How Fast Did the Juneau Icefield Retreat at the End of the Last Ice Age?

Background: The Juneau Icefield in Alaska is an important natural laboratory for understanding how glaciers respond to climate warming because it advances and retreats in response to summer temperature. It is also one of the largest ice masses in North America and one of the longest-studied glaciers in the world! Because anthropogenic climate warming is amplified in the Arctic, understanding how Alaskan glaciers have responded to past warming is essential for improving predictions of future changes. However, little is known about how the Juneau Ice Field responded to past climate changes, such as cold conditions during the Last Glacial Maximum (~18,000 years ago) or warming during subsequent deglaciation. How thick was the Juneau Icefield during the Last Glacial Maximum? At what time did Juneau Icefield reach its thickest extent? How fast and how much did the Juneau Icefield retreat in response to warming during deglaciation? To answer these questions, we will use Be-10 surface exposure-age dating, a technique that tells us how long a rock was exposed to the atmosphere, giving information about how long ago glacier ice retreated from the landscape.

Analysis: We will analyze bedrock samples collected from the Juneau Icefield in Summer 2019. Lab work includes isolating the mineral quartz from rock samples, characterizing elemental composition of the quartz using inductively coupled plasma optical emission spectrometry (ICP-OES), and isolating elemental beryllium from the quartz sample using a variety of chemical separation techniques. Once beryllium is isolated in our lab, we send the samples to Purdue Rare Isotope Measurement Laboratory for measurement by accelerator mass spectrometry (AMS). Lab work will average 20 to 30 hour per week, with the rest of the time used for literature review and data analysis. Students will also have the opportunity to work in MATLAB for data analysis and QGIS (an open-source mapping tool) for geomorphic mapping. We also plan to arrange a field trip to collect rock samples near New York City, providing the student with field experience.

Prerequisites: None. Familiarity with MATLAB and GIS methods a plus.

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What Is the Role of Aerosols in Modulating Atlantic Hurricane Activity?

Background: Atlantic hurricane activity had decadal variability during the 20th century, with a low-level of hurricane activity in the 1970s and 1980s and high-level activity before and after that period. There is substantial debate in the climate community about the role of anthropogenic aerosols during this period of low-level hurricane activity. While some attribute the low-level activity to the Atlantic Multidecadal Oscillation, others consider that emissions of anthropogenic aerosols from the USA and Europe significantly contributed to the cooling of the North Atlantic and the occurrence of fewer hurricanes during this period. We propose to investigate this problem by analyzing existing climate model simulations with and without anthropogenic aerosols emissions from 3 different global climate models (Westervelt et al. 2017; 2018). We anticipate that our results will help elucidate this problem.

Analysis Required: Standard environmental proxies for tropical cyclone activity in these models would be calculated (e.g. potential intensity, genesis index, ventilation index), focusing on the differences in the aerosols and aerosol simulations. Preliminary analyses of the simulations have already been done, which will make further analysis much easier and doable as a summer project. The model simulations were done with low-resolution models, so the tropical cyclones in these simulations are not realistic. In the 2nd part of this project, we would generate synthetic Atlantic hurricanes from these models using the Columbia Hazard Model or CHAZ (Lee et al. 2018) and environmental fields from these model simulations. We would then compare the differences in hurricane activity using these synthetic storms. The results from the environmental proxies and the synthetic hurricanes will lead to a better understanding of the role of aerosols on Atlantic hurricane activity.

Pre-requisites: Programming experience is required using Python and/or MatLab. Interest in atmospheric sciences and hurricanes is a must. Physics, Chemistry and Calculus would be a plus.

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What Are the Drivers of Arsenic Contamination and Heterogeneity in Groundwater in Southeast Asia and the USA, and How Can We Predict Arsenic Concentrations Effectively Across Spatial Scales?

Background: Chronic exposure to arsenic (As) in groundwater is a staggering public health crisis and threat to food security, afflicting over 200 million people worldwide. Levels of As in groundwater often range from safe to very dangerous over small spatial scales, making it challenging to understand the environmental conditions and their interactions that govern As mobility and toxicity in groundwater. We are unable to predict groundwater As concentrations with enough confidence to assess exposure levels or to make effective management decisions that reduce the risk of chronic As poisoning. The objective of this project is to identify key hydrologic and biogeochemical variables that control groundwater As concentrations and heterogeneity across household-level to regional scales in Southeast Asia and the USA. We then aim to develop clear mechanistic linkages and high-resolution geospatial information that can be used with machine learning to evaluate and predict groundwater As contamination. Groundwater As exposure and the adverse health effects are also inequitably distributed, resulting in environmental injustice for vulnerable underrepresented communities. This is particularly true in the Upper Midwest of the U.S., where native American communities suffer from higher rates of illnesses that are potentially linked to excessive As exposure from drinking water. This project will provide critical information on potential levels of As in drinking water within American Indian communities of Minnesota, North Dakota, and South Dakota. Improved understanding of the causes of groundwater As contamination in these communities will help advise effective mitigation efforts to reduce the risk of chronic As exposure. The student's research will help to identify levels of As exposure, safe drinking water sources, and environmental mechanisms which can inform management decisions that are needed to reduce health disparities for indigenous populations

Analysis Required: The student's anticipated tasks will include 1) the aggregation of existing datasets and generation of new data types; 2) data synthesis and analysis using geospatial and visualization techniques; and 3) development of mechanistic linkages with groundwater As contamination. The student will also have the opportunity to 4) leverage machine learning to predict groundwater As concentrations across spatial scales; 5) pair predictions with population density data to evaluate risk of exposure within communities; and 6) integrate temporal climate data to evaluate future scenarios. All tasks can be completed remotely.

Prerequisites: We are seeking an undergraduate student to participate in cutting-edge research that crosses interdisciplinary fields of environmental science, public health, geospatial analysis, and data science. The anticipated research project will involve the fusion of various types of large datasets from remotely-sensed and field-collected measurements (e.g., surface hydrology and topography, groundwater geochemistry, climate, and population density).The desired skills required for this project include 1) coursework in environmental science, geoscience, and statistics; 2) proficiency and interest in data analysis; 3) familiarity and interest to learn geographical information system (GIS) software and R statistical computing platform; and 4) experience or interest in learning data graphing and visualization techniques in R.

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What Do the Macrofossils of Maplecrest Bog, Catskills, Tell Us About the Paleoenvironment of the Region?

Background: Pollen analysis provides a stratigraphic record of vegetational history for a region, and when combined with macrofossil analysis, a complete local and regional picture of the environment is produced. We extracted a 7.8 meter sediment core from the eastern margin of Maplecrest Bog, northeastern Catskills, New York, and the pollen record reveals 13,000 years of regional vegetational history. We have dated key intervals of the core with AMS C-14 dates on macrofossils. However, the remainder of the macrofossil component has only been completed down to 1.5 m depth (about 1000 years ago).
The remainder of the core awaits macrofossil analysis, which will define some of the interesting questions concerning local species at the site, and the climatic implications of these species. Today, red spruce, balsam fir, and bog species such as leatherleaf and sphagnum are present, but prior to the last millennium we think the site was a pond. Questions of the type of birch trees present (paper birch, grey, or yellow birch?), whether the hemlock decline affected the bog site, and whether alder expanded in the Younger Dryas are all critical to the vegetational history.

Analysis Required: The student will use screens to separate identifiable macrofossils from the bulk sediment samples, and then use a microscope to pick and store the macrofossils for ID with the help of the advisor. We hope to visit the site.

Prerequisites: Skills needed are an interest in bog plants and paleoenvironmental history, and dissecting microscope interest.

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What Can We Learn From Dissolved Gases About Changes in Ocean Circulation and Biogeochemistry in the Northern Atlantic?

Background: Ocean circulation patterns have changed during Earth's climate history and there are concerns that the currently rapidly increasing levels of greenhouse gases in the atmosphere will change deep water formation rates and affect the Earth's climate system in the very near future with potentially devastating consequences. The distribution of dissolved gas tracers in the ocean at various times can help us detect if these changes have already been happening. Lamont owns an extensive library of gas samples extracted from the Atlantic Ocean in the 1980s that are waiting to be analyzed. We are planning to measure a subset of these samples for some basic parameters (e.g. pressure and Ar/N_2 concentrations) to check for integrity of these samples that have now been stored for up to 40 years. In collaboration with Woods Hole Oceanographic Institution and the Hebrew University in Israel we will then analyze these samples for noble gas ratios and oxygen isotopes to better understand changes in ocean circulation and biogeochemistry over time.

Analysis Required: The undergraduate intern will work in the laboratory at Lamont primarily with a gas chromatograph and a vacuum system for splitting samples to check the integrity of samples. The gas chromatograph will have to be modified and tested to improve analytical accuracy. The intern will also assist in the sample preparation and data analysis of the measurements performed at the partner institutions.
Prerequisites: A lab science class is required.

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How Does Increasing Extreme Heat Impact the Health of Agricultural Workers?

Background: Global warming is increasing the risk of extreme heat around the world. Agricultural workers are particularly susceptible to heat illness, as they work outdoors, often during warm parts of the year. However, it is uncertain how exposure to dangerous heat conditions has changed for agricultural workers over recent decades, though there is evidence of an increase in heat-related illness for such workers in some regions. Understanding this changing risk to agricultural workers is critical for projecting the impacts of climate change on worker's health, and on the productivity of the agricultural sector.

Analysis: This project will use high resolution climate data alongside global agricultural calendars to quantify where and when agricultural workers experience extreme heat and how much this risk has changed due to warming. The student will conduct data analysis for both climate model outputs (CMIP6 models) and agricultural calendar data, interpret results, and contribute to (and co-author) a journal article that will be submitted for publication.

Prerequisites: basic programming skills in MatLab, R, or Python."

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Can Low Cost Sensors Help Close the Air Pollution Data Gap in Sub-Saharan Africa?

Background: Air quality is a major crisis globally, leading to about 5 million premature deaths every year. In sub-Saharan Africa, there is little air pollution data available to characterize the problem, and a lack of focus on solutions. The Westervelt group, along with many partners, is working to close the alarming air pollution data gap in sub-Saharan Africa. With expertise from local universities, environmental ministries, and stakeholders, we are running an 8-city, 50-node air pollution monitoring network that is quickly expanding. Our focus is mainly on PM2.5 (fine particulate matter) though we also conduct measurements of gas-phase pollutants such as $NO_{x,}$ O_3, CO, and SO_2. We are also actively engaged in air quality computer modeling in sub-Saharan Africa.

The gold standard for surface observations of air pollutants are so-called reference monitors, which cost tens to hundreds of thousands of dollars and require substantial scientific experience to maintain. Low cost sensors, which are simpler devices that can measure air pollutants via indirect methods such as optical scattering, have the potential to revolutionize air quality monitoring, especially in places such as sub-Saharan Africa where resources may be limited. In order to get useful, actionable data out of low cost sensors, scientists must perform careful calibration and performance evaluation of these devices, otherwise low quality data may proliferate. As part of a larger project in Nairobi, Kenya, a network of 25 NO2 and PM2.5 low cost sensors have been deployed surrounding a single reference monitor for each species. This provides a unique opportunity to generate high quality air pollution data for the first time in a growing megacity. Similar measurement setups are either already in place or will be in place in early 2021 in Accra, Ghana, and Kinshasa, Democratic Republic of the Congo.

Analysis Required: The student will be given low cost and reference PM2.5 data from at least one of the cities listed above, and will be tasked with conducting data analysis including seasonal statistical averages, data trends, diurnal cycles, geospatial maps, and other analyses. The student will also develop calibration factors for the low cost sensors to correct them towards reference-grade using statistical methods such as multiple linear regression and machine learning. Ultimately the results, which include the first ever calibrated ground-based PM2.5 measurements in some of the cities, will be published in the peer-reviewed literature.

Prerequisites: Applicants should have experience in a scientific data analysis packages such as Python, MatLab, R, etc. Interest in air pollution and climate change is required, but detailed previous knowledge of the topics is not necessary. Any prior experience in air quality data, computer modeling, and measurements is a plus. Students majoring in any science or engineering discipline will be competitive candidates.

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How Different Are the Fine Particulates in the Air Between NYC and Surrounding Suburban Areas?

Background: Air pollution, especially particulate matter (PM) poses a considerable risk to human health. Most previous monitoring and characterization efforts have been focused on fine particulates PM2.5 (particles < 2.5 µm in size). Finer particulates PM1 (particles < 1 µm in size), mostly coming from combustion, dust, bacteria and viruses and making up a significant portion of PM2.5, are more harmful when inhaled and travel to the deeper areas of the lungs and enter the bloodstream. PurpleAir, a recently available but worldwide deployed low-cost air quality monitor which had more than 9,000 units by the end of the year 2019, can monitor real-time fine particulates of size <1, 2.5 and 10 µm simultaneously and has all the data publicly available. This rapid growing network of PurpleAir sensors has provided numerous continuous PM monitoring data and great opportunities for enhancing research on public exposure to these particles. The few ongoing calibration efforts for PurpleAir data have focused on PM2.5, but no effort has been made to calibrate PM1. Very few studies have utilized the real-time particle counts of the 0.3, 0.5, 1.0, 2.5, 5, and 10 µm size fractions.

Analysis Required: We propose to conduct collocated experiments of PurpleAir, the DiSCmini ultrafine particle counter (from testo, detects 0.01 to 0.7 micrometer size range) and other air monitors in indoor and outdoor environments at urban (NYC) and suburban (Dominican College, Lamont-Doherty Earth Observatory) sites to explore the calibration of PurpleAir PM1 and PM2.5 data. This project will set up various air monitors, e.g. PurpleAir, DiscMini, microPEM with filter, microAeth, at a few urban and suburban sites to collect data throughout the summer. Data can be downloaded from the monitors and/or accessed remotely. Lab and field work includes setting up the air monitors, maintaining, and downloading data. Data analysis work includes comparing PM1, PM2.5 levels at different sites from various monitors and developing models to calibrate PurpleAir PM1 and PM2.5 data using particle size distribution, temperature, humidity and filter mass.

Skills Required: Knowledge of basic statistics, e.g. regression. Also knowledge of computer programming or data analysis tools such as R or Python are a big plus.

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