What Is the Origin of Sn Rich, Ni Bearing Coatings on Pelagic Foraminifera In Pre-Modern Hudson River Sediments?

Background: We have identified layers containing multiple Sn coated pelagic foraminifera in two Hudson River cores. From previous ^{14}C dating of the cores, we know that the layers formed 1000 to 3000 years ago. In the Sn coated foraminifer we were able to thin section, the Sn coating contains detectable levels of Ni that have been verified with electron microprobe analysis. The origin of the Sn coating the foraminifera is perplexing. Because they occur in pre-modern sediments, the Sn cannot be from industrial pollution. The association of Sn with Ni suggests that the Sn might come from a special type of cosmic dust. Sn -rich dust (over 10% Sn!) has been found associated with Pb in ice core samples and has been attributed to infall of materials from outside the solar system. We found Sn rich dust associated with Ni in ice core samples with ages from 533 to 539 C.E, and attributed it to ablation of material from Halley's comet during its passage around the Sun at 74-79 year intervals. However, only some passages of Halley's comet are both sufficiently close to the Earth and in Earth crossing orbit and can serve as a source of cometary dust. Both hypotheses are consistent with Sn originally sourced from cosmic dust. If so, high concentrations of Ni, Sn and Pb in pre-modern Hudson River sediments may follow long-term solar or cometary cycles.

Analysis Required: The intern will help to sample and process samples for measurements of Sn, Pb and Ni on one Hudson River core using X Ray Diffraction and Plasma Mass Spectrometry, depending on their overall concentrations. The student will also sieve samples from Ni rich and Ni poor regions of the core to look for further pelagic foraminifera, both coated and uncoated. We will characterize the pelagic foraminifera isotopically layer by layer, both to confirm their source region and to characterize their Sn rich coating.
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 chemistry or physical geology. Some experience with light microscopes is desirable but is not required.

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

Can We Use Historical Events like the Fall of the Peekskill Meteorite 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. Anthropogenic burning can produce layers with a higher content of low melting point metals like Pb. Floods can produce layers that are high in magnetic susceptibility and heavy minerals. Falls of meteorites can also produce layers with high magnetic susceptibility. We have identified layers with unusually high magnetic susceptibility in four Hudson River cores taken along the transit path of the 1992 fall of the Peekskill meteorite. Meteorite fragments exhibit extremely high values of magnetic susceptibility due to their high content of magnetite. X-Ray diffraction (XRD) has found magnetite in the < 63-micrometer size fraction in Cs rich sediments (post 1954) from the cores taken off Peekskill, NY. The magnetite could have been derived from ablation of the Peekskill meteorite but also could represent transport of heavy minerals during recent large floods. In this project, we seek unique stratigraphic markers for the fall of the Peekskill meteorite and recent floods by examining the coarse fraction for meteorite fragments, glass and heavy minerals and by characterizing the geochemistry, mineralogy and crystallinity of the fine fraction.
Analysis Required: The intern will help to sample and process samples for measurements of metals, mineralogy and magnetic susceptibility on Hudson River cores taken near Peekskill New York. 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 industrial pollution and/or meteoritic magnetite 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: Karin Block (kblock@ccny.cuny.edu), Dallas Abbott (dallashabbott@gmail.com) and Ben Bostick (bostick@ldeo.columbia.edu)

What is the Role of Microplastics in the Aquatic Environment and Their Impact on Marine Organisms?

Background: Plastic pollution is now recognized as one of the most significant threats confronting our rivers and global oceans. One of the single most important shortcomings of plastics is that they do not degrade easily and can persist in the aquatic environment for months, years and even decades, eventually making their way into the food chain in the form of small microplastic particles. While it is well known that many marine zooplankton, fish and even shellfish ingest marine microplastics, there is very little known as to how microplastics impact the physiology and growth rates of marine animals. As part of the intern program, students will have the opportunity to participate in field studies to study the types of microplastics found in the waterways around New York City, characterize these particles and investigate their impacts on the feeding and growth rates of marine organisms. Results from this study will be used to test the following hypotheses:

- H_1 - Biological interactions with plastics predominantly occur in regions of high productivity and close to sources of microplastic pollutants, such as near waste water treatment plants.
- H_2 - Marine microplastics are actively consumed and cycled by a variety of marine organisms, including pelagic mesozooplankton and mesopelagic fish. These organisms facilitate the sequestration of plastic to deeper waters and marine sediments.

Prerequisites: College-level, lab-based biology and/or chemistry class.

Mentors: Joaquim Goes: jig@ldeo.columbia.edu, 845-365-8467, Beizhan Yan: byan@ldeo.columbia.edu, and Kali McKee.

What Is the Role of Ocean Acidification and Hypoxia in Outbreaks of *Noctiluca* In the Arabian Sea?

Background: *Noctiluca* is a mixotrophic marine dinoflagellate that houses a large population of small endosymbiotic phytoplankton within its cell. This organism has become a dominant bloom-forming species during the winter monsoon in the northern Arabian Sea since the late 1990s, and field and preliminary shipboard studies have shown that it can more effectively photosynthesize under reduced dissolved oxygen concentrations than its purely autotrophic phytoplankton competitors (e.g. diatoms). Our earlier studies show that warming of the Eurasian land mass due to climate change is causing a land-ocean thermal gradient favorable to stronger summer monsoonal winds which increase upwelling and consequently biological production. Our recent work that compares the historic dissolved oxygen content of waters in the northern Arabian Sea with recent measurements shows that dissolved oxygen continues to decline so blooms of this organism are expected to increase even further. This project will utilize laboratory experiments and cultures of *Noctiluca* to investigate how this species maximizes its photosynthesis under hypoxic conditions and high CO_2 concentrations and the potential effects of those conditions in heterotrophic feeding *versus* utilization of endosymbiont-derived products of photosynthesis. As such, anticipated tasks for a research assistant include: culture maintenance and manipulation, planning of growth rate and grazing experiments, and utilization of different instruments and techniques including dissolved oxygen sensors and titration, FlowCAM (a cell imaging system), and static and fast rate repetition fluorometry. Additionally, the assistant will be exposed to the statistical analyses of results from such replicated experiments.

Skills Required: Many of the techniques specific to the project will be taught in the context of the work. However, a basic set of analytical lab skills (e.g. keeping a sterile environment, precise measurement of liquids and solids, general lab safety) is required. A basic understanding of cellular biology (e.g. cell structure, processes of photosynthesis, respiration, etc.) is also an asset but not necessary. Ability to understand the implications of these blooms in the context of climate change and society.

Mentors: Helga do Rosario Gomes: helga@ldeo.columbia.edu, 845-365-8467
Joaquim Goes**:** jig@ldeo.columbia.edu and Kali McKee

How Is the Mid-Pleistocene Transition Expressed in the XRF and Physical Properties Records In U1474?

Background: The Agulhas Current is the largest western boundary current in the world's ocean, transporting 70 million cubic meters per second of water along the southeastern margin of Africa. The Agulhas Current is formed by several current sources that come together along the margin of Africa, and it is fully constituted at the northern end of the Natal Valley off Durban South Africa. At its retroflection, ~20% of the current "leaks" into the Atlantic Ocean and carries heat and salt to the northern North Atlantic where deep water is formed. Changes in the Agulhas Current are known to be related to changing rainfall patterns in southern Africa, and it is important to understand how changes in the past were expressed in the sedimentary record. For this summer we are particularly interested in the mid-Pleistocene transition - the transition between when the cyclicity of ice sheet volumes changed from a 40 kyr period to a 100 kyr period. IODP Expedition 361 drilled six sites near the African margin to understand the greater Agulhas Current system over the last 5 million years. Site U1474 is located in the headwaters region of the fully constituted Agulhas Current. The development of a benthic isotope record from U1474 will provide refinement for the shipboard timescale, and will allow a close look at changes across the mid-Pleistocene transition.

Analysis required: This project will require picking and weighing benthic foraminifera from approximately 150 samples for stable isotope analyses, and using the stable isotope data to refine the time scale of existing XRF and physical properties records from U1474.

Prerequisites: Some knowledge of sedimentology and/or stratigraphy and an interest in paleoceanography.

Mentors: Sidney Hemming (sidney@ldeo.columbia.edu, 845-365-8417) (plus Ian Hall and Expedition 361 Scientists)

Where Did the Iceberg Alley Dropstones Originate? What Do They Tell Us About Antarctica's Glacial and Geological History?

Background: Most of the continent of Antarctica is covered by ice sheets, and thus learning about Antarctica's history is enhanced by studying dropstones, pieces of rock that are brought to the ocean by icebergs and dropped on the ocean floor when the icebergs melt. In addition to providing information about the subglacial geology, these rocks can help us to understand Antarctic ice sheet responses to climate changes of the past and specifically what parts of the ice sheet were most actively calving icebergs. International Ocean Discovery Expedition 382 will be taking cores in "Iceberg Alley", a region of the Southern Ocean where the icebergs are focused. Scientists from Expedition 382 will use sediment cores to investigate the long-term climate history of Antarctica, seeking to understand how polar ice sheets, atmospheric CO_2 and global sea level varied. One aspect of the research will be to study the geochronological and thermochronological evidence for the sources of dropstones at different time intervals (details will depend on what is recovered from the cruise and what is available at the beginning of the summer).

Analysis required: This project will require some rock identification and description of dropstones from marine samples collected from iceberg alley during IODP expedition 382, and crushing and mineral separation. Where appropriate, samples will be dated with 40Ar/39Ar geochronology, and some will be used for training in thermochronology (at a two-week workshop at University of Arizona.

Prerequisites: Some knowledge of rocks and an interest in geochronology and Antarctica

Mentors: Sidney Hemming (sidney@ldeo.columbia.edu, 845-365-8417), Trevor Williams (trevor@ldeo.columbia.edu), Maureen Raymo (raymo@ldeo.columbia.edu), Stephen Cox (cox@ldeo.columbia.edu)

How Did Deep Ocean Circulation Change Across the Mid-Pleistocene Transition? How is It Related to Changes in the Agulhas Current System?

Background: The Agulhas Current is the largest western boundary current in the world's ocean, transporting 70 million cubic meters per second of water along the southeastern margin of Africa. The Agulhas Current is formed by several current sources that come together along the margin of Africa, and it is fully constituted at the northern end of the Natal Valley off Durban South Africa. At its retroflection, ~20% of the current "leaks" into the Atlantic Ocean and carries heat and salt to the northern North Atlantic and aids in the formation of deep water in that region. Deep water formation in the North Atlantic has a strong impact on global climate, particularly glacial-interglacial cycles that have dominated Earth's climate over the past million years. For this summer we are particularly interested in the mid-Pleistocene transition—a time period where the cyclicity of glacial cycles and ice sheet volumes changed from 40 kyr period to 100 kyr period. IODP Expedition 361 drilled six sites near the African margin to understand the greater Agulhas Current system and its impact on regional and global climate over the last 5 million years. Site U1479 is located in off the coast of Cape Town South Africa and monitors remnants of the deep water mass formed in the North Atlantic and are known as North Atlantic Deep Water (NADW).

Analysis required: This project will require sieving ~50 sediment samples from site U1479 and preparing them for neodymium isotope analysis. Neodymium isotope chemistry is performed in the trace metal chemistry lab via ion exchange chromatography. For this project, the intern will learn how to perform clean chemistry and will prepare samples for measurement on the MC-ICP-MS instrument.

Prerequisites: Some knowledge of lab wet chemistry and an interest in paleoceanography.

Mentors: Sophie Hines (shines@ldeo.columbia.edu, 845-365-8401) (plus Sidney Hemming, Ian Hall, and Expedition 361 Scientists)

What Is the Metal Contamination History in the Hudson River?

Background: Urban estuaries such as the Hudson River Estuary in the New York metropolitan area have a complex environmental history. Changes in industrialization, use and coastal development resulted in a legacy contaminant history that is preserved in the sediment record. Over the last 20 years we have collected numerous sediment cores from different parts of the Hudson River. While we have analyzed details of the surface distribution of metals, the variations of metal content with depth, and thus the long-term historical record, have not been systematically investigated. We expect that selected sediment records from different sections of the Hudson River will yield records of the different industrial and economic activities along the Hudson River over the last few centuries. As part of this project we will analyze variations in metal content of selected sediment cores using measurements with an X-ray florescence (XRF) scanner. We will compare down-core changes in metal content with the current distribution of metals on the surface and historic industrial activities along the Hudson River.

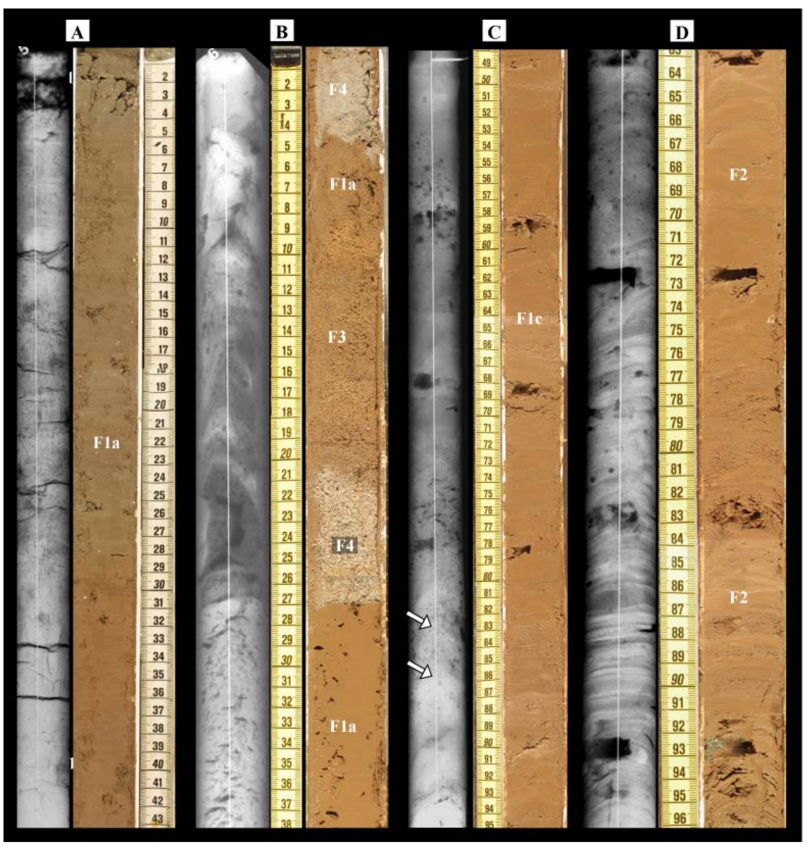
Analysis Required: Under supervision of the mentors the student would participate in analyzing selected sediment samples in the lab using the XRF scanner and in integrating and comparing the results for different parts of the Hudson River. Data analysis and integration will be done using Excel and GIS software.

Prerequisites: Confidence in working with Excel and potentially ArcGIS is preferred but not required.

Mentors: Tim Kenna, tkenna@ldeo.columbia.edu, (845-365-8513)
Frank Nitsche**,** fnitsche@ldeo.columbia.edu, (845-365-8746)

What Does the Chemical Composition of Lake Sediments In Argentina Tell Us About Past Climates?

Background: Lake levels and sedimentary cores from Subtropical South America provide an important archive of wet and dry periods in the past. These environmental fluctuations are affected by changes in the South America Monsoon System, an important climate system that today impacts the continent's low-mid latitudes. Changes in the chemical and isotopic composition of the lake sediments provides valuable information about dust sources, water sources and changes in rainfall. During dry intervals, when the lake levels are dropping, evaporites (Halite, gypsum and calcite) form; these well-preserved evaporate sediments are suitable for geologic dating by an isotopic method known as U-series disequilibrium, which can help us to obtain a chronology of past lake level changes and the associated changes in subtropical climates. This project aims to generate a preliminary record of radiogenic isotopes (U, Th, Nd, Pb, Sr) in lake sediments from subtropical Argentina during the past 45,000years.



Cores from the Salina Ambargasta in Argentina. The sediments show alternation between dry and wet periods that affected the lake, its former levels, and chemical compositions of the sediments. These cores cover 45,000 years of time, but are poorly dated, which is a focus of this project.

Methods: The project involves processing existing sediment samples in the LDEO clean chemistry lab (4 weeks) and measuring them by ICP-MS and MC-ICP-MS in order to determine isotopic compositions iof interglacial and glacial sediment samples from a few lakes in Argentina (2.5 weeks). The remainder of the time will be spent processing the data, combining them with other existing data, and interpreting the paleoclimate implications.

Mentors: Yael Kiro
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What is the Role of Chemistry and Aerosols Following Volcanic Eruptions and Their Impact on Earth's Climate?

Background: Large volcanic eruptions such as the 1991 eruption of Mt. Pinatubo represent some of the largest short-term disruptions of our climate system. Gaseous volcanic emissions are chemically converted to aerosols, tiny particles that alter the radiation balance of the Earth's climate. The Mt. Pinatubo event, the strongest eruption of the 20th century, still serves today as a benchmark case in understanding how volcanic injections influence climate. Since 1991, our methods of representing the climate forcing of volcanic emissions have not changed significantly. All of the eruptions of the historical period are smaller in magnitude than this '91 event. Climate models do a reasonably good job at representing events of this magnitude, and smaller.

A few years ago was the 200th anniversary of the 1815 eruption of Mt. Tambora, an event 3-4 times the size of Mt. Pinatubo. Climate response in observations is generally smaller than that simulated by state-of-the-art climate models. This mismatch has motivated much model development, and a new project specifically focused on the climate impact of larger-than-Pinatubo events.

Analysis required: NASA Goddard Institute for Space Studies has developed a new means of implementing volcanic eruptions that capitalizes on decades of development in implementing gas-phase chemistry and aerosol microphysics in the climate model. The intern will assist us in analyzing and preparing simulations for the upcoming VolMIP (Volcano Model Intercomparison Project), an endorsed CMIP6 experiment. CMIP is the coordinated suite of experiments done by climate modelers that are used to prepare the 7-yearly IPCC report – the Intergovernmental Panel on Climate Change. This report represents the state-of-knowledge of the entire field of climate research.

Some relevant reading: framing the volcano representation: http://www.pages-igbp.org/products/pages-magazine/6911-23-2-volcanoes-and-climate; VolMIP project: http://www.volmip.org; IPCC: http://www.ipcc.ch.

Prerequisites: the intern will do analysis on existing GISS climate model simulations and will set up new simulations. For this reason, it is important that the intern have experience with a programming language (FORTRAN, C, or similar), and proficiency in a high level scripting language (Python, R, IDL, MatLab, or similar). Knowledge of the netcdf file format will be an advantage.

Mentors: Allegra LeGrande, legrande@ldeo.columbia.edu; Kostas Tsigaridis, kostas.tsigaridis@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. 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. 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 ICY-LAB and other 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 climate 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 is the Lithosphere Affected by Continental Assembly? Learning from the Norumbega Fault Zone, Maine

Background: The lithosphere of eastern North America was assembled through the addition of many continental fragments, spread over the many plate tectonic events that occurred during the last three billion years. The most recent of these continental collisions, about 400 million years ago, added the Madagascar-sized Avalonia microcontinent to eastern North America. In New England, its emplacement involved a substantial amount of transform motion along the Norumbega Fault, an ancient analog of California's San Andreas fault. While rocks of Avalonian origin are preserved on the Earth's surface along much of the Maine coast, the degree to which the deeper lithosphere is preserved is unknown. Original Avalonian mantle lithosphere may be preserved at depth or it may have been destroyed during the emplacement process. In this project, we will use seismological tools to characterize the similarities and differences in physical properties such as sound velocity and metamorphic fabric to compare the lithosphere on the two sides of the fault, using high-quality seismic data from stations in New England. Our goal is to understand whether the mantle lithosphere still retains the "patchwork quilt" signature of its formation, or whether it has been entirely replaced by newer material.

Analysis Required: The intern will be involved in analyzing and interpreting this novel data set and may also take part (schedule permitting) in field trips to download data.

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)

Public Health: How Can We Quantify Personal Exposure to Second Hand Smoke?

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

Analysis Required: This project will consist of running chamber experiments 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 is aided by running computer programs in R or Python to deconvolve absorption signatures. Lab and field work will require average 20 hrs/wk, with the rest of the time being focused on data analysis, literature review, etc.

Prerequisites: None, though Introduction of Physics (Introduction to electricity, magnetism, and optics) or equivalent and knowledge of R or Python would be a plus.

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

How Has Mediterranean Region Hydroclimate Varied over the Past Millennium?

Background. Over the past century much of the Mediterranean region, including the Middle East, has dried which has already caused significant social stress. Climate models project increasing aridification in coming decades due to rising greenhouse gases. The climate record to date, however, is a combination of both radiatively-forced change and natural variability. The extent to which each contribute to the recent record of drying is not fully known. Further, since the instrumental record is short, it is not known what the full range of natural variability - in terms of spatial patterns and temporal variability – is in the region. Recently the Lamont Tree Ring Lab developed a gridded, tree ring-based, annually resolved, record of spring-early summer surface moisture availability for Europe, North Africa and the Middle East that covers the past millennium. This record – the Old World Drought Atlas (OWDA)- provides an unparalleled opportunity to examine the full record of past and present climate variability and change in the Mediterranean region.

Project. The student(s) will use the OWDA to determine the spatial and temporal characteristics of Mediterranean region hydroclimate variability over the past millennium. The student(s) will determine what modes of climate variability operate in the region, what spatial patterns of hydroclimate variability and the timescales (interannual to centennial) they operate on. Whether changes in solar irradiance and volcanism drive climate anomalies will also be examined. The OWDA-based results will be compared against similar analyses of climate model simulations of the last millennium to assess model ability to reproduce realistic climate variability and change. If time and ability allows, the student could also determine the detailed physical mechanisms of variability and change in terms of atmospheric circulation and moisture transport anomalies. The project will benefit the student by providing an opportunity to work with a strong climate dynamics group on a cutting-edge problem in a part of the world highly vulnerable to climate change.

Prerequisites. Students should have basic knowledge of climate dynamics. They should be familiar with standard statistical techniques (correlation, regression, spatial statistics like Principal Component Analysis, significance testing, time series analysis) and have some programming ability (E.g. Excel, Python, MatLab, Ingrid).

Mentors: Richard Seager seager@ldeo.columbia.edu, Mingfang Ting ting@ldeo.columbia.edu Yochanan Kushnir kushnir@ldeo.columbia.edu

How Does Nutrient Availability Affect Phytoplankton Community Structure in the Amazon River Plume?

Background: The project involves field research in waters of the Western Tropical North Atlantic influenced by the Amazon River Plume during the high river flow season. The Amazon Plume region supports diverse plankton communities in a dynamic system driven by nutrients supplied by transport from the river proper as well as nutrients entrained from offshore waters by physical mixing and upwelling. This creates strong interactions among physical, chemical, and biological processes across a range of spatial and temporal scales. The field program will link direct measurements of environmental properties with focused experimental studies of nutrient supply and nutrient limitation of phytoplankton.

Analysis Required: The undergraduate student will be involved in nutrient amendment experiments where surface water is incubated under different nutrient conditions to see how the phytoplankton community evolves during the course of 48-72 hours. The student will help set up the experiment and sample the different treatments every 12 hours. The student will analyze the data of phytoplankton biomass measured using a spectrofluorometer and the nutrient concentrations from an autoanalyzer. The student will also be trained in using bio-optical instruments to make measurements of phytoplankton optical properties to understand how the community changes in various part of the Amazon River plume. The project involves a 4-week research expedition in the Atlantic Ocean.

Prerequisites: Two lab-based courses in college level biology.

Mentor: Ajit Subramaniam: ajit@ldeo.columbia.edu

What is the Flux of Microplastics into the Deep Sea?

Background: Microplastics including microbeads are synthetic polymer particles that have found extensive use as a replacement for natural exfoliating materials in personal care products and abrasives in cleaning supplies. They typically range between 5 μm and 1 mm and are made of polymers such as polyethylene, nylon etc. that are not easily degraded and are potentially toxic to marine life. They enter the aquatic environment primarily through surface runoff or effluent release from wastewater treatment plants. Recent studies have shown that microplastics are capable of adsorbing a wide variety of toxic organic compounds found in waste treatment plants, for example PCBs (polychlorinated biphenols) and polycyclic aromatic hydrocarbons (PAHs, carcinogens), and can therefore serve as efficient vectors for dispersal of pollutants. After being released to coastal waters, microplastics can find their way offshore or even into the deep sea. Microplastics were observed in the Mariana Trench, 10,898 meters (35,756 feet) below the ocean surface. Although some studies have been conducted, the types and fluxes of microplastics to the deep sea are still largely unknown.

Analysis Required: This project will analyze abundances and types of microplastics in sediment traps collected from the Gulf of Mexico. Sinking particles in the water column have been collected by traps at three locations in the northern Gulf of Mexico since 2010. Lab work includes isolating microplastics from other sinking particles, characterizing microplastics using several optical approaches, and identifying them using advanced pyrolysis gas chromatography /mass spectrometry (GS/MS). Lab work will average 30 hrs/wk, with the rest of the time being focused on data analysis, literature review, etc. We also plan to arrange a field trip to an urban lake in New York City to collect sediment cores.

Prerequisites: General chemistry and lab courses are required; Organic chemistry with interests in biological and environmental issues would be a plus.

Mentors: Beizhan Yan, yanbz@ldeo.columbia.edu, 845-365-8448; Joaquim Goes, jig@ldeo.columbia.edu, 845-365-8467

How Smart Can Air Quality Monitors Get? Developing Interactive Smart Watch Apps to Improve Data Collection Rates

Background: Assessment of air pollution exposure is essential to many public health studies. Citizens of different age ranges have participated in studies to collect exposure and health data. Desirable results, however, have not always been obtained due to subject unreliability in properly managing devices or wearing them at the required times. These become major issues if no sampling data is received. The problem is how to motivate and assist study participants in performing correctly the tasks of setting up air quality monitors and wearing them at the required times. We have been developing interactive smart watch apps to improve the data collection rates from air quality monitors by our study participants.

Analysis Required: This project will consist of developing smart watch apps and testing them with deployment of both personal and residential air monitors, as well as comparing personal exposure obtained from personal vs. residential vs. central site air monitors. Fieldwork includes deploying air quality monitors and smart watches. Data analysis includes air monitor data download, processing and analysis by running computer programs in R or Python, and mapping exposure using GIS.

Prerequisites: None, though knowledge of R, Python, or GIS would be a plus.

Mentors: Qiang Yang: qyang@ldeo.columbia.edu, 845-365-8629; Steven Chillrud: chilli@ldeo.columbia.edu, 845-365-8893.

What Does Ice Growth Look Like Through an Infrared Lens? The Effect of Ice on Air-Sea Gas Transfer

Background: Recent years have seen extreme changes in Arctic sea ice cover and climate. Marginal ice zones (MIZ), or areas where the "ice-albedo feedback" driven by solar warming is highest and ice melt is extensive, may provide insights into the extent of these changes. Furthermore, marginal ice zones play a central role in setting the air-sea CO_2 balance making them a critical component of the global carbon cycle. Incomplete understanding of how the sea-ice modulates gas fluxes renders it difficult to estimate the carbon budget in marginal ice zones. Here, we investigate the turbulent mechanisms driving gas exchange in leads and polynyas, specifically in the presence of ice growth using laboratory measurements.

Infrared (IR) measurements have long been used in oceanography to determine the ocean's surface temperature. Satellite IR measurements have been used to generate global maps of sea surface temperature while small-scale IR remote sensing measurements have been used to study upper-ocean processes and to understand the mechanisms for air-sea interaction. Here, we will analyze infrared imagery of ice formation in fresh and salt water using a state-of-the-art IR camera. We will investigate the structure of sea ice formation and its relationship to super-cooled surface temperature. We will examine the impact of varying ice growth characteristics on air-sea gas exchange rates of important greenhouse gases such as CO_2 and O_2. Finally, we will compare the sea ice crystallization formation processes to those of other convective supercooling environments such as deep-ocean lava flows.

Analysis Required: This project will require data processing and analysis of an existing laboratory data set. This will require at least 20 hours/week. The remainder of the summer will be spent performing additional experiments using infrared imaging techniques.

Pre-Requisites: Undergraduates majoring in physics, engineering (mechanical, electrical, or similar) or applied mathematics.

Mentor: Christopher J Zappa: zappa@ldeo.columbia.edu, Ph:845-365-85