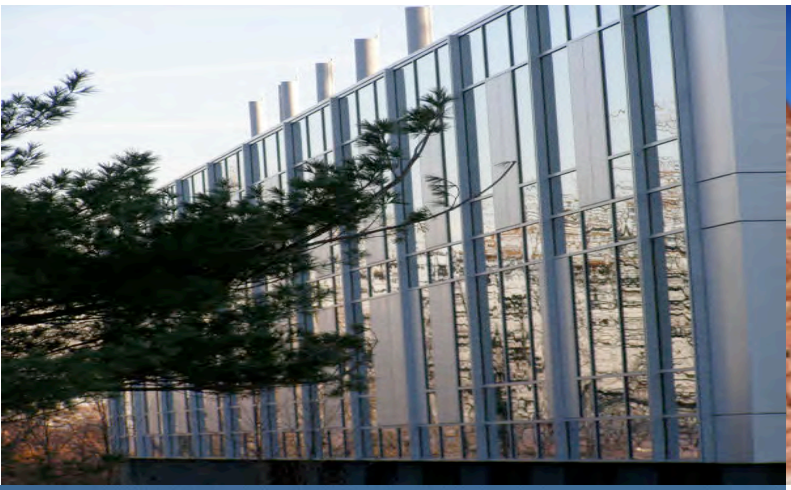
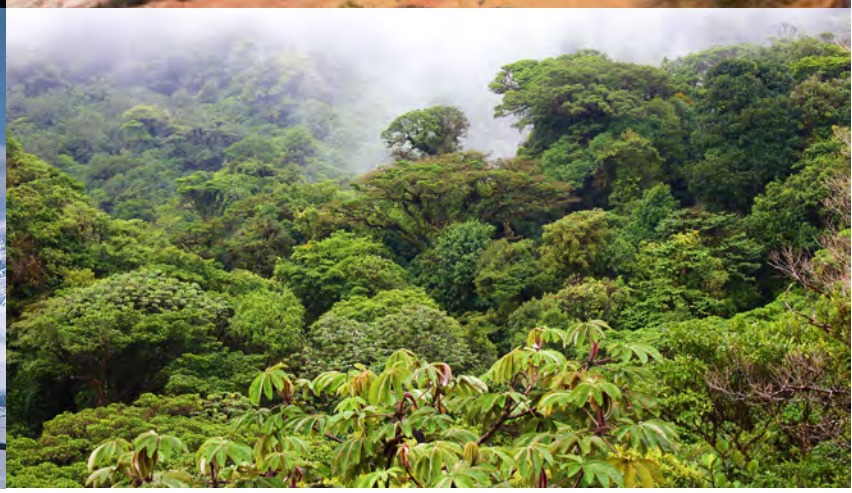
2013 Lamont-Doherty Earth Observatory Postdoctoral Symposium



Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

From the Office of the Director

Greetings! Welcome to the second LDEO Postdoctoral Symposium. Since its founding in 1949, Lamont-Doherty has been a leader in the earth sciences. Our scientists were among the first to map the seafloor and provide concrete proof for the theory of plate tectonics. We have collected deep-sea sediment cores in order to understand Earth's past climate, and have explored the ice capping both the North and South Poles with sophisticated instruments. We were the first to predict an El Nino event and have illuminated the oceans' role in triggering abrupt climate change. We work to understand how the deep earth feeds global volcanism and triggers earthquakes; how the atmosphere changes when we add greenhouse gases and other pollutants; how the oceans transport great quantities of heat and control the ever-changing cycles of climate. When such fundamental earth processes occur catastrophically, as they have in recent years with the 2004 Indian Ocean tsunami, 2005 Hurricane Katrina, 2011 Japan earthquake and 2012 Super-storm Sandy, everyone is reminded that earth sciences play a central role in human survival.

With each year, our understanding of Earth improves. Yet, new discoveries await us. It is that next insight on the horizon that keeps our researchers excited to learn more about how and why earth changes as it does. Our diverse and vibrant community of postdoctoral scientists represents our youngest and newest talent, working towards our goal to develop and communicate new knowledge about the origin, evolution and future of the natural world. Our postdoctoral scientists are being trained by our more senior scientists to become future leaders in their respective fields, advancing our knowledge of the natural world even further.

We hope that this Postdoctoral Symposium provides you with an overview of the fundamental research carried out by our dynamic group of postdoctoral scientists.

Sean C. Solomon
Director
Lamont-Doherty Earth Observatory

Arthur Lerner-Lam
Deputy Director
Lamont-Doherty Earth Observatory

Kuheli Dutt
Assistant Director
Academic Affairs & Diversity
Lamont-Doherty Earth Observatory

2013

Postdoctoral Symposium

Wednesday, September 18, 2013 - 9:45 a.m. to 4:30 p.m.

Lamont-Doherty Campus
Gary C. Comer Building, Seminar Room, 1st floor

09:45 – 09:50 **Welcome Note**
Sean C. Solomon, Director, LDEO

09:50 – 11:20 **Geochemistry Division**
Presenters: David Ferguson, Elizabeth Ferriss, Yael Kiro, Bess Koffman, Ricardo Ramalho, Kristoffer Szilas, Nivedita Thiagarajan, Yakov Weiss, Nicolas Young

11:20 – 11:30 **Coffee break**

11:30 – 11:50 **Marine Geology & Geophysics Division**
Presenters: Meredith Reitz, Kirsty Tinto

11:50 – 12:30 **Seismology, Geology & Tectonophysics**
Presenters: Nicholas van der Elst, Patty Lin, Lei Wang, Cian Wilson

12:30 – 1:10 **Lunch Break**

01:10 – 2:00 **Biology & Paleo Environment Division**
Presenters: Dario M. Benito, Nina Keul, Kim Popendorf, Alessio Rovere, Kevin Uno

02:00 – 2:40 **Ocean & Climate Physics Division**
Presenters: David Chapman, Kevin Grise, Lee Murray, Karen Smith

02:40 – 3:00 **Coffee & Dessert**

03:00 – 4:30 **Poster Session**
Presenters: David Chapman, Laureen Drab, Nigel D'Souza, Elizabeth Ferriss, Allison Franzese, Clement Hibert, Denny Hsieh, Julia de Juan, Bess Koffman, Patty Lin, Kim Popendorf, David Porter, Cristina Recasens, Isla Simpson, Kisty Tinto, Luke Valin, Cian Wilson

To RSVP please email Kuheli Dutt at kdutt@ldeo.columbia.edu
Note: Hourly shuttle buses run between Morningside and the Lamont Campus.
For more information please go to the
"Visitor Information" section of the LDEO website:
http://www.ldeo.columbia.edu/campus-services/administration/columbia-university-lamont-shuttle-bus-schedule

Lamont-Doherty Earth Observatory
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ORAL SESSION ABSTRACTS

Geochemistry

Comparing eruptions of varying intensity at Kilauea via melt inclusion analysis

David Ferguson

Over the past 500 years explosive summit eruptions from Kilauea volcano, Hawaii, have exhibited a range of eruption magnitudes, from large basaltic sub-plinian events to Hawaiian lava fountains of various intensity. Knowledge of the factors controlling such dramatic changes in explosivity and mass discharge rate is vital for understanding the dynamics of explosive basaltic magma systems, but these remain poorly constrained. At Kilauea this information also has important implications for hazard assessment, as future eruptions may be far larger than those observed historically. To investigate the processes associated with eruptions of varying magnitudes we have analyzed the composition and dissolved volatile contents (H2O-CO2-S-Cl-F) of olivine-hosted melt inclusions, sampled from tephra deposits associated with three eruptions of different sizes: a moderate lava-fountain (1959 Episode of Kilauea Iki); an exceptionally high lava-fountain (1500 CE Keanakāko'i reticulite) and a basaltic sub-plinian eruption (1650 CE Keanakāko'i layer 6 scoria). Over this time period (~500 years) we find no major shifts in the major element composition of primary melts feeding the Kilauea magmatic system, and melt inclusions from all eruptions record similar maximum water (~0.7 wt% H2O) and CO2 (~300 ppm) contents, regardless of eruption magnitude. Co-variations between other volatile species, such as CO2 and S, do not support a role for excess volatiles (i.e. CO2) in the larger eruptions via 'gas-fluxing'. Our data therefore suggests that major shifts in eruptive magnitude are unlikely to be linked to either changes in the primary volatile content of the melts or excess gas supplied by open-system degassing of deeper melts. Rather we find evidence for significant variations in the shallow degassing behavior of magmas associated with the larger Keanakāko'i eruptions (sub-plinian and strong lava-fountaining events) compared to that from less vigorous moderate Kilauea Iki lava-fountaining events. On plots of CO2 versus H2O, Kilauea Iki MI's record volatile contents consistent with equilibrium degassing of magma rising from a depth of ~3 km. In contrast, the volatile contents of melts from the more explosive eruptions appear to be strongly affected by degassing processes at shallow depths (< 300 m), indicating variations in the ascent and storage of melts over this time-period. These changes in storage conditions may be linked to variations in the depth of the summit caldera, which was significantly greater during the older more explosive eruptive phases.

Water diffusion in nominally anhydrous minerals

Elizabeth Ferriss

The diffusion of incorporated water in nominally anhydrous minerals (NAMs) such as olivine and pyroxene has two important applications in volcanology and geodynamics. First, water diffusion profiles in volcanic phenocrysts are potential clocks to measure the magma ascent rate, a key parameter determining the explosiveness of an eruption. Second, tiny (even ppm-level) amounts of water have a profound effect on the physical properties (strength, rheology, melting, conductivity, attenuation, ionic diffusivities) of the NAMs that make up the bulk of Earth's mantle (olivine, pyroxene, garnet, wadsleyite). Therefore, the deep Earth water cycle is critically important for our understanding of plate tectonics and geodynamics. Much of our knowledge of water in the deep Earth comes from measurements of xenoliths and mantle inclusions, but the usefulness of these measurements (as well as our ability to interpret magnetotelluric data) depends on accurate knowledge of the rate, anisotropy, and mechanism of the diffusion of water into or out of the sample. I will discuss my new approach for simplifying the experimental procedure as well as the results and implications of laboratory experiments on the minerals olivine and diopside.

Halite precipitation during interglacial periods in the Dead Sea basin

Yael Kiro

The ICDP Dead Sea Deep Drill core contains thick sections of halite which precipitated during the dry intervals over last two interglacials. These sections may provide a record of seasonal and other time-scales climate changes during these dry events. The halite is divided into two major types: (a) large transparent preferentially oriented chevron structuredcrystals with abundant fluid inclusions, which are associated with detritus between the crystals, and (b) small opaque crystals. These two types of halite often alternate and seem to represent seasonal changes, which is compatible with the average sedimentation rate of the halite.The type of the crystals is probably controlled by the limnological structure of the lake, which is affected by the climatic conditions of the region. Occurrences of the halite include thick sections of large crystals with detritus, and alternations between very fine crystals and detritus. The alternation of the fine crystals and detritus may be the result of a meromictic structure,like the structure of the Dead Sea until the 1970's, and may represent conditions similar to the present. The alternation between the two types of halite suggests a monomictic (seasonally stratified) structure, where the large crystals which grow on the lake bottom represent a mixed water column during the winter, and the small crystals form on the lake surface while the lake is stratified during the summer. Winters are associated with higher fresh-water and sediment input into the lake, which is represented by the detritus and the absence of small crystals. This structure is very similar to the present structure of the lake, which is a direct result of the extensive utilization of the fresh-water sources around the lake, suggesting conditions much more arid than today.

Geochemistry

Evaluating New Zealand as a Source of Dust to West Antarctica during the Last Glacial Maximum

Bess Koffman

This project, begun in June 2013, will evaluate the hypothesis that New Zealand was a significant source of dust to the Southern Ocean and hence West Antarctica during the Last Glacial Maximum. We will characterize the New Zealand dust source by collecting samples from well-dated glaciogenic and other aeolian source sediments and analyze them for major and trace element chemistry and strontium, neodymium, lead, and helium isotopic ratios. We will make corollary measurements on samples of glacial-age ice from the Allan Hills (Victoria Land) and the Siple Dome A and Byrd 1968 deep ice cores (West Antarctica) to assess dust provenance in these previously unstudied regions of Antarctica.

Uplift, flank collapses and mega-tsunamis in the Cape Verde Archipelago

Ricardo Ramalho

The Cape Verde Archipelago - the type-example of a hotspot on a stationary plate environment with respect to its melting source - exhibits ubiquitous evidence for quaternary uplift. This uplift is possibly associated to a regional growth pulse of the Cape Verde Rise, the largest bathymetric anomaly in the Earth's oceans. We aim to date uplift tracers across the Cape Verdes and test a regional vs local uplift mechanism. If considerable uplift trends occur at a regional scale, its source must be associated with hotspot swell development and dynamics. Conversely, if highly differential uplift trends occur at a local scale, affecting nearby islands differently, local intrusion-related mechanisms are the most likely explanation. Quaternary uplift tracers in the Cape Verdes consist essentially of relative sea-level markers such as marine terraces and lava deltas, which are potentially dateable with surface exposure dating, U-Th (on corals) and Ar-Ar (on lava deltas) geochronology. Surface exposure dating will also be applied to date a recently-discovered mega-tsunami deposit on northern Santiago which probably is associated to the giant flank collapse of Fogo volcano, one of the most active volcanoes in the Atlantic, suggesting that ocean island flank collapses may indeed generate mega-tsunamis with devastating near-source effects.

Archaean geodynamics - geochemical evidence from SW Greenland

Kristoffer Szilas

The question of when modern-style plate tectonics began on Earth is controversial and currently there is no scientific consensus. Mesoarchaean supracrustal belts from the Tasiusarsuaq terrane of SW Greenland contain rare metavolcanic rocks of andesitic composition. These reveal striking geochemical similarities with modern andesites from subduction zone environments. The Mesoarchaean andesites have fractionated trace element patterns with distinctly negative Nb-, Ta- and Ti-anomalies, as well as positive Hf- and Zr-anomalies. Trace element modelling shows that crustal assimilation cannot account for these patterns. A petrogenetic model is proposed, which invokes extensive binary magma mixing of mafic and felsic end-members in roughly equal proportions in order to produce the Mesoarchaean andesites. The large mixing ratio is confirmed by their Hf-isotope compositions relative to pre-existing crust. This suggests that these andesites formed by similar magmatic processes, as are currently operating at convergent margins, for which recent studies have also emphasized the importance of binary magma mixing. Therefore the occurrence and the petrogenesis of metavolcanic andesites from SW Greenland support the notion that subduction zones have been operating for at least 3 billion years.

Abrupt pre-Bolling/Allerod warming and circulation changes in the deep North Atlantic

Nivedita Thiagarajan

The last deglaciation was marked by several rapid climate events, each associated with large changes in atmospheric temperature and pCO2, that have been linked to changes in the deep circulation of the ocean. Of these events, the abrupt temperature rise in the Northern Hemisphere and restart of the Atlantic Meridional Overturning Circulation at the start of the Bolling/Allerod is the most dramatic feature of the Northern hemisphere deglaciation. However the mechanism for this warming and circulation change is not known. We present coupled radiocarbon and U-series dates, along with clumped isotope temperature estimates, from water column profiles of fossil deep-sea corals in the western North Atlantic to constrain the deep ocean's ventilation rate and temperature history around this time. Here we show an abrupt increase in temperature at depth, with cooler water above, in the middle of Heinrich Stadial 1 (HS1) that must be associated with increased salinity to preserve the static stability of the water column. These warmer waters also have very low D14C values and their appearance clearly pre-dates the Bolling/Allerod warming of the North Atlantic region. The source of this warm, salty, and depleted-D14C water mass is likely to be the Southern Ocean. This HS1 profile is distinct from the modern, the Last Glacial Maximum, and the Younger Dryas water columns. It indicates that the deep ocean played an important role in forcing dramatic Northern Hemisphere warming by storing heat at depth that then preconditioned the system for a subsequent abrupt overturning event at the Bolling/Allerod.

Geochemistry

Microinclusions in Diamonds: composition, source and mantle metasomatism

Yakov Weiss

Direct samples of metasomatic high-density fluids (HDFs, either melts or supercritical fluids) are trapped as myriads of nano-scale inclusions during the growth of fibrous diamonds and represent the medium in which these diamonds grew. These HDFs vary in composition between silicic, saline and high- and low-Mg carbonatitic end-members. The physical strength of the diamond ensures the pristine nature of the fluids, allowing direct chemical investigation of the deepest available samples of metasomatic fluids and sheds light on mantle sources and processes that promote diamond genesis. HDFs of different major-element composition share similar incompatible-element characteristics, regardless of their host diamond provenance. Two principal patterns, "Planed" and "Ribbed", are characterized by differences in the highly incompatible elements from Cs–Pr. Similarities of canonical ratios, Nb/(Th, U, La) and K/U, between MORB and OIB samples and HDFs with "Planed" patterns suggest that an asthenospheric source for these HDFs is plausible; direct production of HDFs by melting the asthenosphere avoids the circular "chicken and egg" reasoning that has plagued diamond and kimberlite genesis. The "Ribbed" incompatible-element pattern in HDFs evolved during percolation of HDFs with a "Planed" patterns through a previously metasomatised lithosphere that carries accessory phlogopite, ilmenite and rutile. The story of diamonds is interwoven with that of kimberlitic volcanism, but the genetic relationship between them has been debated ever since kimberlite was first identified. Major- and trace-element similarities between high-Mg HDFs and kimberlites suggest a genetic link between the two. The close relation between HDFs that were trapped at depth and kimberlites sampled at the surface, places constraints on the chemical composition of kimberlitic magmas at depth and indicates that their incompatible-element compositions did not change much en route.

Retreat of the western Greenland Ice Sheet during the middle Holocene

Nicolás Young

Geophysical ice-sheet models routinely depict the western margin of the Greenland Ice Sheet (GrIS) as displaying enhanced sensitivity to climate change compared to other ice-sheet sectors. As a test of their validity, however, ice-sheet models must be able to reconstruct past GrIS change by duplicating the geologic record. Of particular interest, is reconstructing and modeling western GrIS behavior through the early and middle Holocene because this time period encompasses the most recent interval of regional warmer-than-present temperatures. Here, I review published model simulations of GrIS behavior that span the Holocene and compare these simulations to available and in progress geological reconstructions of GrIS change over the same time interval at two locations in western Greenland. I will highlight the difficulties in reconstructing smaller-than-present ice extent, and also highlight potential strengths and weaknesses of current model simulations.

Layers of volcanic tephra in Northern Patagonia. Picture contributed by David Ferguson.

ORAL SESSION ABSTRACTS

Marine Geology & Geophysics

River avulsions in the presence of tectonic tilting

Meredith Reitz

In Bangladesh, the set of active rivers of the Ganges-Brahmaputra Delta overlie a landscape that is being continually modified by tectonics. The response of rivers to a surface being altered by tectonic tilting or other causes of spatially variable subsidence is generally understood to be a preferred path direction toward regions of higher subsidence. Quantifying the pattern and magnitude of this effect remains however an open question. Recent experimental work has suggested an equilibrium-slope explanation for the timescale and conditions for avulsion. Here we adapt this model to the context of variable subsidence, developing a new framework to quantify its effect on channel avulsions. We find that regions of higher subsidence both draw avulsions more frequently, and result in longer channel residence times in these locations. Finally, we apply this theory to Bangladesh, where we use a map of regional variable subsidence to predict the variation in avulsion timescale and frequency for the Brahmaputra River. Comparison between our predictions and our stratigraphy-derived estimates of avulsion timescale shows encouraging consistency. The work presented here represents the first quantitative, general framework for the influence of variable tectonics or subsidence on large-scale nodal avulsion timescale and path direction.

Quantifying surface melt in western Greenland from zigzag patterns in exposed stratigraphy

Kirsty Tinto

Ice strata exposed in the ablation zone at the western margin of the Greenland ice sheet form zigzag-shaped outcrops visible in the summer months from the air and in satellite images. Ice penetrating radar show that these strata dip at a low angle into the interior of the ice sheet. The zigzags form either by folded strata being cut by planar surface topography, or planar strata being cut by a surface incised by meltwater channels. Over time, ice flow moves the ice sheet stratigraphy towards the margin, but surface melt moves the outcrop of this stratigraphy down dip, i.e. towards the interior of the ice sheet. The shallow dip of the strata exaggerates the horizontal expression of the surface lowering. By examining satellite imagery from the summer months, we are able to use the year-to-year displacement of the outcropping zigzag strata to compare the relative influence of ice flow and surface melt. The method successfully identifies years of documented high melt, and can be used to discern the variation of melt rates away from instrumented stations.

Dead Sea. Picture contributed by Yael Kiro.

ORAL SESSION ABSTRACTS

Seismology, Geology & Tectonophysics

Enhanced remote earthquake triggering at fluid injection sites in the Midwestern U.S.

Nicholas van der Elst

A dramatic increase in seismicity in the Midwestern United States may be related to increased deep wastewater injection. We have systematically examined the last several years of seismographic data at several sites of suspected anthropogenic seismicity, in order to resolve previously undetected small earthquakes and offer a clearer picture of the onset and evolution of induced seismic swarms. Importantly, we found advanced warning signs at three sites that experienced moderate magnitude earthquakes in 2011, in the form of remotely triggered earthquakes. Remote triggering is a phenomenon whereby small swarms of earthquakes are set off by the passing seismic waves of distant very large earthquakes. This phenomenon has been well established for the last several decades, particularly in natural hydrothermal and volcanic settings, where circulating pressurized fluids play a role in generating earthquakes. Remote earthquake triggering can only operate on faults already very near failure, so this observation strongly suggests the presence of critically stressed, fluid-filled faults. Remotely triggered swarms appear to be an advance indicator of larger induced earthquakes, at least in some locations.

Lithospheric structure of the central Pacific: early returns from the NoMelt experiment

Patty Lin

Recent advances in laboratory measurements and theoretical models of the seismic properties of mantle rocks predict seismic velocity profiles for mature oceanic lithosphere that are fundamentally inconsistent with the best observations of seismic velocities in two ways. However, direct seismic observations of detailed lithosphere structure are limited. In 2011-2013, we conducted the NoMelt experiment on ~70 Ma Pacific lithosphere between the Clarion and Clipperton fracture zones. The experiment consists of a 600x400 km array of broad-band (BB) ocean bottom seismometers (OBS) and magnetotelluric (MT) instruments, and an active-source reflection/refraction experiment. The BB OBS array was recovered in January 2013, and we present preliminary observations derived from one year's recording of teleseismic earthquakes. Of the 27 deployed instruments, 21 were recovered, most of which produced useful data on the seismometer and/or the differential pressure gauge in the 10-100 s period band. We identified 39 energetic events that produced outstanding P and S body waves, which we will use for receiver-function analyses to look for the reflected and converted energy. High signal-to-noise Rayleigh waves are observed from over 27 events with Mw 6.5 or larger. These observations will be used to produce a radially anisotropic model of the lithosphere and underlying asthenosphere in the central Pacific.

Kalman filtering for decade-length modeling of GRACE gravity

Lei Wang

The monthly gravitational spherical harmonic coefficients (SHCs) produced by the Gravity Recovery and Climate Experiment (GRACE) satellite mission contain a wide range of time-dependent geophysical signals. However, the GRACE SHCs contain order-dependent correlated errors in short-wavelength components, manifesting themselves as north-south elongated linear stripes in the map of surface mass changes. These systematic 'stripe' noises degrade the accuracy and spatial resolution of GRACE solution. In this study, we build a Kalman filter for statistically rigorous separation of geophysical signals and correlated 'stripe' contamination in a series of GRACE monthly SHC estimates. The key to this procedure is to design a covariance matrix that includes both geophysical signals and the correlated errors, reflect not only the spatial spectral features but also the temporal correlation among them. A major benefit of the technique is that, in preserving statistical information, we are able to estimate the impact on the SHC uncertainties of the destriping. This approach would therefore be an appropriate 'front end' for the more statistically rigorous and self-consistent modeling of seasonal and longer-term signals, and statistical techniques recently developed to combine GRACE and other data for simultaneous estimation of glacial isostatic adjustment and present-day melting signals. The results indicate that the new approach can remove the striping features to a remarkable degree, but of course as with any stochastic filter the results depend critically on understanding the statistics of various signals.

Seismology, Geology & Tectonophysics

Controls on the migration of fluids in subduction zones

Cian Wilson

Arc volcanism associated with subduction is generally considered to be caused by the transport in the slab of hydrated minerals to sub-arc depths. In a qualitative sense it appears clear that progressive dehydration reactions in the down-going slab release fluids to the hot overlying mantle wedge, causing flux melting and the migration of melts to the volcanic front. However, the quantitative details of fluid release, migration, melt generation and transport in the wedge remain poorly understood. In particular, it is challenging to explain the robust location of the volcanic front with respect to intermediate depth earthquakes (e.g. 100+/-40 km; England et al., 2004, Syracuse and Abers, 2006) given the variability of fluid release depths in global subduction zones (e.g. van Keken et al. 2011). Reconciling these results implies some robust mechanism for focusing fluids and/or melts toward the wedge corner. When driven by buoyancy alone, fluid migrates through the mantle wedge along a near vertical trajectory. Only interactions with the solid flow at very low values of permeability or high values of fluid viscosity can cause deviations from this path (Cagnioncle et al, 2007). However, in a viscous, permeable medium, additional pressure gradients are generated by volumetric deformation due to variations in fluid flux. These pressure gradients can significantly modify the fluid flow paths. We present a range of high-resolution models that include a more complete description of coupled fluid and solid mechanics (allowing the fluid to interact with solid rheological variations) together with rheologically consistent solution for temperature and solid flow. Focusing on idealized geometries and thermal histories we discuss how successful these interactions are at focusing both fluids and hot solids to sub-arc regions. We will also evaluate the efficacy of current wet melting parameterizations in these models.

ORAL SESSION ABSTRACTS

Biology and Paleo Environment

Large-scale response of trees to climate in the eastern deciduous forests

Dario Martin-Benito

In order to understand the effects of precipitation, temperature, and drought in a broad biogeographical context, we conduct a dendroclimatic study of broadleave tree species in the humid deciduous forests of the eastern US. For these analysis we combined a network of tree-ring width chronologies from eight species along a 1700 km latitudinal transect, from Georgia to Maine. Our results indicate that summer drought and warm temperatures limit growth of all tree species, regardless of geographical location. Species-specific as well as regional responses were also observed. A progressive change in this drought response with latitude is evident: the influence of precipitation on tree growth decreases from north to south while temperature effects follows the opposite trend. Results from these analyses might prove useful for future dendroclimatic reconstruction and for the accurate prediction of the response of these forests to future climate changes through climate/vegetation models.

Double trouble: Tracing the effect of Ocean Acidification and Ocean Warming in the shells of Arctic Pteropods

Nina Keul

Two CO2 induced stressors currently challenge the Ocean's Surface Waters: Ocean Warming and Ocean Acidification. Both of these have especially strong effects in high-latitude surface waters, such as the Arctic ocean, where the rate of warming is nearly double the global average. Pteropods are pelagic molluscs, producing shells made out of aragonite, a metastable form of calcium carbonate, which is more soluble than calcite in seawater. Despite being present in high numbers in certain oceanographic settings ("pteropod oozes"), the potential use of pteropods as paleooceanographic proxy carriers has not been explored yet. We have cultured the arctic pteropod, Limacina helicina, under a combination of different pCO2 values and temperatures, ranging from present/ preindustrial values to those projected for the Arctic Ocean by the end of this century. Trace elemental to Calcium ratios (TE/Ca) and the correlation with changes in pCO2 /temperature and their potential use as proxies will be critically discussed. In this context, the TE/Ca of two Arctic pteropod species, will be presented from a 13 year sediment trap in the Arctic Fram strait, a decade that has seen the most rapid and drastic changes in the surface waters of the Arctic.

Biology and Paleo Environment

Microbial phosphorus dynamics in the oligotrophic Gulf of Mexico

Kim Popendorf

Phosphorus is a limiting macronutrient for biological productivity in many areas of the ocean, making its availability and microbial utilization an important lever in controlling microbial activity and ultimately the role that microbes play in the global carbon cycle. Of particular interest is the relative role of phytoplankton and heterotrophic bacteria in the cycling of phosphorus, as these groups of microbes have distinct functional roles in the ecosystem and potentially different phosphorus acquisition and utilization strategies. In field samples from the oligotrophic Gulf of Mexico, I have combined radioisotope tracers with cell sorting flow cytometry and preparative-high pressure liquid chromatography analysis to measure the relative uptake of dissolved inorganic phosphate and adenosine triphosphate (as a representative organic phosphorus compound) into the bulk cells and into the phospholipids of Prochlorococcus, Synechococcus (the most abundant phytoplankton in the Gulf) and heterotrophic bacteria. This novel combination of analytical tools provides a way to measure the production rate of specific biochemicals in individual microbial groups, providing new insights into microbial phosphorus dynamics in a nutrient-depleted environment.

Mid Pliocene sea levels between eustasy, isostasy and dynamic topography

Alessio Rovere

Proxy data suggest that during the Mid-Pliocene Warm Period (MPWP) atmospheric CO2 levels were roughly similar to today (between 350 and 450 ppmv) and that global average temperature was elevated by as much as 3°C with respect to pre-Industrial values. Estimates of sea level (SL) during the MPWP range from +10 m to more than +40 m relative to present (Raymo et al., 2011, Nature Geoscience), reflecting uncertainties in our knowledge of the sensitivity of the East Antarctic, West Antarctic and Greenland Ice Sheets to modest climate warming. The southeast US coastal plain is of historic importance in MPWP SL studies (Dowsett and Cronin, 1990, Geology). Since the late 1960s, the Pliocene shorelines in this area have been the subject of numerous studies aimed at defining shoreline traces, fossil deposits and elevation. In this study we present the results of a field expedition aimed at documenting the elevation of MPWP shoreline traces from Virginia to Florida. High-accuracy GPS vertical measurements and DEM data were acquired across the topographic-geomorphic margin of the Pliocene and younger shorelines. Field data and analysis of DEMs provide evidence the position of the Pliocene shoreline margin. Analyzed in light of glacial isostatic adjustment, the shoreline is inclined rising to the north as much as 50 m across the study area, mostly as a result of post-depositional deformation due to processes related to dynamic topography.

Plio-Pleistocene paleoenvironmental records from molecular biomarkers in East African Rift sediments

Kevin Uno

Stable isotope analysis of molecular biomarkers (e.g., leaf wax n-alkanes) derived from terrestrial plants is a widely used proxy in lacustrine and marine sediments. I am extending the application of the method to paleosols in the Omo-Turkana and Awash Basins in East Africa. Isotopic records from paleosols differ from those in lacustrine and marine sediments because the majority of biomarkers in paleosols are thought to accumulate in situ as soils develop, thus circumventing the longstanding issue of uncertainty in biomarker provenance in sediments from marine and large lacustrine basins. The paleosol biomarker record will elucidate changes in vegetation and hydroclimate¬ based on stable carbon and hydrogen isotope ratios in leaf waxes (δ13CLW and δDLW, respectively). Aridity is a particularly important climatic variable that is difficult to quantify in the geologic record. I am working towards development of an aridity proxy using combined δDLW with soil carbonate δ18O (δ18OSC) values measured from the same paleosol sample. Finally, δ13CLW and δ13CSC data from the same sample will be compared to test for consilience between the two isotopic proxies.

ORAL SESSION ABSTRACTS

Ocean and Climate Physics

El Nino Prediction using deep Vector Autoregressive Models

David Chapman

A recent comparison (Barnston et al, 2012 (BAMS) shows the ENSO forecasting skill of dynamical models now exceeds that of statistical models, but the best statistical models are comparable to all but the very best dynamical models. In this comparison the leading statistical model is the one based on the Empirical Model Reduction (EMR) method. Here we report on experiments with multilevel Vector Autoregressive models using only sea surface temperatures (SSTs) as predictors. VAR(L) models generalizes Linear Inverse Models (LIM), which are a VAR(1) method, as well as multilevel univariate autoregressive models. Optimal forecast skill is achieved using 12 to 14 months of prior state information (i.e 12-14 levels), which allows SSTs alone to capture the effects of other variables such as heat content as well as seasonality. The use of multiple levels allows the model advancing one month at a time to have about the same skill for a 6 month forecast as a model constructed to explicitly forecast 6 months ahead. We infer that the multilevel model has fully captured the linear dynamics (cf. Penland and Magorian, 1993 J. Climate). Finally, while VAR(L) is equivalent to L-level EMR, we show in a 150 year cross validated assessment that we can increase forecast skill by improving on the EMR initialization procedure. This improved initialization increases model skill especially for deep models that exhibit more than 4 Levels.

The Ozone Hole Indirect Effect: Cloud-Radiative Anomalies Accompanying the Poleward Shift of the Eddy-Driven Jet in the Southern Hemisphere

Kevin Grise

This study quantifies the response of the clouds and the radiative budget of the Southern Hemisphere (SH) to the poleward shift in tropospheric wind patterns induced by the development of the Antarctic ozone hole. Climate model experiments, in which only stratospheric ozone depletion is specified, indicate that 1) high and mid-level clouds closely follow the poleward shift in the SH mid-latitude jet stream and that 2) low-level clouds decrease across most of the Southern Ocean. Similar cloud anomalies are found in satellite observations during periods when the SH jet stream is anomalously poleward. The hemispheric-annual-mean radiation response to the cloud anomalies is calculated to be approximately +0.25 W m-2, arising largely from the reduction of the total cloud fraction at SH mid-latitudes during austral summer. While these dynamically induced cloud and radiation anomalies are considerable and are supported by observational evidence, quantitative uncertainties remain from model biases in mean-state cloud-radiative processes.

Factors controlling variability in the oxidative capacity of the troposphere on glacial-interglacial time scales

Lee Murray

The oxidative capacity of the atmosphere controls the lifetime of many trace gases of importance for humanity and climate. It responds to meteorological conditions, tropospheric emissions, and overhead stratospheric boundary conditions, all of which have likely changed since the Last Glacial Maximum (LGM; 19-23ka before present) as a result of changing climate and recent human influence. We present a step-wise, offline-coupled climate-biosphere-chemistry framework to identify the most important factors controlling levels of tropospheric oxidants on glacial-interglacial time scales. We perform detailed O3-NOx-CO-VOC-BrOx-aerosol simulations of tropospheric composition with the GEOS-Chem 3D global chemical transport for four different time-slices: the present day (ca. 1990s), preindustrial (ca. 1770) and two possible realizations of the LGM. The model is driven by meteorological fields from the GISS ModelE general circulation model, land cover from the BIOME4-TG global terrestrial equilibrium vegetation model, and historic fire emissions from the LMfire model, and it includes an online linearized stratospheric chemistry scheme. We test the sensitivity of model results to uncertainty in lightning and biomass burning emissions. Contrary to some recent studies, we find reduced oxidant levels in all preindustrial and paleo climates relative to the present day. Key variables controlling the tropospheric oxidative capacity over glacial-interglacial periods include overhead stratospheric ozone, tropospheric water vapor, and lightning emissions. Variability in mean OH is insensitive to biomass burning emissions. Our simulations are broadly consistent with ice core records of Δ17O in sulfate and nitrate at the LGM, and CO, HCHO, black carbon, and H2O2 in the preindustrial. Our results imply that the observed variability in ice-core methane is predominantly source-driven by wetland emissions. The potential for reactive chemistry feedbacks on glacial-interglacial cycles is discussed.

Ocean and Climate Physics

Antarctic sea ice trends, stratospheric ozone, and internal climate variability

Karen Smith

The observed positive trends in Antarctic sea ice pose a challenge to our undestanding of the climate system, in that one would expect sea ice to melt in a warming climate, as the Arctic shows. In addition, models participating in the Climate Model Intercomparison Project (CMIP) Phases 3 and 5 are unable to simulate the observed positive trends. Recent single-forcing experiments where only stratospheric ozone is changed, show that ozone depletion causes negative sea ice trends and, conversely, that ozone recovery will mitigate the future sea ice loss associated with increasing greenhouse gases. Hence, over the observational period, models indicate that both greenhouses gases and ozone depletion would act in the same direction, and produce negative sea ice trends. However, investigation of trends in CMIP5 pre-industrial control model integrations reveal that both positive and negative trends, with amplitudes much larger than the one in the recent observation, can occur in the absence of forcing agent, solely as a consequence of internal climate variability. This suggests that the recently observed trends may be a reflection of such variability rather than of a response of the to anthropogenic forcings.

Tabular iceberg, Antarctica. Picture contributed by Bess Koffman.

POSTER SESSION ABSTRACTS

Biology & Paleo Environment

Synergy of oil, nutrients, and microbial predators in influencing microbial processes in the Gulf of Mexico.

Nigel D'souza

The Deepwater Horizon oil spill resulted in an estimated 600 million liters of oil being released into the Gulf of Mexico. The fate of this oil, and its impact on the ecosystem, still remains uncertain, especially due to the depth and magnitude of the spill. While a large percentage of this released oil was found to be broken down by oil-degrading microbes in the water column, the dynamics of these processes remain unclear. The goal of this study was to elucidate the impacts of oil, nutrient availability, and microbial predation on microbial communities in the Gulf of Mexico water column. Experimental additions of oil and inorganic nutrients were combined with dilution experiments that minimize predation on bacteria, to assess the influence of these variables on the activity of water column bacteria from offshore waters of the Gulf of Mexico. Addition of oil, and reduction of bacterivory were found to increase biological oxygen demand (BOD), with concomitant trends in cell counts, and in the production of enzymes involved in oil degradation. Nutrient additions showed similar BOD increases in surface waters, but not in deep waters. Thus, predation and nutrient availability are important factors controlling microbial processes in the presence of low concentrations of oil.

Microbial sources of intact polar membrane lipids in the Western North Atlantic Ocean

Kim Popendorf

Membrane lipids are essential structural components of microbial cells. In the surface ocean, lipids comprise a substantial portion of cellular biomass (ca. 11-23% of the organic carbon in plankton) and cellular nutrient requirements (1-28% of plankton phosphate needs). Production of membrane lipids is obligate for both growth and replication of cells, thus membrane lipids are a significant cellular investment of resources and play a key role in the cycling of carbon and nutrients in the ocean. While it has long been understood that lipid composition varies across microbial groups, the microbial origins of the intact polar lipids in the surface ocean remain to be fully explained. This study focused on identifying the microbial sources of intact polar diacylglycerolipids (IP-DAGs) in the surface waters of the western North Atlantic Ocean using three distinct approaches: (i) 13C-labeled substrates were used to trace lipid production by photoautotrophs and heterotrophic bacteria, (ii) cell sorting flow cytometry was employed to separate cyanobacteria and heterotrophic bacteria for IP-DAG analysis and (iii) regrowth incubations were conducted to examine the production of IP-DAGs duringgrowth of heterotrophic bacteria. Our results indicate that several classes of IP-DAGs have the potential to be useful biomarkers for studying microbial processes in the sea.

Osorno Volcano, Chile. Picture contributed by David Ferguson.

POSTER SESSION ABSTRACTS

Geochemistry

Water diffusion in nominally anhydrous minerals

Elizabeth Ferriss

The diffusion of incorporated water in nominally anhydrous minerals (NAMs) such as olivine and pyroxene has two important applications in volcanology and geodynamics. First, water diffusion profiles in volcanic phenocrysts are potential clocks to measure the magma ascent rate, a key parameter determining the explosiveness of an eruption. Second, tiny (even ppm-level) amounts of water have a profound effect on the physical properties (strength, rheology, melting, conductivity, attenuation, ionic diffusivities) of the NAMs that make up the bulk of Earth's mantle (olivine, pyroxene, garnet, wadsleyite). Therefore, the deep Earth water cycle is critically important for our understanding of plate tectonics and geodynamics. Much of our knowledge of water in the deep Earth comes from measurements of xenoliths and mantle inclusions, but the usefulness of these measurements (as well as our ability to interpret magnetotelluric data) depends on accurate knowledge of the rate, anisotropy, and mechanism of the diffusion of water into or out of the sample. I will discuss my new approach for simplifying the experimental procedure as well as the results and implications of laboratory experiments on the minerals olivine and diopside.

Assessing the role of the Subtropical Front in regulating Agulhas Leakage at the Last Glacial Termination

Allison Franzese

It has long been thought that north-south migrations of the Subtropical Front (STF) south of Africa might strongly regulate the Agulhas Leakage on glacial-interglacial timescales, and recent papers have argued that such migrations play a key role in glacial climate and in global climate transitions due to that regulation (e.g. Bard and Rickaby 2009; De Deckker et al. 2012). As the STF is a zone of high meridional sea surface temperature (SST) and sea surface salinity (SSS), gradients, changes in the location of the STF can be addressed by measurements of SST and SSS proxies in appropriate deep sea cores. Although many proxy records from the Southern Hemisphere show variability consistent with reduced Agulhas Leakage and/or a more northern position of the STF during glacial times, there are currently no high resolution reconstructions of changes in the SST and SSS gradients that define the STF in this key region south of Africa. This project fills in a significant geographical gap in glacial reconstructions of the STF by using a meridional transect of cores from the western flanks of the Agulhas Plateau, between the latitudes of 38°S and 42°S. I am using paired measurements of planktonic Mg/Ca and δ18O as proxies for SST and SSS, to explicitly reconstruct the position of the STF over the past 25,000 years, covering the time period of the Last Glacial Termination, and I plan to combine these with measurements of proxy tracers of particles and water mass. Initial results from the southernmost cores show that the STF migrated southward during the Termination. I am currently working on more northern cores to assess whether the STF was in a more northward position during the LGM. This represents an important step in testing the hypothesis that southward migrations of the STF allowed for increased Agulhas Leakage, which helped to trigger enhanced NADW formation and increased the meridional overturning circulation associated with glacial terminations.

Late Holocene Microparticle Deposition at WAIS Divide

Bess Koffman

We develop and interpret a late Holocene (past 2400 years) record of dust deposition from the West Antarctic Ice Sheet (WAIS) Divide deep ice core in order to reconstruct past changes in atmospheric circulation and to characterize the products of explosive volcanic eruptions. Using our coarse particle percentage record (defined as number of particles mL-1 [4.5-15]/[1-15] μm diameter *100), and through comparison with spatially distributed climate reconstructions from the Southern Hemisphere (SH) middle and high latitudes, we infer latitudinal shifts in the position of the SH westerly wind belt during the Medieval Climate Anomaly (MCA; ~950-1350 C.E.) and Little Ice Age (LIA; ~1400-1850 C.E.) climate intervals. We suggest that the SH westerlies occupied a more southerly position during the MCA, and shifted equatorward at the onset of the LIA (~1430 C.E.) in response to high-latitude SH cooling and a contraction of the SH Hadley cell. In addition, we present a new method for inferring the relative location (low vs. high-southern latitude), and therefore potential climatic impact, of past eruptions based on the particle size distribution (PSD) of micrometer-sized ash particles.

Geochemistry

Mineral dust in the southern latitudes: Source areas, deposition and paleoclimatic implications

Cristina Recasens

Wind-blown dust can be used to trace past and present atmospheric circulation patterns, through the study of its geographical provenance, its spatial distribution and temporal variability. Antarctic and marine records indicate that Patagonia has been a principal source of dust for the southern latitudes, particularly during glacial times. In order to unravel the role of glaciations in dust supply, we plan to define the dust sources from Southern South America that are recorded in the southern latitudes, and compare them with the sinks or final resting places of the dust. We analyzed material from potential dust source areas in Patagonia, including glacial deposits and the dust component in cores taken from lakes, in order to define their geochemical signatures using chemical compositions and Sr, Nd, Pb and He isotope ratios. To improve our understanding of dust provenance and transport mechanisms downstream from South America and part-way to Antarctica, we analyzed the fine (<5 μm) fraction terrigenous input into the Southern Ocean by studying the 12.76-m piston core TNO57-6, from 3751 m water depth on the Agulhas Ridge in the Southeast Atlantic, north of the present-day position of the Subantarctic Front and South of the Subtropical Convergence Zone. Due to this core's location and depth, and the position of the winds and marine currents, we suggest that the major input of sediment comes from wind-blown dust material originating in South America. Comparing the results from these different settings, including possible sources and resting places, will allow for a better understanding of the changes in dust supply and provenance through time, and improve understanding of past atmospheric dynamics at middle to high latitudes

Gulf of Mexico. Picture contributed by Kim Popendorf.

POSTER SESSION

Marine Geology & Geophysics

The earthquake sedimentary record in marine sediment from cores in the western part of the Marmara Sea, Turkey

Laureen Drab

The North Anatolian Fault (NAF) is a 1500km long dextral strike-slip fault that accommodates the extrusion of the Anatolian Plate away from the Arabia/Eurasia collision zone at a rate of 20-25mm/yr. The submarine part of the North Anatolian Fault in the Sea of Marmara is a very significant hazard for the 12 million people living in Istanbul (Turkey). An accurate seismic risk assessment necessitates paleoseismological data, which can be retrieved in the Marmara Sea by using sediment cores. Here a record of turbidites was obtained in five cores spanning the Tekirdağ Basin, the Western High and the Central Basin linked by the Tekirdağ Fault Segment. We characterized earthquake-related sedimentary events by combining X-ray imagery, magnetic susceptibility, granulometry and XRF measurements. Time constrain was obtain with 14C dating and 210Pb data. The turbidites are synchronous at different sites across the two basins and through the structural high pointing to shaking by earthquake as a possible triggering mechanism. In particular the M=7.4 1912 Mürefte earthquake let a distinctive sedimentary imprint in all the studied cores. Radiocarbon dating implies a turbidite recurrence interval of about 300 years. The low number of seismoturbidites documented in the Central Basin compare to the Tekirdağ Basin suggests quasi-synchronous ruptures of the Tekirdağ Segment and the adjacent Central Segment of the NAF or a partial seismic slip on the Central Segment. Both scenarios have implications regarding seismic hazard. Finally though we obtained a paleoseismological record of the ruptures along the Tekirdağ Segment, further chronological constraints are needed to better date the events and to confirm the completness of the obtained record.

Bathymetric Controls On Observed Tidewater Glacier Retreat In Northwest Greenland

David Porter

Although many of the largest glaciers in Greenland are losing mass, the large variability in observed mass wastage of the remaining glaciers clouds interpretation of the proposed external forcings, such as warming of the ocean or atmosphere. Some glaciers are accelerating and thinning while other nearby glaciers advance and gain mass. Recent efforts suggest that increased ocean temperatures may be responsible for the observed glacial retreat in Greenland and Antarctica through increased basal melting beneath floating ice tongues and vertical ice faces of tidewater glaciers. Knowledge of fjord geometry is crucial for ice-ocean interaction because the availability of ocean heat to the ice will be restricted by narrow sills and shallow grounding lines. New estimates of fjord bathymetries in northwest Greenland, using airborne gravimetry measurements from NASA Operation IceBridge flights, are compared to estimates of ice acceleration and mass wastage of neighboring glaciers. We determine that the geometry of glacial fjords play a large role in determining the stability of outlet glaciers. Deep sills and deep terminus grounding lines will allow greater interaction with the deep and warm Atlantic water off the shelf break. For two neighboring glaciers in northwest Greenland, we find that the glacier with a deeper grounding line, and presumably in contact with more warm water, is flowing faster and experiencing larger mass loss over the past decade. Such broad correlations between grounding line depths and mass wastage are a starting point in an effort to understand the variability of observed retreat of outlet glaciers in northern Greenland.

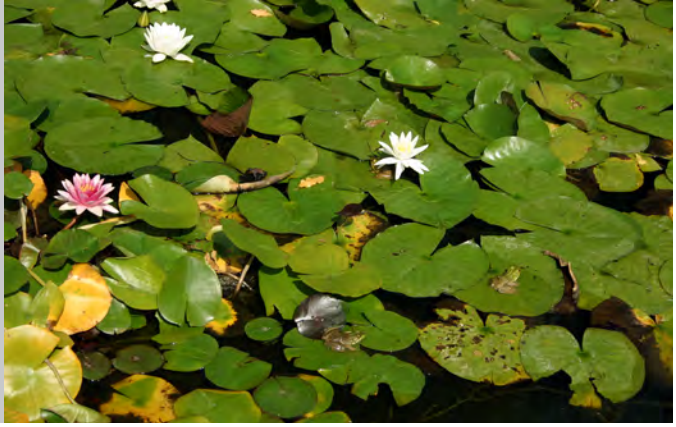
Bathymetry in fjords of Northwestern Greenland from Operation IceBridge aerogravity

Kirsty Tinto

Understanding of the influence of water circulation on the melting and dynamics of Greenland glaciers is hampered by a lack of basic information on fjord bathymetry. Here we present results from Operation IceBridge aerogravity surveys along the axes of 17 fjords of northern Greenland and in a coast-parallel grid across the northwestern fjords in order to provide bathymetric models for this difficult to access region. In front of Petermann Glacier, in northern Greenland, we identify a bathymetric sill at ~600 m depth, 28 km in front of the 500 m deep grounding line. The maximum depth in this fjord is ~1200 m but shows asymmetry, with the eastern side ~ 500 m deeper than the west. In Northwest Greenland, the recently released IBCAO v3 shows deep troughs in the continental shelf but does not resolve the connection between these troughs and the channels of the outlet glaciers that cut the coast. The changes observed in velocity and surface elevation of these glaciers does not follow a simple spatial pattern, and the influence of ocean waters is not fully understood. The new IceBridge survey provides a bathymetry model of the area between the marine IBCAO data and the grounded glaciers and indicates for the first time the linking pathways at depth of individual outlet glaciers to shelf troughs.

POSTER SESSION ABSTRACTS

Ocean & Climate Physics



El Nino Prediction using deep Vector Autoregressive Models

David Chapman

A recent comparison (Barnston et al, 2012 (BAMS) shows the ENSO forecasting skill of dynamical models now exceeds that of statistical models, but the best statistical models are comparable to all but the very best dynamical models. In this comparison the leading statistical model is the one based on the Empirical Model Reduction (EMR) method. Here we report on experiments with multilevel Vector Autoregressive models using only sea surface temperatures (SSTs) as predictors. VAR(L) models generalizes Linear Inverse Models (LIM), which are a VAR(1) method, as well as multilevel univariate autoregressive models. Optimal forecast skill is achieved using 12 to 14 months of prior state information (i.e 12-14 levels), which allows SSTs alone to capture the effects of other variables such as heat content as well as seasonality. The use of multiple levels allows the model advancing one month at a time to have about the same skill for a 6 month forecast as a model constructed to explicitly forecast 6 months ahead. We infer that the multilevel model has fully captured the linear dynamics (cf. Penland and Magorian, 1993 J. Climate). Finally, while VAR(L) is equivalent to L-level EMR, we show in a 150 year cross validated assessment that we can increase forecast skill by improving on the EMR initialization procedure. This improved initialization increases model skill especially for deep models that exhibit more than 4 Levels.

A diagnosis of the seasonally and longitudinally varying mid-latitude circulation response to global warming

Isla Simpson

Global climate models predict that future increases in greenhouse gas concentrations will be accompanied by changes in the Northern Hemisphere mid-latitude circulation. It is often concluded, based on a zonal mean analysis, or basin wide analysis, that a general feature of mid-latitude circulation change is a poleward shifting of the eddy driven mid-latitude jet streams and associated storm tracks. Here, the CMIP-5 models are used to assess the extent to which this is true when considering longitudinal and seasonal variations. The mid-latitude circulation response is found to vary considerably with season and longitude with various features that do not resemble a poleward shifting of the climatological circulation. In the winter season, the Pacific jet stream shifts equatorward on the Eastern side of the basin with implications for the climate of the west coast of the USA. On the Eastern side of the Atlantic basin, there is more of an extension of the jet stream rather than a poleward shift, with implications for Mediterranean climate. A momentum budget analysis is used to identify the role of transient eddies in maintaining these circulation responses with an aim to further understand the mechanism behind the mid-latitude circulation response to climate change.

Space-based constraints on atmospheric oxidation: from urban pollution plumes to the remote atmosphere

Luke Valin

We explore the potential for space-based constraints on the hydroxyl radical (OH), the most reactive oxidant in the atmosphere (Lifetime ~ 0.001 s – 1 s) and responsible for the removal of pollutants and greenhouse gases (e.g., NO2, CO, CH4, HCFCs) as well as the formation of tropospheric ozone and processing of aerosols. We use space-based measurements of nitrogen dioxide (NO2), an emitted species that is removed by OH, to investigate the chemistry of OH within urban plumes and we use measurements of formaldehyde (CH2O), a reactive intermediate of methane oxidation (CH4 + OH -> CH2O -> CO2), to investigate variability of atmospheric oxidation in the remote atmosphere on daily to inter-annual time scales. Using both measurements and models we present several methods for constraining tropospheric OH chemistry from space and discuss the technical factors that limit further advances.

POSTER SESSION ABSTRACTS

Seismology, Geology & Tectonophysics

Automatic location and volume estimation of rockfalls through seismic signals at Piton de la Fournaise volcano (la Réunion)

Clément Hibert

The permanent seismic network set up on the Piton de la Fournaise volcano by the Observatoire Volcanologique du Piton de la Fournaise (OVPF) is particularly well suited to studying seismic signals generated by slope instabilities. The analysis and monitoring of rockfalls through the seismic signals they generate provide a unique opportunity to study the temporal changes of slopes stability and the potential link with external forcing. One of the major constraint concerning the study of a long period of time is the large amount of data that must be processed. The volume estimation and the localization of rockfalls from their seismic signals require a precise picking of their onset and their duration, which, if done manually for thousands of events, might be extremely tedious and time consuming. However, the emergent nature of the onset and the phaseless nature of the seismic signals generated by rockfalls, plus the lack of a large number of stations recording these events, prevent the use of classical seismology tools. A new Kurtosis-based picking method making it possible to precisely pick the onset time and the final time of the rockfalls seismic signals has been developed. Automation of the identification of the events at the source of the seismic signals recorded at the Observatoire du Piton de la Fournaise is done by using a decision process based on the fuzzy-set, built from criteria defined on the waveform and the frequency content of the seismic signals. We mainly focus our method on the discrimination between rockfall and volcano-tectonic seismic signals. We then propose a location method, based on this precise picking and on a surface wave propagation model computed for each station from a Fast Marching Method. Furthermore, the energy of each rockfall is computed automatically, providing an estimate of the rockfall volume [Hibert et al., 2011]. As a result, the location and the volume of most rockfalls occurring from May 2007, after the major collapse of the Dolomieu crater, to May 2011 have been studied. Our analysis shows that the relationship of the rockfalls activity with the eruptive activity of the Piton de la Fournaise volcano may provide interesting insights for a better forecasting of summit eruptions.

On the Moho Topography Relief and 3-D Density Structure of Antarctica from Gravity Data

Hsien-Hsiang (Denny) Hsieh

In this study, we focus on the 3-D geometry of the density structure and Moho surface relief derived from satellite gravity data (GRACE), in combination of satellite altimeter data (ICEsat), Antarctic ice sheet thickness (BEDMAP), and global crustal thickness (CRUST 2.0). BEDMAP and ICESat data offers more precise water depth and ice thickness information on shallow layers as initial model and effectively constraints for reducing the non-uniqueness in the potential inversion calculations. The crustal thickness from CRUST 2.0 is considered as a rough crustal model in initial model. GRACE data provides complete gravity anomaly coverage on the entire Antarctica continent. Comparing the forward gravity anomaly from the initial model with GRACE gravity data, the large scale difference is attributable to the deeper structure effects, such as Moho topography reliefs. Thus, the inversion calculation is used to mainly invert for the Moho surface reliefs by further step. We considered the different gridding scheme for ice thickness, water depth, topography, and crust thickness. The results of Moho surface relief are derived from an adjustment of grid size algorithm and by least-squares fitting. The inversed Moho depth structure of Antarctica, ranging from 15 km to 50 km, is approaching the density Isostatic balance.

Sea-level variability in the Bay of Bengal at seasonal timescales

Julia de Juan

Sea level is affected by a wide range of processes, resulting in a response that varies on seasonal, interannual, and decadal time scales, and that has clear regional variations. One cause of this variability, of many, is the seasonal exchange of water between the continents and the ocean, which induces changes in the shape and gravity field of the Earth. This so-called 'self-attraction and loading' (SAL) causes a spatial and temporal variation of sea level, with an annual amplitude that ranges from ~2 mm to >18 mm. Previous studies show that the effect of SAL on the annual cycle of sea level is larger in the Bay of Bengal than anywhere else on Earth. In addition, tide-gauge measurements show among the largest disagreements with ocean model predictions and near-coastal altimeter measurements in this region. The study of sea level in the Bay of Bengal is important, both socially and scientifically. Three rivers converge in Bangladesh, with one of the world's highest annual discharge. The large delta covers the highly populated regions of southern Bangladesh and West Bengal. River flow is highly seasonal, with almost all discharge taking place during the summer monsoon. These conditions result in widespread flooding over Bangladesh every summer. This large hydrological load is the cause for the observed large annual SAL effect in this region, and accounts for at least part of the discrepancy between tide-gauge measurements and ocean-model predictions. Our study also highlights the need for high-resolution regional ocean models in this area. Careful inspection of tide-gauge time series suggests that the variations in sea level may also be strongly impacted by local effects.

Seismology, Geology & Tectonophysics

Imaging the attenuation structure beneath the northwestern margin of Colorado Plateau: Integrating seismic body-wave observations and forward modeling

Patty Lin

The upper mantle beneath the Colorado Plateau (CP) is characterized by high seismic velocities in the plateau interior and lower seismic velocities beneath the plateau margins. The seismic velocity contrast across the margins has been interpreted as a thermal-mechanical modification of the sub-CP lithospheric keel, by various mechanisms. Using teleseismic P- and S-wave spectra from the La Ristra 1.5 Array and EarthScope USArray Transportable Array (TA), we measure t*, the seismic parameter representing integrated attenuation along a ray path, across the western margin of the CP. To first order, both tp* and ts* varies from higher in the Basin and Range to lower in the CP, which suggests that coherent variations in attenuation are present across the Northwestern margin of the CP. However, the gradients of dt* for the two sets of NW and SE wave fields are significantly different, with a sharper gradient observed for the NW set. Finally, we perform forward modeling of viscoelastic wave propagation considering melt fraction, water content and additional attenuation mechanisms. From 1D forward models of viscoelastic wave propagation, we show that teleseismic t* measurements are very sensitive to intrinsic attenuation structure at the lithosphere scale (upper 400 km) beneath the array.

TerraFERMA: The Transparent Finite Element Rapid Model Assembler for multi-physics problems in the solid Earth Sciences

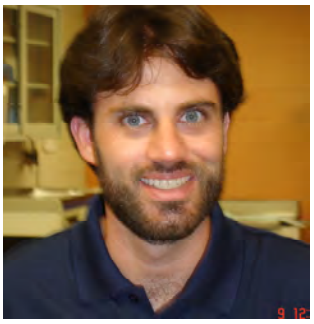
Cian Wilson

We discuss a new software infrastructure, TerraFERMA, the Transparent Finite Element Rapid Model Assembler for the exploration and solution of coupled multi-physics problems. The design of TerraFERMA is driven by two overarching computational needs in Earth sciences. The first is the need for increased flexibility in both problem description and solution strategies for coupled problems where small changes in model assumptions can often lead to dramatic changes in physical behavior. The second is the need for software and models that are more transparent so that results can be verified, reproduced and modified in a manner such that the best ideas in computation and earth science can be more easily shared and reused. TerraFERMA leverages three advanced open-source libraries for scientific computation that provide high level problem description (FEniCS), composable solvers for coupled multi-physics problems (PETSc) and a science neutral options handling system (SPuD) that allows the hierarchical management of all model options. TerraFERMA integrates these libraries into an easier to use interface that organizes the scientific and computational choices required in a model into a single options files, from which a custom compiled application is generated. Because all models share the same infrastructure, models become more reusable and reproducible. TerraFERMA inherits much of its functionality from the underlying libraries. It currently solves partial differential equations (PDE) using finite element methods on simplicial meshes of triangles (2D) and tetrahedra (3D). The software is particularly well suited for non-linear problems with complex coupling between components. We demonstrate the design and utility of TerraFERMA through examples of thermal convection and magma dynamics. TerraFERMA has been tested successfully against over 45 benchmark problems from 7 publications in incompressible and compressible convection, magmatic solitary waves and Stokes flow with free surfaces. We have been using it extensively for research in basic magma dynamics, fluid flow in subduction zones and reactive cracking in poro-elastic materials. TerraFERMA is open-source (LGPL) and available as a git repository at bitbucket.org:/tferma/tferma.

Osorno Volcano, Chile. Picture contributed by David Ferguson.

Meet our Postdoctoral Scientists

Shima Abadi
Research: My research interests focus on reconstructing and localizing of a sound source signal under water in an unknown environment. One of the main applications of my research is localizing marine mammals under water and analysis of whale calls before, during, and after periods of active source activity. I am currently working on the data recorded by R/V Langseth operations in Cascadia 2012. It has been documented that certain baleen whale calls have been recorded by OBSs. I will use the data recorded by seismic streamers to look for any changes in calling patterns in the vicinity of active source seismic operations.
Email: shimah@ldeo.columbia.edu
Division: Marine Geology & Geophysics



Craig Aumack
Research: My research focuses on the sea ice community living within land-fast Arctic sea ice, the accumulation of organic and inorganic carbon within the ice during the Arctic Spring-Summer, and the ultimate fate of that carbon once its exported from the ice. In addition to annual field sampling, I am conducting lab experiments testing the settling velocities of sea ice algae under varying nutrient regimes. Overall, we hope to discern the various abiotic and biotic factors influencing the growth and release of organics to the underlying marine communities.
Email: caumack@ldeo.columbia.edu
Division: Biology & Paleo Environment

David Chapman
Research: My background is in computer science and my research interests have evolved from video game graphics to weather satellite image processing and eventually instrument climate records. I am studying autoregressive El Nino forecasting as part of the MURI collaboration between LDEO and UCLA for Low Dimensional Extended Range prediction.
Email: chapman@ldeo.columbia.edu
Division: Ocean & Climate Physics

Emilie Dassie
Research: I am interested in understanding and reconstructing the South Pacific Convergence Zone (SPCZ) movements since the mid-1800s. I am using a network of coral records (mainly oxygen isotope data) from Fiji and Tonga areas to track the interannual to long-term displacements of the salinity front, located at the southeastern edge of the SPCZ.
Email: edassie@ldeo.columbia.edu
Division: Biology & Paleo Environment

Nicole Davi
Research: I use tree-rings to reconstruct climate. For the past several years I have focused on reconstructing drought/streamflow in Mongolia. I am also interested in science education and have been teaching teachers about climate change at the American Museum of Natural History.
Email: ndavi@ldeo.columbia.edu
Division: Biology & Paleo Environment

Julia de Juan
Research: I use geodetic measurements to study glacier dynamics, regional sea level, and crustal deformation. I utilize different scientific data sets and models for this research, including Global Positioning System (GPS) measurements, tide-gauge records, and ocean tides and ocean circulation models. I am currently working on a project aimed at understanding the response of sea level to the gravitational and mass-loading changes in the Bay of Bengal.
Email: dejuan@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics

Nigel D'Souza
Research: My research focuses on studying impacts of oil and natural gas inputs on the microbial and planktonic community in the Gulf of Mexico, focusing on changes in community composition, activity, and fate of the organisms. In addition to lab based microcosm manipulations, I will also use data from water-column profiling and satellite remote sensing, to map the impacts of oil inputs on the microbial and planktonic communities.
Email: ndsouza@ldeo.columbia.edu
Division: Biology & Paleo Environment

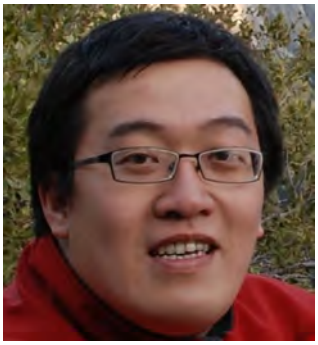
David Ferguson
Research: My research is in the areas of volcanology and igneous petrology. I am interested in the processes associated with the generation and eruption of magma, particularly the links between volcanism, tectonics and climate. Current projects include volcanism during late-stage continental break-up in Afar, Ethiopia, post-glacial volcanism in southern Chile and the dynamics of explosive eruptions at Kilauea.
Email: davef@ldeo.columbia.edu
Division: Geochemistry

Elizabeth Ferriss
Research: I am a mineralogist interested primarily in the incorporation and behavior of impurities and trace elements. My current project is to determine how water diffuses through clinopyroxene and apply that information to understanding magma ascent rates and mantle composition. In the past, I have worked on projects related to nuclear waste management and Ti incorporation in zircon.
Email: ferriss@ldeo.columbia.edu
Division: Geochemistry

Allison Franzese
Research: My research interests involve the application of isotope geochemistry to Paleoceanography. I am particularly interested in variations of the surface return flow of the global thermohaline circulation (THC) during the late Pleistocene glacial cycles. I am currently working on the relationship between the latitude of the subtropical front and the Agulhas Leakage over the last glacial termination.
Email: franzese@ldeo.columbia.edu
Division: Geochemistry

Kevin Grise
Research: My research focuses on atmospheric dynamics and their role in variability and long-term change in the climate system. I explore key questions about the dynamics of the climate system through statistical analyses of intra-seasonal, inter-annual, and decadal variability in observational data sets. My current research focuses on interactions between the troposphere and stratosphere, both in the tropics and the extratropics.
Email: kgrise@ldeo.columbia.edu
Division: Ocean & Climate Physics

Clément Hibert
Research: My research focuses on the remote study of gravitational instabilities using seismology. I developed methods to identify, locate and estimate the volume of rockfalls occurring at Piton de la Fournaise volcano. My work has shown that the rockfall activity can be used as a precursor of summit eruptions. My current project is to investigate short and long-period seismic waves generated by catastrophic landslides all over the world, in order to trace back the dynamics and the properties of these phenomenon.
Email: hibert@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics



Hsien-Hsiang (Denny) Hsieh
Research: My research focuses on studying volcanic group, MOHO topography, and crustal structure by gravity and magnetic data. I utilize the inversion methods for the research areas, including Antarctica, north Vietnam, and Taiwan. My current project is to use seismic data with gravity and magnetic data to joint inversion the complex structure of Taiwan area by Eurasian Plate and Philippine Sea Plate.
Email: dennyh@ldeo.columbia.edu
Division: Seismology Geology & Tectonophysics

Leslie Hsu
Research: As part of the Integrated Earth Data Applications (IEDA) group, I am working on geoinformatics projects which preserve, search, and manage geochemical and earth surface data. My background is in experimental geomorphology and active tectonics.
Email: lhsu@ldeo.columbia.edu
Division: Marine Geology & Geophysics

Nina Keul
Research: My broad research interests are in ocean acidification. The calcium carbonate shells produced by foraminifera are traditionally used in paleooceanographic studies to derive seawater characteristics of past oceans, such as temperatures, salinities and carbonate chemistries. I am assessing whether pteropods, small pelagic molluscs that also form calcium carbonate shells, can be used in a similar way, closing knowledge gaps where foraminifera are conspicuous by their absence.
Email: nkeul@ldeo.columbia.edu
Division: Biology & Paleo Environment.

Yael Kiro
Research: I am studying the paleoenvironment and paleoclimate of the Dead Sea and the Levant using halite petrography and the chemical composition of fluid inclusions from the Dead Sea core. Other research interests include water–rock interaction, coastal aquifer systems, sea–groundwater interaction, modeling and the geochemistry of the Dead Sea.
Email: ykiro@ldeo.columbia.edu
Division: Geochemistry

Bess Koffman
Research: I study past climate variability by looking at atmospheric dust and trace elements deposited on polar ice sheets. My current research is focused on the geochemical fingerprinting of dust in the Southern Hemisphere. The overall goal is to identify atmospheric transport patterns and to gauge the importance of different dust sources in terms of iron deposition into the ocean in past climates.
Email: bkoffman@ldeo.columbia.edu
Division: Geochemistry

Sarah Lambart
Research: I am an experimental petrologist. My research interests include understanding mantle melting and basalt genesis processes. This research is articulated on the role of mantle heterogeneities and magma-rock interactions in the genesis of basalt. I discuss this topic via an experimental approach coupled to thermodynamical modeling. I will also work on the experimental development of the reactive cracking process. This project seeks to find a way to increase the natural process that consists in the conversion of CO2 gas to stable solid carbonate minerals in peridotite and so provide new sites for the storage of the industrial CO2.
Email: sarahl@ldeo.columbia.edu
Division: Geochemistry

Victoria Lee
Research: I am working on the application and development of a geochemical method for determining sediment ages and transport times (the "uranium-series comminution age method", applicable to Quaternary fine-grained detrital material). I am currently investigating how marine paleoclimate proxy records may be affected by deep-sea sediment transport. My other work includes fluvial and glacial sediments, and chemical weathering.
Email: vlee@ldeo.columbia.edu
Division: Geochemistry

Patty (Peiying) Lin
Research: I am primarily interested in using seismic waves to study planetary interiors, like heterogeneities and seismic discontinuities, which hold important clues on a planet's compositional, thermal, and dynamical state, as well as its evolution. My research especially centers on using array approach to push the resolution to shorter scales.
Email: pattylin@ldeo.coolumbia.edu
Division: Seismology, Geology and Tectonophysics

Dario Martin Benito
Research: My research interests focus on the effect of climate and other environmental factors on trees and forest ecosystems by using dendrochronology and tree growth modelling. I am working on past environmental and ecological changes in tropical Asian, Mediterranean, and Eastern North American forests.
Email: dmbenito@ldeo.columbia.edu
Division: Biology & Paleo Environment

Christine McCarthy
Research: My research explores the mechanical properties of ice and rock at various length and timescales. I conduct dynamic ice friction experiments to examine the influence of tides on the flow speeds of tidewater glaciers. I also look at how various industrial contaminants affect the viscosity of polycrystalline ice.
Email: mccarthy@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics

Lee Murray
Research: My research focuses on quantifying the chemistry-climate interactions of short-lived, chemically reactive gases in the troposphere. I am especially interested in how these processes vary across a wide range of time scales, and between different global atmospheric models. I especially examine the role of lightning, a major source of fixed nitrogen to the atmosphere.
Email: ltmurray@ldeo.columbia.edu
Division: Ocean & Climate Physics

Kim Popendorf
Research: I study the role of microbes in ocean biogeochemical cycles, with a particular focus on microbial phosphorus dynamics in oligotrophic surface waters. I am interested in both the influence of nutrient availability on microbial processes and the influence of microbial processes on basin-scale chemical fluxes. To study these microbial processes I employ a variety of analytical techniques including isotope labeling in environmental samples, cell sorting flow cytometry, and mass spectrometry analysis of cellular biochemicals.
Email: kimdorf@ldeo.columbia.edu
Division: Biology & Paleo Environment

David Porter
Research: I am interested in the interactions between different components of the climate system, focusing on the interplay between the atmosphere, ocean, and ice near polar ice shelves and tidewater glaciers. Currently, I am investigating the role of the ocean in the observed changes of many of Greenland and West Antarctica's outlet glaciers.
Email: dporter@ldeo.columbia.edu
Division: Marine Geology & Geophysics

Ricardo Ramalho
Research: I am a geologist interested in oceanic hotspot dynamics and the origins and evolution of ocean island volcanoes. Currently I am exploring the application of surface exposure dating to quaternary uplift reconstructions based on relative sea-level tracers, in order to gain insight on dynamic topography and intrusive processes. I am also investigating the application of these techniques to study volcanic landscape evolution and to date mega-tsunamis associated to giant flank collapses.
Email: rramalho@ldeo.columbia.edu
Division: Geochemistry

Cristina Recasens
Research: My research focuses on understanding the changes in dust supply and provenance in the southern latitudes. I want to define the dust sources from Southern South America and investigate the role of glaciations in dust supply, by comparing the sources with the sinks or final resting places of dust. For this purpose, I use Sr, Nd, Pb, Hf and He isotopes and major and trace elements chemistry. My previous works focused on Late Quaternary environmental changes recorded in lacustrine sediments in southern Patagonia using a multiproxy approach, and specializing for my PhD in freshwater diatoms.
Email: recasens@ldeo.columbia.edu
Division: Geochemistry

Meredith Reitz
Research: In my research, I study various patterns in geomorphology that arise from sediment transport acting in different settings, using analytical, modeling, and experimental approaches. My current work focuses on the channel dynamics and effect of changing boundary conditions on the Ganges-Brahmaputra river delta, and also on the granular flows of landslides.
Email: mreitz@ldeo.columbia.edu
Division: Marine Geology & Geophysics

Alessio Rovere
Research: My research has focused on different issues related to earth and environmental sciences, with particular emphasis on physical geography of coastal environments. Being a scientific scuba diver, some of my works are on underwater coastal geomorphology. In particular I study Pleistocene and Holocene sea level changes by means of geomorphological, sedimentological and archaeological markers
Email: rovere@ldeo.columbia.edu
Division: Biology & Paleo Environment

Isla Simpson
Research: My research interests focus on the dynamics of variability and change in the mid-latitude jet streams and the coupling between the stratosphere and troposphere. Currently I am working on understanding climate model biases in Southern Hemisphere mid-latitude variability and understanding the influence of future stratospheric circulation changes on predicted Northern Hemisphere tropospheric climate change.
Email: isla@ldeo.columbia.edu
Division: Ocean & Climate Physics

Karen Smith
Research: I am an atmospheric scientist interested in better understanding climate variability on seasonal to decadal time scales. I observational data analysis and simple and complex computer models to study the variability of the large-scale circulation of the mid- and high latitudes. I am currently studying the influence of stratospheric ozone depletion and recovery on the coupled variability of the Antarctic atmosphere-cryosphere system.
Email: ksmith@ldeo.columbia.edu
Division: Ocean & Climate Physics

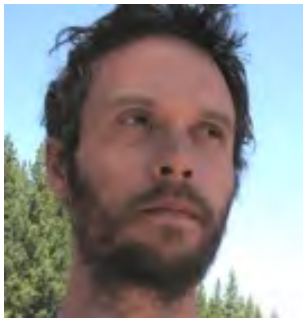
Kristoffer Szilas
Research: My research focuses on the geochemistry of rocks in SW Greenland from the Archaean Eon, some 3.8 to 2.5 billion years ago. One of the main questions have been to understand what type of tectonic setting was likely responsible for the volcanic rocks in that region. I am currently working on a research project about the origins of ultramafic rocks. These very old rocks are somewhat enigmatic, because at the moment nobody knows if they represent magmas, cumulates or mantle rocks. Either case will have important implications for our understanding of the earliest volcanic rock record on Earth.
Email: kszilas@ldeo.columbia.edu
Division: Geochemistry

Nivedita (Nithya) Thiagarajan
Research: My research focuses on using stable (d13C, d18O) clumped isotopes and radiogenic isotopes (14C and U-series) to reconstruct ocean temperature and circulation in the past, focusing on the last glacial cycle.
Email: nivedita@ldeo.columbia.edu
Division: Geochemistry

Kirsty Tinto
Research: I work on aerogravity and magnetic data from Antarctica and Greenland collected with Operation IceBridge. I invert the potential field data for bathymetry and geology and investigate how these influence glacier flow.
Email: tinto@ldeo.columbia.edu
Division: Marine Geology & Geophysics

Kevin Uno
Research: My primary research interest is in reconstructing ancient terrestrial ecosystems using light stable isotopes (H, C, N, & O) and other geochemical tools. I analyze isotopes from leaf waxes extracted from Plio-Pleistocene paleosols from East Africa to evaluate vegetation and hydroclimate over the past ~4 million years. I also study modern and fossil teeth and tusks of East African mammals using histological and stable isotope methods.
Email: kevinuno@ldeo.columbia.edu
Division: Biology & Paleo Environment

Luke Valin
Research: I investigate patterns of atmospheric oxidation, the process by which pollutants are formed and removed from the atmosphere. Formaldehyde, a trace gas, is formed primarily by the oxidation of methane but also the oxidation of less abundant organic compounds. Spatially-detailed measurement of formaldehyde is possible from satellite-based UV/Visible spectrometers. I am using these measurements and atmospheric models to study the processes controlling atmospheric oxidation.
Email: lcvalin@ldeo.columbia.edu
Division: Ocean and Climate Physics



Nicholas van der Elst
Research: I am an earthquake physicist specializing in statistical seismology and experimental granular mechanics. My research at Lamont focuses on how a fault becomes primed for failure during the interseismic cycle, and whether the triggering of small earthquakes can be used to infer the state of stress on a fault.
Email: nicholas@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics

Lei Wang
Research: I work on spaceborne gravimetry using contemporary orbiting satellites, such as Gravity Recovery And Climate Experiment (GRACE) and Gravity field and steady-state Ocean Circulation Explorer (GOCE). I also work on interpretations of gravity changes associated with mass redistribution phenomena in the earth system, particularly the coseismic and postseismic gravity changes due to great subduction earthquakes.
Email: leiwang@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics

Yakov Weiss
Research: My research focuses on understanding the systematics of He isotopic compositions in mantle-derived melts. Combined with major and trace elements and other isotopic compositions on MORB and OIB samples, as well as pristine micrometer-scale melt-inclusions trapped within diamonds the heterogeneity of the Earth's mantle and geodynamics processes can be better restricted.
Email: yweiss@ldeo.columbia.edu
Division: Geochemistry

Cian Wilson
Research: I develop (and use) numerical models for fluid- and geo- dynamics. My current project is focused on modeling fluid migration in subduction zones but I'm also involved in work with landslide-generated tsunami, high Rayleigh number flows, plume ascent rates in non-linear rheologies and numerical algorithms for free surfaces.
Email: cwilson@ldeo.columbia.edu
Division: Seismology, Geology & Tectonophysics

Nicolás Young
Research: My primary research interest lies in reconstructing the paleo-dimensions of Arctic ice masses through the Holocene to better understand patterns of Holocene climate change in the Arctic. To do this, my research utilizes cosmogenic surface-expousure dating to pinpoint moments in time when glaciers were in expanded or retracted states. I am also interested in the interplay between climatic and dynamic processes in dictating ice-sheet behavior.
Email: nicolasy@ldeo.columbia.edu
Division: Geochemistry

Camili, in the Artvin province of Turkey. Picture contributed by Dario Martin Benito.

Notes

Northern Greenland. Picture contributed by Kirsty Tinto.

Aappalaartoq mountain, Greenland. Picture contributed by Kristoffer Szilas.

Brochure cover designed by Miriam Cinquegrana. Photos of Lamont Campus courtesy Bill Menke.

Contact
Office of Academic Affairs & Diversity
LDEO Directorate
Lamont-Doherty Earth Observatory
The Earth Institute at Columbia University
61 Route 9W, Palisades, NY 10964
Email: kdutt@ldeo.columbia.edu
Website: http://www.ldeo.columbia.edu/academicaffairs