Can We Use Historical Events as Stratigraphic Markers in the Hudson River?

Background: The Hudson River has a long history of Pb pollution due to burning of hydrocarbon fuels and local incineration. Pb pollution is dangerous to human heath. Catastrophic burning of human industrial sites can produce layers with a higher content of low melting point metals like Pb and Sn. We found two layers with a higher volatile metal content in Hudson River core CD2-29A (taken off Manhattan) that appear to coincide with major catastrophic events. The first is a Pb peak two times above background at the level of the 1866 burning of a Pb paint factory in Brooklyn. The second is high Sn at the level of the 1916 explosion of munitions that damaged the Statue of Liberty. We have also developed a Cs-137 and Pb record for cores CD2-29A and LWB1-8, the latter taken off Yonkers, New York. The Cs record for LWB1-8 shows two known peaks, in 1963 and 1971, from nuclear testing and an accident at Indian Point power point respectively. Our newest data from LWB1-8 shows three younger Cs peaks, in 1986, 1981 and 1977. These may be related to respectively, the Chernobyl nuclear disaster in 1986, the last atmospheric tests by China in Oct 1980 and a 1977 nuclear disaster in Eastern Europe. Because the top is too old, we cannot test these events in core CD2-29A. We wish to replicate our younger Cs chronology in a core taken off Peekskill New York, a core that also contains possible fragments of the Peekskill meteorite. Meteorite fragments exhibit extremely high values of magnetic susceptibility. Because the Peekskill meteorite fell in 1992, any core that contains meteorite fragments is young enough to record these "new" Cs events.

Analysis Required: The intern will help to sample and process samples for measurements of Pb, Sn, Cs and magnetic susceptibility on three Hudson River cores. The student will also sieve cores for meteorite ablation spherules and characterization of grain size distribution and particle compositions. The latter is necessary to distinguish high magnetic susceptibilities derived from fires and incineration from high magnetic susceptibilities derived from erosion during large floods. We will also image and analyze interesting particles with visible light and scanning electron microscopes.

Prerequisites: Intense interest in geology and environmental events. One prior course in either environmental science or physical geology. Some experience with light microscopes is desirable but is not required.

Mentors: Dallas Abbott (dallashabbott@gmail.com) and Ben Bostick (bostick@ldeo.columbia.edu)

How do Invasive Species and Meteorite Dust Affect Hudson River Sediments?

Background: The invasion of the zebra mussel in 1992 is known to have affected the productivity of diatoms in the Hudson River at Haverstraw Bay and above Haverstraw Bay in Peekskill. We found a change in biogenic silica content in one core taken near Peekskill that might correspond either to the years 1992 or 1993. Our studied core lies along the transit path of the Peekskill meteorite over the Hudson. This core contains a layer with very high magnetic susceptibility and possible fragments of the Peekskill meteorite. High magnetic susceptibility is characteristic of meteorite dust. There are suggestions in the literature that the change in diatom productivity caused by the invasion of the zebra mussel may have been later in the lower Hudson River from Peekskill to Haverstraw Bay. Two as yet unexamined cores also lie along the transit path of the Peekskill meteorite and also contain a layer with extremely high magnetic susceptibility. The goal of this study is to understand how the invasion of the zebra mussel affected the content of biogenic silica in Hudson River sediments and to see if changes in biogenic silica content occur at or above the stratigraphic horizon with the largest proportion of ablation spherules from the Peekskill meteorite. To provide the best chronology, we will also conduct Cs-137 and Pb-210 dating of our cores. All measurements will be contrasted and correlated with ITRAX geochemical profiles of the cores.

Analysis Required: The intern will help to sample and process samples for measurements of magnetic susceptibility, biogenic silica, Ir and Cs-137/Pb-210 dating of two Hudson River cores along the transit path of the Peekskill meteorite. The student will also sieve cores for meteorite ablation spherules and characterization of grain size distribution and particle compositions. We will also image and analyze interesting particles with visible light and scanning electron microscopes.

Prerequisites: Intense interest in geology and environmental events. One prior course in either environmental science or physical geology. Some experience with light microscopes is desirable but is not required.

Mentors: Karin Block (kblock@ccny.cuny.edu) and Dallas Abbott (dallashabbott@gmail.com)

How Do You Find Hurricanes in a Climate Model?

Background: The 2017 Atlantic hurricane season was devastating to the US. One of the constant questions asked is if climate change was responsible for the extreme season. One way to understand how climate change affects tropical cyclones (general name for hurricanes globally) is to find and track hurricanes in the output of the climate models and see how and which of their characteristics change (or not) under climate change. In order to do that, first it is necessary to have a baseline of the characteristics of the climate model tropical cyclones in the present climate. As the climate models' resolution increases, it is possible to simulate tropical cyclones much similar than the observed ones. We propose in this project the characteristics of tropical cyclones in a high-resolution climate model in the present climate. We can ask many questions of those simulated hurricanes: Can the model tropical cyclones reproduce the response of the hurricanes to El Niño and La Niña? How about other models of climate variability? How much internal variability is there? If exactly the same model was run using the atmospheric data available (reanalysis) how much closer is the tropical cyclone activity to the observed one, than when the model is only forced with sea surface temperature? These are many of the questions that we can examine. There is a large range in the ability of the climate models in simulating tropical cyclones and will be important to determine the ability of new models (as the one that will be used in this project) before making climate change projections with the model.

Skills required: Experience in programing. MATLAB or python experience highly desired. Ability to work with large datasets. A minimum of 20 hrs/wk on the project will be expected. Students of atmospheric sciences, computer science, mathematics, physics or engineering preferred.

Mentor: Suzana J. Camargo: suzana@ldeo.columbia.edu, 845-365-8640

Does Anyone in Your Household Smoke? Improving Methods for Assessment of Second Hand Smoke Exposure for Public Health Studies

Background: Assessment of second-hand cigarette smoke (SHS) is essential to many public health studies yet current methods are fraught with problems. Questionnaires are subjective and the primary biomarker cotinine is quite problematic for determining SHS exposure due to subject-to-subject variations in uptake and metabolite half-life. We have been developing personalized methods for quantitative assessment of SHS exposure based on multi-wavelength absorbance of Teflon filters. Prior work has suggested interference of this method when black carbon loadings become moderate or high. This project is focused on the use and comparison of real-time methods to lab based methods for quantifying SHS exposure.

Analysis Required: This project will consist of running chamber experiments at LDEO where known amounts of different combustion sources (ethylene soot, cigarette smoke, incense) are mixed and characterized by different real-time and laboratory methods. Field samples from residential settings will also be evaluated. Data analysis will be aided by running programs in R to deconvolve absorption signatures from various combustion sources. Lab work will require average 20 hrs/wk, with the rest of the time being focused on data analysis, literature review, etc.

Prerequisites: None, though it would be a plus to have prior lab experience, already taken a course equivalent to an introduction to electricity, magnetism and optics or equivalent, and have knowledge of R or an equivalent programming language.

Mentors: Steven Chillrud, chilli@ldeo.columbia.edu, 845-365-8893; James Ross 845-365-8507

How Did Climate Variability Impact the *Rapanui* People of Easter Island?

Background: Easter Island is famous for the *Rapanui* culture that is manifested as mysterious anthropomorphic stone statues called *moai*. The decline of the *Rapanui* culture on Easter Island has been attributed to a socio-ecological collapse triggered by over-exploitation of natural resources, a story line that has been presented as an example of how humans can negatively impact their own society by first destroying their habitat. Over time, this view has become the main foundation of Easter Island's history, and it is still widely accepted. However, it is possibly founded upon a premature and inaccurate interpretation of early studies of sediment records from lakes and marshes on Easter Island. I am trying to better understand the environmental and climatic conditions that existed before the arrival of the first settlers on Easter Island (sometime between 800-1200 A.D.) and during the few hundred years post-settlement, when the population first flourished and then declined. The objectives of the project are to 1) generate new climate records that we can use to understand the natural changes in precipitation that took place on Easter Island during the last 2,000 years, 2) pinpoint the timing of the arrival of the first settlers, and 3) determine when the first evidence for large-scale deforestation practices (burning) took place. The results of this project will help us understand the importance of natural climate changes in the mysterious history of the Easter Islanders.

Analysis Required: This project will involve sedimentological analyses of sediment cores collected from lakes and bogs on Easter Island. The student researcher will work on developing a variety of stratigraphic records to understand the history of sedimentation at these sites before, during, and after the settlement period. The researcher will examine the sediment cores for climate and human-impact indicators, and will conduct analyses in the organic geochemistry lab to study lipid molecules from the cores, which contain valuable climate information about the past.

Prerequisites: Student should have a keen attention to detail and excellent organizational skills.

Mentor: Billy D'Andrea: dandrea@ldeo.columbia.edu , (845) 365-8654

Does the Bloom Forming Mixotroph *Noctiluca scintillans* Have Special Photosynthetic Capabilities to Survive in a Low Oxygen Acidic Ocean?

Background: Over the last decade and half, the Arabian Sea ecosystem has undergone a dramatic shift. Diatoms the ubiquitous, unicellular, siliceous photosynthetic organisms that thrive in the nutrient-rich waters of the winter monsoon have been replaced by an unusual mixotrophic dinoflagellate *Noctiluca scintillans* (NS) (Fig. 1). Our fieldwork has shown that NS blooms are facilitated by intrusion of low oxygen waters from the Arabian Sea's 'dead zone' because they can photosynthesize at higher rates and thrive under low oxygen conditions than diatoms. But hypoxia or the depletion of oxygen caused by excessive organic material and its heterotrophic degradation by microbes also produces excessive CO_2 and acidic ocean conditions. A lowered oceanic pH can restructure marine ecosystems by decreasing the ability of some organisms to produce shells, change metabolism of some animals, boost phytoplankton photosynthesis through increased CO_2 availability but also limit access to essential minerals and nutrients. Blooms of NS covering vast expanses of the Arabian Sea for almost 3 months are disrupting the delicate balance of the ecosystem by causing declines in biodiversity and damage to local fisheries. How then will NS react to a lowered pH caused by anthropogenic inputs of CO_2 as well as from increased degradation of organic matter, a large part of it from domestic and industrial outfall from mega cities bordering the Arabian Sea? Despite the progress that we have made in understanding this organism, its physiology remains largely unknown. What is particularly a matter of concern is that NS is slowly expanding its range with recent reports of its occurrence in Tanzania, Seychelles, Thailand, Vietnam, Malaysia, Indonesia and several other countries in Southeast Asia.

Fig 1: Single Cell of NS with its green endosymbionts

Experimental Plan: We have been able to grow NS in the laboratory; perhaps the only live culture in the world. This project will use NS cultures to conduct controlled incubation experiments that investigate the combined impact of low oxygen and pH on the ability of NS to survive and grow to bloom proportions over other phytoplankton. NS and diatoms cultured from the Arabian Sea will be exposed to a range of range of oxygen and pH conditions and growth monitored. Dissolved oxygen, pH, chlorophyll a concentrations, cell counts, variable fluorescence and nutrients will be measured over the course of the experiments using oxygen sensors, a FlowCAM imaging system and fast rate repetition fluorometry. Statistical tests will be employed to assess the results.

Mentors: Dr. Joaquim Goes (jig@ldeo.columbia.edu) and Dr. Helga do Rosario Gomes (helga@ldeo.columbia.edu)

Pre-requisite for Students: Background in biology, with interests in issues related with the environment and societal well-being.

What Caused Atmospheric CO_2 to Decline During the Mid-Pleistocene Transition?

Background: From 1,200,000 to 600,000 years ago, Earth's climate underwent a fundamental shift called the Mid-Pleistocene Transition. During this time, glacial periods gradually became more severe and prolonged, and changed from 40,000 to 100,000 year pacing, without a change in the periodicity of forcing by solar insolation. Abruptly at around 900,000 years ago, a number of other facets of Earth's climate system underwent a shift: ice sheets grew in size, deep ocean circulation drastically changed, and the concentration of atmospheric CO_2 during glacial periods decreased. What caused this dramatic climatic shift? Where was this missing CO_2 stored, and did reduced CO_2 help to cause the Mid-Pleistocene Transition?

Studies of climate during the last glacial period have implicated the deep ocean as a likely reservoir for carbon storage, removing CO_2 from the atmosphere and causing global cooling. In our study, we seek to investigate the extent to which the deep Pacific Ocean stored carbon during the Mid-Pleistocene Transition, as the deep Pacific today is Earth's largest exchangeable carbon reservoir. We will accomplish this by reconstructing the carbon chemistry of deep waters using trace element proxies in benthic foraminifera. Foraminifera are single-celled protists that live in the deep sea and whose shells record the seawater chemistry that they grow in. Specifically, the B/Ca ratio of foraminiferal calcite can be related to the carbonate ion content of deep waters, which is directly related to carbon storage. Ultimately, we seek to understand how ocean circulation and carbon cycle feedbacks affected atmospheric carbon dioxide and global climate across this key period of climatic change.

Analysis Required: In this study, a summer intern will generate a B/Ca record from benthic foraminifera from a sediment core taken in the deep Western Equatorial Pacific Ocean at ODP Site 805. The intern will utilize methods of sediment washing, picking of relevant foraminifer species, and analysis for B/Ca and other trace elements via Inductively Coupled Plasma Mass Spectrometry (ICP-MS) here at LDEO. This project offers the opportunity to gain skills in analytical geochemistry and sample processing that are applicable to a wide range of fields in the geosciences.

Prerequisites: There are no specific laboratory skills required, as all training will be received on-site. The intern should have an interest in climate studies, geochemistry, or studying past environmental change.

Primary Mentor: Laura Haynes, laurah@ldeo.columbia.edu
Secondary Mentor: Bärbel Hönisch, hoenisch@ldeo.columbia.edu

Did Icebergs Cause the Most Dramatic Climate Changes of the Last Ice Age?

Background: The last ice age was punctuated by repeated abrupt climate changes that involved dramatic cooling of the northern hemisphere at times when much of southern hemisphere was warming. These climate shifts occurred at times of episodes of catastrophic iceberg discharge from the vast Laurentide ice sheet that covered much of North America, and the melting icebergs may have reduced northward heat transport by weakening the large-scale Atlantic meridional overturning circulation (AMOC). Although computer simulations consistently suggest it is possible, and this mechanism is widely favored as a potential explanation for these otherwise puzzling climate oscillations, some studies have argued that the bipolar temperature changes actually happened first, thus causing iceberg outbursts into the glacial ocean. A seagoing expedition to the Labrador Sea in the northwest Atlantic as part of the ICY-LAB project in the summer of 2016 recovered several sediment cores from this key area where the icebergs emanated. The cores hold the promise of an answer to whether the icebergs initiated the climate changes, or were instead released subsequently as glaciers grew in response to the northern cooling. What is needed is a sequence of evidence in the same sediments, from locations proximal to the ice sheet that can unequivocally clarify the roles of icebergs, ocean circulation and sea-surface temperature (SST) change. Our simultaneous investigation of proxies for all three processes in these new cores can provide such insight.

Analysis Required: This project will require a student to process samples taken from the ICY-LAB cores, identify and quantify ice-rafted debris, determine the relative abundance of polar foraminifera species, and select and prepare specimens for isotopic analysis. They will then apply visual and simple time-series analyses to assess the sequence of climatic events. Training / guidance will be provided for all procedures. Lab work will require 20 hrs/wk.

Prerequisites: None, although knowledge of basic oceanography and climate are helpful.

Mentor: Jerry McManus: jmcmanus@ldeo.columbia.edu, 845-365-8722

How Similar are the Mini-Hotspots in Eastern and Western North America?

Background: The mantle beneath western North America has long been understood to contain upwelling regions that are hot enough to melt and cause volcanism. The Yellowstone super-volcano, which is atop a long-lived mantle plume, is one such volcanic area, but many smaller volcanic fields, such as those near the Colorado plateau, are associated with smaller-scale mantle upwelling (or “mini-hotspots”) of less certain origin. More recently recognized mini-hotspots occur in the mantle beneath eastern North America, too. Two of these regions, one beneath Virginia and the other beneath southern New England, are especially prominent and may have had a long term influence on the evolution of the continent’s eastern margin. In this project, we will use seismological tools to characterize the similarities and differences in physical properties such as temperature and flow pattern, of the eastern and western mini-hotspots. We will rely on making a standardized set of measurements on each of four-to-six carefully-selected mini-hotspots, so that differences can be clearly attributed to the Earth, as contrasted to measurement technique and will rely upon the very high quality seismic data collected by EarthScope Transportable Array. Our goal is to understand the similarities and differences in the geodynamical processes that sustain these regions of mantle upwelling.

Analysis Required: The intern will be involved in analyzing and interpreting this novel data set in a MatLab based software environment.

Prerequisites: The intern needs to be willing to learn a little seismology and to spend a long time staring at wiggly lines. Some prior exposure to the physics of vibrations and waves and to data analysis would be helpful.

Mentor: Bill Menke (menke@ldeo.columbia.edu, http://www.ldeo.columbia.edu/users/menke/, 845-304-5381)

Nevertheless, They Persisted. How do Sunlight and Temperature Impact the Persistence of Waterborne Microbial Contamination?

Background: In accordance with EPA determined standards, water quality is often assessed by its load of fecal indicating bacteria (FIB), like *Escherichia coli* and *Enterococcus* in water samples. The classification FIB is used because these bacteria "indicate" potential sewage contamination, which can contain many other human and animal pathogens, such as *Salmonella* and *Shigella*. Despite a common source, FIB and their co-occurring pathogens may have significantly different traits, which could cause them to respond differently to various environmental factors, like light exposure, turbidity, and temperature. If, under some conditions, FIB abundance did not approximate the abundance of co-occurring pathogens, water quality measurements would have to be adjusted to detect higher pathogen loads without relying on FIB as the indicator.

This project will focus on the effects of certain environmental factors that cause pathogen mortality, namely sunlight and temperature. Previous studies demonstrate that FIB are highly sensitive to sunlight and notably sensitive to temperature. Are other sewage-associated bacteria similarly light and temperature sensitive? And how do these sensitivities change if the microbes are attached to particles? By exploring how sunlight or ambient temperature degrades particle-associated and free-living pathogen populations, the student will determine species-specific light-induced and temperature-induced mortality rates. These mortality rates will be crucial for understanding how key traits of different pathogens affect their persistence in natural waterways. Previous work in our lab has defined the mortality curves for FIB. By comparing results from this study on co-occurring pathogens with preexisting FIB mortality data, the student will constrain when FIB can or cannot be used to approximate co-occurring pathogen abundance. This testing of the reliability of current water quality measurements under different environmental conditions will allow the student to work at the intersection of microbial ecology and applications for public health.

Analysis Required: This project will require field work for obtaining water samples from the Hudson River. Additionally, the student will conduct laboratory-based experiments that utilize basic, microbiological techniques (*e.g.* microbial culturing, environmental-perturbation simulation, measuring various environmental parameters) and then analyze their data.

Prerequisites: Some knowledge/experience in microbiology and basic statistics would be helpful.

Mentors: Elise Myers: emyers@ldeo.columbia.edu; 845-365-8597
Andrew Juhl: andyjuhl@ldeo.columbia.edu; 845-365-8837

Can Big Data Answer Big Questions About the Global Carbon Cycle?

Background: Peatlands, places where partially decayed plant matter accumulates, are an important part of the Earth's climate system—they are the primary locations where carbon from the atmosphere is sequestered on land. While they cover only 3% of Earth's land surface, global peatlands hold 30-40% of soil organic carbon—up to 1000 Gt, double the amount of carbon in the pre-industrial atmosphere. This estimate is, however, a minimum. Peat occurs both in the Boreal/Arctic and in the Tropics, and while the amount of carbon in high-latitude peatlands is relatively well constrained, the amount of carbon in tropical peatlands is largely unknown. Two key datasets are essential to quantifying carbon in tropical peatlands. First is a map of the locations and areas of tropical peatlands, while the other is measurements of the depth and age of peat deposits. While much progress has been made in making a map of tropical peat, a dataset of the depth and age of these peatlands remains gaping with holes. Part of this problem can be solved with geoinformatics. The peatland literature is full of appropriate measurements of peat age, but these have never been compiled before, which would allow the use of newly developed algorithms to estimate peat accumulation rate (carbon sink) and total peat carbon (carbon stock) for tropical peatlands. The goal of this project is to use text and data mining techniques, both new and old, to compile and interpret measurements of carbon accumulation in tropical peatlands. The results of this project will be a giant leap forward in our understanding of the global carbon cycle, as both the sink and stock of carbon in tropical peat is an essential, but missing piece for global carbon cycle models.

Analyses Required: The student will use data mining, textual analysis, and statistical techniques to compile, organize, and analyze carbon accumulation data in tropical and extratropical peatlands. The work will also include interaction with a global network of peatland scientists and carbon cycle modelers.

Prerequisites: No specific skills are required, but a knowledge of, or at least an interest in, statistical software environments (R, Stata) would be helpful.

Mentor: Jonathan Nichols (jnichols@ldeo.columbia.edu; 845-365-8428)

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How Do Metals Segregate in Subduction Zones and Planetary Bodies?

Background: How do immiscible fluids travel through a permeable medium? Immiscible fluids are found in various geological environments, such as in magmas (e.g. Fe-S-O liquid) generated in subduction zones and during core formation in small planetary bodies (e.g. S- and C-rich melts/metal alloys). While the movement of single fluids within geological media has been studied extensively, our understanding of the motion of multiple immiscible fluids in geological contexts is limited. Questions remain about how these fluids travel with respect to each other and how factors such as wettability, density, fluid fraction, and matrix geometry influence fluid segregation. Answers to these questions have major implications for processes such as the formation of ore deposits and planetary differentiation. The proposed project will begin to address these questions using analog experiments in fluid mechanics.

Description of tasks: The student will use analog experiments to simulate the transport of immiscible fluids through a particle matrix. Dyed fluids with different wettability ratios and different densities, such as water and oil, will be mixed to form a suspension of droplets and pumped into a tank full of water + compacted particles. The rate of fluid injection and the relative amounts of fluids in suspension will be varied. The experiments will be filmed to observe the morphology and position of the liquid phases while they flow through the particle matrix. The goal is to understand segregation processes due to interfacial energy and density contrasts, by answering the following questions:

1) What are the wetting and non-wetting phases?
2) Does the morphology of the non-wetting phase change?
3) Does density-driven segregation occur?

These experiments can be extended to fulfill a year-long research project. Indeed, hydraulic behaviors of the liquids are dependent on the geometry of the pore space. Therefore, the student can further experiment with both a mono- and multi-particle matrix with different grain shapes and sizes. The student will construct a regime diagram to illustrate the results of the experiments.

Skills required: Good data management and organization skills. Must maintain a clean work environment. Familiarity with image processing techniques is a plus.

Mentors: Julie Oppenheimer: julieo@ldeo.columbia.edu
External collaborator: Amanda Lindoo: alindoo@carnegiescience.edu

What Makes a Good Fossil Climate Record?

Background: Records reconstructing climates of the past are primarily produced by sand-grain-sized fossil shells and provide the basis for climate models used to simulate the future of Earth's climate, including how it will change via human influence. The most traditional type of past climate record reconstructs variations in the oxygen isotope composition of seawater, which varies as ice sheets grow and melt through time. To provide the best paleo-data for modeling studies, which in turn best estimate how ice will melt and sea level will rise with elevated CO_2 concentrations, the best microfossils must be analyzed. But what makes a good fossil shell? This is a fundamental question that has not been truly possible to answer until recent advances in technology and instrumentation. This project seeks to identify features that identify the quality of fossil preservation, while demonstrating that differences in preservation affect oxygen isotope values used to construct traditional climate records. Samples from the deep-sea sediment core at ODP Site 1063 (Bermuda Rise) will be provided spanning from the peak of the last ice age (~20,000 years ago) until the middle of the current warm period (~5,000 years ago). The student will learn to identify relevant fossil species, and assess and quantify the quality of their shell preservation. Once this is completed, the student will produce his/her own paleoclimate record spanning the transition from the last ice age to the current warm period.

Analysis Required: This project will require ~1-2 days of stable isotope analyses on an Isoprime Dual-Inlet Mass Spectrometer, in Troy, NY (in the lab of an active collaborator). These data will be generated between weeks 6-7 of the 10-week program. The first 6-7 weeks will be spent identifying and imaging microfossil specimens, while learning how to properly identify individual fossil species and quantifying preservation. The last 2-3 weeks of the project will require the student to interpret their own paleoclimate record and determine how fossil preservation affects signals recorded in ocean sediments.

Prerequisites: Some background in geology, specifically sedimentology, paleontology, and/or geochemistry would be ideal, but not required.

Mentors: Robert Poirier: rpoirier@ldeo.columbia.edu, 434-203-9304, Reinhard Kozdon: rkozdon@ldeo.columbia.edu, 845-365-8619, Maureen Raymo, raymo@ldeo.columbia.edu, 845-365-8801.

What Conditions Affect Fossil Preservation?

Background: Records reconstructing climates of the past are primarily produced by sand-grain-sized fossil shells and provide the basis for climate models used to simulate the future of Earth's climate, including how it will change via human influence. The most traditional type of past climate record reconstructs variations in the oxygen isotope composition of seawater, which varies as ice sheets grow and melt through time. To provide the best paleo-data for modeling studies, which in turn best estimate how ice will melt and sea-level will rise with elevated CO_2 concentrations, the best microfossils must be analyzed. But what makes a good fossil shell? How do the depositional location, sedimentation rates, and sediment content affect fossil preservation? These are fundamental questions, that have not been truly possible to answer until recent advances in technology and instrumentation. This project seeks to define the relationship between local environmental conditions and the quality of fossil preservation, while demonstrating that differences in preservation affect oxygen isotope values used to construct traditional climate records. Samples from the deep-sea sediment core at ODP Site 1059 (Blake Outer Ridge) will be provided spanning from the peak of the last ice age (~20,000 years ago) until the middle of the current warm period (~5,000 years ago). The student will learn to identify relevant fossil species, and assess and quantify the quality of their shell preservation. Once this is completed, the student will produce his/her own paleoclimate record spanning the transition from the last ice age to the current warm period. The student from this project, and the parallel "What makes a good fossil record?" project will compare results from two unique locations, to determine the extent to which different environments affect the quality of climate records.

Analysis Required: This project will require ~1-2 days of stable isotope analyses on an Isoprime Dual-Inlet Mass Spectrometer, in Troy, NY (in the lab of an active collaborator). These data will be generated between weeks 6-7 of the 10-week program. The first 6-7 weeks will be spent identifying and imaging microfossil specimens, while learning how to properly identify individual fossil species and quantifying preservation. The last 2-3 weeks of the project will require the student to interpret their own paleoclimate record and determine what physical properties affect fossil preservation, and thereby climate signals recorded in ocean sediments.

Prerequisites: Some background in geology, specifically sedimentology, paleontology, and/or geochemistry would be ideal, but not required.

Mentors: Robert Poirier: rpoirier@ldeo.columbia.edu, 434-203-9304, Reinhard Kozdon: rkozdon@ldeo.columbia.edu, 845-365-8619, Maureen Raymo, raymo@ldeo.columbia.edu, 845-365-8801.

What Can Molecular Fingerprints of Modern Plants Tell Us about Ancient Ecosystems?

Background: Geoscientists rely on modern earth systems as models or analogs for earth systems in the past. For this project, we will explore the geochemistry of modern plants from eastern Africa in order to improve our ability to identify plant types in the geologic past. By identifying plant types in the past, we can begin to accurately and quantitatively reconstruct past ecosystems and in doing so, we can explore the vegetation structure (i.e., habitats) of our hominin ancestors and more broadly, the possible effects of ecosystem changes on human evolution.

This project will focus on using molecular fingerprints, or biomarker profiles, of modern African plants to address the question "What can molecular fingerprints of modern plants tell us about ancient ecosystems?". We will extract plant biomarkers (i.e., leaf waxes) from modern plants from Kenya. Biomarkers will be separated and purified in preparation for analysis using gas-chromatography mass spectrometry. Once analyzed, the biomarkers will be identified and quantified to yield biomarker profiles. We will then explore how the biomarker profiles from modern plants can be used to identify plants in the geologic record.

Analysis Required: This project will involve solvent extraction of biomarkers from plants followed by column chromatography to separate and purify compounds. Lab work will require 20-40 hrs/wk.

Prerequisites: None, although knowledge of organic chemistry is a plus.

Mentor: Kevin Uno; kevinuno@ldeo.columbia.edu, 845-365-8308.

Does Frequent Tidal Flooding Lead to More Significant Cumulative Environmental and Health Impacts than Superstorms in New York City?

Background: Marine environments near cities often suffer from poor water quality because of legacy contaminants and ongoing pollution. The health impacts from contaminants in urban waters are likely to increase when coastal flooding carries those contaminants back onshore and deposits them into urban landscapes (e.g., coastal flooding by Hurricane Sandy), expanding the possible routes of exposure, and the number of people potentially exposed. In addition to such large events, which occur infrequently (~ once per decade), many NYC neighborhoods are also impacted by minor storms and tides (i.e. nuisance events), though little is known about the environmental and health impacts of nuisance floods. The high frequency of such events may lead to significant cumulative impacts. Assessing the health risks of onshore contaminant transport is hampered by fundamental knowledge gaps related to how different contaminants are mobilized and deposited across the range of coastal flooding severity and frequency and differences in the environmental persistence of various contaminants. This project is a highly interdisciplinary, multi-level translational study linking local water and underwater sediment quality with onshore contamination levels along gradients of flooding frequency within the area of Jamaica Bay, New York. This summer, we will collect outdoor soils from areas close to Jamaica Bay and measure levels of flood-borne contaminants in these samples (e.g., PCBs, Hg), link them to levels in the indoor environment, and finally measure objective and subjective stress (hair cortisol and questionnaire based measures).

Analysis Required: This project will require fieldwork to collect soil, indoor dust and hair samples, and to interview subjects from areas close to Jamaica Bay. Additionally, the student will conduct organic and microbiological analyses and will then analyze their data.

Prerequisites: Some knowledge/experience in chemistry and basic statistics would be helpful.

Mentors: Beizhan Yan, LDEO, yanbz@ldeo.columbia.edu
Andrew Juhl, LDEO, andyjuhl@ldeo.columbia.edu
Pam Factor-Litvak, Mailman School of Public Health, prf1@cumc.columbia.edu

Is biking and breathing in NYC bad for your heart? A validation and health study on whether there is a cardiovascular hit for biking in close proximity to traffic.

Background: There is overwhelming evidence that exercise is good for you, but should we be avoiding exercise in close proximity to traffic emissions? The overall goals of this project include, 1) validation of a new personal level approach to assessing potential inhaled dose of particulate air pollution, and 2) assessment of this approach for cardiovascular impacts of short-term exposures during biking exercise.

Analysis Required: This project will require preparation of environmental and physiological monitors for the field study of bikers who regularly commute to work. Field work in NYC will include deploying the monitors. Analytical work will include measurement and analysis of spatial and temporal variability in black carbon, fine particulate matter, activity level, GPS coordinates, volumetric breathing rate, blood pressure, and heart rate.

A research assistant will be a great addition to the current team to ensure the accomplishment of recruiting a large number of subjects, simultaneous deployment of several monitors, and data collection.

The research assistant will benefit from working with colleague undergraduate, graduate students and senior research scientists in enhancing project management skills and specific technical skills such as data cleaning and spatial and temporal analysis of air pollution data. This project can help the student research assistant to improve the understanding of air pollution and environmental public health research.

Prerequisites: Knowledge of GIS and a programming/data analysis language such as R is a big plus.

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