artificial Intelligence (AI) and Machine Learning (ML) based solutions to achieve occupant thermal comfort in buildings, control heating and cooling systems efficiently, adapt lighting and temperature to occupancy patterns, and change energy use in response to carbon-sensitive energy prices. Furthermore, to improve the scalability of the ML models and ensure they get deployed in real-life buildings, I implement transfer learning algorithms to adapt the models from one environment (room/building/occupant) to others, without requiring significant manual data collection and labeling in the target environment. My research continues to inspire numerous follow-up research on smart building design and analysis helpful for developing standards to be followed for smart building construction. Furthermore, considering the heterogeneity of buildings, my research on transfer learning will help scale up the above solutions to multiple buildings in a seamless manner.

<u>Social impacts of climate change</u>

Modeling drivers of internal displacement from climate

Rachel Green (she/her/hers)

In the 2021 Global Report on Internal Displacement, 30 million people were estimated to have been displaced by weather related disasters in 2020 (IDMC 2021). By 2050, projections indicate that as many as 216 million people could be displaced worldwide due to climate change (Clement et al. 2021). To understand where and when populations are most at risk to becoming displaced, it is necessary to develop innovative data monitoring and predictive analytics. The Horn of Africa, including Somalia, has been subject to frequent periods of food insecurity due to climate variation and internal conflict. Somalia is prone to back-to-back severe, prolonged droughts that often trigger intensive flooding, leaving subsistence farmers and pastoralists vulnerable to significant crop and livestock production. This research explores the timing and severity of drivers to internal displacement on a weekly basis across Somalia using data from the United Nations High Commission for Refugees (UNHCR) Protection and Return Monitoring Network. The work is grounded in spatial interaction gravity-type modeling of origin-destination flows. By examining the relative importance of drought events, flooding, conflict, and food security indicators in shaping mobility patterns in both rural and urban areas, we can improve anticipatory action. Contributions from this research include the development of empirical methods to blend climate, social and population data to build contextual understanding of situations that provoke displacement. Further, findings will inform effective practices for both scientists disseminating climate information for crisis applications as well as decision makers and responders identifying vulnerable hotspots. References: IDMC (2021) Global Report on Internal Displacement.; Clement, Viviane, Kanta Kumari Rigaud, Alex de Sherbinin, Bryan Jones, Susana Adamo, Jacob Schewe, Nian Sadiq, and Elham Shabahat. 2021. Groundswell Part 2: Acting on Internal Climate Migration. Washington, DC: The World Bank.

POSTER PRESENTATION ABSTRACTS

Poster Session A
Evening, Friday, October 28, 2022

<u>Urban design and climate policy & solutions</u>

Environmental Drones: Empowerment through Socio-Technical Transition

Katherine Hasnain (she/her/hers)

The application of drones in environmental research is a revolutionary concept: it is a cost-cutting tool that empowers researchers to monitor environmental impacts and to deter ecological hazards at their incipiency. The environmental use of drones originates from the exigencies of ecological observation and avoids the substantial drawbacks associated with alternative technologies such as manned aircraft and satellite photography (Koh & Wich, 2012). As a new remote-sensing technology, environmental drones have been employed to map the effects of climate change and to empower communities to protect their environment. Although drone use has been explored within the conservation sciences, there has been little engagement within the social sciences (Millner, 2020). I ask the question: How does the theoretical framework of socio-technical transition inform the current uses and barriers of environmental drones? My research fills an important gap in the literature and accomplishes several firsts: 1) it examines drone usage across environmental fields, and 2) it collects individual interviews from drone researchers. I investigate this question via semi-structured interviews with researchers experienced in environmental drone use. As a result of the ongoing socio-technical transition, I predict that the use of drones will become a major environmental technology. Drones are a new vector for access and empowerment in conservation which will reshape the field of environmental research.

Identifying the Challenges to Sustainable Urban Last-Mile Deliveries: Perspectives from Public and Private Stakeholders

Thomas Maxner (he/him/his)

While freight transportation is a necessary activity to sustain cities' social and economic life—enabling the movement and deployment of goods and services in urbanized areas—it also accounts for a significant portion of carbon dioxide (CO_2) emissions. The urban freight ecosystem is a complex network of agents, both public and private. Reducing CO_2 emissions from urban freight requires the collaboration and coordination between those agents, but the motivations behind their goals, strategies for achieving those goals, and the challenges faced by each agent may differ. In this paper, we document the strategies aimed at reducing CO_2 emissions considered by cities and private companies with the goal of understanding the challenges to progress faced by each. To accomplish this, we interviewed officials from purposefully sampled city departments in North America and private companies involved in city logistics. We found that cities face challenges related to a lack of strong leadership, resources, and policy tools. Companies must consider technological challenges, costs, and their workforce before reducing emissions. Cities and companies are challenged by the disaggregated nature of the urban freight "system"—a system that is not organized at the municipal scale and that is driven by performance and customer expectations.

Environmental impact of an export-oriented residual-based wood pellet trade between PNW and Asia

Hemalatha Velappan (she/her/hers)

The U.S. Pacific Northwest (PNW) has been experiencing bigger and more frequent wildfires over the past decade. Approaches used to mitigate wildfires, such as thinning, result in residual biomass being left in the forest as slash piles. A substantial portion of these residues are considered waste and are burnt, emitting harmful particulate matters such as PM 2.5, which is known to cause lung-related ailments, asthma, and chronic obstructive pulmonary disease (COPD). Utilizing residues to produce bioenergy products such as pellets can be an alternative approach to avoid air pollution and mitigate wildfires. However, there is no significant domestic market for pellets to establish a profitable industry.

After the Fukushima nuclear disaster, Japan looks at alternative energy sources, including renewable energy and coal. The introduction of policies and incentive schemes to promote renewable energy makes Japan an excellent bioenergy export destination for pellets producers in the PNW. However, it is essential to understand whether producing pellets in the PNW and shipping them to Japan is environmentally and economically beneficial than alternative sources such as coal.

We found that substituting coal with PNW's residual biomass for generating electricity in Japan could result in a 90% reduction in global warming and a 67% reduction in pile burning-related PM2.5 pollution on average. Economically, a pellet mill with 40,000 tons production capacity selling to Japan could gain 15–33% profit annually over their cost. We estimated that Washington state could save around $4 million of fuel and $5 million of costs associated with avoided air pollution per year by diverting a portion of the residues to this pellet mill. Although Japan would incur an economic loss by substituting coal with pellets due to the lower price of coal, the overall social benefit is positive if the hidden environmental costs of burning coal are included.

Future Land-Use + Future Precipitation: Evaluating Changes in Flooding Associated with Hurricanes Florence, Floyd, and Matthew in a Future Climate

Katy Hollinger

Hurricanes Floyd (1999), Matthew (2016), and Florence (2018) caused large amounts of precipitation and devastating flooding throughout much of eastern North Carolina (NC). While these storms were very impactful when they occurred, the question exists of how much worse they could have been had they occurred in a future, warmer climate. To address this question, we completed a series of numerical model simulations for both a present-day and a future warmer climate. Even though each storm behaves slightly different, each future version of the storm results in an increase in the amount of precipitation over NC, as well as an increase in the rate at which the precipitation falls over NC. While these simulations allow us to quantify how much precipitation these three storms may produce in a future climate, we have yet to evaluate what might happen when that rainfall reaches the surface, and how it might impact local infrastructure and communities. By combining hydrological and atmospheric modeling, the goal of this study is to pair future projections of precipitation with future projections of land-use and urbanization for cities across eastern NC that were impacted by all three storms (such as Raleigh or Wilmington). By varying the combinations of present and future land-use and present and future precipitation, we can get a better understanding of what urban infrastructure planning may be necessary for the future in order to reduce the impacts from the flooding associated with these heavy precipitation events.

Social impacts of climate change

Community resiliency in the built environment: The effect of climate change on Seattle's emergency weather shelters

Anisha Azad (she/her)

King County currently ranks 3rd in the nation for the number of people experiencing homeless. Amid an affordability housing crisis, the number of people experiencing homelessness continues to grow in Seattle. In historically redlined communities, residents disproportionately experience homelessness because of gentrification. Resources for people experiencing homelessness, concentrated in densely populated Seattle neighborhoods, support the community's resiliency towards inclement weather. Locally, the effects of climate change have induced an increasing amount of extreme heat, unhealthy air quality index, and freezing temperature days in the past decade. People experiencing homelessness are the most vulnerable to inclement weather. Permanent congregate and emergency shelters serve as lines of defense against both mild and severe weather events. Amidst the ongoing Covid-19 pandemic, service providers have had to adapt to mitigate the impacts of a public health crisis on homeless shelters. Underrepresented and underreported, Seattle's homeless population faces increasing health risks associated with climate exposure and infectious disease. Operators of homeless shelters also experience additive stress from environmental factors. Labor shortages, occurring during inclement weather, result in inadequate shelter availability. People are left out on the street, facing unhealthy exposure to the elements. The purpose of this study is to gain insight into the respective living and working dynamics of shelter operators and clientele, focusing on moments of environmental stress. Through interviewing representatives of Seattle's most densely populated areas, the compounding health disparities associated with living in redlined neighborhoods could offer insight into the disproportionate effects of climate change on Seattle's most underserved communities.

Save the Farms: Nonlinear Impact of Climate Change on Banks' Agricultural Lending
Ted Liu
The agricultural sector is particularly susceptible to the impact of climate change, both in terms of production and access to bank financing. This paper contributes to the literature by investigating how vulnerability to climate change affects U.S. farms' credit access, using a novel panel dataset at county level. The results show that increasing exposure to climate change can reduce bank lending to farms, and such impact is nonlinear. Additionally, while the contemporaneous effects are significant, the impact of climate change on bank lending also materializes over time. While the overall effects are negative, more granular analysis suggests that different farm groups fare differently. With growing vulnerability to climate change, small to medium farms almost always experience some loss of loan access and funding. In comparison, large farms see less severe credit contraction, and in some cases may even see improvement in funding. While such patterns hold for the United States as a whole, the paper sheds light on the range of regional heterogeneity as well.

Does humidity matter? Prenatal heat and child growth in South Asia
Katie McMahon
Extreme heat under climate change has already begun to threaten health, particularly for mothers and babies in the hottest parts of the world. When exposure occurs in utero, extreme heat can undermine child growth and development, leading to devastating later-life consequences for both health and socio-economic stability. However, different types of prenatal heat may pose different risks for child health, acting through either physiological heat stress or maternal malnutrition. To isolate the former mechanism, we assess the specific impact of humid heat extremes on child height attainment in four South Asian countries using fine-scale climate records, trimester-level exposure identification, comprehensive data on child growth and demographics, and a rigorous fixed effects design. Our results provide new insight into which heat events are most dangerous for early life health and when, in a region where near-annual heat waves already affect millions and are projected to worsen under further climate change.

<u>Tropical dynamics and convection</u>

Impacts of the Madden–Julian Oscillation on the diurnal cycles of deep convection and precipitation over the Congo Basin
Kathrin Alber (she/her/hers)
Tropical forests are global epicenters of biodiversity and important modulators of climate change. The recently documented drying trend over the Congolese rainforest has drawn worldwide attention to its vulnerability to climatic change. The Congo is also a hotspot for deep convection where thunderstorms and rainfall have a strong diurnal cycle. Various modes of variability such as the Madden-Julian Oscillation (MJO), the leading mode of intraseasonal variability in the tropics, further impact precipitation and deep convection over the Congo and thereby also influence the diurnal cycle. This study therefore analyzes the impacts of the MJO on

diurnal variations of deep convection and precipitation over the Congo and explores possible mechanisms leading to the observed changes, using GridSat-B1 and TRMM satellite and ERA5 reanalysis data. Results show that convection and precipitation are increased during the MJO enhanced phase and decreased during the suppressed phase, where the difference between the two phases is largest during the morning hours when convection is weakest. Additionally, convection is shown to be shallower during the MJO suppressed phase and deeper during the enhanced phase, possibly due to the observed enhanced upward vertical velocity in the mid- and upper levels and the stronger divergence in the upper atmosphere during the enhanced phase. Results also indicate that the MJO may influence the type of precipitation, i.e., convective and stratiform. While the fractions of convective precipitation are similar during the enhanced and suppressed phases, the fraction of stratiform precipitation is higher during the enhanced phase, mainly during the morning hours.

Shifting gears of soil moisture–climate regimes under increasing CO2

Hsin Hsu

The full range of soil moisture (SM) at any location can be separated into dry, transitional, and wet regimes by key thresholds of SM: the wilting point (WP) and critical soil moisture (CSM). Each SM regime exhibits different relationships between SM and surface heat fluxes. When SM falls within the transitional regime, it controls evaporation rates, affecting atmospheric heat and humidity. Accordingly, SM regimes correspond to different gears of land-atmosphere coupling. We have determined global patterns of SM regimes, WP, and CSM and their future changes from several climate models. Results show that the range of SM extends into unprecedented coupling regimes in many locations under increasing CO2. The strongly coupled transitional regime emerges most often, seen in currently humid areas of the tropics and high latitudes. SM in many semiarid regions migrates from the dry and the wet regimes into the transitional regime. This could be attributed to the change in SM distribution (moistening effect) and changes in CSM (energy effect) under global warming; both responses are seen in climate models. Quantifying these two contributors to disentangle which factors contributes toward the emergence trend of the transitional regime is our next step.

Non-local Controls on Tropical Cyclogenesis: A Trajectory-based Genesis Potential Index

Lingwei Meng

Tropical cyclone genesis (TCG) is a continuously evolving process initiated by convective TC precursors or "seeds" and influenced by environmental conditions, both local and non-local, along the seed-to-TC trajectory. Genesis potential indices (GPIs) have previously been constructed to evaluate TCG frequency using local environmental variables. Currently, the role of non-local environments on TCG remains elusive and they are not included in any GPI. In this study, we first investigate the local environmental factors that are most influential on seed genesis and TC genesis, respectively, over the Eastern North Pacific (ENP) and North Atlantic (NA). A sequential feature selection algorithm (SFS) applied to 20 candidate variables identifies the upward motion as the dominant factor regulating the seed genesis over both basins, and the vertical wind shear (heating condition) as the leading factor favoring TCG in the ENP (the NA). We next propose trajectory-based GPIs (traj-GPIs), which aim to link the TCG frequency to the environmental conditions at the seed genesis points. The approach is to construct spatial filters using observed trajectory densities and to merge adjacent non-local environments into each grid-point by convolving the filters with the environmental fields. SFS is again used to identify the dominant filtered factors, followed by the Poisson regression to produce the "traj-GPIs". Then seed activity, driven mainly by upward motion, and maturation, controlled primarily by vertical wind shear or heating, is captured simultaneously. Traj-GPIs provide a more accurate reproduction of spatiotemporal variations than the original GPIs.

Assessment of Stratospheric Wave Activity Associated with the Madden-Julian Oscillation (MJO) and its Potential Impact on the Quasi-Biennial Oscillation (QBO)
Sadiksha Rai
The Madden-Julian Oscillation (MJO) and Quasi-Biennial Oscillation (QBO) are known to provide sub-seasonal to seasonal predictability, yet their dynamics and interactions are not fully understood. Many recent studies have found that the MJO amplitude tends to be higher during the easterly phase of the QBO and vice-versa, over the Maritime Continent and warm pool regions during boreal winter. It is often believed that this relationship arises through the modulation of upper-troposphere and lower stratosphere lapse rate by the QBO, but the impacts of the MJO-related deep convection on the evolution of the QBO have not been examined in depth. Vertical momentum fluxes by stratospheric equatorial Kelvin and Rossby-gravity waves generated by tropical deep convection are known to play important roles in the dynamics of the QBO. It is hypothesized that the stratospheric waves can be modulated by the MJO convective activities, which can then influence QBO evolution and contribute to the observed MJO-QBO relationship. Hence examining the potential changes in the stratospheric wave activity associated with the MJO and its potential impacts on the QBO is the main objective of this study. The results show that enhanced MJO activity is associated with slightly faster downward propagation of the QBO, though wavenumber-frequency spectral analysis of reanalyses zonal winds does not show any MJO impacts on stratospheric wave activity. While analyzing high-frequency stratospheric waves from EAR data, they were found to be significantly modulated by active MJO activities which might be the reason behind the faster downward propagation speed of the QBO.

Diagnosing convective organization in different phases of the MJO: a modeling study
Mingyue Tang
It has been hypothesized that the initiation and the propagation of the Madden-Julian Oscillation (MJO) are related with the organization of convective clouds that make up the larger-scale convective envelopes. The organizational modes of such clouds, on the other hand, can also be greatly affected by environmental conditions that may vary across the MJO life cycle. Although

the existence of different degrees of organization during various phases of the MJO is well documented in observations, the mechanisms responsible for such differences are yet to be fully understood. Here, this problem is approached following a modeling perspective, using a combination of Eulerian and Lagrangian numerical models. First, observational data from the Dynamics of the MJO (DYNAMO) campaign is used to validate high-resolution model simulations obtained using the Weather Research and Forecasting (WRF) and the System for Atmospheric Modeling (SAM) models. Then, different organizational indices are introduced and their application to diagnose convective organization in the model simulation during different phases of the MJO is discussed. Finally, Lagrangian diagnostic tools are used to investigate at a process level how convective features, like cold pools, modulate the degree of organization at different stages of the MJO. This analysis demonstrates the importance of both the environmental conditions affected by the MJO and the smaller-scale convective dynamics to vary tropical convective organization, and will hopefully be useful to better understand the two-way feedback between MJO and convective organization.

A Vertically Resolved MSE Framework to Study Convective Self-Aggregation Over Diverse Climates

Lin Yao

While convective storms have a great influence on society, it is still challenging to understand what processes drive storms and how they interact with climates. Recent studies have drawn attention to a phenomenon called convective self-aggregation (CSA), where random convective storms spontaneously aggregate into large-scale organizations over uniform sea surface temperature (SST). We care about CSA because it is a toy analog to tropical cyclones and Madden-Julian Oscillation, and it can significantly change the climate.

Here, we built a vertically resolved moist static energy (MSE) framework to study CSA. The framework can quantify the contribution of various processes at given altitudes to the development of CSA. The results showed that most of the MSE variance associated with CSA is concentrated in the boundary layer in the current climate (Yao, Yang, and Tan 2021). This finding supports the hypothesis that processes in the boundary layer are essential to the development of CSA. To further understand CSA over diverse climates, we define a depth (H), below which the air contains 70% of MSE variance in the troposphere. This is the layer that aggregates most. The result shows that H first decreases with SST in colder climates (< 295 K) and then increases with SST in warmer climates. In the warmer cases, H is related to the scale height of saturated vapor pressure. This relationship can predict how the layer that aggregates most changes with warming. The framework can be further applied to reveal the essential processes of tropical cyclones and the MJO.

Clouds, radiation, and climate sensitivity

Seasonal and spatial variations of marine low cloud mesoscale structures

Celeste Tong

The radiative effects of marine low clouds are one of the major uncertainties in predicting the future climate, and different types and different mesoscale convective structures have different radiative properties. In this study, we use satellite observations to investigate the seasonal and spatial variations of six classifications of marine low clouds and meteorological factors, such as sea surface temperature and estimated inversion strength, related to the occurrence frequency of each classification.

Sensitivity of climate state to the efficiency of atmospheric heat transport

Zhihua Zheng (he/him/his)

Atmospheric Heat Transport (AHT) is a key process of the climate system as it moderates the climatological equator-to-pole temperature contrast and its response to global warming (e.g., polar amplification). However, there is a lack of understanding of how changes in heat transport impact the inter-model spread of future climate change. Here we use a Moist Energy Balance Model (MEBM) to explore the impacts of AHT efficiency (described by diffusivity) on the climate mean state and future change. Three groups of experiments were conducted to investigate (1) the effects of the magnitude of diffusivity; (2) the spatial pattern effect of diffusivity; and (3) the relative role of sensible and latent heat diffusion. We find that both climate mean state and future change are sensitive to the diffusivity magnitude, but limits do exist. Changing the spatial pattern of diffusivity in extra-tropics has a stronger impact on climate fields than that in the tropics. Different ratios of sensible and latent heat diffusion would lead to dramatically different climate state and response. Our results also highlight the sensitivity of hydrological cycle to AHT efficiency and would help future efforts in interpreting and constraining inter-model spread of climate projections.

Atmospheric chemistry

Meteorological controls on Southern Ocean CCN-active aerosols

Qing Niu (she/her/hers)

The Southern Ocean's (SO) clouds fields have emerged as one of the lynchpins in our understanding of the Earth's climate system. Yet previous global climate models failed to accurately represent cloud phase distributions in this observation-sparse region. Clouds, precipitation, and aerosol data collected by the Atmospheric Radiation Measurement during the 2017-18 Measurement of Aerosols, Radiation, and CloUds over the pristine SO (MARCUS) Experiment are used to study the meteorological controls on marine boundary layer aerosols in a pristine environment. This is the first study that analyzes seasonal variation for aerosol-cloud interaction at latitudes south of 62S in summertime Australia SO, releasing clear different Cloud

Condensation Nuclei (CCN) sources and sinks.Results show that there is no significant correlation between CCN number concentration measured at 0.2%, and 0.5% supersaturation and horizontal surface wind speed (U). However, a positive correlation for aerosol concentration with diameter $500 < D < 1000$ nm, and a negative correlation for aerosol concentration with 60 nm $< D <$ 100 nm exists with U. This positive correlation shows N500-1000 may be dominated by sea spray aerosols generated by wind-wave interaction, while the negative correlation is consistent with the competing source of DMS (dimethyl sulfide) oxidation and sink of H2SO4 on super-micron sea salt during high winds. Results from air mass back trajectories, wind, aerosols properties, precipitation, and cloud base height are consistent proofs. These results focusing on CCN-active help optimize global models on how natural aerosols influence cloud microphysics.

Beyond the Lockdowns: Satellite Observations of Aerosol Optical Depth during the First Year of the COVID-19 Pandemic

Sarah Smith (she/her/hers)

Anticipated future reductions in aerosol emissions are expected to accelerate warming and substantially change precipitation characteristics. Therefore, it is vital to identify the existing patterns and possible future pathways of anthropogenic aerosol reductions. The COVID-19 pandemic prompted abrupt, global declines in transportation and industrial activities, providing opportunities to study the aerosol effects of pandemic-driven emissions changes. Here, measurements of aerosol optical depth (AOD) from two satellite instruments were used to characterize aerosol burdens throughout 2020 in four Northern Hemisphere source regions (Eastern & Central China, the United States, India, and Europe). In most regions, record-low measures of AOD persisted beyond the earliest "lockdown" periods of the pandemic. Record-low values were most concentrated during the boreal spring and summer months, when 56% to 72% of sampled months showed record-low AOD values for their respective regions. However, in India and Eastern & Central China, the COVID-19 AOD signature was eclipsed by sources of natural variability (dust) and a multi-year trend, respectively. In the United States and Europe, a likely COVID-19 signal peaks in the summer of 2020, contributing as much as -.01 to -.03 AOD units to observed anomalies.

Poster Session B
Evening, Friday, October 28, 2022

<u>Environmental management & agriculture</u>

Community Engagement in Academia: Collaborating with Local Government to Assist in Rain Garden Development

Natasha Dacic (she/her/hers)

Climate research is often motivated by societal concerns, but then conducted without regard for or communication with the communities that it affects. Moreover, academic standards of achievement focus on publishing journal articles and reports that are tailored towards academics, making scientific knowledge and articles inaccessible to stakeholders and decision-makers. Even when scientists want to engage with stakeholders, most physical scientists lack training in the tools and best practices needed for community engagement. We, members of the Department of Climate and Space Sciences and Engineering at the University of Michigan, set out to bridge this gap by developing a course for the Winter 2021 semester that centered student-run scientific collaborations with community members. As a part of this course, students and advisors collaborated with the Washtenaw County Water Resources Commission to identify ideal rain garden locations based on multiple criteria. Our work produced research that was immediately and directly actionable, allowing us to both develop the skills necessary for working with local partners and to explicitly incorporate community equity considerations into our scientific methodology. Here we present the first iteration of this course and the final deliverables of rain garden locations to highlight the success of the project.

Highlighting the co-benefits of climate action to increase climate change engagement among Western agricultural landowners: a survey experiment approach

Lauren Hunt (she/her/hers)

Meaningful climate change action requires public support across sectors. Despite increasingly severe climate impacts to US agriculture, many agricultural producers do not adapt to or mitigate climate change. Barriers to action include politicization, adherence to social norms, or the perception that climate change is not personally threatening. Some research suggests that climate action co-benefits, or the positive social, economic or environmental benefits that a climate change program provides, might increase engagement. In a global study, decision-makers' support for climate action increased when they were provided information about the co-benefits of climate change strategies, even among those who do not believe climate change is real (Bain et al., 2016). However, other research has shown that highlighting climate co-benefits is unlikely to affect policy support (Bernauer and McGrath, 2016). Therefore, it is still unclear whether including co-benefits changes engagement in climate programs or actions. Furthermore, the appeal of co-benefits has not yet been tested explicitly in agricultural communities (Fleming et al., 2019). Our study will help resolve this ambiguity by testing if programs which emphasize climate co-benefits influence preferences for engagement. To do so, we will administer a survey experiment and conduct a conjoint analysis to examine policy preferences and choices among Western agricultural producers in OR, ID, and MT. Our findings will improve our understanding of the drivers of climate programmatic support, explore the tradeoffs producers make when deciding whether to engage in agricultural programs and practices, and inform the design of future climate programs and policies.

Winter wheat yield prediction at field scale combining satellite imagery, weather, and management data in Kansas, USA

Rebecca Lima Albuquerque Maranhao (they/them/theirs)

Accurate prediction of winter wheat yield at the field scale is critical to addressing crop production challenges and reducing the impacts of climate variability. Remote sensing provides observations over large areas at regular intervals making it useful and low-cost for large-scale crop modeling. This study aimed to investigate the potential of satellite imagery in predicting winter wheat yields at field scale in Kansas, USA. We are analyzing 656 agricultural fields across the state from 2016 to 2018 by the performance of different sensors Landsat, MODIS and Sentinel. Linear regression and random forest (RF) models were built to predict winter wheat yield based on NDVI variables: the NDVI area under the curve and NDVI weekly data. Zonal analysis and prediction with weather and management variables were conducted using RF. Landsat NDVI variables presented the best performance with R^2 0.54, RMSE 0.80 Mg ha-1. The RF prediction model performed better by zones (North Central, South Central, West) when including weather and management variables. NC and SC presented the best performance with RMSE of 0.69 Mg ha-1 and 0.61 Mg ha-1 compared to West, RMSE=0.92 Mg ha-1. The results showed that is possible to predict yields in earlier stages of the growing season, however, accuracy will depend on weather conditions, especially in SC and West. NDVI variables during anthesis and grain filling are the most appropriate for winter wheat yield prediction. Finally, we highlight the importance of using more homogenous climate crop zones for winter yield prediction using satellite imagery in Kansas.

Machine learning-inspired weather forecasting for solar photovoltaic potential

Chinedu Nsude

Although the Nigerian weather provides very favorable weather conditions for clean power generation, there is little penetration of renewable energy systems in the region since over 95% of the power is fossil fuel generated. This is because there is no detailed report showing the potential of clean power generation systems due to the dysfunctional meteorological stations in the country. This paper seeks to fill this knowledge gap by providing a machine learning-inspired forecasting of the environmental weather parameters that can be used by manufacturing companies in evaluating the profitability of citing renewable energy systems in the region. Crucial weather parameters like the daily air temperature, relative humidity, atmospheric pressure, wind speed, and rainfall are scraped from NASA for a period of 19 years (viz 2004-2022), resulting in the collection of 6,664 high-resolution data points. This data is used to build diverse regressive neural networks with varying hyperparameters to find the best network arrangement. In summary, low mean squared error of 710-3 and high regression correlations of 96% are obtained during the training.

Monitoring Future Land Surface Temperatures using CA-Markov Model: A case study of Ibadan, Nigeria

Henry Olasunkanmi Olayiwola

Rapid pace of urbanization in many cities of the world has led to the transformation of natural landscapes into artificial surfaces with considerable effects on the environment. It has occasioned inadvertent alterations in surface thermal characteristics, local and regional climate and the geophysical conditions of the urban environment. Increasing rate of urbanization with continuous alterations on the natural surface features is expected to continue with its attendant problems in the near and far future. Thus, this study adopted geospatial techniques using Landsat observed TM, ETM+ and TIRS/OLI data for the years 1984, 2000 and 2018 to investigate the spatial and temporal variation in Land Surface Temperature (LST) associated with urbanization processes in the city of Ibadan, Nigeria. An attempt was made to project future surface thermal changes by simulating LSTs for 2028, 2038 and 2048, using Cellular Automata Markov (CA-Markov) Model and a stepwise multiple regression analyses model. Quantitative analysis on the past and future LST impacts of urban land cover change was carried out. The simulations showed that the temperature values ranged between 24.65°C – 39.40°C in 2028, 25.31°C - 42.52°C in 2038 and from 25.89°C – 44.21°C in 2048. Notable increases in the simulated LST in the urban areas, particularly the city centers were observed to be relatively higher when compared with past years. The rural and suburban areas are experiencing rapid urbanization, which led to transitions from low and medium temperature to relatively higher projected temperatures in the future years.

Ecoclimate & biological responses to climate change

Range stasis in the North Cascades: A sign of plant resiliency or sensitivity to climate change?

Katie Goodwin (she/her/hers)

Climate change is causing many species' ranges to shift upslope to higher elevations as they track their climatic requirements. However, a recent study found that many plant species in the North Cascades, WA have not recently shifted their ranges despite having experienced warming. Whether this range stasis indicates sensitivity or resiliency to climate change remains unclear. Delayed mortality may slow low elevation range contractions while time lags and barriers to colonization may slow or prevent high elevation range expansions into newly suitable climates. In combination, these processes indicate a lagged sensitivity to climate change. Meanwhile, small-scale variation within the landscape may create pockets of suitable habitat within otherwise unsuitable elevations that buffer range shifts and indicate climate change resiliency. In this study, we combine a seed addition experiment across species' elevational ranges with herbaria records to assess how seedling recruitment varies across the range of 25 plant species in the North Cascades. Preliminary results suggest more seedling recruitment in the historically cooler part of ranges and a mismatch between adult occurrence and where new seedlings can establish. Whether range stasis results from a resilience of some locations to climate change or an inability of species to respond to climate change will have very different implications for conservation. By comparing species climatic ranges to seedling recruitment patterns, we identify potential colonization and mortality lags and suggest that range stasis indicates delayed vulnerability to climate change in the North Cascades.

Investigating the Influence of the Stomatal Slope Parameter on the Earth System

Amy Liu (she/her/hers)

Plants on land play a role in regulating carbon fluxes and the water cycle, but it is difficult to project how plant functioning will change under a future climate and how those changes will impact local climate and hydrologic extremes. Plant processes are dictated by the stomatal conductance, which correspond to the aperture of the plant stomata. Stomatal conductance is represented in Earth system models (i.e. Community Earth System Model, CESM) through various models that all have an empirically fit parameter. In the Medlyn model for stomatal conductance, that parameter is the stomatal slope parameter, and typically one value is used to represent each plant type. However, the range within and across plant types is large, which implies a large variance of plant responses on the Earth system. Using one stomatal slope value has implications on the Earth system and our climate projections. We vary the stomatal slope parameter to evaluate its influences on the Earth System under different CO_2 concentrations, and how that changes with atmospheric and leaf area feedbacks.

Temperature, Rainfall, and Fire in the Alpine Zone of the Rwenzori Mountains, Uganda-D.R.C

Andrea Mason (she/her/hers)

High-elevation tropical regions are believed to be some of the most sensitive to climate change. In Africa, the effects of climate warming are already detectable as mountain glaciers have significantly retreated in the past few decades. In addition to glacial retreat, recent incidences of drought, fire, and flooding suggest that climate warming may already have begun to impact a variety of ecosystem processes and services; however, the short duration of observational records limits our ability to test whether these changes result from shifts in precipitation, temperature, or human activities. The Rwenzori Mountains, located on the border between Uganda and the Democratic Republic of the Congo, is one such region. Recent large-scale fires in the alpine zone undercut assumptions that fires were impossible in the cold, moist highest elevations. To put these recent climatic and environmental changes into context, we use paleoclimate and fire proxies (GDGTs, leaf wax isotopes, and charcoal) to reconstruct climate during the most recent deglaciation and Holocene in the Rwenzori Mountains. Here, we present sediment core biomarker and isotope records from two different high-elevation lakes in the Rwenzori's: Lake Africa (3895 m asl) and Lake Kopello (4017 m asl). These records serve to improve our understanding of Afroalpine climate-ecosystem dynamics and evaluate how high-elevation tropical regions may respond to anthropogenic warming.

Plant community shifts in response to climate change in Pacific Northwest montane forests

Kavya Pradhan (she/her/hers)

Understanding organismal responses to climate change is key to assessing future vulnerability and impacts on ecosystem functioning. As organisms shift their distributions in response to climate change, one potential implication at the community level is the predictable replacement of cold-adapted species by warm-adapted species (thermophilization). However, communities could also respond with no change or with unpredictable reorganization leading to novel communities. To assess how tree and the understory forest communities in the Pacific Northwest have responded to recent warming, we revisited vegetation plots at Mount Rainier National Park originally surveyed four decades earlier. Using joint species distribution modeling, we first modeled relationships between plant communities and climate. We then quantified floristic temperature (i.e., the temperature of the plant community) and used this to assess how much communities have shifted relative to observed changes in climate. We found that climate explains a large amount of variation in plant community composition and that communities have thermophilized. However, even though community shifts were in the direction expected (leading to warmer floristic temperatures), shifts were lagged relative to observed warming – implying that lagged responses are likely. We also found that understory communities have shifted more than tree communities, implying that novel communities may arise with future warming. Overall, our results suggest that communities are partly responding to climate change as expected, but lags in community shifts and different rates of change of tree vs understory communities will likely lead to community reorganization.

Investigating Dinophysis response to prey scarcity in Nauset Marsh
Serena Sung-Clarke (she/her/hers)
Harmful algal blooms (HABs) are globally occurring phenomena that pose a risk to human and ecosystem health. Much is still unknown about the exact conditions that lead to specific types of blooms or how climate change will impact their distribution and timing. Many species in the dinoflagellate genus Dinophysis produce diarrhetic shellfish toxins (DSTs). These toxins can poison humans or other animals who consume shellfish grown in Dinophysis bloom-contaminated waters. Their distribution is changing: the first Dinophysis-related shellfishing closure in the United States occurred in Texas in 2008. Since then, there have been numerous Dinophysis-related shellfish closures in the Northeast U.S., Washington, and the Gulf of Mexico. Complicating our understanding of Dinophysis ecology is their need to feed specifically on the ciliate Mesodinium to survive and grow. Despite that, blooms of Dinophysis are frequently reported in the absence of co-occurring or preceding Mesodinium blooms. My work explores how Dinophysis survive without prey through investigation of D. acuminata blooms in Salt Pond, a terminal kettle hole in Cape Cod’s Nauset Marsh. Particularly intense blooms here caused shellfishing closures in 2015 and 2019 in the apparent absence of their prey. Using observations from the Imaging FlowCytobot (IFCB), CTD, and pigment profiling, I analyze how Dinophysis are retained in Salt Pond in the absence of their prey and characterize the progression of the bloom. Cell behaviors (e.g., dividing, mating) and thin-layer movements are assessed within and between years and are also compared to Dinophysis behavior in a continuous culture system.

Disentangling the Relative Impacts of Temperature and Vapor Pressure Deficit on Tropical Forest Photosynthesis

Claire Zarakas (she/her/hers)

Tropical forest photosynthesis can decline at high temperatures due to (1) biochemical responses to increasing temperature and (2) stomatal responses to increasing vapor pressure deficit (VPD), which is associated with increasing temperature. It is challenging to disentangle the influence of these two mechanisms on gross primary production (GPP), because temperature and VPD are tightly correlated in tropical forests. Nonetheless, quantifying the relative strength of these two mechanisms is essential for understanding how tropical GPP will respond to climate change, because increasing atmospheric CO_2 concentration may partially offset VPD-driven stomatal responses, but is not expected to mitigate the effects of temperature-driven biochemical responses. We used a demographic ecosystem model to quantify how plant traits and physiological process assumptions (e.g. about photosynthetic temperature acclimation and plant hydraulics) influence the relative strength of modeled temperature vs. VPD effects on light-saturated tropical forest GPP. We simulated sites spanning different humidity regimes -- including Amazon forest sites and the experimental Biosphere 2 forest -- to test which process and functional trait assumptions best capture the GPP responses to VPD vs. temperature identified in observational studies. Next, by simulating idealized climate change scenarios, we quantified the divergence in GPP predictions under model configurations with stronger VPD effects compared to stronger direct temperature effects. Our findings underscore the importance of distinguishing between direct temperature and indirect VPD effects, and demonstrate that the relative strength of temperature vs. VPD effects in models is highly sensitive to plant functional parameters and assumptions about photosynthetic temperature acclimation and plant hydraulics.

<u>Polar climate</u>

Iceberg Impacts on Prydz Bay, Antarctica

Alan Gaul (he/him/his)

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

Seasonality in atmospheric heat transport to the Arctic under increased CO_2
Lily Hahn (she/her/hers)
Increased moisture transport to the Arctic is a key contributor to Arctic-amplified warming under increased CO_2. In contrast, anomalous equatorward transport of dry static energy damps Arctic warming under increased CO_2. While these changes in poleward heat transport have been investigated in the annual mean, their seasonality has received less attention. Here we investigate seasonal changes in poleward heat transport across the latest generation of climate models under abrupt CO_2 quadrupling. These models consistently project the greatest increase in moist atmospheric heat transport in summer, and the greatest decrease in dry atmospheric heat transport in winter. To investigate what causes these seasonal patterns, we apply a diffusive heat transport perspective, in which poleward heat transport is proportional to the equator-to-pole gradient in moist static energy. We also investigate the significant intermodel spread in these heat transport changes. This study extends previous results that changes in moist and dry heat transport partly compensate each other by showing that this compensation occurs during different seasons. Our results suggest that these poleward heat transports impact Arctic warming in different ways: reduced dry heat transport in winter may directly damp Arctic warming, while increased moist heat transport in summer may increase winter warming indirectly, through increased summer sea-ice loss and seasonal ocean heat storage.

Recent upper Arctic Ocean warming expedited by summertime atmospheric processes
Zhe Li
The observed upper (0 – 50 m) Arctic Ocean warming since 1979 has been primarily attributed to anthropogenically driven changes in the high latitudes. Here, using both observational and modeling analyses, we demonstrate that a multiyear trend in the summertime large-scale atmospheric circulation, which we ascribe to internal variability, has played an important role in upper ocean warming in summer and fall over the past four decades due to sea ice-albedo effect induced by atmospheric dynamics. Nudging experiments in which the wind fields are constrained toward the observed state support this mechanism and suggest that the internal variability contribution to recent upper Arctic Ocean warming accounts for up to one quarter of warming over the past four decades and up to 60% of warming from 2000 to 2018. This suggests that climate models need to replicate this important internal process in order to realistically simulate Arctic Ocean temperature variability and trends.

Climate change in sensitive regions

Systematic approach to quantify the resilience of climate vulnerable Boreal Forests
Sohail Akram
Natural disturbances such as fire and drought affect millions of hectares of global forests annually and are highly climate-dependent. The frequency of heatwaves and summer drought are

expected to increase over the coming decades and could modify forest stand composition, structure and landscape patterns. Changes to forest ecosystems impact the critical provisioning, regulating, and cultural services that society and forest sectors depend on. Some forest ecosystem services may be lost or transformed as disturbance regimes and forest structure changes alter the state of systems. We can make forests more resilient to disturbances despite not being able to end climate change. To develop more resilient forests, the first of three steps of this project is to build a framework of forest ecosystem indicators and identify their threshold values according to historic conditions. Users, such as land managers, will be able to identify common disturbances by forest type, quantify short-term resilience to each threat and assign potential long-term resilience scores. With the combined use of forest stand biotic and abiotic characteristics, a framework has developed that allows for both stand-scale resilience assessment and landscape-scale treatment. In the second step, climate-sensitive simulation models will be used to project future forest changes and assess if the expected structure and composition will reduce or enhance resilience. In the third step, various management strategies will be evaluated to see if there is improvement in the resilience score of less resilient areas that have been highlighted in step two. A fire and drought resilient landscape will provide sustainable ecosystem services to society.

Future Climate Simulations for the Salish Sea Using Dynamically Downscaled Atmospheric Projections

Eva Gnegy (she/her/hers)

The Salish Sea, a marginal sea located between Vancouver Island, mainland British Columbia and Washington state, supports an active and diverse ecosystem in addition to the economic and recreational activities of nearly 9 million locals who live along its shores. Given the Salish Seas' importance, future climate projections can provide useful information for how to manage the resources and services it provides in the years to come. However, global climate models are often too coarse in spatial resolution to capture the small-scale features of coastal regions, especially ones like the Salish Sea that are also largely affected by topography. To fill this gap in knowledge, the Weather Forecast Research (WRF) model is being used to dynamically downscale the latest Canadian Earth System Model (CanESM2), a coarse global climate model, to create a high-resolution projection for the Salish Sea basin. Dynamical downscaling is a modeling technique that extrapolates the effects of large-scale climate processes from the coarse models, using them as initial boundary conditions to drive high-resolution models, allowing for small-scale processes, especially those affected by local geography (e.g. coasts, topography), to be resolved within the model rather than parameterized. A historical period (1986-2005) will be completed for validation and to assess the changes in the Salish Sea, and future simulations (2045-2065) will be created under two climate mitigation scenarios: representative concentration pathway (RCP) 4.5 (moderate mitigation) and RCP 8.5 (no mitigation). Common atmospheric variables and extreme events will be analyzed, and this model will be used to drive ocean models. The goal of this project is to identify vulnerable regions for conservation and protection in future climates.

Impactful high-wind events on the U.S. Northeast shelf: Categorization and climatological trends using supervised machine learning

Lukas Lobert (he/him/his)

The coastal oceans are the biologically most productive seas worldwide and respond sensitively to the timing, strength, direction, and steadiness of high-wind forcing patterns. While it is well understood how large-scale atmospheric shifts due to climate change cause more persistent weather patterns, the large variability and collective analysis of different patterns can cover potential statistical trends. Distinguishing between divergent wind patterns with distinct ocean forcing signatures can counteract the variability dilemma when addressing how wind forcing trends have already affected the coastal ocean. Focusing solely on local observations makes the analysis independent of the data availability bias of spatial data assimilation products. Here, we present that data from a single surface weather buoy south of New England are sufficient to meaningfully cluster and distinguish between large-scale high-wind patterns over Northeast-America despite considerable correlation. A fully-connected Neural Network produces a mean validation accuracy of 91% when classifying steady large-scale high pressure systems over East Canada that are associated with the strongest changes in the Southern New England ocean stratification. Impactful propagating cyclone systems are less well classified by the single mooring, likely due to the variable positional relationship between the stationary mooring and the propagating storms. The high validation accuracy for East-Canadian Highs allows to investigate climate change trends of this particular impactful high-wind event category across the 40-year local observational record. Changes in timing, duration, and strength would have implications for the fall stratification breakdown in the Southern New England coastal ocean which initiates the fall phytoplankton bloom.

CMIP6 models exhibit systematic bias in the representation of West African temperature and rainfall

Oghenekevwe Oghenechovwen

Five percent of the world's population live in tropical West Africa, where livelihood and wellbeing are linked to seasonal climate. For example, agriculture, water resources, and power generation are largely rain-fed and ultimately depend on mesoscale convective systems (MCSs) and the West African monsoon (WAM) which feed and deliver rainfall over the region. In this study, we evaluate the performance of the latest generation of Earth System Models (ESMs) and regional climate models (RCMs) in simulating the seasonal cycle of West African rainfall and surface air temperature through a recent 32-year period (1983 to 2014). We find a systematic bias in how climate models of varying complexities simulate these. In contrast to observation (Global Precipitation Climatology Project) and reanalysis (ERA5), fully coupled ESMs, uncoupled ESMs (fixed SST configuration), and RCMs are cooler inland and hotter along the coast, while rainfall is overestimated over the Sahel and Sahara. We go further and perform a climate model genealogy and process-based analyses, which reveals the importance of parameterisation schemes, resolution, and land surface-atmosphere mechanisms in explaining the systematic bias over this region. This study is therefore vital for targeting model development where it is most likely to improve confidence in climate variability and change modelling.

Poster Session C
Evening, Saturday, October 29, 2022

Biogeochemical Cycling

Analysis of Nutrient Cycling in the Gulf of Mexico 'Dead Zone': Climate Impacts

Nicole Mucci (she/her/hers)

Hypoxia, or low concentrations of dissolved oxygen, alters biogeochemical cycling of nutrients in marine ecosystems. Coastal waterbodies experience hypoxia because nutrient inputs from land fuel primary production and microbial metabolism, consuming oxygen in the water column. Coastal areas experiencing hypoxia are termed “dead zones”, as reduced dissolved oxygen decreases ecosystem services, lowers water quality, and depletes fisheries. Samples from the Northern Gulf of Mexico "Dead Zone", an area that regularly experiences hypoxia, were collected in Spring 2021 and Summer 2022 to see the direct impacts of nutrient loading and eutrophication on a coastal system. The Gulf of Mexico is fed by the Mississippi River, bringing runoff from agricultural lands that drain 41% of the contiguous United States, leading to algal blooms and drawdown of dissolved oxygen in the Gulf. My research aims to quantify how fluxes of nutrients, including nitrate, ammonium, and phosphate, change due to lowered dissolved oxygen in bottom waters. Hypoxia in coastal environments is expected to be exacerbated by climate change because oxygen solubility decreases, microbial respiration increases, and water column stratification strengthens with warmer water temperatures. Moreover, hypoxic conditions can form positive feedbacks where nutrients are recycled from sediment more effectively than in oxic conditions, further promoting phytoplankton growth and hypoxia. My research aims to further constrain nutrient cycling during hypoxia to understand how coastal biogeochemistry will respond to future climate change.

Carbon cycle

Constraining the cellular response of phytoplankton to temperature and resource availability

Zoe Aarons (she/her/hers)

As anthropogenic climate change progresses, particular attention has been drawn to the potential of marine phytoplankton to buffer rising atmospheric carbon dioxide concentrations. Because phytoplankton fix a total of 35-65 gigatons of carbon each year, understanding how these organisms respond to predicted increases in both temperature and nutrient depletion is necessary for constraining the future carbon budget. Theory predicts that community-wide growth rate increases with temperature, but laboratory experiments indicate that this response is dampened when nutrients are limiting. In order to explore the mechanisms driving the coupled impacts of temperature and nutrient concentration, I will adapt the existing cellular allocation model of Inomura et al., 2020. The “Cell Flux Model of Phytoplankton” (or CFM-Phyto) allocates carbon, nitrogen, and phosphorus to key macromolecular pools in autotrophs, such that growth rate and stoichiometry are related as a function of these pool sizes. Here I will introduce explicit nutrient uptake to resolve the cellular response to external nutrient availability. I will also modify the existing model to include temperature-dependent cellular processes as based on fundamental theories of enzyme kinetics. This adapted model will allow for a better understanding of how resource availability drives phytoplankton response to temperature, which has implications for the response of phytoplankton to both spatial and temporal variability in environmental parameters.

Beyond PIC/POC/DIC/DOC - the molecular face of our ocean's ticking clock

William Kumler (he/him/his)

Marine carbon already has an abundance of classifications – particulate vs dissolved, organic vs inorganic, labile vs refractory – but these broad terms hide important distinctions in molecular diversity and tell us nearly nothing about the true functionality of the environment. A high-resolution solution is offered by metabolomics; the comprehensive study of all small metabolites in the cell. With this paired liquid-chromatography mass-spectrometry method I’ve assayed nearly eight hundred metabolites in the North Pacific Subtropical Gyre, the planet’s largest biome, to detect and quantify components of marine carbon. This analysis allows us to estimate the lability of various molecules and calculate differences in carbon to nitrogen ratios, with implications for nutrient cycling, elemental stoichiometry of cells, and carbon flux in the ocean’s most dynamic reservoir.

Reversibility of Changes in the Permafrost Carbon Pool Under Temperature Overshoot Scenarios

Takuma Mihara

With the current rate of climate change, a temperature overshoot scenario will likely be required to meet the Paris Agreement target of 1.5°C. Temperature overshoot scenarios are future trajectories where global mean surface air temperature warming initially surpasses the target, and is later restored with negative CO2 emissions using carbon dioxide removal. Changes in the permafrost carbon pool in response to various overshoot scenarios are systematically investigated using an Earth system climate model of intermediate complexity. Here, overshoot magnitude and overshoot duration above 1.5°C are incrementally altered in the model to test for the response of permafrost carbon. Reversibility of the lost carbon after temperature stabilization in the latter half of the millennium is also assessed. Future warming will cause substantial permafrost carbon release in the atmosphere, and will contribute to additional warming due to a positive climate-carbon cycle feedback. A detailed understanding of the carbon cycle response will help improve predictions of future climates.

Assessing Integrated Satellite-Float Productivity Estimates in the NASA EXPORTS Campaigns

Shawnee Traylor (she/her/hers)

The NASA-led EXPORTS project seeks to quantify the fate and export of carbon from the euphotic zone via the biological carbon pump (BCP), which sequesters CO_2 from the atmosphere and suppresses atmospheric concentration by ~200 ppm. The strength of the BCP can be assessed in part by the rate of net community production (NCP), the sum of all primary production minus respiratory losses. This excess fixed carbon is available for export to the deep ocean, where it can be sequestered from the atmosphere for centuries to millennia. Two field campaigns captured the end members of a range of carbon cycling states: the productive North Atlantic spring bloom and the iron-limited subarctic North Pacific. Ship-based operations were bolstered by satellite observations and autonomous assets, including two BGC-Argo floats at each site. The floats carry biogeochemical sensors to enhance the spatiotemporal sampling range and produce biogeochemical budgets. We present a comparison of NCP measured in situ by floats to satellite- and hybrid float-satellite-based estimates during the campaigns. Float-derived NCP employs a mass balance approach using oxygen and nitrate data, while satellite-based estimates are made using algorithms that utilize observed sea surface temperature and modeled net primary productivity via the VGPM, CbPM, and CAFE algorithms. These model algorithms are implemented with both satellite-only and hybrid float-satellite inputs to explore a synergistic approach between BGC-Argo and remote sensing capabilities. We discuss how our results compare across estimation methods and how they reflect the distinct nature of the study sites' cycling regime.

Determining The Drivers Of Long-Term Carbon Change Using Coastal And Open Ocean Time-Series Data.

Treasure Warren (she/her/hers or they/them/their)

Research in ocean carbon change has expanded dramatically over the past decade resulting in increased access to data, instruments, and scientific social networks. Using the wealth of increased time series data I aim to answer the question: What are the drivers of carbon change at various locations throughout the globe? I hypothesize that at most open ocean locations surface ocean pCO_2 concentrations are primarily driven by atmospheric CO_2 concentrations. Preliminary findings at open ocean locations are consistent with this hypothesis. Coastal areas may face additional drivers such as changes in circulation and increased biological production. To test this hypothesis I will start by characterizing trends in deseasoned time series and determine which time series have statistically significant trends. Once a significant long-term trend is identified I will use various analyses, such as the first order Taylor expansion of the carbonate system, to determine the drivers of the trend. Some locations may incorporate feedback loops or multifaceted drivers; for example a long term increase in seawater temperature will impact the solubility of CO_2 and oxygen. I predict that coastal waters will experience more variable rates of ocean acidification in the future compared to their open ocean counterparts due to multifactor drivers of carbon change that are specific to coastal regions.

The Role of Carbon Cycle and Nonlinear Feedbacks in Driving Multiple Equilibria and Climate Oscillations

Fangze Zhu

An intriguing mechanism of the Pleistocene glacial-interglacial cycles is the phenomenon of synchronization between internal free oscillations and orbital forcings, which suggests that orbital forcings act as the “pacemaker” rather than the driver of the climate variations. The goal of this study is to investigate the key processes and feedbacks driving the internal dynamics, with special interests in the role of carbon cycle due to its long response time and the positive CO_2 feedback that causes instability. First, we investigate mechanisms of the previously identified four stable climatic equilibria in the idealized MITgcm coupled with a prognostic carbon cycle: Warm, Cold, Waterbelt, and Snowball states. Using custom radiative kernels, the equilibria are studied through the state dependence of radiative feedbacks. The systematic decrease in surface albedo feedback from Cold to Warm states is offset by an increase in longwave water vapor feedback. The key role of carbon cycle is a dramatic lengthening of the adjustment time near the Warm state, a timescale comparable to orbital forcings. Then, we focus on the role of carbon cycle in free oscillations near the Warm equilibrium: the appearance and disappearance of the self-sustained, millennial-scale climate oscillations. It is hypothesized that the oscillator is caused by carbon cycle, sea ice, deep water formation and meridional overturning circulation. A decomposition of ocean carbon pumps will be conducted to identify essential processes that account for air-sea carbon exchanges.

<u>Ocean heat content & large-scale circulation</u>

Seasonality of Internal Tide using Argo Floats

Tongxin Cai (she/her/hers)

Internal tide transport heat, energy and other climatically significant tracers (e.g. carbon and greenhouse gases) in the ocean interior via breaking. It has been long considered as the primarily power to supply deep-ocean mixing, fuel the ocean circulation (Munk & Wunsch, 1998) and thus aids in shaping the climate system. Climate models traditionally include internal tide’s effect through passive and unchanging parameterization with large uncertainty. Understanding the impact of internal tide-driven mixing on climate requires the improved knowledge of the life cycle of internal tide. Although we have seen increasing attention on internal tide and improvements on observational technology, questions remain unanswered on their dynamical evolution, largely due to the complexity of the wave-wave interactions, as well as the interaction with topography and background currents. A global mapping of the seasonal internal tide helps to understand its variation due to the seasonal change of stratification and time varying interaction with the mesoscale dynamics. Zhao (2021) has investigated the seasonality of Mode-1 M2 internal tide from satellite altimetry and here we compare it with the result from Argo floats and explain the mechanism. We expect significant seasonal variability of internal tide in the tropical zone, as shown by the satellite altimetry. Using both Argo profiling (0-2000 m) and parking measurements (1000 m) along with nontidal (e.g., mesoscale eddies) correction prior to tidal analysis will reduce the mapping uncertainties. This work will guide the development of future parameterization of internal tide-driven mixing as a fully interactive component of climate models.

Strong abyssal stirring and particle transport underneath a surface intensified current
Sean Chen
Strong near-bottom velocity events at abyssal depths, known as the ‘benthic storms’, contribute to ocean energy budget and may be important for constraining past ocean and climate conditions from sediment records. While these events have generally been observed in areas with high surface eddy kinetic energy, the dynamical mechanism of its formation is not well understood. We use a 3D primitive-equation ocean model with an idealised zonal channel configuration to demonstrate that the destabilisation of a strongly baroclinic surface current, such as the Gulf Stream, can lead to exceptionally strong, sediment-resuspending abyssal flows. With an exponential stratification, pressure anomalies extending down to the bottom, driven by baroclinic instability of the surface current, lead to the development of a cyclogeostrophically balanced flow with little vertical variation. Ageostrophic flow in the deep cyclones develop upwelling with speeds comparable to settling speeds of fine-size particles typically observed in the abyssal ocean. While the presence of topographic β by a sloping bottom inhibits the growth of eddy size, Lagrangian fluid particle trajectories from the simulations suggest that fine sediments may be stirred up to approximately 600 m above the bottom regardless of topography and transported over long horizontal distances. Our study yields insight into the connections between upper ocean dynamics and near-bottom processes and calls for further research in vertical energy transfer in the ocean.

Quantifying the relative role of atmospheric and oceanic processes in driving air-sea interaction in the Gulf Stream region
Jacob Cohen (he/him/his)
Using observations of sea surface temperature (SST), mixed-layer heat content (MLHC), and turbulent heat flux (Q) in the North Atlantic Ocean, we quantify the relative strength of oceanic and atmospheric processes in driving the upper ocean heat budget. The lagged covariance of SST/MLHC to Q allow quantification of the feedback of between the ocean and the atmosphere. The depth of the ocean that participates in the exchange of heat with the atmosphere is then estimated by the ratio of the SST and MLHC feedbacks. This effective depth of air-sea

interaction H represents the volume per unit area that participates in the exchange of heat with the atmosphere via turbulent fluxes over a month. Year round H peaks in the core of the Gulf Stream from 75W to 65W and in the Northern half of the Southern Recirculation gyre. The ratio of H to the mixed layer depth (R) gives an estimate of the renewal rate of the mixed-layer heat content from interior ocean processes relative to that from atmospherically driven surface fluxes. High values of R indicate the dominance of ocean processes relative to atmospheric variability on controlling mixed-layer heat content variability. R peaks within the core of the Gulf Stream where the oceanic influence is at least five times as big as that of atmospheric processes. We also examine seasonal dependence of R and find that wintertime R exhibits similar results to the year round R, while in summer, the results are not robust within the core of the Gulf Stream.

Inverting benthic foraminiferal records for Little Ice Age surface climate evolution
Brynnydd Hamilton (she/her/hers)
While sedimentary records are critical to resolving the climate of the Common Era, recent publications that attempt to synthesize paleoceanographic records have identified inconsistencies in cross-record comparison that may be due to spatial or temporal differences, proxy biases, or age model uncertainty. Here, we use a new collection of high-resolution Common Era δ18O records from marine sediment cores in the high-latitude North Atlantic (Lu, et al., in prep.) as a case study for the application of a linear inverse model to this problem. The δ18O of foraminiferal tests is commonly used as a proxy for paleoclimate, as it is a conservative tracer and is affected by temperature and seawater δ18O during calcification. We apply the Total Matrix Intercomparison (TMI) method (Gebbie & Huybers; 2010), which inverts modern-day observations of ocean tracers to solve for global circulation pathways, to analyze 11 different records of benthic foraminiferal δ18O. This approach interprets our paleoceanographic records in the context of the global ocean circulation, allowing us to extrapolate changes in regional water mass characteristics over the Common Era. The linear nature of this methodology allows for the propagation of age model uncertainty, the largest quantifiable source of uncertainty in these records. We find that signals of the Little Ice Age are coherent in our dataset and inversion, despite age model uncertainty of ~250 years. Our analysis focuses on changes in climate in the Medieval Climate Anomaly to Little Ice Age transitionary period, which adds to our understanding of the North Atlantic ocean's response to prolonged climatic changes. To contextualize the inversion of these North Atlantic records, we analyze the Ocean2k dataset, a global paleoceanographic sea surface data compilation. We aim to establish the magnitude and spatial pattern of the Little Ice Age climate signal in the ocean, and quantify its impact upon modern-day climate.

Subtropical water mass anomaly production and propagation
Cora Hersh (she/her/hers)
Subtropical cells are currents that connect subducting subtropical waters to upwelling sites along the equator. After forming at the surface through air-sea interaction, water masses are subducted

into the main thermocline and their properties (e.g. salinity, temperature) persist for thousands of kilometers downstream. This tight connection between the subtropics and the tropics, on a time scale of 5-15 years, is well established in a time-averaged sense. Recently, evidence has emerged on a regional basis for the persistence along flow pathways of significant interannual anomalies of these properties. These anomalies have the potential to persist, without mixing away, from their formation in the subtropics until upwelling in the tropics, creating ocean "tunnels" equivalent to the better-studied atmospheric "bridge." A better understanding of this phenomenon could improve regional predictability of climate on a few year to decadal time scale. Taking the first global view of subtropical water mass anomaly propagation, we compare anomaly events in the observational Argo float dataset with output from the Estimating the Circulation and Climate of the Ocean (ECCO) reanalysis. Our analysis demonstrates that long-lived interannual water mass anomalies, lasting multiple years and several thousand kilometers, are common along mean advective pathways in the subtropics in all basins (except the North Indian) in both the Argo and ECCO datasets. Despite some notable differences between the Argo and ECCO records, we determine that interannual water mass anomaly propagation is well-represented enough in ECCO to perform modified forcing experiments to investigate the factors that influence anomaly formation and persistence.

Model Comparison of North Atlantic Current Biases and their effect on the Atlantic Meridional Overturning Circulation

Taydra Low (she/her/hers)

The Atlantic Meridional Overturning Circulation (AMOC) is a system of surface and deep currents that play a key role in moderating Earth's climate. The North Atlantic Current (NAC) – the northward flowing surface branch of the AMOC in the subpolar region – is the main conduit by which warm waters are transported from the subtropics to high latitudes. This is the partly why Europe has milder winters compared to the United States. Having accurate climate models is important for understanding and predicting future climate scenarios, but there is a longstanding model bias in the placement of the NAC. We compare the NAC pathway biases in climate models of varying configurations and resolutions to see how AMOC is affected. To quantify the surface impacts on AMOC we use water mass transformation (WMT), which connects surface buoyancy forcing to overturning circulation. The analysis focuses on decomposing the buoyancy forcing into its heat versus freshwater flux components with reference to the location of surface density. Analyzing this surface-forced WMT allows for the characterization of climate model biases. It is hypothesized that having the wrong placement of the NAC can impact the magnitude of surface density, misplacing it relative to high surface heat fluxes that are key for making water denser and eventually sink. The results of this research will provide a clearer understanding of sources of linked NAC pathway and overturning biases, aiding in the development of more accurate climate models.

Drivers of mid-depth Pacific cooling trends in an ocean reanalysis

Anthony Meza (he/him/his)

Recent studies have shown that, on average, the global abyssal ocean is warming. However, a comparison of the 19th century HMS Challenger expedition data with current observations indicates that the oldest ocean waters might instead be cooling at a rate of 0.02°C-0.08°C per century. The estimated cooling trend comes as a result of signals from the Little Ice Age being propagated from the surface to the mid-depth through the global meridional overturning circulation. This is a non-negligible rate when one considers the planetary heat budget and subsequently the equilibrium climate sensitivity. Thus, quantifying the contribution of the mid-depth (2000 - 3000 meters) ocean in the planetary heat budget is essential for differentiating between internal variability and anthropogenic forcing. In this work, we assess the sensitivity of the mid-depth Pacific Ocean heat budget to initial conditions and atmospheric forcing within a dynamically consistent state estimate developed by the "Estimating the Circulation and Climate of the Ocean" consortium (ECCO V4r4). Corroboration of mid-depth temperature trends in the Pacific using observations is challenging due to the lack of data below 2000 meters and the timescale of the forcing in question. ECCO V4r4 allows us to make progress on this issue by incorporating data while simultaneously satisfying conservation laws. Preliminary results show that within ECCO V4r4, the mid-depth Pacific cools at a rate of 0.01°C-0.05°C per century below 2000 meters, consistent with previous estimates using historical data. Still, the question remains whether this cooling is a result of model biases or is indeed a robust result of the data assimilation process. The goal of this work is to determine which depth levels of the Pacific exhibit realistic (data-informed) trends, and which are artifacts of numerical drift. Our assessment consists of spatial and temporal analysis of temperature trends and budget terms in the mid-depth Pacific Ocean from 1992-2018. Careful consideration of numerical artifacts is taken to draw inferences about trends that may influence or are influenced by modern-day climate.

Drivers of Indonesian Throughflow Heat and Freshwater Transport on Multidecadal Timescales

Shawn Wang (he/him/his)

The Indonesian Throughflow (ITF) plays a critical role in regional and global climate as an oceanic passageway of heat and freshwater redistribution between the Pacific and Indian Oceans. However, the relationship between multidecadal variations in Indo-Pacific atmospheric forcings and ITF heat and freshwater transport is not well understood. In this study, we use a series of ocean simulations to analyze how heat and freshwater transport in the upper 300m of the main passageway of the ITF, the Makassar Strait, varies on multidecadal timescales. Preliminary findings suggest that wind changes play a dominant role in driving ITF variability relative to surface heat and freshwater fluxes. At thermocline depths in the Makassar Strait, heat transport varies in synch with the Interdecadal Pacific Oscillation (IPO) but at the surface (0-100m) and beneath the velocity maximum (150-250m), heat transport exhibits long term trends over the last

60 years, likely related to modern climate change. Our study highlights that a multitude of natural and human-induced drivers can influence ocean physics on these timescales.

Hydrology & geomorphology

The role of groundwater in moderating summer stream temperatures

Lea Antesz (she/her/hers)

Stream temperature is one of the most important parameters for the health of aquatic organisms. If the water temperature gets too high, fish and other organisms are not able to survive in that environment. In North America, summer air temperatures are projected to rise over the next decades and the likelihood and intensity of extreme heat events are expected to increase, due to anthropogenically driven climate change. Thus, the summer low flow period can become problematic for aquatic organisms and some species might even face extinction. However, the temperature in many streams is moderated by natural processes, like shading from riparian vegetation or contributions from cool water sources. Since groundwater maintains a relatively stable temperature year round, typically cooler than summer stream temperatures, groundwater that discharges into the stream can moderate stream temperature in the summer. This allows aquatic organisms to find cool refugia at temperatures they can tolerate. This research project focuses on improving the understanding of the moderating effect of groundwater discharge and cool mountain headwaters on high summer temperatures and potentially extreme heat events. The objective is to find areas in the stream where groundwater discharge plays an important role in temperature moderation. To address this research question, stream temperature data are being collected using several different methods, from in-situ temperature loggers to thermal infrared images acquired using a drone and satellites. The research findings can be used to inform water allocation decision-making, to ensure that groundwater discharge to these sensitive areas of the stream is not being reduced by groundwater pumping in the vicinity of the stream.

Assessing Multi-decadal Riverbank Erosion and Human Displacement along the eastern Bank of Jamuna River in Bangladesh

Md Sariful (Sharif) Islam (he/him/his)

River bank erosion is one of the major climate driven hazards occur in Bangladesh every year. It causes loss of houses, land, and livelihood which threatens health and food security of these vulnerable communities. Thousands of people are being displaced annually. Due to anthropogenic and climatic influences, it is predicted that the erosion will be increased in the future. To curve extreme erosion and displacement of people, quantification of magnitude and severity of erosion is vital. With an aim to assess the magnitude and severity of riverbank erosion, this study investigates the spatio-temporal changes in riverbank movement and its impact on human displacement in the Jamuna river region of Bangladesh. Multi-temporal Landsat imagery from 1990 to 2020 were used to quantify the rate of decadal riverbank movement. The End Point Rate (EPR), Linear Regression Rate (LRR), and Weighted Linear

Regression (WLR) were used to quantify the erosion rate. To assess the impact of riverbank movement, this study used gridded population data product of WorldPop. Our results revealed that this region has experienced extreme erosion in the last three decades. The erosion rates are found to be among the highest in the world. Our result also suggest that thousands of people are being displaced per year due to extreme erosion. We believe that the findings of this study will be helpful for policy makers in managing and developing associated mitigation and adaptation strategies for this part of the deltaic environment in Bangladesh.

Exploring the influence of glacial isostatic adjustment on the evolution of the Red River in North Dakota

Samuel Kodama (he/him/his)

Glacial Isostatic Adjustment (GIA) is a process that can create 10s-100s of meters of topographic uplift over thousands of years. In tectonically inactive areas, GIA controls topographic change and therefore controls topography dependent processes such as river flow. The Red River in North Dakota has been topographically forced by GIA since its inception. The Red River began flowing north from North Dakota into Lake Winnipeg around 8 ka as Glacial Lake Agassiz drained. The modern Red River has an extremely shallow slope (0.0001/1) and, as a result, floods frequently. The general pattern of topographic change caused by GIA along the Red River since 8 ka is upstream subsidence and downstream uplift with local topographic changes on the order of 10s of meters. As a result, the slope of the Red River has been non-uniformly decreasing since 8 ka. We look for signals in the evolution of the Red River's morphology that reflect this non-uniform GIA forcing. We use river meanders as a mechanism to explore this GIA forcing. A river will meander in order to decrease its slope and since GIA has been non-uniformly decreasing the slope of the Red River, we expect the meander response of the Red River to also be non-uniform and a lesser response in the areas where GIA forcing is greatest. We measure meander distance and meander cutoff distribution along the Red River to quantify the spatial trends of the rivers meander response.

Validation Of The Community Earth System Model To Investigate The Response Of The Mississippi River System To Long Term Climate Change

Michelle O'Donnell (she/her/hers)

The Mississippi River is an economic artery of the United States, and flooding along its course is a perennial hazard to trade, agriculture, industry, and communities. Projections of changes in flow on the river in the future are uncertain, making future impacts of flooding equally unclear. Records of flooding from proxies held in sediment cores and tree rings are critical for extending hydrologic records in the basin, but these paleoflood data provide a limited picture of hydroclimatic variability and change over time. The Community Earth System Model Last Millennium Ensemble (CESM-LME) compliments these proxy records by providing fully coupled output from a state-of-the-art earth system model over the period 850-2005 CE under multiple forcing scenarios. Here, we validate CESM-LME simulations of hydrologic variables over the Mississippi River Basin including river discharge, runoff, precipitation, evapotranspiration, and snowmelt. By comparing observations and reanalysis datasets to CESM-LME output variables most relevant to the hydroclimatology of the basin, we are able to evaluate changes across different time periods and scenarios for the major subbasins of the Mississippi, and provide a means to investigate drivers of those changes to understand the behavior of the Mississippi River Basin over the last millennium, including the regionally warm and dry Medieval era (ca. 1000-1200 CE). Together, these data allow us to understand the response of the Mississippi River and its tributaries to changes in climate and evaluate the suitability of using CESM for projections of river flow for the next century.

Long‑term monitoring data reveals drivers of changes in groundwater quality

Sacha Ruzzante (he/him/his)

Groundwater vulnerability to contamination is dynamic and depends on both the intrinsic susceptibility of the aquifer and exposure to a source of contamination. A proactive global strategy for managing and preventing future contamination events requires an understanding of the drivers that will result in changes to aquifer vulnerability. On human timescales, these drivers are likely to include direct anthropogenic influences, both at the surface and within the subsurface, and effects of climate change. While these influences are relatively well-understood at local and watershed scales, they are less well-characterized at large (national and global) scales. Historical data can be analysed to assess the relative importance of human activities and climate variability on the occurrence of contamination. We use a dataset of groundwater chemical concentration measurements from over 20 thousand sampling sites across the United States from 1950 to 2021 to analyse spatial and temporal trends in several anthropogenic and geogenic chemical contaminants. Using regression analyses, we relate changes in water quality to spatially and temporally explicit land use, population density, and climate data. We find that many areas have experienced deteriorating water quality and that the effects of human actions will have consequences for decades to come. We discuss implications of the current work for predicting global regions of concern: regions where groundwater resources are likely to become substantially more vulnerable to contamination.

Poster Session D
Evening, Saturday, October 29, 2022

Extreme events

Characterizing the evolution of marine heatwaves using clustering methods

Cassia Cai (she/her/hers)

Extremely warm surface ocean temperatures are becoming more common in over one-third of the world's coastal oceans. This can result in the increased vulnerability of many marine ecosystems. Marine heatwaves (MHWs) are prolonged anomalously warm surface ocean temperature events. MHWs can have significant ecological and socio-economic impacts, ranging from geographical species shifts, coral bleaching, and the collapse of regional fisheries. A number of high-profile MHWs, including the Great Barrier Reef 2002, Northwest Atlantic 2012, and Northeast Pacific 2013-2015, have occurred in the last two decades. The evolution of MHWs, including the build-up, persistence, and decay, is not well understood. Some MHWs have been shown to be connected in space and time to each other through the tropics, such as mid-latitude MHW events in the Indian and Pacific Oceans. The 2013-2015 Northeast Pacific MHW's long duration was shown to be influenced by tropical interactions such as El Niño events and El Niño-associated large SST changes while its intensity, where the local maximum SST increased by over three standard deviations above normal, was influenced by extratropical anomalies. By applying clustering methods on MHWs in CESM Large Ensemble climate model projections tracked using the novel morphological image processing package Ocetrac, the questions I will answer are two-fold: (1) How do marine heatwave characteristics cluster in space and time? and (2) How important is ENSO variability in determining those clusters? This work will advance our mechanistic understanding of how one MHW relates to another and our understanding of the evolution of MHWs.

The Role of a Subseasonal Planetary Wave Pattern on US Heat Waves

Valentina Castañeda (she/her/hers)

In the United States, the frequency, intensity, and duration of heat waves have increased rapidly in recent decades, and this increase will continue in the coming years due to climate change (Meehl and Tebaldi 2004). These extreme events have caused severe impacts in terms of human morbidity and mortality, in addition to affecting water resources, ecosystems, agriculture, and infrastructures. While heat waves are local phenomena, a planetary-scale wavenumber-five pattern has been shown to be statistically related to the occurrence of the events (Ding and Wang 2005; Teng et al. 2013). However, the physical mechanism through which the global waves cause a local phenomena is not well understood. In this work, we hypothesize that atmospheric basic state dictates the Rossby wave propagation, hence determining resulting heat waves. We approach this problem using a combination of idealized modeling and observational analysis guided by Rossby wave theory. We implemented the idealized model with a dry dynamic core (Held and Suarez 1994) reconfigured by Wu and Reichler (2018) to evaluate if the internal dry atmospheric dynamics dictate the existence of wave number 5 pattern. In addition, we explore the relationship between mid-latitude soil moisture and the standing variability of the circulation pattern. The results contribute to understanding the dynamics behind heat waves, and this may lead to improve its forecasting beyond the typical 10-day lead time. A deep comprehension of heat waves prediction and its social-economic impacts requires close collaboration across different sub-disciplines, such as land, aerosol and ocean interaction with the atmosphere.

Convectively coupled Kelvin waves in a warmer climate

Mu-Ting Chien (she/her/hers)

Convectively coupled Kelvin waves (CCKWs) contribute a significant fraction of tropical intraseasonal precipitation variability. They have profound impacts on extreme weather events in the tropics and beyond, making reliable future projections of their changes in response to global warming an important task. Our research aims to understand the changes in CCKW variability in a warmer climate with a focus on the role of stratiform processes and longwave cloud-radiative feedback, which are thought to be growing and damping processes for CCKWs. Specifically, we test the following two hypotheses: i) in a warmer climate, tropical convective systems produce more abundant stratiform clouds, which increases eddy available potential energy (EAPE) production within the waves, ii) longwave cloud-radiation feedback weakens as the climate warms, which also increases EAPE production thereby the growth of CCKWs. To test the two hypotheses, we conduct aquaplanet simulations by perturbing sea surface temperature conditions mimicking future warming scenarios using the Community Earth System Model version 2. Additionally, a series of mechanism-denial experiments will be conducted, in which stratiform cloud variability and longwave cloud-radiative feedback are disabled or weakened, to examine the role of each physical process in amplifying CCKWs. The expected outcome of the ongoing research has the potential to lead to a better representation of CCKWs in global climate models, which will ultimately lead to a more reliable future projection of CCKWs and their associated extreme weather events under global warming.

Atmospheric circulation patterns associated to the coldest and warmest extreme episodes registered at Carlini Station in Potter Cove (South Shetlands, Antarctica)

Alfredo J Costa

This work aims to analyze near-surface air temperature at Carlini Argentine Antarctic Station, in Potter Cove (PC), in order to study the coldest and warmest events, during the 1985-2022 period, in this area of 25 de Mayo (King George) Island at the South Shetland Archipelago, which is located to the northwest of northernmost Antarctic Peninsula (AP). The coldest event was registered between the 23 and 26 July 1994, with a record-breaking low temperature of -27.3°C, while the warmest on 7 and 8 February 2022 reaching a record-breaking value of +13.6°C. Reanalysis data from NCEP/NCAR and ERA5 from ECWMF are used to study the associated circulation patterns of these extreme events in PC, which are associated to easterly (northerly) large-scale air advection in the coldest (warmest) extreme event. Even though, reanalysis data resolution may not be suitable for understanding the whole forcings of such local events, they give an approximate diagnosis of the situation which led to the conditions for the observed extreme events. Additionally, sea ice extent may have played a relative role for the development of the cold extreme event as well as a foehn effect could have played a role for the warm event.

Constraining the global fingerprint of the 8.2ka event with Laplacian eigenmaps

Alexander James (he/him/his)

Paleoclimate time series can be thought of as low-dimensional representations (embeddings) of the climate system which produced them. Understanding what these embeddings tell us about past climates is the main goal of time series analysis on such records. Linear techniques such as spectral and wavelet analysis provide insight into changes in the periodic behavior of the climate, but are intrinsically limited. Novel tools from nonlinear time series analysis, specifically recurrence matrices, allow us to examine changes in other kinds of climate behavior that are reflected in these records. Laplacian eigenmaps (Malik, Chaos 2020) is one such technique that provides information about when fundamental shifts in climate dynamics have occurred. This is done by leveraging time delay embedding to construct a manifold that is theoretically diffeomorphic (e.g. mappable in a way that preserves structure) with the attractor of the climate system. Laplacian eigenmaps then establish when the shape of this reconstructed manifold changes and, by extension, when the shape of the climate system's attractor has changed. We first validate our approach on physically-motivated synthetic data to better understand how to interpret the results of this technique. We then apply it to a global compilation of paleoclimate records (Kaufman et al., Sci Data 2020) in order to identify the spatial imprint of the 8.2ka event on regional climate regimes. We learn more about the extent of this event's influence as it appears in the paleo record and document the teleconnections that were present at the time.

Downscaling Climate Model Projections of Humid Heatwaves

Polina Khapikova (she/her/hers)

Climate extremes are some of the most direct ways humans see the impact of climate change. Particularly, coincident highs of temperature and humidity are an emerging public health crisis in low latitudes, especially the coastal subtropics. In humid conditions, humans are physiologically less able to deal with high temperatures, so humid heatwaves cause heat stress more easily than dry heatwaves. Wet bulb temperature is a commonly used meteorological quantity for incorporating the impact of humidity into the way humans experience temperature. Observations show that wet bulb temperature extremes already exceed safe limits in the subtropics on short timescales. However, the current resolution of global climate models and gridded observational products like reanalyses is too low to capture wet bulb temperature extremes as they can be highly localized in space and time. Therefore, it is difficult to trust future projections of modeled extremes to the extent necessary for adaptation efforts to occur. To address this, we analyze the distribution and tails of wet bulb temperature across state-of-the-art climate model ensembles and present the results. Then, we use machine learning methods to obtain high-resolution predictions of wet bulb temperature in current and future climates. This is crucial for improving predictions of humid heatwaves and understanding the risks they pose.

Constraining Future Projections of Atmospheric Rivers

Ankur Mahesh

Atmospheric rivers (ARs) are extreme weather events that can alleviate drought and cause billions of dollars in flood damage. By transporting significant amounts of latent energy towards the poles, they are crucial to maintaining the climate system's energy balance. Since there is no first-principles definition of an AR grounded in geophysical fluid mechanics, AR identification is currently performed by a large array of expert-defined, threshold-based algorithms. The variety of AR detection algorithms have introduced uncertainty into the study of ARs. We train convolutional neural networks (CNNs) to detect ARs while representing this uncertainty. To detect ARs without requiring new labelled data and labor-intensive AR detection campaigns, we present a semi-supervised framework to generalize CNNs across climate datasets, input fields, and resolutions. Using idealized climate simulations, we rigorously assess whether the CNNs arrive at the right answers for the right reasons. In a single-layer quasigeostrophic simulation, we observe that all the water vapor transport can be attributed to AR-like filamentary structures, and we test whether the CNNs' detections are consistent with this observation. Lastly, we leverage the CNNs and the role of ARs in meridional latent energy transport to develop a more objective method for AR detection.

Predictability of Persistent Marine Heatwaves in the Extra-tropical Pacific

Evan Meeker (he/him/his)

Marine heatwaves (MHWs) are extreme events that occur over a range of spatial and temporal scales, impacting ocean ecology, fisheries, and atmospheric patterns. The largest, most intense, and most persistent MHWs occur at the 1000 km and interannual scales, indicating potential predictability through slowly evolving climate drivers. Here, we investigate the atmospheric and oceanic processes responsible for predictability of the 2013-2015 Northeast Pacific MHW, known colloquially as "The Blob." We assess the predictability of the Blob using climate predictions from the Community Earth System Model (CESM) Seasonal to Multi Year Large Ensemble (SMYLE). SMYLE hindcasts, or forecasts of past events, are initialized every 3 months from 1970-2019 from observations. After initialization, each hindcast is run as a fully coupled physical model for 24 months, with no further information from observations provided. Then, SMYLE's prediction skill is evaluated against the known true climate evolution. We find that the rapid evolution of the Blob is not captured in any SMYLE prediction initialized prior to 2014. However, after the January 2014 peak in sea surface temperature (SST), SMYLE reproduces observed SST magnitudes as well as the size and location of North Pacific SST patterns. We find that SMYLE performance in the Northeast Pacific is tied to the propagation of positive SST anomalies from the Gulf of Alaska to the coastal NE Pacific. The drivers of this propagation, and their representation in CESM and SMYLE, are under further investigation. Based on our results and prior work, we suspect that atmospheric teleconnections to tropical SST are essential to Northeast Pacific MHW predictability.

Climate variability, from seasonal to orbital timescales

Drainage of glacial Lake Agassiz-Ojibway in varve sequences: implications for the meltwater pulses to the North-Atlantic during the last deglaciation

Méliane Carrier-Favreau

During the last deglaciation, variations in area and volume of the Laurentide ice sheet affected the climate through the influx of freshwater in the ocean. Part of the meltwater accumulated south of the glacier to form large glacial lakes, such as Lake Agassiz-Ojibway. The sudden drainage of this lake presumably disturbed the Atlantic meridional overturning circulation and is held responsible for a major cooling period: the 8.2 ka cooling event. Current understanding of this freshwater forcing is limited by the lack of data surrounding the timing, number, and location of drainage events. Finely laminated sediments consisting of alternating fine (winter) and coarse (summer) beds – called varves – provide an annual resolution on the history of Lake Agassiz-Ojibway. The current composite varve sequence comprises a total of ~2100 varves (pairs), but the last segment of the lake's existence remains poorly documented. The varve sequence found around Lake Matagami covers this period but is currently documented at a resolution too low to be correlated with the main varve template or to neighbouring sequences that show evidence for drainage events. To refine the Matagami varve sequence, we collected sequences of ~3 m of varves from the shores of Lake Matagami. The combination of varves measurements, counts, and sedimentological analyses of this sequence should yield a high-resolution varve record that will allow robust correlations with the master sequence and provide insights on the number and timing of drainage events – and their cause(s) – that led to the final drainage of Lake Agassiz-Ojibway. In turn, these results will allow the placements of Lake Agassiz-Ojibway meltwater discharges into the deglaciation framework and improve our understanding of freshwater forcings on climate.

Denali Ice Core record of Common Era North Pacific Temperature

Liam Kirkpartrick (he/him/his)

The atmospheric dynamics of the North Pacific and the region's connections with global climate over the past 1200 years remain difficult to accurately constrain. Existing ice core records point to significant changes in the strength of the wintertime Aleutian Low, storm tracks, and hydroclimate through the Common Era. However, there is substantial variation in North Pacific paleoclimate records from different locations and elevations, and these records have been interpreted in ways that are sometimes in conflict with one another. Here I present the stable water isotope record (δ18O, δD, and the derived deuterium excess) from the Denali Ice Cores, developed from twin surface-to-bedrock cores collected in 2013 from the Begguya (Mt. Hunter) plateau (3900 m) in Alaska, at seasonal to three-year resolution. The cores were sampled using a continuous flow analysis system, and dated by glaciochemical annual layer counting. Methanesulfonic acid and magnesium peaks are used to delineate cold and warm seasons and produce a seasonal isotope dataset through the 20th century. The most remarkable feature in the record is elevated deuterium excess through the LIA (1422-1902), which indicates increased moisture source temperature. I use reanalysis data to explore the potential for a shift in the strength of the Aleutian Low to drive this temperature change, which reconciles the differences between the deuterium excess result and other Common Era temperature reconstructions. This hypothesis is consistent with existing paleoclimate records, and highlights the spatial variability of century-scale climate changes.

A Dynamic Coupled Pathway by which NH Extratropical Cooling Leads to Tropical Response

Matt Luongo (he/him/his)

High-latitude Northern Hemisphere (NH) extratropical radiative cooling has been found to induce a La Niña-like and negative Indian Ocean Dipole-like quasi-equilibrium response in the tropical Indo-Pacific. In this study, we explore the pathway of teleconnections and coupled processes by which extratropical, aerosol-like cooling influences tropical patterns. In a novel set of global climate model simulations, we mechanically decouple the model's ocean from its atmosphere by overriding ocean surface wind stress to mechanistically decompose the total, coupled ocean-atmosphere response into the response of surface buoyancy forcing alone and surface momentum forcing alone. In the NH subtropical Pacific, the buoyancy-forced response dominates: the positive low cloud feedback amplifies sea surface temperature (SST) anomalies in the marine stratocumulus deck off the coast of California. These low cloud-amplified SST perturbations are communicated to the tropics in a Pacific Meridional Mode (PMM) pattern via evaporative cooling from the wind-evaporation-SST feedback. Having reached the tropics, momentum forcing creates zonally asymmetric SST patterns as anomalous surface wind stress from the PMM is able to initiate the momentum-driven Bjerknes feedback in both the Indian and Pacific basins. While the strength of the subtropical low cloud feedback is highly-dependent on model, this pathway of feedback processes seems to be robust across a suite of GCMs such that models with less of a subtropical low cloud response exhibit less of a La Niña response. Our results highlight the important link between these three coupled ocean-atmosphere feedbacks in tropical pattern formation and El Niño-like variability from extratropical aerosol-like forcing.

Shifts in Vegetation and Hydroclimate in the Indo-Pacific Warm Pool during Glacial Extremes

Meredith Parish (she/her/hers)

The Indo-Pacific Warm Pool (IPWP) is characterized by the highest average sea surface temperatures (SSTs) on Earth, fueling intense convection and high precipitation. Despite the global importance of the region, we do not fully understand the controls on IPWP hydroclimate on orbital timescales. Insolation, greenhouse gas concentrations, and the exposure of continental shelves when sea level lower during glacial periods have all been proposed as the dominant forcing of IPWP hydroclimate. We analyzed d13C of terrestrial n-alkanes (leaf-wax) in sediment drill cores spanning multiple glacial-interglacial cycles from Lake Towuti, located in Indonesia in the center of the IPWP, to reconstruct hydroclimate over the past 300,000 years. Leaf-wax d13C reflects hydroclimate in the IPWP because it is influenced by the proportion of C3 vegetation (d13C averages -33‰) versus C4 vegetation (d13C averages -20‰), as well as rainfall and humidity, with wetter conditions leading to more efficient leaf-gas exchange and more depleted d13C values. We find an 8‰ enrichment in d13C only at the most extreme periods of glaciation at the LGM and at the previous glacial interval (MIS 6). The shifts in d13C during the peak of glacial periods support model results indicating widespread drying in the IPWP when the NW Australian shelf is exposed, which only occurs when sea level lowers over 90 m at the peak of the glacial periods. The exposure of the NW Australian shelf caused southwesterlies off Java and Sumatra, leading to increased upwelling, a decreased SST gradient across the Indian Ocean, and slowed Walker Circulation.

Investigating the variability of mesoscale eddies in the Northwest Atlantic 1993-2017
Elena Perez (she/her/hers)
The Gulf Stream is a swift, poleward flowing current that brings warm, salty subtropical waters through the Florida Straits, along the continental shelf of the southeastern United States, to the North Atlantic. Near Cape Hatteras (75W) the Gulf Stream separates from the shelf and the character of the current changes drastically from a topographically trapped western boundary current to a meandering jet. The path gradually widens downstream of Cape Hatteras and varies year-to-year, with some years having a more stable, narrow path and others having an unstable, meandering path. Downstream of Hatteras is where the Gulf Stream's meanders are large enough to create a "loop" where warm and cold core rings are shed between 75W and 55W. Using a dataset of eddy tracks detected from multimission altimetry products we investigate the consequences of Gulf Stream characteristics (position, path, structure, and separation location) on ring formation. As well as the variability of ring formation, track, and interaction with the Gulf Stream and bathymetry. These results are compared against other studies that use similar products but different methods to identify ring formation and their tracks.

Volcanic eruptions and multi-decadal Indo-Pacific variability amplify extreme Indian Ocean Dipole events in Last Millennium Ensemble simulations
Benjamin Tiger (he/him/his)
The tropical Indian Ocean is warming faster than any other basin, and its interannual climate variability is projected to become more extreme under future emissions scenarios with substantial impacts on developing Indian Ocean rim countries. Therefore, it has become increasingly important to understand the drivers of regional precipitation in a changing climate. Intense volcanic eruptions can have significant climate impacts and serve as a useful natural experiment for better understanding the effects of abrupt, externally forced climate change. Previous work has found that volcanic forcing can induce changes in pantropical atmospheric and oceanic circulation regimes, favoring the formation of El Niño conditions in the equatorial Pacific. The volcanic response in the tropical Indian Ocean is much less well constrained. Here, I

use the Community Earth System Model Last Millennium Ensemble (CESM-LME) to investigate the response of the Indian Ocean Dipole (IOD) to intense volcanic eruptions from 850-2005 CE. Post-eruption spatial composites show a strong negative IOD (nIOD) developing in the boreal fall of eruption years. This response is associated with low-level westerly anomalies across the basin and anomalously warm SSTs in the Sunda Strait upwelling region. The magnitude of nIOD tracks eruption intensity, with the most intense eruptions driving the largest decreases in values of the Dipole Mode Index (DMI) well beyond the range of natural variability. This response occurs regardless of the hemisphere of eruption. Post-eruption timeseries composites show a long-term damped oscillatory response in the DMI with excursions significantly beyond the range of natural variability that can take multiple years to return to pre-eruptive baselines. Moreover, the state of the Interdecadal Pacific Oscillation (IPO) at the time of eruption modulates the IOD response to intense eruptions, with negative (positive) IPO phasing favoring more negative (positive) DMI values. The effects of initial IPO phasing result in statistically significant differences in the distribution of the resulting post-eruption DMI. This suggests that the mean state of the Indo-Pacific is an important preconditioning control on the tropical Indian Ocean's response to volcanic forcing.

Proxy development

Accurate annual seawater temperature reconstructions from coral Sr-U

Mariya Galochkina (she/her/hers)

Understanding climate change on the spatiotemporal scales necessary to improve climate projections requires proxy records to enhance short, sparse, and often contradictory observational datasets. Massive long-lived corals on reefs across the global tropics have tremendous potential in this regard, continuously recording information about ocean conditions as they grow. However, extracting this information with the degree of accuracy needed to address societal needs is challenging, driving development of improved coral-based proxies. Here, we show that Sr-U, a novel coral-based proxy, captures annual seawater temperatures to within ±0.2°C of observations over a ~1°C range. Sr-U combines multiple paired U/Ca and Sr/Ca values to correct for non-temperature effects on Sr/Ca. We used laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to capture the full range of temperature variability over the annual cycle in a slow-growing, highly seasonal Bahamas coral (Siderastrea siderea). The 30-year long Sr-U record exhibits a strong negative correlation ($r = -0.64$) with HadISST observational data, capturing the amplitude and timing of average annual temperature. Conversely, average annual Sr/Ca does not correlate with observational temperatures at the site. Furthermore, discrepancies between Sr/Ca values of adjacent skeletal elements within a single S. siderea corallite, equivalent to offsets of 3-4°C, are resolved by Sr-U, which exhibits no statistically significant difference. These observations indicate that Sr-U can be used with confidence to constrain decadal-to-multidecadal variability and secular trends in regions where this information is urgently needed.

Applying the carbonate clumped isotope thermometer in Fayetteville Green Lakes, NY: Developing a process-based understanding of a paleoclimate tool in a modern system

Emma Heitmann (she/her/hers)

Geologic archives provide important information about how the climate system responded to past perturbations, and thus provide insight into our future climate. For example, lake sediments like calcium-carbonate are widely-used for paleoclimate reconstructions because their isotopic compositions are controlled by ambient lake conditions which can be related to earth-surface conditions. The carbonate clumped isotope thermometer has demonstrable potential to reconstruct mean annual air temperature (MAAT) using transfer functions relating lake water to MAAT, however there remains uncertainty about where, when, and how carbonates precipitate in lakes and what temperature is recorded. Here, we present a case-study from Fayetteville Green Lakes, NY (FGL) where we compare observed lake water temperature with the carbonate-recorded temperature ($T\Delta47$). We sampled the top 10cm of a sediment core (ranging in age of ~94-445 years old), and collected newly-precipitated suspended carbonate particles and ambient water temperatures from different depths in the water column throughout the year. Averaged together, the core-top $T\Delta47$ is 33 degreesC (±4 degreesC 2σ), resulting in a MAAT estimate of ~22 degreesC. This $T\Delta47$ is hotter than the highest observed water temperature (25 degreesC) and observed MAAT of ~10 degreesC. This result might imply that FGL carbonates precipitate out of equilibrium, altering the $\Delta47$ value. Future work to analyze water column samples and develop a proxy-system model will help test this hypothesis. Our preliminary results imply that workers should take care when analyzing lake carbonate $T\Delta47$ and consider processes that may substantially alter the clumped isotope values and thus surface temperature reconstructions.

Developing On-Site Paleoenvironmental Records to Provide Direct Tests of Paleoclimatic Change on Past Human Populations.

Yasaman Jafari

For many regions of the world, including the Intermountain West of the US, there are few available paleoenvironmental proxy records that are in close proximity to archaeological sites. The development of on-site paleoenvironmental records from archaeological faunal assemblages establishes more direct connections between past human societies and paleoclimate change. This provides more robust assessments of past human adaptations to climate change. This study proposes a novel method for developing on-site paleoenvironmental records that couples hydrogen, oxygen, carbon, and nitrogen stable isotope analyses with radiocarbon dating of archaeological faunal collections from deeply stratified archaeological sites on the Snake River Plain. The study focuses on three sites that provide isotopic records for environmental change over the past 14,000 years. Tandem sampling for AMS radiocarbon dating and stable isotope analysis on the same animal bone produces a high-precision chronology for changes in isotopic values for each past human occupation level at each site. This enables a direct comparison of time series of isotopic values to the archaeological record for demographic, subsistence, and technological change. These time series of isotopic values for each site will then be compared to downscaled and debiased paleoclimate models for the region. This presentation focuses on how this novel method can be used to 1) enhance validation of paleoclimate models, and 2) investigate the resilience of human populations to past climate changes.

Marine heatwaves reshape plankton community

M. Kelsey Lane (she/her/hers)

Planktic foraminifera, globally ubiquitous marine calcifiers, are commonly used proxies for understanding past ocean climate because of their long fossil record and known correlation with various environmental conditions, such as ocean temperature and pH. We present a new record of planktic foraminifera assemblages during two recent marine heatwaves in the Northeast Pacific, showing that foraminifera community composition changed consistently and over short time scales following the onset of multiple marine heatwaves. Warm water species were abundant during both marine heatwaves, in contrast to the typical colder water assemblage typical to this region, Results suggest that transient changes in fossil planktic foraminifera assemblages could be used to reconstruct the frequency of previous marine heatwaves.